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Public (dis)trust in science in digital media environments

ARTICLE

(Un)certainty in science and climate change: a longitudinal analysis (2014–2022) of narratives about climate science on social media in Brazil (Instagram, Facebook, and Twitter)

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Abstract

This article examines climate change discourse on Brazilian social media from 2014 to 2022 and use a longitudinal approach, analyzing discourse, scientific authority, and eco-emotions on Instagram, Facebook, and Twitter. Methods include TF-IDF for feature extraction, sentiment analysis with VADER, and Named Entity Recognition (NER). A Ridge Classifier was trained on 557 manually classified samples. Findings show no significant increase in challenges to scientific authority or skepticism, but reveal a subtle shift towards using uncertainty as a rhetorical tool to undermine trust in scientific discourse.

Keywords

Environmental communication; Public perception of science and technology; Science communication in the developing world

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1 ▪ Introduction

Trust in science is a complex theme that involves the intersection of communication, public perception, and political practices [Nisbet & Scheufele, 2009]. Scientific denialism, described as the intentional rejection of well-established scientific truths [Diethelm & McKee, 2009], provides a crucial framework for understanding how climate change narratives develop on social media platforms. In this regard, Renata Schiavo [2022] introduces the concept of 'Science of Trust', highlighting the importance of research, policy, and communication strategies in overcoming systemic, community, and individual barriers to trust in science, especially within public health and healthcare contexts. This framework emphasizes the crucial role of these factors in shaping public perception and trust in scientific knowledge. Building on this foundation, our study adopts a longitudinal approach to analyze climate change discourse on Instagram, Facebook, and Twitter.

Recent studies indicate varying levels of public trust in science globally, shaped by political, social, and media dynamics. For instance, Massarani et al. [2022] discuss the erosion of trust in science within Brazil, exacerbated by misinformation campaigns during the COVID-19 pandemic. This decline contrasts with broader global trends, in which trust in science remains relatively high, but faces challenges from digital misinformation and political polarization [Dunlap & Brulle, 2015; Ecker et al., 2022]. Moreover, the Brazilian population's confidence in scientific institutions varies significantly, with public institutions generally perceived more favorably than private entities [Massarani et al., 2022].

In analyzing climate change discourse, it is essential to understand the range of emotional responses, termed 'eco-emotions', that arise in response to environmental issues. Terms like 'eco-anxiety' and 'climate anxiety' capture the psychological impact of environmental concerns on individuals, reflecting a widespread fear of environmental degradation [Pihkala, 2019; Clayton, 2020]. Other related emotions, such as solastalgia, climate grief, and environmental despair have also been documented, illustrating the emotional complexity within climate change narratives [Figueroa, 2017; Comtesse et al., 2021].

On social media, these emotional dynamics are evident, as platforms become arenas for public debate and dissemination of climate-related information. Twitter, Instagram, and Facebook are pivotal in shaping public understanding and attitudes towards climate change, often reflecting broader societal beliefs and biases [Falkenberg et al., 2022; Chen et al., 2023]. However, misinformation and denialist tactics complicate this landscape, undermining scientific consensus and promoting skepticism [Oreskes & Conway, 2010; Vieira de Souza et al., 2021].

In Brazil, climate change discourse has been highly contentious, influenced by political dynamics and the amplification of narratives through social media. During Jair Bolsonaro's administration (2019–2022), climate denialism increased, challenging scientific data and downplaying environmental risks [Toni & Feitosa Chaves, 2022; Salles et al., 2023]. This trend mirrors global patterns where right-wing ideologies often oppose environmental regulations and scientific findings [McCright & Dunlap, 2011; Jylhä & Akrami, 2015]. Social media has played a key role in spreading denialist content, deepening ideological divides, and hindering informed climate discussions [Bloomfield & Tillery, 2018]. This study examines how scientific discourse on climate change impacts public trust and eco-emotions on Instagram, Facebook, and Twitter from 2014 to 2022, analyzing the role of scientific authority in shaping these narratives.

Uncertainty in climate change discourse is often used strategically to question the validity of evidence and create a perception of ongoing debate, even where scientific consensus exists. Oreskes and Conway [2010] show how interest groups use uncertainty to weaken public trust in climate science, while Hulme [2009] notes it reflects the complexity of climate models and data variability. Wynne [1992] explores how the public perceives uncertainty and its use in political debates to support specific agendas.

In this study, we distinguish between 'narratives' and 'discourse' in climate change communication on Brazilian social media. 'Narratives' focus on specific stories and their impacts, while 'discourse' refers to the broader context shaping these stories. Using theories from Bourdieu [1991], Fairclough [1995], and Foucault [1972], we ensure precise use of each term for a deeper analysis of climate change debates in the Brazilian digital landscape.

2 · Information about climate change on social media and the Brazilian context

Climate change discourse on social media has indeed become increasingly significant in shaping public perceptions and attitudes toward climate change. Studies have shown that social media platforms play a crucial role in influencing mainstream media on scientific topics like climate change [Williams et al., 2015]. Platforms such as Twitter have become key spaces for discussions and debates surrounding climate change [Falkenberg et al., 2022]. Chen et al. [2023] highlights the significance of framing climate change messages in a moral, hopeful, and motivational way, as the activism on Instagram of figures like Greta Thunberg demonstrates. Also, studies have shown that Facebook is commonly used for climate change communication due to its ability to facilitate the creation and dissemination of information within virtual communities [Deo & Prasad, 2020].

There are many complexities in communicating climate change through social media and a need for a balanced and insightful knowledge base to effectively engage with audiences on platforms like Instagram [Pearce et al., 2018], especially in a context of climate denialism on social media.

Climate denialism is not solely based on scientific arguments, but is also influenced by social relationships, moral values, and embodied experiences [Bosca, 2023]. Social media plays a significant role in the circulation of climate denial information, with studies pointing out how denialist content spreads through online spaces and conservative media [Bloomfield & Tillery, 2018; Pearce et al., 2018]. The reliance on specific media sources and trust in actors associated with climate denial movements contribute to the perpetuation of denialist beliefs [Sarathchandra & Haltinner, 2023]. Moreover, climate change denial is often associated with ideological factors, such as conservatism and social dominance orientation [Jylhä & Akrami, 2015; Petersen et al., 2019].

In the Brazilian context over the last decade, climate denialism has been a significant issue with various underlying factors. The denial of anthropogenic climate change in Brazil is influenced by social dominance orientation, exclusionism, and conservative political orientation [Jylhä et al., 2016, 2020; Lewandowsky, 2021], and this denialism is particularly prevalent among far-right populists, including the administration of President Jair Bolsonaro [Toni & Feitosa Chaves, 2022; Queiroz-Stein et al., 2023; Salles et al., 2023]. Moreover, the

reluctance of Brazilian decision makers to recognize the urgency of climate change has been contributing to the exacerbation of the climate crises and the endangerment of biodiversity [Silva, 2022; Ferrante et al., 2023].

Furthermore, the denialist approach to climate change in Brazil has been linked to a broader pattern of denialism, which includes downplaying the seriousness of other global challenges such as the COVID-19 pandemic [Fonseca et al., 2021], and has been associated with interests in land use and economic nationalism, reflecting a broader trend of anti-environmental lobbying [Muradian & Pascual, 2020; Miguel, 2022; Salles et al., 2023]. Denialism has also been noted to be part of a global trend, with far-right regimes in various countries, including Brazil, contributing to climate disruption denial [Hudson & Zimmermann, 2019].

However, even with the evolving political and media landscape in Brazil, especially following the election of President Bolsonaro, mainstream media appears to have remained unaffected by climate denial, as most forms of skepticism about climate change continue to be notably absent from television coverage of the topic [Painter et al., 2023]. Consequently, the mainstream media's portrayal seems to be in alignment with the dominant public perceptions of climate change within the country, which predominantly recognize it as a legitimate issue rather than a hoax [3M, 2022; Instituto de Tecnologia e Sociedade do Rio, 2022].

The strong support for Bolsonaro administration's actions against the scientific community on social media [Santini et al., 2023] has fostered a favorable environment for climate change denial. Social media served as a key platform for Bolsonaro's political rise [Alves dos Santos Junior & De Albuquerque, 2019; Mundim et al., 2023], reinforcing far-right ideologies and spreading climate denial while undermining scientific credibility. As a result, Brazil's leading social media platforms are critical for studying how these dynamics promote climate denialism and challenge scientific consensus, revealing a growing divide between social and mainstream media [Cardenal et al., 2019; Pfetsch, 2020; Lycarião et al., 2025].

3 ▪ Intersecting science and sentiment: an examination of climate discourse, scientific authority, and eco-emotions

Given the growing concern about the impact of digital media environments on public trust in science, this study seeks to answer the following research question: Which discourse types, authority types, and eco-emotions prevail in the climate change discourse on major Brazilian social media platforms, and how do they influence public trust in science? This question guides our analysis along three axes: Discourse, Scientific Authority, and Eco-Emotions. Each provides a distinct perspective on the narratives and emotions shaping public understanding of climate change and the relationship between climate communication and trust in science. For instance, the 'Discourse' categories — such as 'denialism,' 'climate alarmism,' 'climate analyst,' and 'climatic context' — are grounded in the works of Oreskes and Conway [2010], Begley [2007], and Hannigan [1995], which explore how various communication strategies are employed to shape public discourse on climate change.

3.1 ▪ *The discourse axis*

The first axis, **Discourse**, is critical to our research question as it explores the various narratives surrounding climate change on social media platforms. Understanding the nature

of these discourses — ranging from climate alarmism to denialism — provides insight into how they might reinforce or undermine public trust in science. For instance, 'new denialism' acknowledges climate change but strategically questions its impacts and the scientific consensus, potentially fostering doubt among the public. 'Discourse' categories include 'denialism' (new and old), 'climate alarmism' (exaggerated portrayal of climate change), 'climate analyst' (objective analysis of global warming), and 'climatic context' (climate issues within broader debates).

In the discourse surrounding climate change, the variety of approaches highlights the complexity of the topic. 'New denialism' recognizes the existence of climate change but strategically challenges its effects, proposed solutions, and even the validity of climate science itself. It often employs scientific arguments to undermine overwhelming evidence, thereby creating doubt [Lahsen, 2013; Shue, 2022; CCDH, 2024]. Shue [2023] further explains that as outright denial of climate change becomes increasingly untenable due to mounting scientific evidence and climate disasters, 'new denialism' manifests as 'deceptive delay,' promoting seemingly climate-friendly policies that, in reality, allow for continued fossil fuel extraction. In contrast, 'old denialism' outright denies global warming and its anthropogenic causes, relying on outdated or refuted theories and completely rejecting established scientific evidence [Oreskes & Conway, 2010]. This evolution from outright denial to more nuanced skepticism reflects a shift in tactics aimed at maintaining credibility within scientific discourse.

Denialism, broadly defined as the intentional rejection of well-established scientific truths and evidence [Diethelm & McKee, 2009], has deep historical roots. As detailed in Oreskes and Conway's 'Merchants of Doubt' [2010], various interest groups have long used strategies to undermine scientific credibility across different fields, including tobacco use and climate change. Similarly, denialism has also targeted historical events such as the Holocaust, exemplified by the legal battles faced by historian Deborah Lipstadt [1993].

Climate change denialism employs a wide range of tactics, such as establishing what has been termed a 'denialist machine' — a network designed to maintain the illusion of a scientific debate where there is none [Begley, 2007]. This network relies on misleading arguments and the distortion of scientific evidence to suggest that climate science is still in dispute. The tactics often include creating skeptical narratives supported by corporate and political interests and using a veneer of scientific language to lend unwarranted credibility to these false narratives [McMahon et al., 2016; Oliveira et al., 2021]. This manipulation significantly affects public and political perceptions of climate change, contributing to what are known as eco-emotions [Pihkala, 2020] — emotional responses related to environmental and climatic concerns, particularly when science is weaponized rhetorically on social media platforms.

As noted earlier, denialism is not a new phenomenon; it utilizes longstanding tactics designed to sustain claims that have been repeatedly discredited by the scientific community. Yet, these claims continue to find resonance within society. Tactics include producing reports mimicking those of reputable organizations like the IPCC, but lacking rigorous academic standards, promoting conspiracy theories, and launching personal attacks on reputable scientists, as discussed by Oreskes and Conway [2010] and Paliewicz and McHendry Jr. [2020].

‘Climate alarmism’ is defined as the tendency to exaggerate or overstate the impacts and immediacy of climate change, often leading to distorted perceptions of reality and heightened psychological distress, such as anxiety and pessimism. This term has been critiqued in academic literature for potentially undermining public trust in climate science by sensationalizing scientific findings [Hulme, 2008, 2023; Russill, 2023]. Hulme [2008] argues that alarmist rhetoric can polarize public opinion and create a sense of fatalism, which may hinder proactive engagement with climate mitigation efforts. Climate alarmism tends to exaggerate the impacts of climate change, often leading to distortions of reality and adverse psychological effects [Håkman Carlmark, 2014].

‘Climate analyst’ refers to individuals or entities that provide balanced, evidence-based perspectives on global warming and its consequences. Their role is to enhance public understanding by critically evaluating scientific data, challenging misinformation, and presenting findings in a manner accessible to non-expert audiences [Archer, 2011; Pidgeon, 2012]. The focus of a climate analyst is on rigorous data analysis and effective communication, aligning with efforts to increase scientific literacy and informed public discourse [Schiavo, 2022]. As highlighted, data and evidence are important in shaping public perception and trust in scientific domains, especially within the context of climate change discourse. In this study, we adopted a data-driven approach, recognizing its importance in addressing the complexities of climate change communication and fostering meaningful public engagement with scientific information [Schiavo, 2022].

Meanwhile, ‘climatic context’ aims to embed climate change within the wider debates surrounding socio-environmental issues. This approach recognizes the interconnectedness of climate change with broader societal and environmental challenges, advocating for a comprehensive understanding that considers climate change not in isolation, but as part of a larger tapestry of global issues [Castree et al., 2014; Elliott, 2018].

3.2 ▪ *The scientific authority axis*

The second axis, Scientific Authority, examines the role of scientific credibility in the narratives present on social media. This axis is directly related to our research question, as it focuses on how the authority of science is either legitimized or contested within digital discourses. By analyzing how scientific authority is portrayed — whether through legitimization, neutrality, or contestation — we can infer its influence on public trust in science.

The ‘Authority’ axis unfolds into ‘legitimation,’ ‘contestation,’ and ‘neutrality.’ ‘Legitimation’ emphasizes that scientific, cultural, and political factors, as well as the influence of scientists and institutions, are crucial in shaping authority and legitimizing environmental narratives in public and academic discourse [Hannigan, 1995; Porter et al., 2018]. Conversely, ‘contestation’ involves challenging scientific authority in denialism, questioning the legitimacy of the scientific community and established consensuses, often resorting to conspiracy theories and discrediting experts to undermine the credibility of scientific evidence [Oreskes & Conway, 2010]. Meanwhile, ‘neutrality’ means viewing scientific authority as subject to questioning and revision, where different theories are respected and considered as long as they are based on robust scientific methods [Porter et al., 2018]. This multiplicity of perspectives underscores the need for a careful and data-driven approach to deal with the complex phenomenon of climate change.

3.3 ▪ *The eco-emotions axis*

The third axis, Eco-Emotions, delves into the emotional responses elicited by climate change discourse on social media. This axis is crucial to understanding our research question because it addresses how emotional reactions, such as 'eco-anxiety' or 'eco-skepticism,' are shaped by the way climate change is communicated. These emotions play a significant role in either supporting or eroding public trust in scientific discourse.

Lastly, 'eco-emotions' encompass a range of emotional responses to environmental issues, including 'eco-anxiety,' 'eco-skepticism,' and 'eco-sarcasm.' These categories are informed by a growing body of scientific literature that examines the psychological impact of climate change on individuals and communities. For instance, Pihkala [2019, 2020] discusses eco-anxiety as a pervasive fear about environmental degradation, while Clayton [2020] and Hickman et al. [2021] explore how eco-emotions like grief, despair, and denialism manifest in response to climate-related events and discourse. These concepts help to frame our understanding of public emotional engagement with climate change and highlight the importance of integrating emotional responses into climate communication strategies.

The tactics of climate denialism, combined with societal beliefs about climate change in Brazil, have had serious impacts on the population's emotions [Mosquera & Jylhä, 2022], leading to what some researchers call eco-anxiety and climate anxiety [Pihkala, 2019, 2020; Clayton, 2020; Hickman et al., 2021]. Eco-anxiety and climate anxiety are commonly used terms, but there is also growing attention towards related concepts, such as solastalgia [Warsini et al., 2014], climate grief [Thomsen, 2016; Comtesse et al., 2021], and environmental despair [Figueroa, 2017; Szeman, 2017], among other emotions [Pihkala, 2020; Mosquera & Jylhä, 2022; Chalquist, 2023]. After exploring various interpretations of eco-anxiety [Randall, 2019; American Psychological Association, 2020; Pihkala, 2020], including EcoAmerica's definition, which describes it as 'a chronic fear of environmental doom' [Chalquist, 2023], we adopted the following categories for analyzing the data: 'eco-anxiety,' 'eco-skepticism,' 'eco-sarcasm,' and 'emotionless'.

Within the context of climate change discourse, 'eco-skepticism' emerges as a subtly nuanced and often misleading approach. While it appears to foster scientific dialogue, it undermines the fundamental scientific evidence that supports public discussions on climate change. This manipulation of information, which Oreskes and Conway [2010] highlight and into which Vieira de Souza et al. [2021] delve further, can obscure the true nature of environmental issues, leading the public astray and hindering the development of effective policies. Thus, 'eco-skepticism' establishes itself as a significant barrier to disseminating precise climate science, frequently cloaking denialism under the guise of intellectual debate while covertly eroding the foundation of established environmental facts.

Contrastingly, 'eco-sarcasm' operates on a different, yet equally influential level. As Dryzek [2010] and Rizzotto et al. [2022] detail, it serves two simultaneous purposes: to offend and to amuse. This rhetorical strategy, laden with irony, allows its users to connect with like-minded individuals through humor while simultaneously distancing and implicitly censoring the subjects of its critique.

The category 'emotionless' was employed when no correspondence was found in the other mentioned divisions. The often 'emotionless' or neutral stance, neither fully engaged nor clearly disinterested, may complicate the analysis, but is crucial for demonstrating all the nuances involved in the public perception of climate change.

4 ▪ Methods

To assess potential influences on public trust and eco-emotions and the utilization of scientific authority in validating narratives and emotions related to climate change, and to assess how this influences public trust and eco-emotions on major Brazilian social media platforms both in favor of and against climate change across three popular social media platforms — Facebook, Instagram, and Twitter — spanning from 2014 to 2022, data was collected from CrowdTangle and the Twitter API using search terms in Portuguese for climate change and/or global warming.** The dataset comprised a total of 161k, 55k, and 2,386k posts for Facebook, Instagram, and Twitter, respectively. We focused on posts and tweets that mentioned terms like 'professor,' 'scientist,' 'science,' 'research,' or 'study,' to identify content validated by scientific authority. We then cleaned the data by removing common words that do not add much meaning (like 'the' or 'and') and grouped similar posts together using a method that finds common patterns in text, called LCS (Longest Common Subsequence) Analysis and discourse similarity (via Fuzzy Clustering). The subset encompassed 17k, 16k, and 169k posts for Facebook, Instagram, and Twitter, respectively, over the same time period. Following the removal of reposts and retweets, the numbers were reduced to 7,258, 14,372, and 6,314 posts, respectively. We applied the Term Frequency-Inverse Document Frequency (TF-IDF) method to identify important words and phrases in the text. We also used n-grams, which are sequences of 2 to 4 words that frequently appear together, to help us understand common patterns and context within the posts. We conducted two additional analyses on each post: first, using the LeIA (Lexicon for Adapted Inference) tool for VADER (Valence Aware Dictionary and Sentiment Reasoner) to measure the sentiment (positive, negative, or neutral) expressed in the posts [Almeida, 2018]. Second, we applied Named Entity Recognition (NER) with the spaCy library, customized for Portuguese, to identify key entities — such as people, organizations, or terms — related to climate discourse and scientific authority. Representative samples from each cluster, totaling 557 samples, were subsequently reviewed manually to identify and characterize explicit narratives present in the posts. This process aimed to offer a deeper understanding of the perceptions and discourses related to climate change, whether validated by scientific background or not, on social media. These analyses directly contribute to understanding how scientific authority influences public trust in science, a central focus of this study.

The manually classified dataset was utilized to train a Ridge Classifier model for text classification, employing the TF-IDF vectorization technique. The Ridge Classifier model, known for its regularization properties, was chosen due to its effectiveness in handling high-dimensional data and its ability to prevent overfitting. Additionally, the NLTK toolkit was employed to remove Portuguese stopwords from the text. Overall, clustering served as a valuable tool in refining our analysis, ensuring it was grounded in actual data while allowing for a more nuanced understanding of the complexities involved in climate change discourse on social media platforms. By utilizing the entire classified dataset, the temporal evolution of discourses was evaluated. Subsequently, the findings will be presented.[1]

1. The method described is well-established in language model practices. The algorithm's design follows train-test methodologies, ensuring the reliability of both the human component (test sample selection) and the automated aspect through Machine Learning (ML) and Deep Learning (DL) processes. This approach maintains consistency and accuracy throughout the analysis.

5 ▪ Results

Figure 1 illustrates the temporal evolution of monthly post frequency across Facebook, Instagram, and Twitter within the studied subset, offering insights into social media activity patterns. It is noteworthy that, between 2014 and 2019, the number of posts per month across each social media platform did not exceed 200. However, from 2019 to 2022, this number increased significantly, with the monthly post frequency rising to approximately five times higher on each platform.

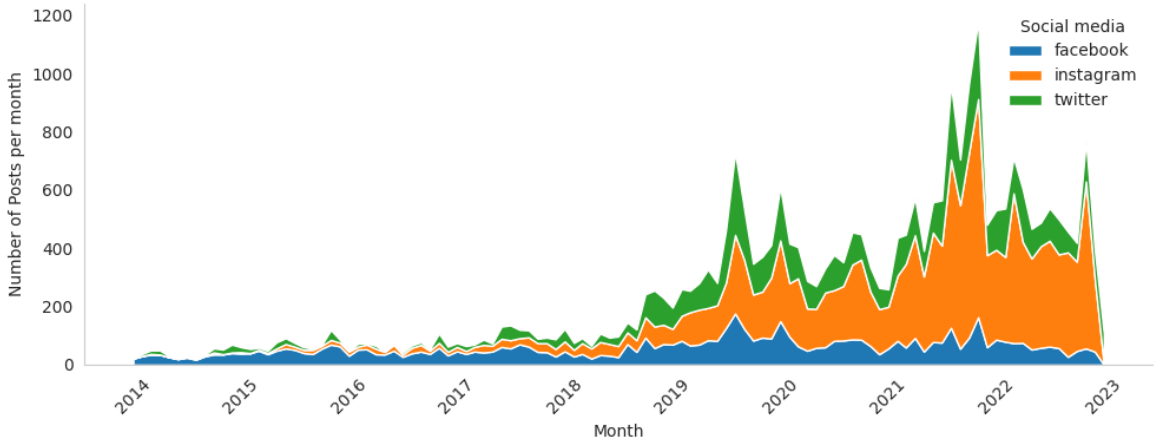

Figure 1. Temporal evolution of post frequency by source: Facebook, Instagram, and Twitter, from the analyzed subset.

Figure 2 shows the variability of total interactions for each social media platform per year, aligning with the absolute post analysis from Figure 1. In the total dataset of the subset, approximately 75% of all posts register interactions below 1,000. Here, 'total interactions' encompasses 'likes,' 'comments,' 'shares,' 'love,' 'wow,' 'haha,' 'sad,' 'angry,' and 'care' for Facebook; total_interactions for Instagram (absolute values extracted from the API); and 'like,' 'reply,' 'retweet,' 'quote,' and 'impression' for Twitter. It is noteworthy that interaction opportunities on Instagram tend to outnumber those on Facebook and Twitter. Instagram tends to generate a higher average number of interactions per post compared to Facebook and Twitter, likely due to the platform's various interaction options, such as likes, comments, and shares, which provide users with multiple ways to engage. Furthermore, the figure indicates no significant increase in interactions starting from 2018, although outliers (representing total interactions above the 75th percentile of the annual sample) have increased by an order of magnitude since 2018, particularly on Instagram. This suggests heightened network activity concerning the subset's addressed themes during this period.

The dominance of 'climatic context' discourse type is evident in Figure 3 throughout the analyzed period and across all three social media platforms, followed by 'climate analyst,' with occasional spikes of this discourse type on Twitter until mid-2018. Other discourse types ('climate alarmism' and the two types of 'denialism') appear in much smaller percentages. Most importantly, neither 'climate alarmism' nor 'denialism' increased during the years of Bolsonaro's administration (2019–2022).

In Figure 4, it is significant to observe the variability in the use of authority for the discourse types outlined in Figure 3 across different platforms. On Facebook, a relatively balanced

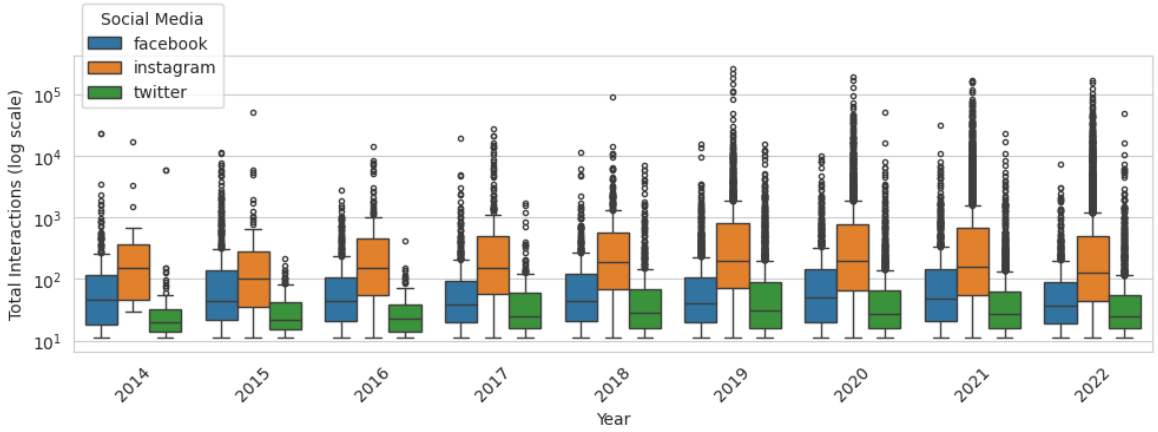

Figure 2. Boxplot illustrating the variability of total interactions in each post per social media platform.

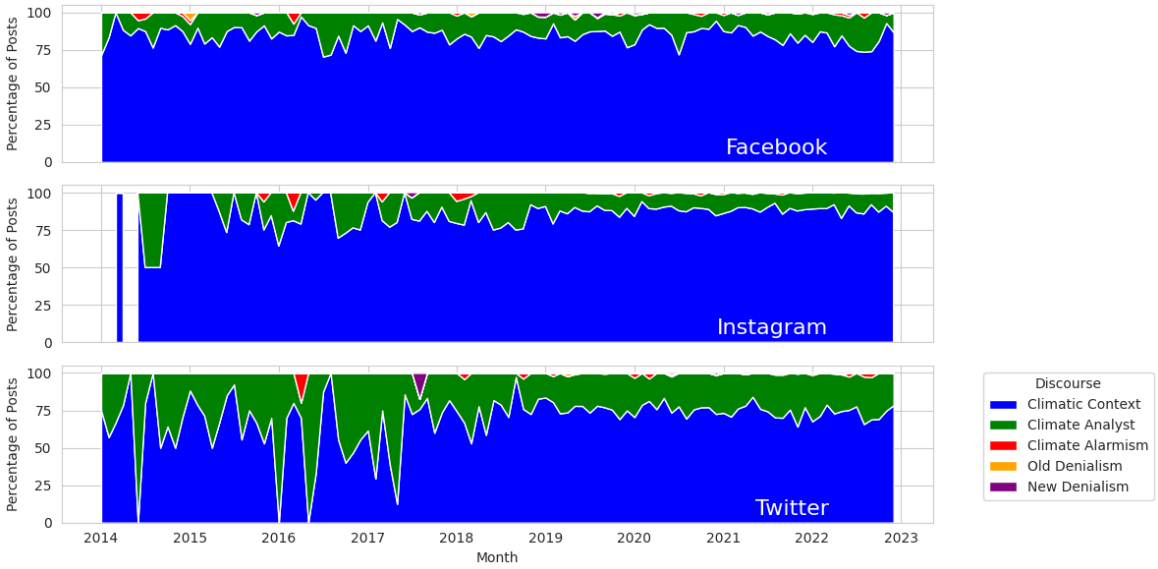

Figure 3. Temporal evolution of discourse types classified by social media platforms using machine learning techniques. The 'missing' period on Instagram in 2014 refers to months where no data was classified.

proportion between 'neutrality' and 'legitimation' is evident, accompanied by a nearly consistent proportion of 'contestation'. However, 'neutrality' on Instagram and Twitter shows a progressive decline over time, making way for an increasing presence of 'legitimation,' while 'contestation' does not appear to gain traction in the posts.[2]

Between 2014 and 2015, there was a significant spike in 'contestation' on Instagram, making it the predominant discourse type during this period. However, this trend was unique to

2. It is important to consider here that this is a 'naïve' classification relying on an analytical control of the classification model used. Although this study has used classifiers from the SVC and Ridge Classifier families, which are not generally considered 'Naïve' themselves. The designation 'Naïve' typically refers to algorithms based on simplified assumptions about the data distribution. Therefore, the question of whether a classifier is 'Naïve' or not depends more on the overall approach and context of use than on the specific nature of the algorithm itself.

Instagram, as similar increases were not observed on Facebook or Twitter, where 'contestation' remained less prominent. This highlights a distinct pattern compared to the other platforms. Furthermore, the atypical presence of 'contestation' on the other platforms, Twitter and Facebook, is also a key observation, indicating significant variations in the use of authoritative discourses across different social networks. Overall, the legitimization of scientific authority either remains consistent or exhibits an increase over time.

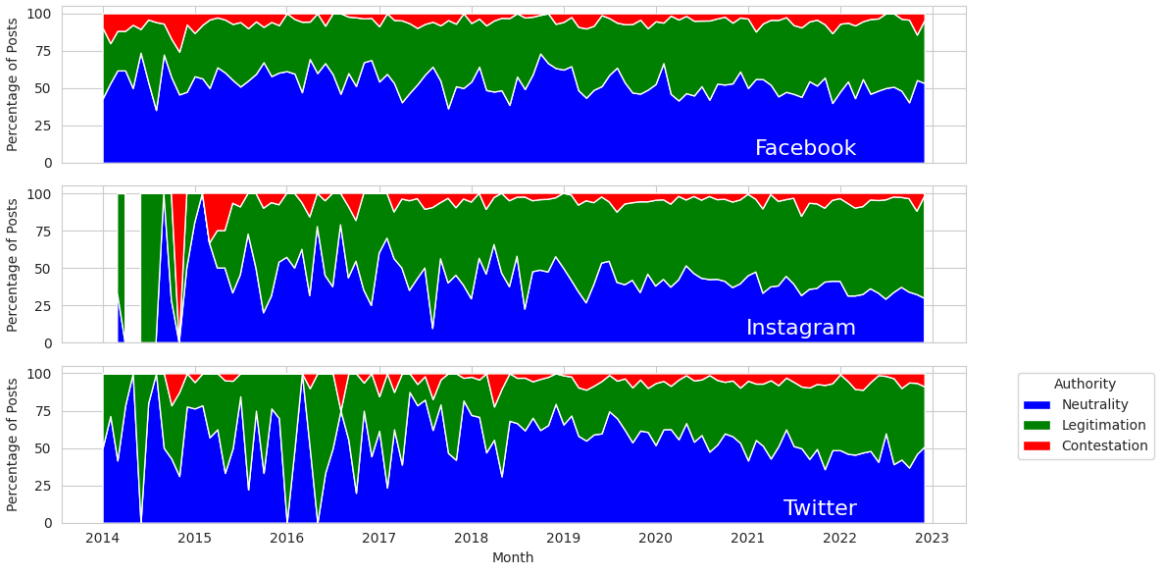

Figure 4. Temporal evolution of classified authority types (Neutrality, Legitimation, Contestation) using machine learning techniques for social media platforms. The 'missing' period on Instagram in 2014 refers to months where no data was classified.

Figure 5 displays the outcome of classifying posts into eco-emotion categories ('eco-anxiety,' 'eco-skepticism,' 'eco-sarcasm,' and 'emotionless') using the classifier as described in the methods section. 'Eco-anxiety' dominates all posts across all platforms, with terms (n-grams) such as 'crisis,' 'resource depletion,' 'suffering,' among others, carrying higher weights. It is intriguing to note that even though the sample consists of public and institutional posts, the tone remains consistently 'distressing,' 'troubling,' or 'stressful.' Moreover, a higher percentage of Instagram posts were labeled as 'emotionless.' Even more noteworthy is the fact that there was no observed increase in either 'eco-skepticism' or 'eco-sarcasm.'

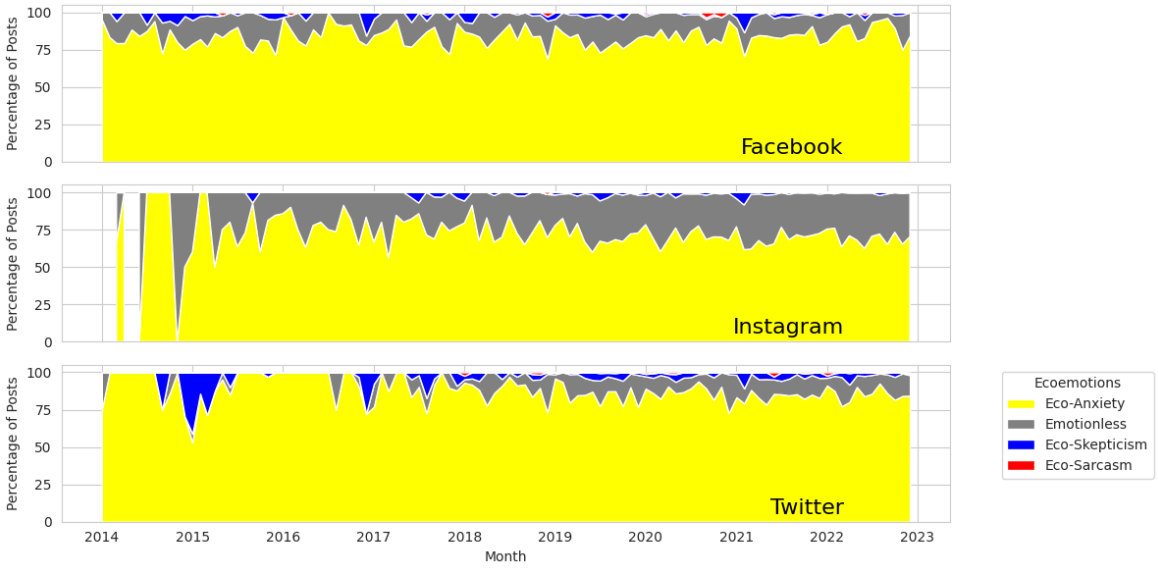

Figure 5. Temporal evolution of classified 'eco emotion' types (Eco-Anxiety, Eco-Skepticism, Eco-Sarcasm and Emotionless) using machine learning techniques for social media platforms. The 'missing' period on Instagram in 2014 refers to months where no data was classified.

To ensure alignment with the main topic introduced, this section has outlined the methodological approach designed to directly address the central research question, which is to infer the potential impact of social media discourse on public trust in scientific authority, particularly in the context of climate change. The chosen methods are specifically tailored to explore this question in depth, allowing for a comprehensive analysis of how different narratives and eco-emotions are shaped on Brazilian social media platforms.

To provide a clearer understanding of the categories within each axis of analysis, we have compiled a table that outlines the categories and provides typical examples, translated into English, from the social media discourse analyzed in this study. This table serves to illustrate the various ways in which climate change is discussed and perceived across Brazilian social media platforms. It helps to contextualize the findings within each axis of analysis — Discourse, Scientific Authority, and Eco-Emotions — by showcasing real-world examples that align with the defined categories.

Table 1, alongside Figures 1 to 5, provides a clear illustration of how different discourse categories ('New Denialism,' 'Climate Alarmism,' 'Climate Analyst') and eco-emotions ('Eco-Anxiety,' 'Eco-Skepticism') on Brazilian social media platforms reflect varying uses of scientific authority in climate change discussions. The examples in Table 1, such as 'New Denialism' ("While climate change exists, the impacts are overstated...") and 'Eco-Anxiety' ("There is a growing sense of fear..."), demonstrate the diverse narratives and emotional responses that potentially influence public trust in science. This analysis, supported by methods like TF-IDF and sentiment analysis, highlights the nuanced ways social media discourse shapes eco-emotions and public perceptions of scientific credibility, directly addressing the research question on the impact of these dynamics on public trust.

Table 1. Examples of Discourse Categories and Eco-Emotions Related to Climate Change on Brazilian Social Media.

Axis of Analysis	Category	Example (Translated to English)
Discourse	New Denialism	"While climate change exists, the impacts are overstated and the proposed scientific solutions are exaggerated and ineffective."
Discourse	Old Denialism	"Global warming is a myth; there is no credible evidence to support it."
Discourse	Climate Alarmism	"Immediate and radical measures are necessary to avoid an impending climate catastrophe."
Discourse	Climate Analyst	"Analyzing the data reveals that climate change is occurring, but we must consider all variables before drawing conclusions."
Scientific Authority	Legitimation	"Leading scientists confirm that urgent actions are required to mitigate climate change effects."
Scientific Authority	Contestation	"Alleged experts are merely funded by political groups to stir up climate panic."
Scientific Authority	Neutrality	"While there are different opinions on the matter, it is crucial to respect diverse scientific perspectives."
Eco-Emotions	Eco-Anxiety	"There is a growing sense of fear about the future of our planet due to the ongoing climate crisis."
Eco-Emotions	Eco-Skepticism	"Some believe that climate change threats are exaggerated and not an immediate concern."
Eco-Emotions	Eco-Sarcasm	"Oh sure, the world is ending because of a 0.1-degree temperature rise. That's definitely the end of civilization."
Eco-Emotions	Emotionless	"There are many reports about climate change, but I'm not particularly worried or interested."

6 ▪ Discussion

In our study, we emphasize the role of social media in shaping public trust in scientific discourse, particularly in the context of climate change. The data reveals that while there has been no marked increase in climate denialism on Brazilian social media, there remains a significant interplay between scientific authority and public perception. This is crucial for understanding how different narratives, whether supportive or critical of climate science, might influence trust. By analyzing eco-emotions such as 'eco-anxiety' and 'eco-skepticism,' the study illustrates how emotions tied to environmental communication reflect broader sentiments of trust or distrust in scientific authority. These findings underscore the importance of transparent and accurate communication by scientific communities to maintain and build public trust in science, especially in digital spaces, where misinformation can quickly spread. In doing so, the study provides insights into the potential effects of these dynamics on public trust.

Importantly, the data from the three analytical dimensions collectively indicate that, contrary to an increase in recent years, climate denialism has remained virtually absent. Such outcomes are in direct contradiction to the expectations set against the backdrop of numerous instances of scientific denialism perpetrated by the Bolsonaro government and its supporters on social media platforms. This divergence prompts a critical inquiry: How can these results be explained? To further contextualize these findings, it would be valuable to compare them with similar studies conducted in other regions where far-right ideologies

have shaped public discourse. For instance, studies in the United States and Europe have shown varying levels of climate denialism [Dunlap & Brulle, 2015] depending on the political climate and media ecosystem [Nerlich et al., 2010]. Such comparisons could reveal whether the Brazilian case represents an outlier or is part of a broader trend influenced by global political dynamics.

There are two primary ways to explain the observed findings. The first explanation stems from the data that are available, while the second arises from considering the data that are absent.

Regarding the available data, a manual inspection of messages with the highest number of likes on each platform suggests the following scenario: actors from Bolsonaro's far-right did not appear among the most influential actors identified. More importantly, their messages with high levels of engagement that were found reveal a rhetoric from the Bolsonaro government markedly different[3] from other agendas where denialist postures were notably and publicly adopted, such as the COVID-19 pandemic [Fonseca et al., 2021]. In summary, despite systematically adopting anti-environmental and anti-scientific policies, the Bolsonaro government has adopted a strategically complacent and even favorable rhetoric on social media and public communication regarding climate change. This stance was strategically complacent and favorable because the government used this agenda on several occasions to demand financial resources from wealthy countries in exchange for adopting protection policies which, most likely, it never intended to implement effectively.

As for the absent data, this stems from the possibility that many explicitly denialist contents were reported and, therefore, excluded by the platforms herein analyzed. These platforms began to adopt more systematic content moderation policies after various scandals and complaints involving their role in disseminating disinformation [Pierri et al., 2023]. Hence, rather than an actual decrease in explicitly denialist content, what may have occurred was its erasure from the public records this research collected. The implications of content moderation practices on research outcomes warrant further discussion [Gorwa et al., 2020]. While these practices are important for curbing the spread of disinformation, they also pose significant challenges for researchers attempting to capture a complete picture of public discourse [Roberts, 2019]. The potential erasure of denialist content due to platform policies could lead to an underestimation of the prevalence of such narratives, highlighting the need for methodological approaches that account for these limitations when analyzing social media data.

The findings demonstrate that while explicit climate denialism has not increased, the strategic use of uncertainty in social media narratives continues to challenge public trust in scientific authority. This subtle form of skepticism can be equally damaging to public

3. For example, the most liked post in the Instagram database by Bolsonaro presents the following message: 'With the work of the Ministry of Science and Technology, we inaugurated the telecommunications services of the Brazilian station in Antarctica. The scientists and military personnel who work there now have access to high-speed fixed internet, 4G connection, Wi-Fi access in the facilities, and TV signal. The station conducts studies on climate change and biotechnology research with the aim of developing advances in medicine and agriculture.' (Free translation). Available on https://www.instagram.com/p/Bu66ByKnVJy/, access on April 3rd, 2024. A more emphatic example is the most liked post by Carla Zambelli (a congresswoman, supporter of the former President) in the Facebook database: https://www.facebook.com/watch/?v=1828630000351776. The post depicts a video that features Bolsonaro speaking at the Leaders Summit on Climate in the USA, which took place in 2021, and, at the bottom of the video, there is a highlighted banner containing the following phrase: 'Brazil is at the forefront of combating global warming.' (Free translation).

perception of science, as it perpetuates doubt and diminishes confidence in scientific consensus.

7 ▪ Limitations and future research

The potential gap in the data due to exclusion by social media platforms highlights the challenges in accurately capturing and analyzing the full scope of discourse surrounding climate change and scientific authority on these central arenas for the contemporary public sphere. However, by each day these platforms become more opaque for scientific inquiry [Economic Times, 2024]. This poses important challenges for past and future research.

Another limitation of this study pertains to the measurement of eco-emotions. It is critical to emphasize that this phenomenon introduces complexities that challenge traditional models of linguistic analysis. The classifier used in this study is relatively basic and may not fully capture the nuanced essence of eco-emotions. In the Brazilian context, the prevalence of irony, mockery, satire, and cynicism in social media posts is notable. Such linguistic nuances can confound most classification techniques, highlighting the necessity for a more in-depth exploration of semantics and the creation of a specialized lexicon to accurately identify eco-emotions. Moreover, the absence of Instagram data in 2014, as illustrated in Figure 5, emphasizes the need for cautious interpretation of these findings.

The lack of an increase in explicit climate denialism on social media platforms may reflect a strategic shift towards using uncertainty to subtly erode public trust in science. This approach avoids direct confrontation with scientific facts, instead fostering doubt and creating a perception of debate, which can be just as detrimental to public confidence in scientific authority.

Nevertheless, the study also reveals promising avenues for future research, given that the emotional variations observed suggest a sensitivity to public discourse and global events. This indicates a dynamic interaction between the public agenda and emotions expressed online. For instance, the observed increase in ‘eco-anxiety’ could be linked to significant events, such as natural disasters or climate change awareness campaigns, which heighten public concern for environmental issues. This interplay offers a fertile ground for future investigations, potentially by correlating eco-emotion dynamics on social media platforms with the occurrence of extreme weather events and awareness campaigns.

8 ▪ Conclusion

In concluding this examination of climate change discourse on Brazilian social media from 2014 to 2022, it is important to reflect on the key findings in relation to our research question: Which discourse types, authority types, and eco-emotions prevail in these discussions, and how might they influence public trust in science? This study aimed to understand the broader role of scientific discourse in shaping public trust and eco-emotions amidst political and media shifts, especially during President Bolsonaro’s administration [Alves dos Santos Junior & De Albuquerque, 2019; Muradian & Pascual, 2020; Miguel, 2022; Mundim et al., 2023; Toni & Feitosa Chaves, 2022; Queiroz-Stein et al., 2023; Salles et al., 2023; Santini et al., 2023]. Contrary to initial expectations, our findings reveal no significant rise in climate denialism or challenges to scientific authority. Instead, a notable cognitive

and emotional alignment with scientific authority was observed, contrasting with the anticipated environment for climate denial and skepticism.

This unexpected outcome challenges two prevalent understandings in the literature: a) the perception of social media as providing fertile ground for climate and scientific denialism [e.g. Bloomfield & Tillery, 2018], and b) the notion of fragmentation and disconnection within the communication structures of the public sphere [e.g. Pfetsch, 2020].

However, these results may have been influenced by an atypical stance from the Bolsonaro government, as while it systematically adopted anti-environmental and anti-scientific policies, it utilized a strategically complacent and even favorable rhetoric towards combating climate change on social media and public communication. This rhetorical strategy was likely employed to solicit financial resources from wealthy countries in exchange for protection policies. This stance, coupled with the possibility of platforms removing explicit denialist content, suggests a complex interplay of factors at work.

The primary contribution of this work lies in identifying the atypical nature of Brazil's far-right stance on climate change within a specific context that did not propagate its usual denialism. This finding opens up avenues for future research to explore the extent to which this atypicality might produce prolonged effects on the discourse of this still influential political movement in the country. Understanding the interplay between political rhetoric, public sentiment, and content moderation practices on social media platforms will be crucial in further unraveling the dynamics of climate change discourse in Brazil and potentially other contexts influenced by similar political ideologies.

Finally, it is important to note that research underscores the importance of understanding how digital environments shape public trust in science. The findings suggest that even in the absence of explicit denialist content, public trust can be undermined through more subtle forms of communication that emphasize uncertainty or skepticism, while this aspect was not visually represented in the data graphics, our research uncovered a significant trend within Brazilian climate discourse.

As we conclude this examination of climate change discourse on Brazilian social media from 2014 to 2022, our findings emphasize the nuanced role that scientific authority plays in shaping public trust and eco-emotions in digital environments. These findings open new avenues for research to explore how this complex interplay of political rhetoric, public sentiment, and content moderation on social media platforms influences climate discourse in Brazil. Future studies could investigate the potential long-term effects of these dynamics, particularly in how they might shape public understanding and policy advocacy for climate action. Additionally, the implications of content moderation practices on the representation and visibility of climate narratives warrant further exploration, especially considering the evolving political landscapes and media strategies that influence digital communication. Understanding these factors will be crucial in developing more effective strategies to foster public trust in science and counteract the subtle forms of skepticism and uncertainty that can undermine scientific authority.

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