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Between Calls for Action and Narratives of Delay: Climate Change Attention Structures on Twitter

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Abstract

The threats posed to society by climate change often fail to become priorities for voters and policymakers alike. Nevertheless, it has been shown that merely paying attention to climate change (online) can increase the perceived severity of the associated risks and thus encourage climate action. Therefore, we focus on public discourse on Twitter to explore the interplay of 'triggers' and discursive features that stimulate attention to climate change. We collected data from 2017–2021, identified each year's top five 'peak' events of climate attention, and applied manual content (N=2,500) and automated network analyses (N=~17,000,000). The results show that while specific events and actors may not trigger and maintain attention permanently, there are discursive features (types of domains, discourses, users, and networks) that continuously shape attention to climate change. Debates are highly politicized and often call for action, criticize administrations, stress negative future scenarios, and controversially debate over the reality of climate change. Attention thereby is amplified within hybrid discourses merging different triggers, being dominated by political, journalist, and news media accounts: political events trigger posts that stress the reality of climate change, whereas tweets on protests and cultural events are amplified if they call for action. However, antagonism and backlashes to such posts are essential features of the peaks investigated. Accordingly, attention is often connected to controversial debates regarding focusing events, polarizing figures (such as Greta Thunberg or Donald Trump), and the formation of counterpublic networks. Which content is amplified highly depends on the subnetworks that users are situated in.

Keywords

climate change; discursive features; content analysis; issue attention; network analysis; Twitter

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1. Introduction: Attention to Climate Change

Climate change poses a serious threat to society, yet the topic has long struggled to rank highly on the public and political agendas. Agenda-setting proposes that the amount of attention an issue receives in the media influences how high it ranks on the public and political agendas (McCombs & Shaw, 1972). For example, Sampei and Aoyagi-Usui (2009) found that increased levels of news media attention to climate change can influence public concern about the issue. More recently, the rise of social media has revived considerations of reverse and intermedia agenda-setting (Neuman et al., 2014). Instead of news media determining which issues get put on the agenda, issues are put on the agenda through a dynamic interaction between news media and social media (Neuman et al., 2014). For example, when investigating the intermedia influence between Twitter's and newspapers' agendas on the topic of climate change, Su and Borah (2019) found that when it comes to breaking news, Twitter is likely to influence newspapers' agendas. In contrast, during non-breaking news periods, newspapers guide Twitter's agenda. It was also found that cross-media agendas of news media articles and political actors on Twitter are interrelated (Gilardi et al., 2022). While debates on Twitter are often only led by a loud minority of users, we argue that the specific composition of highly relevant and influential users, as well as cross-media receptions beyond the platform, make climate discourses on Twitter relevant objects of study to understand how climate change is publicly negotiated.

Bruns and Burgess (2011) suggest that the affordances of the platform make it possible to quickly form collectives. These moments of collective attention can provide momentum for environmental movements and allow them to demonstrate the public support they receive to policymakers (Thorson & Wang, 2020). Public discourses on social media platforms such as Twitter have thus become "too important now to ignore" (Veltri & Atanasova, 2015, p. 4) and can be an indicator of attention given to specific topics over time.

Twitter is used by a diversity of highly relevant journalistic, scientific, and political actors and is particularly relied on during spontaneously emerging events (Hu et al., 2012). Therefore, it is relevant to find out which focusing events (Birkland, 1998) trigger attention to climate change debates in which way. Mediated attention, however, does not necessarily reflect ideological unity on issues: the emergence of "ad-hoc publics" (Bruns & Burgess, 2011) of climate change may allow easier proliferation of (mis-)information and potentially results in polarized communities (Tyagi et al., 2020).

By combining automated and manual analyses, this article seeks to discover which types of issues, events, discourses, and actors attract, shape, and sustain attention to climate change on Twitter. The findings are then clustered and combined with network analysis to identify underlying structures of the debate. Thus, this paper's overarching research question (RQ) is: What are the general patterns and structures of peak attention to climate change on Twitter?

2. State of Research

Mediated climate change attention can be an important proxy to measure how societal climate action is negotiated. Therefore, we try to address the social media perspective of this field of research from two perspectives: The relevance of accumulated attention in the form of focusing events and the community-centered perspective of networked gatekeeping of attention and (counter-)publics regarding these issues beyond the sheer event and amount of attention.

2.1. Focusing Events Producing (Social) Media Attention to Climate Change

Studies on both news media and social media show that focusing events trigger peaks in attention to climate change. In the context of agenda-setting, Birkland (1998, p. 54) defines climate-change-focusing events as relatively rare sudden events that are 'harmful or revealing the possibility of potentially greater future harms', potentially influencing agenda policies and mobilizing the public. Liu et al. (2011) apply a broader definition of focusing events which includes organized events, such as high-profile international conferences, the publications of scientific reports, or the release of movies. We use the term 'focusing events' from here on following Liu et al.'s (2011) expanded definition, thus, to broadly refer to any event which focuses attention on climate change.

On social media, like for traditional news media, the most important focusing events for climate attention include political events (e.g., elections), scientific publications (e.g., IPCC reports), and high-profile international conferences (e.g., COPs; Abbar et al., 2016; Kirilenko & Stepchenkova, 2014; Thorson & Wang, 2020). In addition, social and cultural focusing events also trigger attention, such as climate protests or the Pope's Encyclical (Chen et al., 2022; Thorson & Wang, 2020). Nevertheless, the similarity of issue attention triggers between news media and social media becomes more complex regarding weather events (Neuman et al., 2014). There is consensus in the literature that weather and climate characteristics are not such important drivers of attention in traditional news media (Brulle et al., 2012). In contrast, various empirical studies have shown that social media attention to climate change is triggered by temperature anomalies (Pearce et al., 2019) or extreme weather events (Abbar et al., 2016).

However, a synergy of multiple factors is often responsible for a peak's magnitude (Boykoff, 2007; Hase et al., 2021), and these factors differ significantly between media types and platforms. It has been shown that, when debating climate change protests, journalists criticize government inaction, while "climate movement actors on Twitter advocate for political actions and policy changes [and address] social justice issues" (Chen et al. 2022). As features of posts that trigger attention to climate change on Twitter can deviate strongly from news media coverage of an issue, it is not only crucial to ask *what* events trigger attention, but also *who* generated amplification *in which way*: for example, Newman (2016) found that during the release of the fifth IPCC report most amplified tweets came from individuals and bloggers. Attention to information distributed via Twitter may also differ depending on user types: scientists, journalists, ordinary users, or politicians are relevant at different times and for different communities (Walter et al., 2019). Ripberger et al. (2014) found Twitter activity peaks to be dominated by "public" rather than "expert" tweets on severe weather events. Still, traditional news sources were predominantly shared in discussions about climate change on social media (Pearce et al., 2019). Additionally, Lörcher and Neverla (2015) investigated *how* attention was being drawn during peak events and found that communication during the release of the IPCC report centered mainly around science, whereas posts about COP19 incorporated a diversity of domains such as politics, economy, science, and activism.

Accordingly, attention triggers cannot be reduced to mere focusing events. People may react to tweets regarding events based on whether they contain hoax narratives (Jang & Hart, 2015), imaginations of "climate futures" (Guenther et al., 2022), "discourses of climate delay" (Lamb et al., 2020), evaluations of the role of economies and governments (Murali et al., 2021), calls for action (Chen et al., 2022), or other aspects. Tweets and retweets can then be understood as a proxy for attention and amplification regarding societal issues (Zhang et al., 2018). Nevertheless, Thorson & Wang (2020) found that spikes in attention to specific climate change events on Twitter have short lifespans, "peaking and dying out quickly" (p. 351) with low rates of repeated participation. Gallagher et al. (2021) also stress that retweet-count analyses are just a measure of short-lived attention peaks to topics and do not necessarily represent "sustained amplification" (p. 2). The authors, therefore, argue that amplification of content should be investigated with a focus on distinct and potentially diverging ideological publics that could be situated in the very same debate.

2.2 Networked Gatekeeping: Oppositional Publics of Climate Change Attention

Such real-time, competing evaluations of phenomena such as extreme weather events can temporarily increase the network polarization and controversy of Twitter discourses (Tyagi et al., 2020), which can then positively influence the magnitude of attention peaks (Garimella et al., 2017). Users would then, through "networked gatekeeping", form separate communities that "collectively amplify" content "[t]rough their individual acts of curation and filtering" (Gallagher et al., 2021, p. 2). This results in ideologically-opposing 'ad-hoc publics' of attention, either acknowledging or denying climate change reality or the need for mitigation. Consequently, (re-)tweet counts cannot be understood as a universal form of amplification permeating a general public sphere on Twitter. Instead, research should consider which diverging publics are (not) reached, as "different publics amplify different information sources, meaning that different publics crowdsource different elites" (Gallagher et al., 2020, p. 1). Therefore, (uncommented) retweeting practices are an effective proxy to measure ideological homogeneity within and heterogeneity between politically and ideologically opposing user networks (Barberá et al., 2015).

Pearce et al. (2019) review several studies which found evidence of the formation of echo chambers and polarization on social media, often based on political ideology. These sceptics, however, may not be located within *echo chambers* that generally ignore the mainstream discourse but rather a *counterpublic* "that is in opposition to the mainstream hegemonic public sphere" (Kaiser & Puschmann, 2017, p. 373). This suggests that counterpublics regularly attend to the mainstream discourse, aiming to change it in their interest, resulting in counterpublics more frequently targeting the mainstream than vice versa. Kaiser and Puschmann (2017) found that in an analysis of climate-change-related blogospheres, counterpublics depended heavily on the mainstream, both for keeping track of the debate and reaffirming their

139 contrarian identity. Their work is supported by the findings of Tyagi et al. (2020), who identified polarized retweet
140 networks on Twitter, with "believers" demanding to combat climate change and "disbelievers" attacking them (p. 5).

141

3. Research Aims and Research Questions

143 Based on the insights presented above, it appears crucial to identify overarching patterns and structures of attention to
144 climate change on Twitter. Attention may, in fact, be generated in relatively short-lived peaks. Nevertheless, these peaks
145 may incorporate compositions of focusing events, discourses, and user networks that continuously reemerge. For this
146 purpose, it is important to ask not only *which events* triggered attention, but also *how* climate change issues are debated
147 by *which user networks.*

148 To shed light on these aspects, we analyzed 25 peak moments of activity/attention to climate change on Twitter spanning
149 over five years, from 2017 to 2021. Assuming that social media posts are not only amplified because they refer to relevant
150 event types but also how they contextualize those events, we associated the most-shared posts with domains (e.g.
151 nature, politics, civil society), evaluative discourses (e.g. climate change as a hoax, calls for action, negative future
152 scenarios), user types, and their networked interaction.

153 Understanding (re-)tweets as a proxy for (amplified) attention, we conducted automated network analyses
154 (N=~17,000,000 posts) and a manual, quantitative content analysis of the 100 most retweeted posts per peak day
155 (N=2,500). We initially identified the five peaks of attention per year (concerning tweets, retweets, and replies) and then
156 classified them in order to answer our first research question:

157 **RQ1.** Which types of *focusing events* are associated with attention to climate change on Twitter?

158 Then, we dissected the tweets posted during these events to identify *characteristics of highly amplified tweets*:

159 **RQ2.** Which domains, discourses, and users are most dominant and amplified during peak days of climate change
160 attention on Twitter?

161 We then aimed to cross-reference all of our coding to find *overarching clusters* of discourses, users, and events
162 throughout the timespan of data retrieval:

163 **RQ3:** Which clusters of events, discourses, and actors lead to attention during peak days of climate change attention on
164 Twitter?

165 Finally, this distribution of clusters was investigated from a network perspective in order to find out whether processes
166 of *networked gatekeeping between opposing ideological* publics could be found:

167 **RQ4:** To which extent do network structures and amplified content within them represent opposing ideological publics
168 during peak days of climate change attention on Twitter?

169

4. Methodology

4.1. The Data Sample

172 Our data collection combined two sources: the Online Media Monitor (*OMM*, University of Hamburg) and Twitter's
173 Academic Research API via the academictwitteR R-package (Barrie & Ho, 2021). The API for Academic Research allows
174 retrospective access to Twitter's "real-time and historical public data" as well as "more precise, complete, and unbiased
175 datasets" (Pfeffer et al., 2022). However, the API does not provide researchers with content that has been deleted or
176 banned from the platform. The OMM collected all tweets on climate-change-related issues from 2017 onwards on a daily
177 basis. However, this database did not collect tweets containing the term "climate crisis" which started to emerge within
178 recent years. Also, the OMM only collected information on tweets but no information on who retweeted. Therefore, we
179 combined academic research API search queries with the OMM dataset in order to obtain a more detailed image of the
180 discourse based on tweets containing "#climatechange", "climate change", "#globalwarming", "global warming", and

181 "#climatecrisis", or "climate crisis" between 2017 and 2021 (for more info on search strings and data retrieval, see
182 Appendix 4.1.).

4.2. Peaks of Attention

184 From this accumulated number of tweets and their retweet count, resulting in a total activity of 144,996,316 (re)tweets
185 over five years, we defined 25 peaks of collective attention to climate change. These peak events were chosen as five
186 independent days of the highest activity per year. As some events caused peaks that lasted longer than a day, we merged
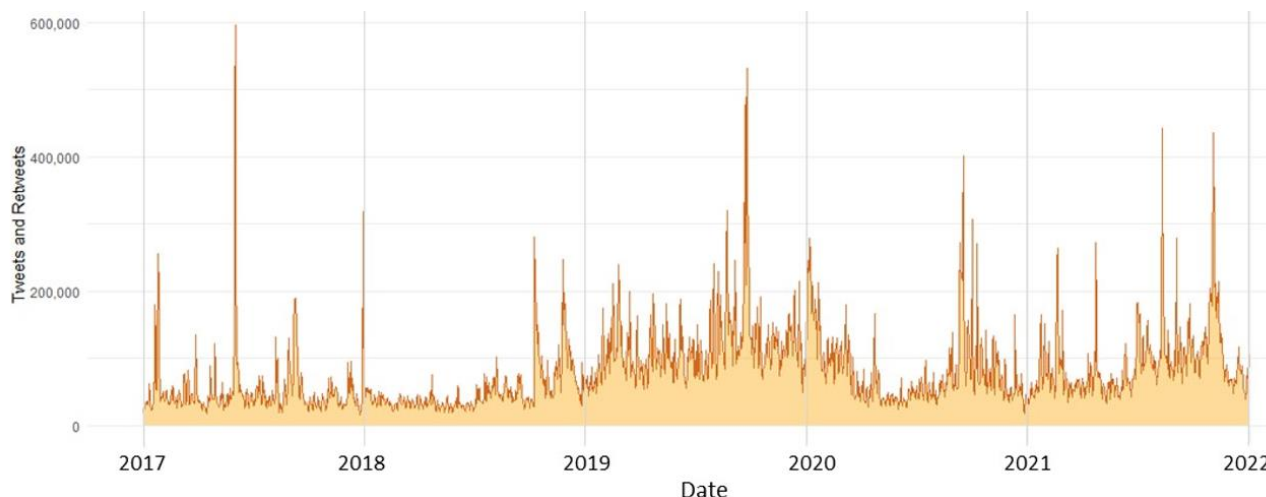187 neighbouring days if they had a tweet count within a minimum of 10% of the initial peak day's tweet count.

188

189 **Figure 1.** Climate activity on Twitter from 2017–2021 by the number of (re-)tweets and replies.

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4.3. Manual Coding of Content, Users, and Event Types

192 To gain an overview of what users were referring to during times of high activity, we applied manual coding of four main
193 variables: event types (RQ1), domains, discourses, and user types (RQ2). We decided to manually analyze the posts
194 because Twitter debates are highly contextual and often only implicitly refer to relevant events, topics, or actors. Also,
195 posts often referred to news items, images, memes, or other material attached. Additionally, our understanding of
196 discourses demanded contextual knowledge about climate change debates beyond automated analysis of textual data.

197 Through inductive and deductive processes, we established two broader concepts for coding the content of the tweets
198 (RQ2): People were not just tweeting about government decisions, deniers, protesters, or future scenarios, but evaluated
199 and described them in particular ways. Our codebook, therefore, included *domains* such as nature, science, politics, and
200 culture, as well as *evaluative discourses* (e.g. climate change denial or debates on societal inequality) that were deemed
201 relevant in the aforementioned literature. We then started coding from an inductive perspective: Two coders categorized
202 the content of 500 randomly sampled tweets in intervals of 100 items. After each interval, the coders re-evaluated and
203 modified the codebook. We then categorized the user types that posted the most-amplified tweets along a domain
204 differentiation (e.g. politicians, scientists, or media).

205 After having gathered specific knowledge about the attention peak's most relevant tweets through the coding process,
206 we labelled each event (RQ1) according to event types on the basis of discussion and mutual agreement (e.g.
207 elections/campaigning, extreme weather events, or releases of scientific reports).

208 For a list of all the coded categories and inter-/intracoderreliability tests, see Appendix 4.2.1.

4.4. Cluster Analysis of Manual Coding

210 As part of RQ3, we performed a cluster analysis to identify patterns of composition between domains, discourses, actors,
211 and event types. First, we checked for appropriate frequencies of categories (i.e., more than 5%) and, in some cases,

recoded variables. In total, 35 variables were included (see Appendix-Table 2.2.). Second, as is common in cluster analysis, we applied single-linkage clustering to identify outliers and had to remove one tweet from the sample. To estimate the number of clusters (i.e., compositions), we applied the most common method in cluster analysis, Ward's method, in a hierarchical cluster analysis. For a long time, Ward's method was known to provide robust solutions (see Morey et al., 1983), even for binary variables (see Matthes & Kohring, 2008). The elbow criterion recommended a six-cluster solution, which we deemed a good fit for the data after checking the four-, five-, and seven-cluster solutions. Due to the high number of tweets, we then decided to apply k-means cluster analysis, specifying the number of clusters as six. The decision for k-means cluster analysis was due to its robustness and its advantage of creating not only cluster identification per tweet but also its distance from the cluster center. Means and t-values were exported and considered when naming and describing the clusters (see Appendix-Table 2.3.); for dichotomous variables, means represent the frequency and t-values indicate the over- or under-representation of variables within the cluster. Taking these two measures into account, naming of clusters was done due to the relevance of variables within the specific cluster and the dissimilarity to other clusters. F-values were used to check cluster homogeneity (which was the case). A discriminant analysis was applied for validation, indicating that 92% of the tweets were clustered the same way, showing a good fit.

4.5. Automated Analysis of User Interactions

Additionally, we conducted a series of automated analyses of user mentions and retweets in order to find the actors that were most attended to and amplified. First, we extracted users mentioned via @-signs in the text to determine the most relevant actors addressed or talked about (RQ2). As has been illustrated, uncommented retweeting can be used as a proxy for affirmative amplification within ideologically-aligned communities. Therefore, we conducted a network analysis of uncommented retweets (RQ4) of all peak events and visualized ten networks (two per year) that were archetypical for the different event types we investigated. Different algorithms, implemented in *gephi* (Jacomy et al., 2014), have been applied for analysis and visualization: The ForceAtlas2 algorithm determines the position of user profiles (as nodes) within a network based on interconnections (as edges) to one another. This force-directed layout simulates physical systems: "Nodes repulse each other like charged particles, while edges attract their nodes, like springs" (Jacomy et al., 2014). ForceAtlas2 thereby spatializes communicative interaction and transforms them "into a map" (ibid.). We then calculated community modularity as value per node based on the density of interaction with other users (Blondel et al., 2008). For some more in-depth analyses, network visualizations were filtered by the k-core parameter to uncover tightly connected parts, hierarchies, and "influential spreaders" (Qin et al., 2020). K-core decomposition partitions a network into levels from loosely connected to more central nodes where each node has at least *k* neighbors. In order to increase comprehensibility and simultaneously avoid excessive distortion of network visualizations, we have only filtered nodes that have coreness 1. These calculations were then combined with data from our manual content analysis to show whether different user networks attended to/amplified different types of tweets. Going beyond questions of ideologically-homogenous amplification, the findings on retweet-based modularity classes were then cross-referenced with analyses of @mention-/reply-practices across communities to measure the degree of intergroup contact between (counter-)publics.

5. Results and Discussion

5.1. RQ1 – Beyond Scientific Reports: Synergetic Focusing Events of Attention to Climate Change

When looking at the results from the manual content analysis, seven general types of events appeared to trigger the vast majority of attention and/or amplification within the Twittersphere, mainly supporting earlier findings (Thorson & Wang, 2017; Hase et al., 2021):

"Governments' Actions/Decisions" (e.g., White House deleting information about climate change from their website), "Extreme Weather Events" (e.g., Australian bushfires), "Releases of Scientific Reports" (e.g., IPCC), "Campaigns/Elections", "Protests", "Cultural Events" (e.g., Oscars), and "Climate Conferences" (e.g., COPs).

Most posts from days of high activity had to be assigned to multiple event types: Except for four days in 2017 and the releases of two scientific reports, the peaks could be assigned to multiple types of events. The data thereby may imply a discursive shift: while in the past, particular events or actions were enough to trigger climate change attention, this changed from 2018 onwards. Supposedly, discourses became more diverse, and climate-change-related protests, political acts, and extreme weather events appeared to be discussed at a higher frequency and in connection with each

other. When comparing the results to Thorson and Wang (2017), a striking difference is the occurrence of extreme weather events, which only contributed to one attention spike in their data (i.e., Hurricane Sandy). In our data, extreme weather was much more dominant. However, it is hard to tell whether they are discussed more or whether they simply occur more often and/or with higher impact. Also, our coding scheme allowed multiple codings of a day, contributing to higher occurrences of each event type. Still, this implies a new diversity of topics triggering climate attention, not being limited to scientific reports but permeating all kinds of societal life (politics, culture, civic engagement, and nature in general).
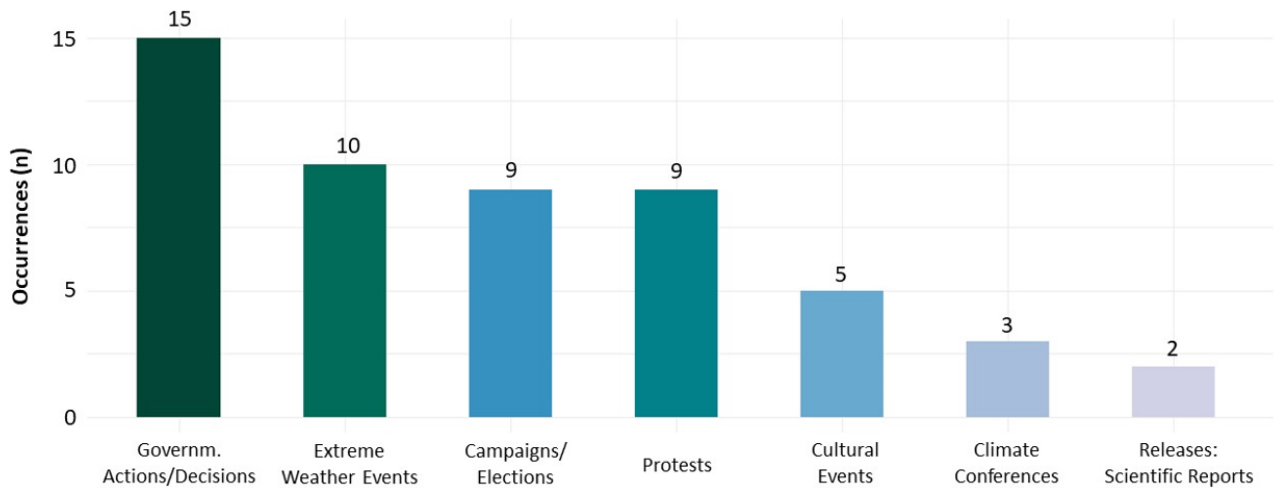

Figure 2a. Distribution of event types (N=53) within the 25 attention peaks (multiple coding was possible).
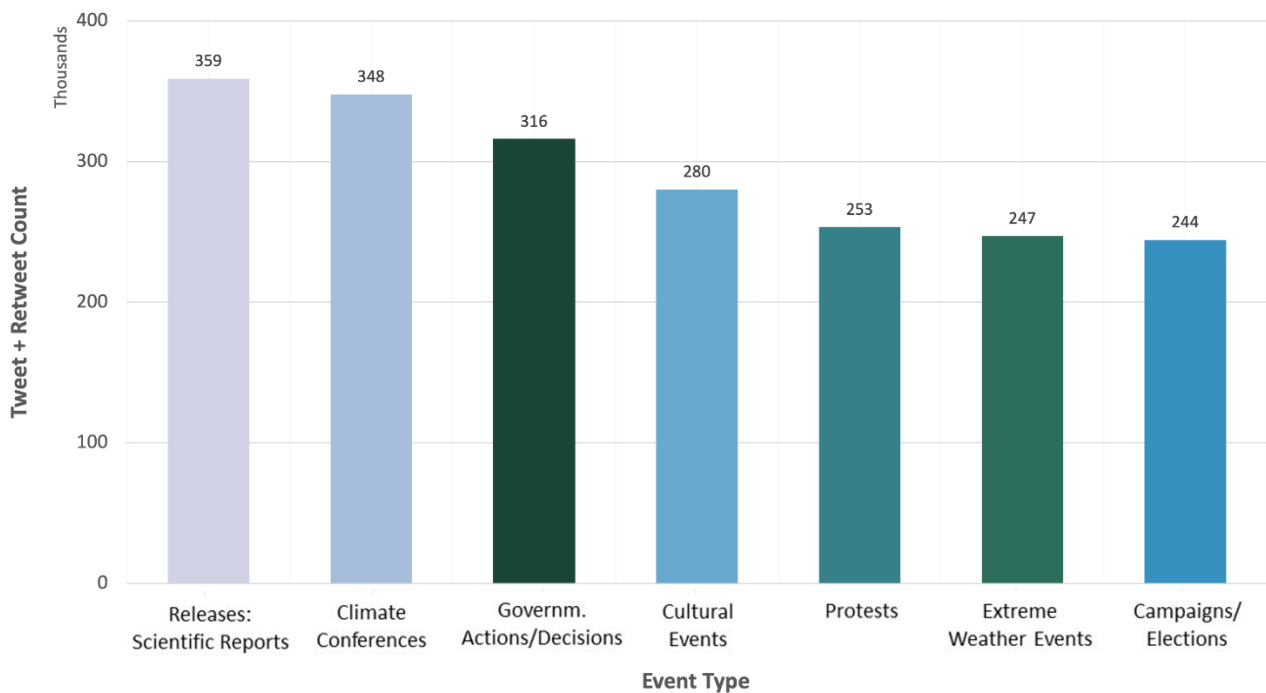

Figure 2b. Distribution of average tweet and retweet count for each event type.

Figure 2a shows the frequency of different event types, while Figure 2b shows the average tweet and retweet count associated with each peak event type. Government Actions/Decisions are the most common triggers of attention. Similarly, they account for the third-highest volume of Tweets and Retweets (see Figure 2b). However, while campaigns and elections were relatively frequently associated with peak events, they were also associated with the lowest volume of tweets and retweets of all the recorded event types. On the other hand, international climate conferences served as relatively rare triggers of Twitter attention to climate change; however, they were associated with the second-highest

278   volume of tweets and retweets. Various peaks in attention were dually associated with Climate Conferences and Protests
279   or Civil Society actions. In particular, multiple speeches by Greta Thunberg caught the attention of Twitter users, namely,
280   her speeches at COP in Katowice (December 2018), the French Parliament (July 2019), and when she testified in front of
281   the U.S. House of Representatives on Earth Day (April 2021). Similarly, there was a large turnout of climate activists
282   involved in "Shut Down DC" protests in Washington D.C. ahead of the UN Climate Action Summit in New York (September
283   2019).

284   Outside the world of politics and activism, many other focusing events were also associated with peaks in attention to
285   climate change. Extreme weather events fell towards the lower end of the spectrum in terms of incidences of tweet and
286   retweet counts; however, they were the second most frequent triggering event types. Releases of major scientific reports
287   showed an opposite trend. Despite only triggering two major peaks during the 5-year window, as shown in Figure 2a, the
288   releases of scientific reports were associated with the highest tweet and retweet volume of any focusing event type,
289   averaging 348,000 per associated peak day (see Figure 2b). These events included the release of the IPCC special report
290   on impacts of global warming above 1.5º in October 2018 and the release of the IPCC 6th assessment report in August
291   2021.

292   **5.2. RQ2 – Most dominant Domains, Discourses and Users: Debating Climate Change Reality and Political Actions**

293   To answer RQ2, we utilized our manual coding categories to consider to which extent domains, discourses, and actors
294   played a role for activity and amplification of posts.

295   As can be seen in Figure 3, national politics was the most dominant domain across the sampled tweets, with nature,
296   media, and science as distant second, third, and fourth. Regarding the discourses, expressions of climate change belief,
297   government criticism, and calls for action against climate change effects were the most frequent. Still, climate change
298   denial and narratives of delay were mentioned relatively often (for detailed definitions of the categories, see Appendix
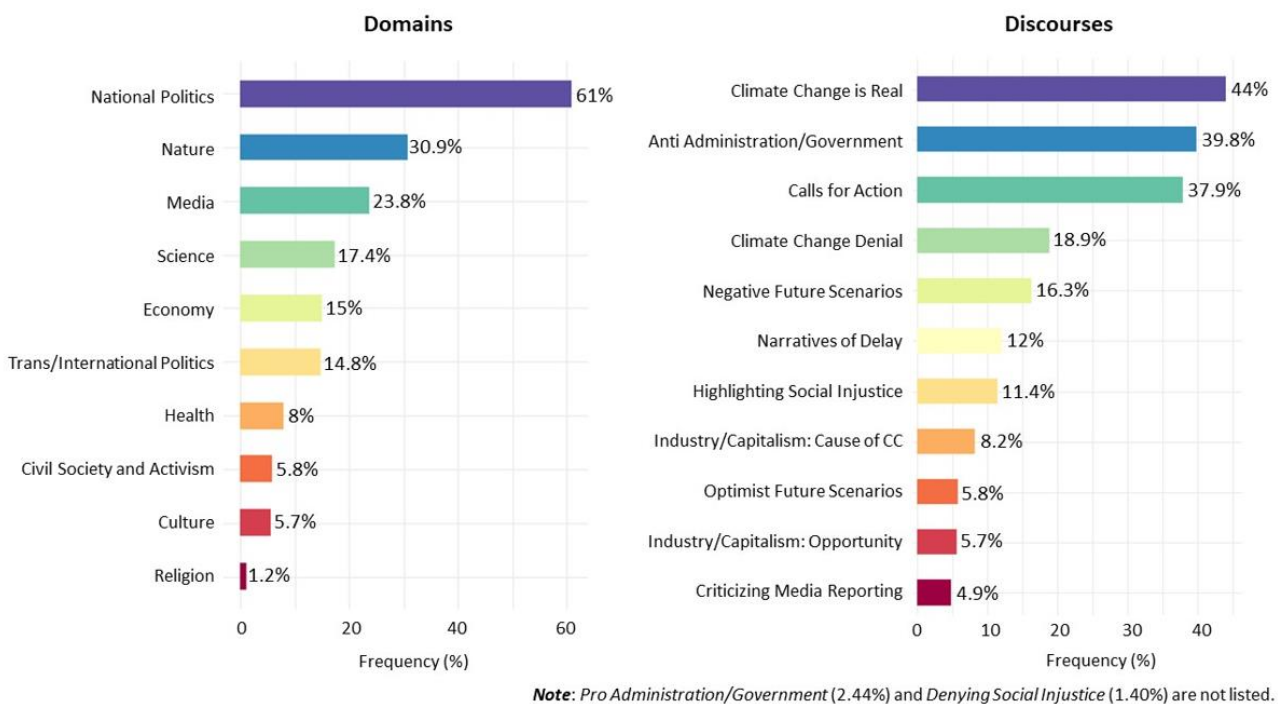299   4.2.3).

300

Note: Pro Administration/Government (2.44%) and Denying Social Injustice (1.40%) are not listed.

301   **Figure 3.** Distribution of domains and discourses explicitly mentioned in coded tweets.

302   From a user perspective, individual journalists and politicians were responsible for the greatest proportion of tweets (20%
303   and 18%, respectively) and were also widely amplified, receiving 21% and 23% of all retweets, respectively. Religious
304   actors were inactive throughout, contributing the lowest number of tweets and receiving the least amplification. Finally,

scientists, international organizations (e.g. UN), and economic actors only minorly contributed in terms of tweet
frequency and retweets received.
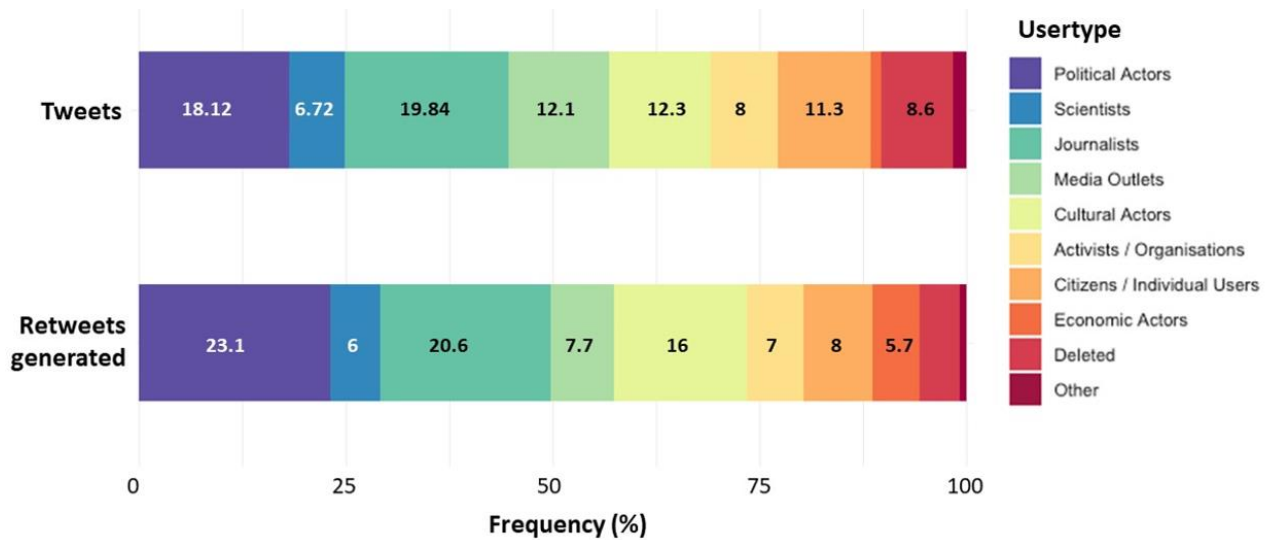
Figure 4. Distribution of user types for tweets and retweets.

Here, our findings support Thorson's and Wang's (2020) earlier findings on climate debates on Twitter: users rarely return
to the discursive site. We found that out of the 896,600 unique users in our dataset, only 161,261 (17.9%) tweeted during
two or more peak events. When looking at specific accounts, analyses showed that potentially polarizing actors such as
Donald Trump and Greta Thunberg were often mentioned, while not or only rarely participating in the discourses: Donald
Trump's tweets were never part of the Top 100 amplified posts of a peak event, while Thunberg's tweets only occurred
five times in our data. They were addressed and discussed but were not part of the discursive peaks from a user
perspective. Still, there were other users – particularly political actors – who were continuously discussed and mentioned
while simultaneously distributing highly-amplified tweets themselves, such as Alexandria Ocasio-Cortez (14 tweets) and
Bernie Sanders (20 tweets). Here, agenda-setting processes of political actors in networked publics seem to work in two
regards: while conservative political actors who potentially delayed climate change action, such as Donald Trump or Boris
Johnson, were mainly talked about and did not participate in climate debates themselves, actors that made climate
change part of their own political agenda actually took part in the debate, making the Twitter activity of such accounts a
potential proxy for their political agenda (see e.g., Gilardi et al. 2022).
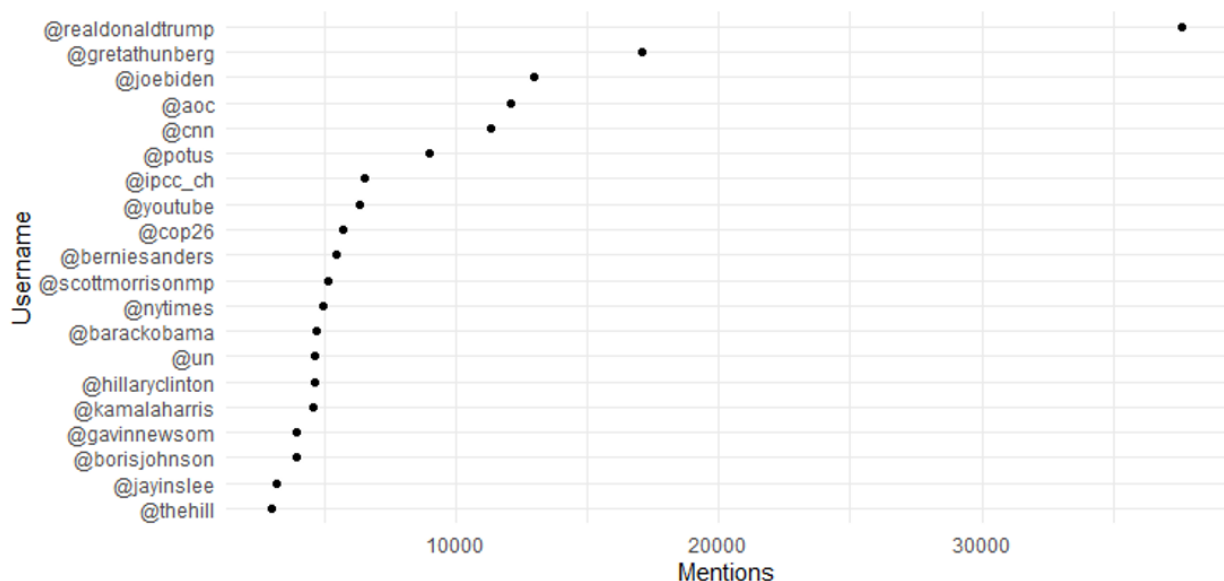
323   **Figure 5.** Most mentioned user accounts during the 25 peak events.

324

325   **5.3. RQ3 – Clusters of Climate Change Discourses that generated Attention**

326   Investigating overarching patterns, we found clusters composed of domains, discourses, actors, and event types that
327   were spread along the dataset, showing patterns that went beyond the individual properties of those particular
328   categories (see Appendix 2 for an overview of means and t-values).

329   *Cluster 1: "Universal Calls for Change" (19% of coded tweets)*

330   The first cluster is mainly composed of relations to nature – however, this cluster generally comprises a wide variety of
331   domains. More significantly, it comprises call-for-action discourses (64%) and, in relative scale to general distribution,
332   significantly higher rates of future scenarios (25%), references to the role of corporate actors and current economic
333   structures for climate change (22%) and social injustice (15%). Despite a lack of explicit references to 'civil society' actors,
334   this cluster is strongly related to occurrences of protests (76%), yet also extreme weather and cultural events (45%), all
335   of those being a trigger for people demanding change and taking action. The biggest event-related triggers, however, are
336   governmental actions and administrative decisions taking place, causing many users – with political actors contributing
337   to a significantly higher degree (28%) – to take a stance on these processes.

338   *Cluster 2: "Scientific Calls for Change" (12% of coded tweets)*

339   The second cluster is comparable to the "universal calls for change" cluster regarding the diversity of domains addressed
340   in the tweets. However, in this cluster, science is highly amplified (50%) in comparison to its overall sample distribution
341   (only 17%). Therefore, it is no surprise that posts associated with this discursive cluster are mostly related to days of
342   releases of scientific reports (59%) and represent disproportionately high participation of scientific actors (12%). These
343   posts also often stressed the reality of climate change (41%) and the need to act (50%) against it. Negative futures that
344   may arise from this climate reality are depicted much more frequently (40%), potentially mirroring how the climate
345   reports triggered climate attention – at least for a short period – through their negative portrayal of what humanity will
346   face.

347   *Cluster 3: "Narratives of Denialism" (14% of coded tweets)*

348   This cluster comprised mainly of (international) politics (88%) and contained the most references to civil society actors
349   and protests (13%) of all clusters. Tweets following this pattern, however, are far from reflecting and appreciating the
350   climate protesters' demands: climate sceptic and denialist discourses (87%), as well as narratives of delay (35%), shaped
351   this cluster, often mirroring backlashes to (inter-)national politics and protests being described as indicators of "globalist"
352   or "socialist" agendas of "climate scams". Therefore, such tweets mainly occurred during times of government actions
353   (98%) or during protests (21%) and climate conferences (28%), as these events bring forward the discussion of potential
354   actions against climate change and their potential antagonists, such as Donald Trump. Tweets from this cluster, therefore,
355   take an antagonistic stance towards debates mirrored by other clusters. This cluster appears to be mostly represented
356   by individuals rather than organizations: individual citizens, deleted accounts of (mostly) individual citizens (14%) and
357   individual journalists (29%) made up for the majority of the posts.

358   *Cluster 4: "Believers Criticizing the Administration" (23% of coded tweets)*

359   The fourth cluster is the most dominant one and mainly incorporated tweets from "anti-hoaxers" or climate "believers"
360   (86%) and those criticizing the government's (in)action (85%) on climate change mitigation. These posts were almost all
361   political (95%) and still associated with a relatively high degree of calls for action (28%). Accordingly, it is not surprising
362   that – compared to the whole sample distribution – relatively high numbers of activists (10%) and cultural actors (19%)
363   are associated with this cluster, almost always referring to events of governmental actions (98%). As the discourse is
364   dominated by US-American communication, this cluster may not appear extraordinary at first glance: governmental
365   decisions could often be associated with Donald Trump's administration. However, even after changes of administration
366   in the US, as well as during events that refer to other countries (e.g. during Australian elections), the same patterns
367   occurred (e.g. peak event 24, Appendix 4.2.2.).

While the clusters that were introduced thus far mirrored interrelations of discourses, events, and actors that could clearly be attributed to a particular stance towards climate change debates, the following two clusters represent attention to more controversial debates and events.

Cluster 5: "Contested Weather Debates" (15% of coded tweets)

Tweets that were assigned to this cluster have a strong relation to the nature domain and thereby, not surprisingly, always relate to extreme weather events (100%), which often co-occurred with cultural events (74%) or political campaigning (73%). However, these natural events – such as wildfires, hurricanes, or floods – do not only trigger one ideological stance in the climate debate. While there is a high number of "believers" (48%) associated with posts from this cluster who also appear to be warning about the implications for future generations (22%), this cluster also involves many climate change deniers (22%) joining the conversation on extreme weather events. These actors then are not mainly triggered by the event itself but by the 'believers' evaluation. While a diverse range of actors – not so many scientists, supporting Pearce et al.'s (2019) earlier findings – participate in these discourses and utilize extreme weather events to illustrate what that might imply for humanity's future, sceptic actors aim to deny this relationship between the event and climate change reality. They state that, for example, wildfires are the result of "bad forest management" or "arsonists", denying that this has anything to do with global warming. Similar patterns are seen in the discussions of cultural events. Often, these events – such as the Oscars, which resulted in a lot of reporting on actors' pledges to do something about climate change – appear to generate a backlash rather than accelerate calls for action in a productive manner. The most amplified posts were most often stressing the hypocrisy of cultural actors rather than supporting their demand to acknowledge climate change reality. It, therefore, is of no surprise that this cluster, just as the "narratives of denialism" cluster, is relatively often associated with deleted accounts (12%) and individual journalists (18%).

Cluster 6: "Contested Political and Social Debates" (17% of coded tweets)

The sixth cluster mirrors a similar pattern yet focuses on other events. Posts from this cluster are always related to days that accumulate debates about protests and political campaigning (100%), often also relating to cultural events (53%). Again, a diverse range of domains occurs within this cluster, mainly politics (66%) and media events (43%), yet also mentioning civil society and activism to a slightly higher degree than average (7%). This cluster contains a high degree of calls for action (46%) and "believer"-discourses (32%). However, it also contains a disproportionally high representation of the antagonistic discourses: narratives of delay (20%) and denial (19%). Here, it seems, discussions of social injustice and the role of industry and politicians are triggered by protests and political campaigning, resulting – to a certain degree – in backlashes of people positioning against these demands. Again, the relatively high number of denialists participating in this discourse appears to be reflected by a relatively high proportion of individual accounts (15%), deleted profiles (13%), and individual journalists (19%) distributing content associated with this cluster.

In conclusion, the separation into seven general event types – despite frequent multi-coding per attention peak – was the main cluster-determining category of our coding scheme. Here, the cluster analysis uncovers patterns of highly homogenous attention to some events (releases of scientific reports) and synergetic effects of controversy during others. We found clusters determined by tweets that mix different entities within their posts (e.g. Donald Trump visiting an international climate conference while Greta Thunberg is protesting against the world leaders, or people talking about California wildfires and relating that to upcoming elections). Most clusters can thus be interpreted as patterns that mainly occur during (combinations of) certain event types.

5.4. RQ4 – Networked Gatekeeping: The uneven Distribution of Climate Change Debates

These discursive clusters, however, were not evenly distributed across one public sphere. Rather, the amplification of certain clusters reflected particular communities. We combined content data with network analyses to investigate whether stances towards climate change were amplified by ideologically oppositional communities and how that affected the overall discourse's structure (RQ4).
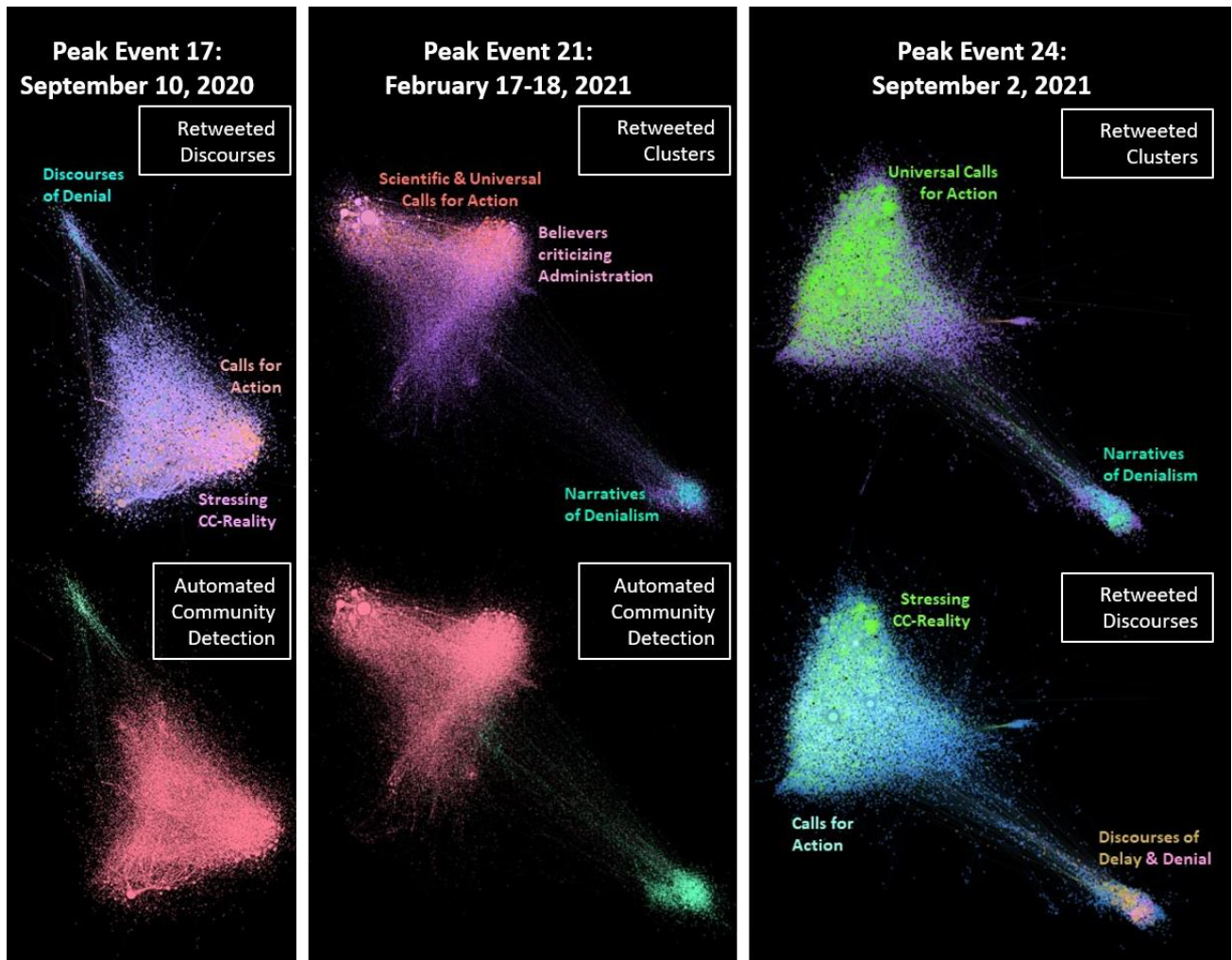
Figure 6. Comparative visualization of content amplification versus automated community detection (modularity classes) that is entirely based on retweet interaction. For two visualizations per year and additional material, see Appendix 3.1.

We created retweet networks of ten archetypical peaks (referring to all event types and years) to investigate which communities were amplified. Three networks were selected for content-related analysis and visualization purposes of the paper, referring to protests, government action and political campaigning (for an overview of all additional peak networks, see Appendix 3.1). To get a better overview, the visualization is filtered by K-Core 2, recursively removing nodes that have degree less than two (see chapter 4.5). The distribution of the manually coded content within the retweet-network was then compared with automated community detection that only considered interaction, but not content, in order to determine to what extent homogenous amplification structures were overlapping with distribution patterns of ideological content (see Methods section).

The networks' structures imply that climate change debates are more politically charged and contested than other Twitter debates (Barberá et al., 2015). We found that different publics amplified oppositional stances on the issues: for most of the days, network structures were polarized, separating into a mainstream debate and a fairly small, respective counterpublic. Supporting findings from Tyagi et al. (2020) and others, these networks appear to be polarized along a line of "believers" and "sceptics". Generally, retweeting denialist content is the main predictor of belonging to the counterpublic network (e.g., 83% of users that amplified *Narratives of Denialism* during Peak Day 21, see Appendix 3.1.2). However, it is interesting that narratives of delay, which are not explicitly denying the reality of man-made climate change but argue against mitigating its effects, sometimes have a bigger probability of being amplified within mainstream networks (see Appendix 3.1.2) and thereby overcome processes of "networked gatekeeping" (Gallagher et al., 2020) with a higher frequency.

Generally, mainstream communities appear to consist of groups that dynamically switch between different attention patterns, amplifying different discourses, depending on the event (e.g., demanding government actions during elections

or stressing climate change reality during extreme weather events, see Figure 6). The application of more detailed community detection parameters, dissecting the network into more than two main communities, unveils that users within the mainstream community frequently share posts by users from other sub-communities, indicating diverse exchange (see Appendix 3.1.3, Figure 3a). Denialism and hoax narratives, however, are continuously prevalent within oppositional networks – no matter the event type. Our network analysis thereby implies that attention rarely spills over to communities 'from the other side'. Highly contested debates, such as discussions on extreme weather events or debates about controversial actions and figures such as Donald Trump, may trigger attention to climate change. Nevertheless, this attention rarely surpasses community borders, resulting in publics talking about climate change but not necessarily with each other.

Attention to climate change does thus not mean the same for the Twittersphere as a whole – and does not indicate to what extent this attention can be translated into productive dialogue. Rather, amplified content and "crowdsourced elites" (Gallagher et al., 2021) appear only to trigger attention within ideologically aligned networked publics. This ideologically aligned attention, however, may cause backlashes of other communities. Throughout our data, we identified recurring patterns: mainstream sub-networks mainly communicated internally, while denialist counterpublics tried to engage to a much higher degree with the opposing communities through @mentions and replies (see Appendix 3.2). Our analysis showed that mainstream communities preferentially self-refer (92%) rather than initiating conversation with the ideologically diverging outgroup community (8%). On the other hand, users belonging to counterpublics almost evenly address users from their own network (52%) and the mainstream (48%). They thereby reach out to (and potentially attack) their respective outgroup far more often, supporting earlier research regarding varying climate debates and media environments (e.g., Tyagi et al., 2020; Kaiser & Puschmann, 2017). From an event-specific perspective, releases of scientific reports tied with extreme weather events as being the least polarizing types of focusing events. That is to say, the counterpublic represented the smallest proportion of the discourse relative to the other event types (see Appendix 3.2.2). Interestingly, peaks associated with the releases of scientific reports are the only days on which the counterpublic preferentially communicates within itself rather than referring to the mainstream. This behaviour may indicate a more pressing attempt to reaffirm sceptical beliefs, which could be more difficult to justify when presented with such incontrovertible evidence.

6. Conclusion: The Interplay of Climate Change Attention Triggers

We found that a majority of focusing events that were discussed on Twitter during attention peaks (RQ1) were related to politics, political actions, or protests. This illustrates a shift towards fewer peaks of attention associated with releases of scientific reports in comparison to research on older Twitter debates on climate change (Thorson & Wang, 2020). Simultaneously, our results support findings that more recent climate debates are more politicized with users increasingly calling for action during protests (Chen et al., 2022) and beyond.

Climate change attention may often be triggered in short-lived peaks. Nonetheless, we found re-occurring discursive patterns going beyond event types (RQ2), supporting initial findings. Highly amplified tweets were mostly politicized and connected to calls for action, stressing present or future threats or feeling the urge to criticize those in charge or thinking differently. Accordingly, while releases of scientific reports still seem to be relevant focusing events, the climate change debate appears to be highly politicized, with politics being the most relevant domain and discussions on governmental actions and events being the most relevant event type and having mainly politicians' accounts being directly mentioned.

Here, journalistic content and debate about it often come together as journalistic and media accounts were, despite the highly politicized discussion, combining for more than 28 percent of the most relevant content, with political actors following closely. Therefore, journalistic contributions appear to ignite discussion on Twitter (Pearce et al., 2019). However, it then seems to matter how these journalistic contributions are discussed beyond the articles' content itself. Throughout our research, it became apparent that it was not just one topic or event that ignited the debate. Rather, it seems that topical hybridity, such as the combination of a climate summit with climate protests and reporting on that, could have resulted in actual attention triggers.

This high degree of politicization of climate change debates may also be a reason for the discursive tension discovered in a majority of the data. Here, both content and network analysis draw a similar picture.

Content-wise (RQ3), even though distributions in the online discourse are far from even, tweets referring to (imaginary) ideological opponents – either "hoaxers that deny climate change reality" or "globalist/socialist narratives based on climate scams" – appear to trigger both activity and amplification of posts. It is therefore not surprising that the cluster

of believers criticizing (inactive) administrations, as well as the two clusters referring to highly polarized debates, are those with the highest rates of (re-)tweets, creating the image of attention being mainly drawn by negativity, controversy, and ultimately polarization, supporting Garimella et al. (2017) and Tyagi et al. (2020). However, both studies explicitly targeted conflicting debates through their research design, while we were able to show that high attention to climate change on Twitter is generally associated with politicization and conflict. Nevertheless, despite common conceptions of social media logics, negativity is not a successful driver of attention on its own. Negative future scenarios, exclusively focusing on decaying ecosystems without connecting their message with politics or calls for action, were rarely amplified.

What is more, highly-amplified climate change content does not evenly permeate the entire Twittersphere (RQ4), but produces structures of ideologically opposing (counter-)publics. The network analysis showed that the formation of climate change 'ad-hoc publics' rarely results in ideological diversity within the discourse and thus does not seem to persuade those who think differently about these issues. Rather, "networked gatekeeping" (Gallagher et al., 2021) appears to produce a mainstream community and opposing "alliances of antagonism" (Kaiser & Puschmann, 2017). The counterpublics, however, appear to be much more engaged with the mainstream public, with nearly half of their mentions/replies addressing their respective outgroup. High levels of attention in the climate change debate can, therefore, not be understood as entirely positive. The question arises to what extent ideological homogeneity or discursive diversity can lead to dialogue between those with diverging views. We showed that different types of events seem to play a role here. Scientific report releases, for example, seem to initiate less inter-group contact than other events while at the same time generating a very homogeneous mainstream community of users who emphasize the reality of climate change. One can only speculate whether this effect results from the rarity and notoriety of such report releases or from epistemological isolation of dissenters with respect to scientific evidence. In any case, the question arises whether such ideologically homogeneous attention peaks are expedient or interaction among dissenters of the climate change debate is more desirable. Here, it will be vital to assess the nature of these cross-group interactions.

Thus, future research should focus on how attention to climate change is connected to either reasonable debate or incivility and how this may vary regarding topics, events, and communities. Thereby, one can evaluate which attributes of (affective) polarization can actually be observed and which factors trigger (non-)polarized debates, thereby overcoming community boundaries and fostering inter-group deliberation. Here, the role of "narratives of delay" should be further evaluated, as at some moments they have transcended counterpublic boundaries and may implicitly promote scepticism towards climate change mitigation. Also, cross-media and cross-platform effects appeared to be essential to our investigation: We observed synergies between the publication of news and media posts that were then utilized as the basis for debates on political actions on and the existence of climate change. Such cross-media flows should be further investigated.

This leads us to limitations to our research: we only investigated communication on one particular platform. While we hope that we made clear why it matters to study communication on Twitter in particular, it is crucial to consider where these insights are distorting the image of public discourses. This is particularly true as recent developments in Twitter's headquarters make it probable that the social media ecosystem will continue to evolve and cause users to migrate to other platforms. Also, it is important not to overestimate the public's engagement with climate change purely based on social media activity. Activism on social media has a relatively low cost to expressing oneself; thereby, participation may not result from deep commitment (Thorson & Wang, 2020). Also, our use of an English language search string neglected tweets in other languages, furthering a dominance (yet, by far not an entirety) of US-based discourses.

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Conflict of Interests

531 The authors declare no conflict of interests.

532 **Supplementary Material**

533 Supplementary material for this article is available online in the format provided by the author (unedited).

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