Contents lists available at ScienceDirect

Global Environmental Change

The climate change research that makes the front page: Is it fit to engage societal action?

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A B S T R A C T

By growing awareness for and interest in climate change, media coverage enlarges the window of opportunity by which research can engage individuals and collectives in climate actions. However, we question whether the climate change research that gets mediatized is fit for this challenge. From a survey of the 51,230 scientific articles published in 2020 on climate change, we show that the news media preferentially publicizes research outputs found in multidisciplinary journals and journals perceived as top-tier. An in-depth analysis of the content of the top-100 mediatized papers, in comparison to a random subset, reveals that news media showcases a narrow and limited facet of climate change knowledge (i.e., natural science and health). News media selectivity reduces climate change research to the role of a sentinel and whistleblower for the large-scale, observed, or end-of-century consequences of climate change for natural Earth system components. The social, economic, technological, and energy aspects of climate change are curtailed through mediatization, as well as local and short-term scales of processes and solutions. Reviewing the social psychological mechanisms that underlie behavioral change, we challenge the current criteria used to judge newsworthiness and argue that the consequent mediatization of climate change research fails to breed real society engagement in actions. A transformative agenda for the mediatization of climate change research implies aligning newsworthiness with news effectiveness, i.e., addressing the extent to which communication is effective in presenting research that is likely to produce behavioral change.

1. Introduction

The record-breaking Pacific heatwave that struck the US and Canada in the summer of 2021, and its related casualties, attracted considerable attention from the media worldwide. So did the scientific article quantifying the virtual impossibility of such an extreme heatwave without the influence of human-caused climate change (Philip et al., 2021). Reported by over 3,300 news media articles around the world (according to the University press office that publicized the article, Department of Earth Ocean and Atmospheric Sciences, 2021, as of July 12, 2021), this article hit the news almost 8 times as much as the most-mediatized climate research paper of 2020. Media attention on the climate change issue is primarily attracted by catastrophic meteorological events (as exemplified by the Pacific heatwave) or political events (COPs, Friday climate strikes; Hase et al., 2021), and only to a lesser extent through communication around scientific publications

alone (Boykoff and Pearman, 2019). And, indeed, recent research on how the term is used in the media revealed that "climate change" is more contentious, more politicized and more focused on serious impacts than other terms like "global warming" (Liu and Huang, 2022). However, by enticing people's awareness of and concern for climate change, media coverage of scientific publications enlarges the window of opportunity within which climate change research can engage individuals and collectives in climate actions (Moser, 2016). In the present article, we bring together an interdisciplinary team to reflect upon the focus of the climate change research that makes the front page and whether such a focus is indeed fit to engage societal action.

Communication is a key lever of climate change governance (Boykoff and Pearman, 2019; Howarth et al., 2020). Yet, the multiple dimensions of climate change, in which complex natural and human aspects are entangled at global and long-time scales, render climate change communication challenging (Howarth et al., 2020; Moser, 2016). The

science and practice of communicating climate change have seen profound improvements over the last two decades, especially following the emergence of climate change communication as a new interdisciplinary field of research (Howarth et al., 2020; Moser, 2016). Briefly, climate communication research builds on social sciences to explore how and to what extent climate change is relayed and framed whilst developing optimized strategies and guidelines for transforming public engagement into actions (Moser, 2016). Amongst communication pipelines, news media are seen as a trusted source of information about climate change and are paramount in addressing the climate change issue (Schäfer and Painter, 2021). Raising climate change awareness and engaging the public to act are not only a matter of how, how much, and to whom (Bain et al., 2012) the climate change is communicated, but also what gets communicated (Moser, 2016). We consider here the engagement, for individuals or collectives, in climate actions as (i) the likelihood that humans, individually and/or in collectives, move toward more pro-environmental behavior (and urge others to do so) and (ii) the extent to which states, from the local to the transnational scales, issue laws and regulations directed at mitigating the effects of climate change. Yet, if news media are to breed significant changes in behavior, it must provide information that dovetails with known psychological triggers for behavioral change (Happer and Philo, 2016). It is under the same condition that the mediatization of climate change research could rise to the challenge of engaging societal action. Here we consider the mediatization of climate change and then review known psychological triggers for behavioral change.

While the term can bear a broader meaning and significance, mediatization of climate change research herein refers to the efforts of outward communication of scholarly articles from climate change research using mass media (e.g., Schäfer, 2014). Mediatization implies a selection, amongst the several tens of thousands of scholarly papers published on climate change research every year, of which are newsworthy. Selectivity for newsworthiness occurs at different steps of the academic institution (from the scientists and the academic press offices), at the level of the scientific journal in which scholarly papers are published, as well as at the level of the mass media agencies (Heyl et al., 2020). Criteria for newsworthiness of research findings are shaped by several factors, including what journalists or scientists perceive as important information, but also economic, practical, political and format contingencies at all institutional levels (Strömbäck et al., 2012). Such criteria may be floating and variable over time, across countries and between mass media (Strömbäck et al., 2012). Yet for some scientific disciplines, the publication output of a scholarly article has been shown to better explain its probability to attract media attention than the content of the paper (Papworth et al., 2015). Our study focuses on the media; admittedly, academic press offices may also have an impact on defining newsworthiness (e.g., Sumner et al., 2016), but this question would require a different data collection, and is beyond the scope of the present article.

Importantly, not all information can be expected to be equally engaging for its readers. Over fifty years of research in social psychology have pointed to a fundamental disconnect between attitudes and behavior, as noted by both the theory of reasoned action and the theory of planned behavior (Ajzen et al., 2011), and other approaches (Sheeran and Webb, 2016). Raising awareness of the causes and consequences of climate change, eliciting fear and other intense emotions, and inducing a positive attitude towards mitigating factors, might not translate into actual behavior change (Ajzen et al., 2011). Thus, we define news effectiveness as communication whereby the public does not feel that they need to avoid, to neglect, to minimize or to discount threatening information, but rather feels empowered by mitigation and adaptation solutions and, in turn, engages in actions that may become the precursor of more substantial future change.

Research in social psychology has identified several mechanisms that explain why information can be avoided, neglected, minimized or discounted, and not necessarily lead to action. First, focusing on a single line of information is likely to reinforce the "selective exposure to information" effect. Both individuals and groups seek information that corresponds to their initial beliefs, preferences and orientations, whether or not that information may help them reach a better decision (Frey and Schulz-Hardt, 2001). Such a phenomenon is a variety of the well-known "confirmation bias", an effect that has been shown to occur to a higher extent in conflictual and threatening contexts (Butera et al., 2018). In recent times, this pervasive tendency has been accentuated by the expansion of on-line contact and the development of reader profiling by the media, enclosing people in informational echo chambers (Spohr, 2017). For instance, so-called climate deniers are not moved at all because they expose themselves to one-sided information about the consequences of climate change (Bain et al., 2012). Second, people process information in either a more central, effortful, attentive, controlled way or in a more peripheral, effortless, distracted, automatic way. Which way, or "route", people will engage in when processing information depends on their ability and motivation (Petty and Cacioppo, 1986). Third, a major psychological barrier that limits pro-environmental behaviors is the individual and collective difficulty in feeling empowered (Gifford, 2011; Gifford et al., 2011; Klöckner, 2013). Individual and collective pro-environmental action has the largest impact when it targets cultural changes (norms, systems, symbols), that is when society at large is involved in changing its own practices (Amel et al., 2017). Such an endeavor is attainable only by coordinated collective effort, which requires a certain level of collective efficacy, that is the feeling that group-level efforts are likely to make a difference to a substantial degree, even globally (Fritsche et al., 2018).

In sum, work carried out in several disciplines converge to outline the complexity of effectively communicating about climate change (Holmes and Richardson, 2020). A substantial body of research has been dedicated to the role of the framing of climate change and of narratives in the media for an effective communication (Howarth et al., 2020). Herein, we are interested in how climate change research is portrayed in the media, i.e., which of recent research findings attract media attention, and whether the research features selected throughout the different filters of newsworthiness are likely to generate effective or ineffective communication. Although it is impossible at this stage to exhaustively list all criteria of news triggers for behavioral change, we herein assume that a mediatization exposing the public to research findings encompassing a diverse range of scientific disciplines, from natural to social science and humanities, covering appraisable time and spatial scales of climate change implications, causes or consequences, as well as potential technical or social solutions, is the most likely to engage people into action. In other words, assessing whether the mediatization of climate change research translates into societal action requires evaluation of how criteria for newsworthiness align with the necessary (but not sufficient) criteria for news effectiveness.

Such an assessment is the aim of this study. First, on the basis of individual counts in the news media to the full corpus of scientific publications produced on climate change during the year 2020, we quantify the selectivity of news media in the reporting of climate change research. We identify the dominant news sources for the media and how this selectivity affects the spectrum of covered disciplines. Second, we identify the distinctive features, in terms of scientific disciplines, motives, time and space- scales covered of the 100 climate-change papers that attracted the most news media attention worldwide compared to the characteristic knowledge produced regarding climate change during 2020. We then assess whether these features contribute to a communication on climate change research likely to engage their readers into action. Finally, we propose a possible new mode of research communication in which newsworthiness is based on news effectiveness, i.e., the extent to which communication is effective in presenting research that is likely to produce behavioral change.

2. Material and methods

2.1. Analysis of the full corpus of published research

The corpus of the scientific publications on the topic of climate change for the year 2020 was retrieved on March 29th 2021 through a Web of Science search using the terms (TOPIC) climate change OR climate warming OR (greenhouse gas*) OR (CO2) AND emissions)) and keeping only articles and reviews (Separate data 1). The full data analysis was conducted on R version 3.6.2. We quantified the degree of mediatization of each scholarly article by the number of news items that mention a scholarly article using the altmetrics score provided by Altmetric.com. We did not include blogs as they play a secondary role in the mass media mention of research papers (Ortega, 2018). We chose Altmetric.com over other altmetrics providers (PlumX or Crossref Event Data) as it offers the widest news media coverage (Ortega, 2018). While all altmetric sources are biased toward English-speaking countries, Altmetric.com is the most geographically and linguistically heterogeneous (Ortega, 2020). Altmetric.com covers 5,000 news outlets (half from the USA) covering general-interest media as well as more thematic ones (Ortega, 2020). It includes print as well as online news outlets. The Altmetric score for news ("msn-counts") for a scholarly article corresponds to the number of mentions in the news outlets from the source database, weighted against the reach of these news outlet. We retrieved the altmetric news score for each scholarly article from articles' DOI using the rAltmetric R package (Ram, 2017). Altmetrics tweets scores were used for a comparative purpose (Separate data 1). Scientific journals were classified into scientific disciplines based on their WOS Research Areas (Separate data 2). Journal Impact Factors were extracted from the scholar R package (Keirstaed, 2016). The contribution of each journal to the production of climate change research was computed and compared to their contribution to news media. Papers that receive at least one news media mention are referred to as 'mediatized papers'. The Journal news mention corresponds to the sum of news mentions for the articles published in a given scholarly journal during 2020. Significant differences within distributions were detected using chi-squared tests using adjusted standardized deviations to identify the categories leading to significant differences (Agresti, 2007). Selective mediatization in journals was tested comparing their contributions to knowledge publications and news media using their impact factors (categorized in groups) as an additional categorical variable, using an ANCOVA with post-hoc tests.

2.2. In-depth analysis of top 100 mediatized papers, and comparison to a randomly selected subset

For in-depth analysis of articles content, the top 100 mediatized papers (100 greatest altmetrics news scores) were compared to a randomly selected subset of 100 papers published in 2020 (Separate data 3). Papers were first sorted by disciplines (same categories as for 2.1, while those covering more than one category were categorized as pluri or cross-disciplinary). Further analyses concentrate on papers from natural science or cross- and pluri-disciplinary papers including natural science as they largely dominated the paperset. Papers (with blinded altmetric scores and blinded parent subsets) were assessed by 4 independent and naïve examiners (1 assessor rated the 200 papers, while the other 3 rated 50 papers, so papers had 1–3 assignments per criterion). Each examiner coded articles according to the following criteria:

1. Spatial scale of the study (ordinal variable of five mutually exclusive levels). Global scale: a very large spatial scale, providing an assessment at a global scale or for multiple sites distributed over both hemispheres; Continental scale: a large spatial scale (about the size of a continent, or of an ocean), providing an assessment at a continental scale or for multiple sites distributed over one hemisphere; State/country scale: a moderate spatial scale (about the size of a US state or

of a European country), providing an assessment at a national-state scale; Local scale: a small spatial scale (limited number of sites within a well-circumscribed area). NA if not relevant for the study.
2. Time-scale of the study (ordinal variable of four mutually exclusive levels). Past-current; Near future (<2050); Mid-term century (2050–2060); End of the century (>2060); NA if not relevant for the study.
3. Main motive of the study (nominal variable of five mutually exclusive levels). Rate-magnitude of changes: the study documents how fast-how much an environmental variable linked to climate change (as a cause or a consequence) has been or is projected to change. Process understanding (=Processes): the study investigates a given process linked to climate change (as a cause or a consequence); Efficiency of measures (=Measures): the study evaluates the efficiency-feasibility of a practice, a technology, a policy for limiting the causes or consequences of climate change; Roadmap: the paper is a review or a roadmap, synthetizing different papers to provide potential solutions and lever of actions; Model improvements-new method (=Methods-Models): the study 's objective is to improve a model, by providing better parametrization or structure, or to develop or improve a method to monitor the causes and consequences of climate change or to develop a new technology.

Inter-coder reliability was tested and ensured using Krippendorff's α and inter-coder agreement with Fleiss's κ, using the R Package 'irr' (see Appendix A for further details).

3. Results

A total of 51,230 papers was published on climate change, for the year 2020, within 5,796 scientific journals (Fig. 1A), leading to 36,355 mentions by international news media. The media attention concentrates on 9% of papers (≥1 mention in news media), while 2% of them reach extensive media attention (≥10 mentions). The news report on research findings which originate from a restricted subset (13%, hereafter referred as to news mentions) of the scientific journals that published climate change research in the year 2020; with 41% of the media news from papers published in the only 6 high-profile journals, i.e. 3 from the *Nature* portfolio, *PNAS* and 2 from the *AAAS* series (Fig. 1B). Although the representation of journals in the news mentions is partly associated with the volume of climate change papers they published during 2020, there is a preferential mediatization that is a positive function journal impact factors (Fig. 1C, Appendix B.1). The selection of which research merits public attention, and how much it is publicized in the media, is therefore associated with the perceived scientific reputation of academic journals.

In 2020, about 60% of papers were published in disciplinary journals dedicated to the natural sciences, 19% in journals dedicated to technologies and energies, 8% in journals dedicated to social science and economics, 5% for agriculture and 3% for medical and health journals (Fig. 1D, Appendix B.2). The disciplinary proportions of 2020 are fairly consistent with those obtained for the overall climate change research production (from 1986 to 2018, Callaghan et al., 2020). The share of articles from disciplinary journals decreases in mediatized papers and news mentions, for all but medical and health science (Fig. 1E; see also Appendix B.2). Journals dedicated to technologies and energies, and agriculture, occur 4–5 times less in mediatized news than in produced knowledge; and articles from social science and economics journals contribute half of their share in mediatized news as compared with produced knowledge. In contrast, general and multidisciplinary journals are disproportionately over-represented in the mediatized science, their share increasing from only 5% of published climate research papers, to 21% of mediatized papers and 39% of the mediatized news mentions (Fig. 1F). As a matter of comparison, the same metrics computed for mentions in the social network Twitter revealed a lesser predominance of high-profile journals and are more representative of all disciplines
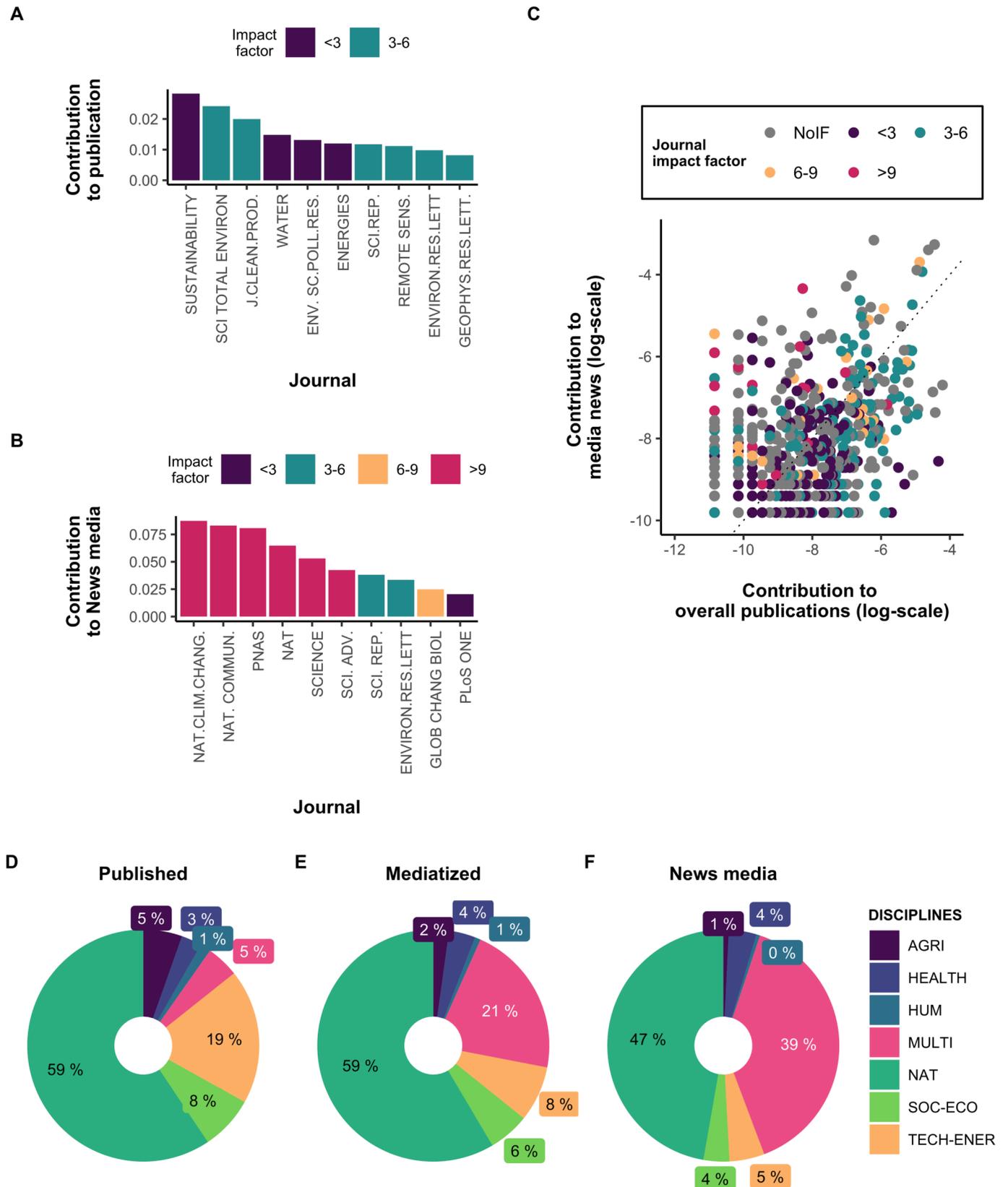
Fig. 1. A. The 10 journals that published the most scientific articles on climate change in 2020. B. The 10 journals which harnessed the most news mentions in 2020. Color codes are for journals impact factors, C. Relationships between the scientific journals contribution to climate change research publications and contributions to news media (Pearson's $r = 0.20$, Ancova, $F_{1,794} = 194$, $p < 10^{-15}$), as function of journals impact factors (Color code, Ancova, $F_{4,794} = 17$, $p = 10^{-14}$ with Tukey's post-hoc tests, SI-1a). The dotted line indicates mediatization in direct proportion to production. Distribution of journal disciplines for (D) papers published in 2020, (E) for mediatized papers and (F) for news mentions. AGRI = Agriculture, HEALTH = Health and medical science, HUM = Humanities, MULTI = General and multi-disciplinary science, NAT = Natural science, SOC-ECO = Social and political science, economics and business, TECH-ENER = Technology and engineering, energy and fuels. Details of statistical tests are provided in SI-1.

(Fig. 1, Appendix C).

Multidisciplinary journals publish research from a vast array of disciplines but do not necessarily favor pluri- or cross-disciplinary studies (Solomon et al., 2016). The breakdown by journal disciplines, therefore, indicates preferred sources for media news but provides little information on the scientific domains of mediatized versus produced knowledge. In order to evaluate how journal selectivity of news media might influence the discipline and content of what is publicized, we conducted an in-depth analysis of the top-100 mediatized scientific articles (38% of all media attention in 2020), and we compared these articles with a subset of 100 scientific papers randomly selected from the full corpus of published climate change research in 2020. The 10 most mediatized scholarly articles of 2020 are displayed in Appendix D. The distribution of scientific disciplines within the randomly selected subset of papers (Fig. 2) mirrors that of the overall production of knowledge (Fig. 1D). In the top-100 mediatized papers, disciplinary diversity is lower (Gini-Simpson index = 0.41, for 0.56 in the random subset), natural and health sciences are over-represented (+22% and + 400% respectively) to the detriment to other disciplines (-63% for social science and economics and −55% for technology and energies). Except for health and medical science, the level at which scientific disciplines are over and under-represented in the mediatized papers matches closely the disciplinary over- and under-representation already observed for high-profile multidisciplinary journals as reported in other studies, i.e., over-representation of bio- and geosciences, under-representation of social science, engineering, humanities and agriculture (Milojević, 2020).

Further in-depth analysis of the papers' content targets natural science, or pluridisciplinary papers that contain natural science, which represents 82% of the top 100-mediatized papers.

The quantification or projections of the rate or magnitude of climate-driven changes dominate by far the mediatized research, leading to a clear over-representation as compared to the random subset (63% of the top-mediatized papers, i.e., more than twice as much as in the random subset _27%_Appendix E.2a). Process understanding, methodological improvements and efficiency of measures are in contrast two- to seven-times less present in the mediatized paperset as compared to the random paperset (Fig. 3A, Appendix E.2a). Projections for the end-of-the-century are overrepresented in the top-mediatized papers (three times more than for the random subset, Fig. 3B, Appendix E.2b), especially those for very large spatial scales (global scales occur seven times more than in the random subset, Fig. 3C, Appendix E.2c). Overall, 56% of the top-100 mediatized papers on natural science report rate or magnitude of climate-driven changes at continental or global scales (40% being projections by the end-of-the-century), while those represent only 4% of the random paperset.

4. Discussion

The primary intention of our study is to characterize the current mediatization model used to judge newsworthiness, i.e., to identify which specific features of scholarly papers on climate change define their ability to attract worldwide news attention. After acknowledging the limits of our approach, we discuss how the selective sourcing of news media shapes the climate change research that is brought to public attention. We then evaluate whether the specific features of climate change research that get preferentially selected for mediatization bring to the public information likely to minimize the selective exposure to information, peripheral processing and lack of empowerment. We conclude by a critical view of the current mediatization model of climate change research and propose a transformative agenda.

A prerequisite of the study is thereby to quantify the degree of mediatization of scholarly papers through altmetrics, and for that purpose, we rely on papers' news score provided by Altmetrics.com. As of other altmetrics providers, the news outlet data sources referenced and monitored by Altmetrics.com is non-exhaustive, and English-speaking news outlets (77%), as well as news outlets from the USA and United Kingdom (68%) are over-represented (Ortega, 2020). Previous studies have emphasized the hegemony of English-speaking, general news outlets in the reporting of research papers, likely because scientific publications are most written in English (Ortega, 2021), and we chose the provider that minimized the international bias. However, the selected features that we identified are likely to be representative of the mediatization model for anglophone countries, and more generally countries from the North, rather than an unbiased worldwide portrayal.

Our analysis reveals that the climate change research that is brought to public attention by news media, at least for countries of the global North, arises from a limited number of journals that published all climate research, with multidisciplinary journals and journals perceived as top-tier being over-selected sources for research mediatization. High-profile multidisciplinary journals have editorial choices favoring bio- and geosciences over social science, engineering, humanities and agriculture (Milojević, 2020). There is also a high degree in redundancy in the reporting of scientific articles within the news media. General-interest and health news outlets, the major reporters of scientific findings, tend to co-mention many of them (Ortega, 2021). Thereby, a few articles get a lot of news mentions, limiting the diversity of information to which readers are exposed (Ortega, 2021). The selective sourcing of news media for high-profile journals and strong degree of co-mention in news outlets thereby come with a loss of disciplinary diversity of the research brought to public's attention, with over-emphasis on natural science and health, while research findings produced on the social, economic, technological and energy-related aspects of climate change are curtailed back through the mediatization process. The selectivity is even found within the dominant natural science. Mediatized scientific
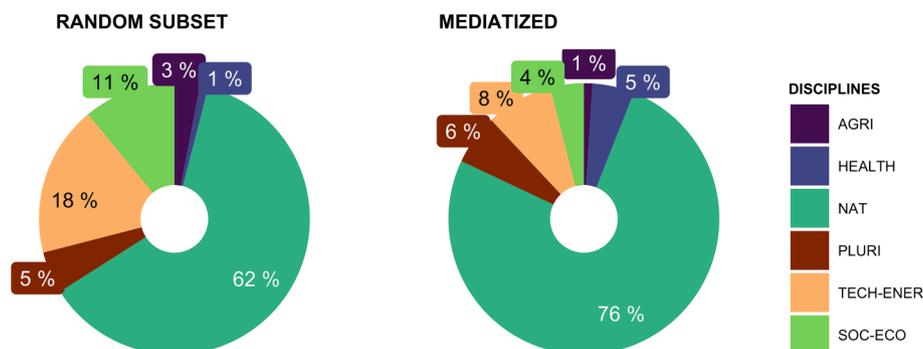

Fig. 2. Distribution of disciplines for papers of the randomly selected subset (left panel) and in the top-100 mediatized papers (right panel). AGRI = Agriculture, HEALTH = Health and medical science, NAT = Natural science, PLURI = pluridisciplinary science, HUM = Humanities, SOC-ECO = Social and political science, Economics and Business, TECH-ENER = Technology, engineering, Energy and fuels.
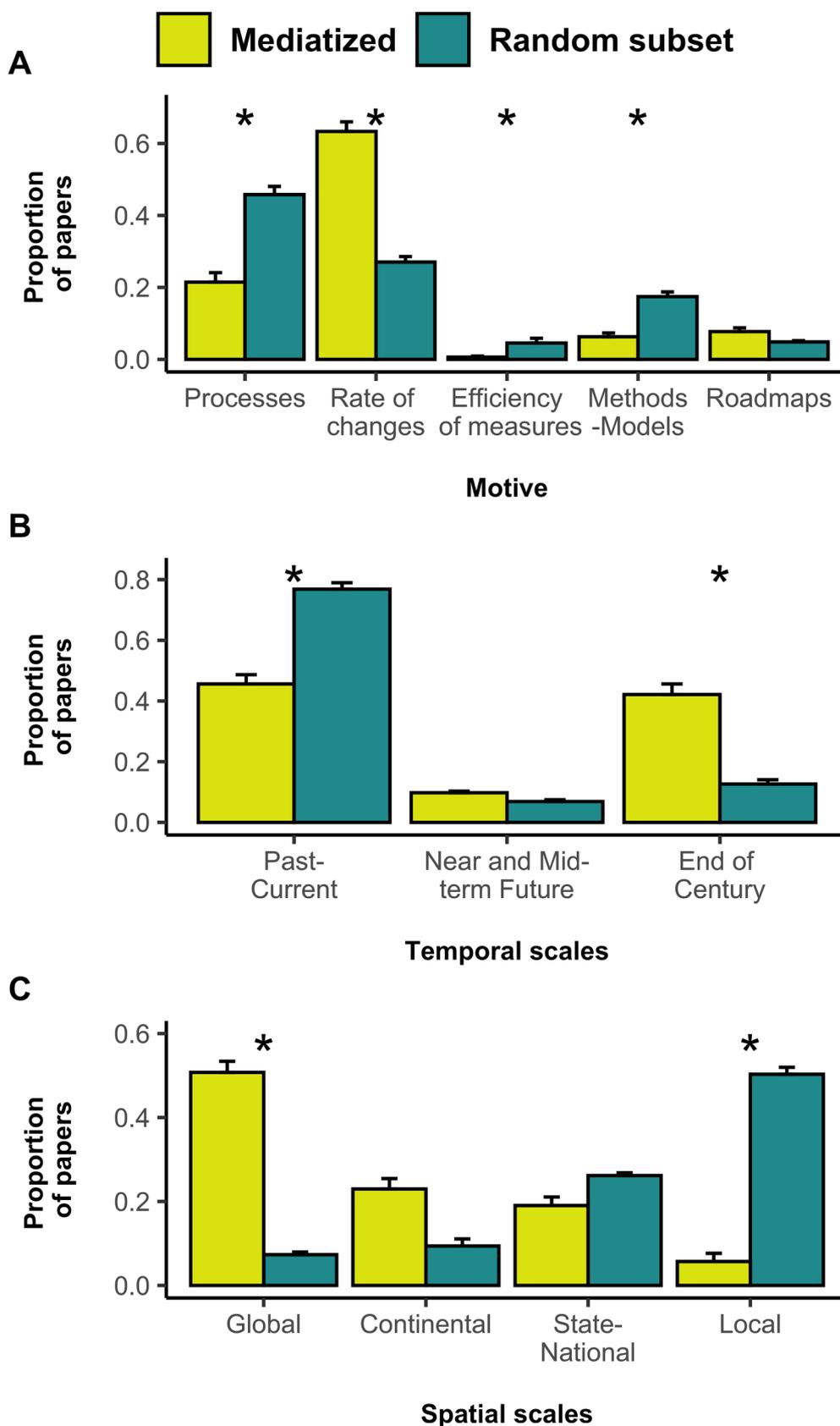
Fig. 3. Compared distribution (mean + standard deviation) of (A) motives, (B) study temporal and (C) spatial scales within the top-100 mediatized and the randomly selected subset of climate research papers published in 2020. Processes = process understanding, Methods-Models = Methodological improvements. The content analysis was conducted for natural science papers and multidisciplinary papers that contained natural sciences (n = 82 for the top-100 subset and n = 67 for the random subset). * denote consensus for significant differences in the proportions between the random and top-100 subsets, from Chi-squared tests of all four coders. See Appendix E for statistics.

publications are selectively concentrated on the worldwide magnitude of the current consequences of climate change, and projected risks by the end of the century for natural Earth components. The hegemony of high-impact factor, broad-readership journals on the mediatization has already been observed in other scientific fields (Papworth et al., 2015). High-profile journals are most likely to rely on strong press offices, maintain professionalized press relations, and promote papers through press releases and commentaries, and therefore to attract news media attention (Franzen, 2012). Moreover, news outlets judge the newsworthiness of a given paper from the reputation and name recognition of the scientific journal in which it was published (Franzen, 2012). Last, whether a scientific finding is potentially of interest for the public, beyond academia, is one of the criteria applied during the triage of manuscripts in many high-profile journals (Franzen, 2012). Altogether, the criteria currently applied for judging the newsworthiness of a research finding are not in the sole hands of the journalists, but also, upstream, in those of the editorial board of high-profile journals.

Our analysis showed that the currently applied criteria for newsworthiness lead to a mainstreamed, monolithic portrayal of climate change research as a sentinel and whistleblower for human impacts on changing climate expressed essentially in a biophysical sense, sometimes extending to potential health impacts. Mediatized information excludes other kinds and scales of research that are an important part of climate change research. What are the possible outcomes of such mediatization processes in terms on engagement of societal action?

First, this single-lined mediatization is likely to reinforce the "selective exposure to information" effect. Thus, although the media overwhelmingly focus on breaking news in climate science that points to the severity of climate change in the future, it is not granted that media users will expose themselves to scientific information reporting an "inconvenient truth". It is important to note that selective exposure does not necessarily imply that people avoid disconfirming information; they can simply ignore it. For example, research on the influence of anti-tobacco campaigns and warnings has long shown that smokers engage in an "immunization" process that allows them to carry on their behavior while being exposed to anti-tobacco messages (Falomir-Pichastor and Mugny, 2004; Leventhal and Cleary, 1980).

Second, the over-reporting of large-scale or end-of-the-century consequences for climate change likely amplifies peripheral information processing. Conversely, our analysis shows that the local consequences of climate change, which could make feel people more concerned and therefore elicit central procession of information, are virtually absent in the media. Mediatized long- and large-scale trajectories portray climate change as acting far away in space and some time into the future, and create both an emotional distance and a psychological distance (Maiella et al., 2020; McDonald et al., 2015), with the reported information that may reduce the readers' motivation to engage in central processing (Jasanoff, 2010; Liberman and Trope, 2008). As a result, even if news media succeed at producing exposure to and popularizing climate change research, this will not necessarily convert into action, however catastrophic the associated future is portrayed to be.

Third, preferentially emphasizing the global scale of consequences of climate change, whose long-term stakes appear as determined only by national and international policies (i.e., as modelled in the different scenarios of the International Panel for Climate Change) may reduce the public's perception of collective efficacy. In the event that media readers and viewers proceed to a deep analysis of the broadcasted content, and feel concerned and able enough to invest in action, it is not granted that such action will follow. Our study shows that research findings evaluating the efficacy of potential measures are under-reported. Thus, as far as the impact of mediatized science is concerned, even content that is properly vulgarized and understood may result in inaction because the task ahead appears overwhelming to a single individual while only resting in the hands of political power (Thaker et al., 2019).

The current mediatization of climate change research is therefore more likely to reinforce the barriers between information and action. In addition, the results of the present study revealed the under-reporting of decision-oriented papers pointed to actionable climate solutions and the selected mediatization of research findings that quantify the long-range, long-term extent of climate change impacts; this has the potential to elicit fear for its consequences. Indeed, the magnitude of the climate change impacts associated with lack of solutions can be construed as a threat, which is defined in psychology as when individuals are not able or do not feel able to cope with a stressor (Lazarus and Folkman, 1984). Feelings of threat, in a turn, are precursors of the emotion of fear (Tanner et al., 1991). However, the appeal to "fear"—widely used in environmental, health, safety and political campaigns (Ruiter et al., 2014) — may be ineffective in changing behavior when not accompanied by specific recommendations on how to cope with threat, or even yield boomerang effects (Leventhal et al., 1965; Reser and Bradley, 2017). Research on the role of visual and iconic representations of climate change also shows that such representations do attract attention, but are not effective at triggering motivation for personal engagement (O'Neill and Nicholson-Cole, 2009).

First, multiplying communication efforts on the sole aspect of how large and serious climate consequences might reinforce climate anxiety, whose impact on pro-environmental attitude and behavior change varies greatly from one study to another (from a paralysing factor to a trigger for action; e.g., Crandon et al., 2022; Verplanken et al., 2020). Second, the experience of fear does not necessarily imply an accurate appraisal of risk, and laypeople, and sometimes even experts, have a biased perception of probabilities and risks (Slovic, 2016). One example among many is the phenomenon of comparative optimism, whereby individuals are convinced that they are less likely to experience negative events and more likely to experience positive events than are other individuals (Weinstein, 1980). Third, some targets of fear-appeal climate change communications may perceive that their freedom to act is constrained by the content of the message (e.g., reducing one's carbon footprint often means travelling less). In such case, they may react by opposing attitude or behavior change, and even go in the opposite direction (psychological reactance, Rothbaum, 1982). Relatedly, emerging research suggests that fear appeal reduces the very credibility of the news media that present it, increasing cognitive resistance (Feldman and Hart, 2021). Fourth, the literature on fear appeal, not only related to climate change, has identified a sizeable number of moderators and boundary conditions to its persuasiveness. For example, a *meta*-analysis by Witte and Allen (2000) had already shown that fear appeals are most persuasive when they elicit the perception that changing behavior is effective in countering the danger. However, if this is not the case, fear appeal may elicit defensive responses such as minimization, denial and avoidance of the message. More recent reviews and *meta*-analyses have identified similar caveats, but a fierce debate on the main effect, the general efficacy of fear appeals is still going on (e.g., Kok et al., 2018; White and Albarracín, 2018). Last but not least, coping with a catastrophic view of climate change may not be a matter of choice but simply there being no other choice. People continue to live in risky locations (e.g., flood-prone) and may be fully aware that climate change is likely to increase the associated risk, but they do not have the resources (broadly-defined) to do anything other than continue to cope with the ongoing rolling-on of ordinary day-to-day life (Van Voorst, 2015).

5. Conclusion

The process by which some research findings get selected for news mediatization in the field of climate change research is not likely to engage societal actions. We show that current criteria for newsworthiness select very specific features of climate change research that may move the public but that are unlikely to trigger public movements. The mediatization around scientific findings on climate change research in news media remains locked in both (i) a "knowledge deficit model", assuming that the lack of public knowledge on the seriousness of climate change is the cause for a lack of actions (Suldovsky, 2017), and (ii) the

notion that climate change science is a natural science that does not need to mingle with other sciences. Such a communication model has been a first, and in some respects successful, step to increase the public's awareness about climate change (Howarth et al., 2020) but it remains insufficient to move climate initiatives forward. For instance, 93% of European citizens consider climate change to be a serious problem (Eurobarometer, EU, 2021) and skepticism is low. Yet, a recent survey also emphasizes that awareness is not coupled to willingness to change lifestyle (Henley, 2021). The mediatization of climate change research is self-perpetuating the perception that climate change is mostly an environmental problem, undermining how its inner societal, economical, justice, philosophical and even technological dimensions are however key to the solutions (Swim and Bloodhart, 2018).

In light of the current mediatization mode of climate change research that emerges from our analysis and the extant research on individual and collective behavior change, newsworthiness and news usefulness do not align. A transformative mediatization model would require that the public can interact with information that quantifies and projects climate change, but also proposes decision-oriented solutions and takes into account knowledge from the social and human sciences, avoiding the drivers of inaction that come from the current focus of mediatized climate change research. Solutions-oriented journalism commonly experiences lower levels of cognitive resistance (McIntyre, 2019). Balancing the global focus to a place-based communication, accounting for local specificities, has the potential to advance climate initiatives (Gislason et al., 2021). Indeed, easy-to-implement acts create an engagement that leads people to persist in and to generalize their actions (Kiesler, 1971), especially if the commitment is public (Pallak and Cummings, 1976).

Shifting models implies that the gatekeepers of mediatization, i.e. newsrooms, press offices of academic institutions and wealthy top-tier journals which are the far dominant source of news (Heyl et al., 2020) should also revisit their agenda. "Usefulness" is a normative construct that requires us to ask what is useful and for whom. Media outlets are not just groups of benevolent journalists seeking to transform societies but highly politicized and directed units, centered also on raising revenue. Press officers and offices within Universities do not simply exist to promote action climate change policies; they exist to raise the profile of their institutions and if certain media outlets want to do this in certain ways, they will have to conform to them. Top-tier prestigious journals have an interest in getting their work read, whether to sustain subscriptions and submissions or to prime citation to their work and the metrics that drive the academic publication industry (e.g., impact factors). The symbiosis between the normative goals of these three sets of partners is likely to explain why climate change communication via the media is biased to certain disciplines, spatial scales and time scales. It is interesting that in social media, where the influence of gatekeepers is less preeminent, and as we evidenced for Twitter, the disciplinary mediatization of research findings is more balanced. With news usefulness defined as the ability to engage society in climate actions—through the publication and mediatization of more solution-oriented, interdisciplinary outputs that take into account the public's resistance to change—both researchers and news professionals may move from being the whistleblowers of the problem to being part of the solution.

6. Data availability

The data that support the findings of this study are openly available on Mendeley data (https://doi.org/10.17632/trkcw9h2th.1).

Separate data 1: full corpus of scientific articles published on climate change over the year 2020, with altmetrics scores for news and tweets.

Separate data 2: categorization of Web of Science Topics into disciplines.

Separate data 3: content analysis for the TOP-100 and random subsets.

CRediT authorship contribution statement

Marie-Elodie Perga: Conceptualization, Methodology, Data curation, Visualization, Investigation. **Oriane Sarrasin:** Investigation. **Julia Steinberger:** Investigation. **Stuart N. Lane:** Investigation. **Fabrizio Butera:** Conceptualization, Methodology, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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Author contributions

MEP and FB conceived the study, MEP conducted the data analysis, FB, OS and SL formalized the social psychology section, all authors contributed in writing and editing the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2023.102675.

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