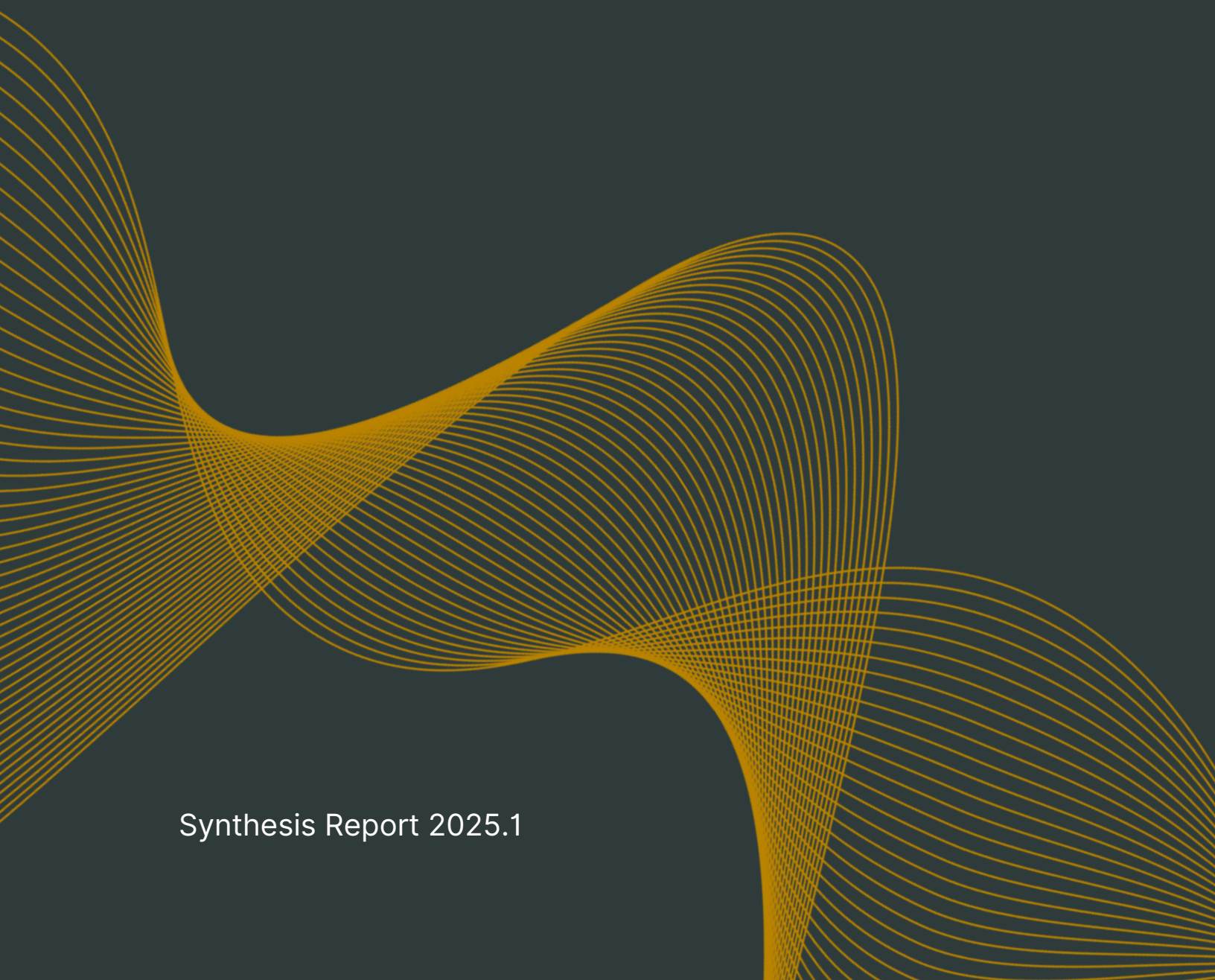
IPIE
International Panel on the Information Environment

# Information Integrity about Climate Science

## A Systematic Review



Synthesis Report 2025.1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## SYNOPSIS

The human response to the climate crisis is being obstructed and delayed by the production and circulation of misleading information about the nature of climate change and the available solutions. This report presents a synthesis of the state of knowledge from scholarship addressing the crisis of information integrity about climate science.

This report builds on a systematic review of studies (n = 300) between 2015 and 2025. Systematic reviews provide one of the most well substantiated and widely applied approaches to assessing the state of knowledge for a given domain of research.

The findings indicate that powerful actors—including corporations, governments, and political parties—intentionally spread inaccurate or misleading narratives about anthropogenic climate change. These narratives circulate across digital, broadcast, and interpersonal communication channels. The result is a decline in public trust, diminished policy coordination, and a feedback loop between scientific denialism and political inaction.

There is a severe gap in research on climate information integrity in the Global South, where impacts are likely to be significant but poorly documented.

Key takeaways from the synthesis include:

1. coordinated misinformation campaigns actively shape climate narratives;
2. scientific consensus is frequently misrepresented in media;
3. regulatory enforcement and access to data remain uneven globally;
4. information integrity research is heavily concentrated in the Global North.

The report concludes with an assessment of policy recommendations that have been made over time, identifying for policymakers the four areas where impact has been consistently positive:

- **legislation** to ensure standardized carbon reporting and labelling,
- **litigation** to ensure enforcement of the standards,
- **coalition building** across stakeholder groups,
- **education** of policymakers and the public.

This consolidated evidence base affirms a scientific consensus and specifies the urgent measures policymakers (see SFP2025.2) must enact to shield humankind—and the planet we depend on—from an accelerating climate threat.

# CONTENTS

# SECTION 1. INTRODUCTION

## Background and context

Climate change represents an existential risk [1] to the long-term livelihood of humanity and biodiversity. A near-universal scientific consensus has indicated that anthropogenic sources—fossil fuel consumption, industrial production, intensive agriculture, automated transportation, and other human interactions with the natural environment—are key to an accelerating climate crisis [2].

Research in the natural sciences has documented both the requirements for a so-called green transition to phase out fossil fuels and achieve a sustainable form of human life on Earth, and the courses of action that are needed to accomplish this transition [2]. Recognizing the nature of the climate crisis and responding to the scientific evidence, the international community has repeatedly committed itself to acting on climate change.

Following on from the 1992 United Nations Framework Convention on Climate Change (UNFCCC), as affirmed by the 1997 Kyoto Protocol, the 195 parties to the 2015 Paris Agreement reiterated a global commitment to limiting carbon emissions in order to counter the clear and present danger of the climate crisis. Key goals included keeping global warming to no higher than 2°C and preferably 1.5°C above pre-industrial levels, reducing greenhouse gas emissions by 43% by 2030, and reaching a net-zero balance by 2050 [3].

Ten years on, however, the climate crisis remains more urgent than ever: “The first 12-month period to exceed 1.5°C as an average was February 2023 – January 2024, boosted by El Niño, when the average temperature worldwide was estimated to be 1.52°C higher than 1850–1900” [4].

Scholarly and political debate has raised further issues of global climate justice [5]. These issues arise from the historical responsibility of the Global North for the climate crisis and its derived responsibilities of securing the necessary resources to sustain the livelihood of peoples of the Global South, and of humanity as such.[1] In addition, there are important differences *within* the group of Global South countries. Dependence on fossil fuels and investments in renewable energies varies considerably for rising economies and small states. Two countries alone, India and China, account for almost 60% of the group's emissions, another eight countries add 18%, making a total of 78%, and the remaining countries represent only 22% [7]. So far, however, ongoing formal and informal communications and exchanges of information about ways forward have failed to generate the required climate action (Sustainable Development Goal 13) [8].

A great divide between what humanity knows and what the present human cohort does is manifest, maintained and deepened by the ways in which information about climate change is produced and circulated through contemporary media and other channels of communication. This crisis of information integrity is intensifying and exacerbating the climate crisis.

[1] While this Report refers to the Global North and South, it recognizes that variable terms are employed in research and public debate to capture an unequal past and present, including an alternative terminology that refers to majority and minority worlds. See further [6].

## SECTION 2. CONCEPTUALIZATION

### Definitions and delimitations of information integrity

Recent years have witnessed a growing interest among scholars and policymakers in the idea of information integrity. At issue across various domains of theory and practice have been questions of how well a given item or set of information captures particular aspects of the natural or social world, and the extent to which the information in question provides a dependable resource for individuals and collectives to use to act in and on those worlds. In media and everyday conversations, as well, concerns regarding information integrity have been articulated in terms such as misinformation, disinformation, and fake news. In the longer history of ideas, arts, and sciences, information integrity recalls classic challenges of ascertaining the truth of representations of reality and of human understanding of reality.

The concept of information integrity was originally created in the academic field of information security, which has built on computer science, information science, cybersecurity studies, and adjoining areas of inquiry [9]. Here, a central concern has been integrity in the specific sense of preservation of the original contents and forms of military, national-security, and corporate information by restricting or limiting modifications, as well as tracking any (authorized or unauthorized) access to the information through proof chains registered in file data and metadata. The ISO 27000 standard for Information Security Management Systems (ISMS) defines information security as the "preservation of confidentiality, integrity and availability of information," and information integrity as the property of accuracy and completeness of information [10]. An additional range of disciplines and fields—public administration, organizational science, sociology, political science, international relations, law, and philosophy—have also relied on terminologies that refers to information integrity, typically when studying the quality and

applicability of information that lends direction to and helps coordinate the operation of major social institutions [11].

In a further extension of the concept, information integrity has come to refer to frameworks and criteria for assessing the increasing quantities and diverse qualities of information that flow through publicly accessible communication systems [12], such as the digital platforms that have become pivots for the local and global uses of the internet. In the context of public debate and democratic participation, information integrity includes questions of who is in a position to produce and circulate information in the first place; the availability and accessibility of infrastructures enabling the production and circulation of information; the quality of the resulting information products; and the extent to which individuals and publics gain relevant and actionable insights from the information on offer. A case in point is the climate crisis, which calls for the necessary and sufficient information to be communicated and acted upon by citizens, national policymakers, and international agencies.

The United Nations (UN) has played an important role in placing the issue of information integrity on public and policy agendas, including for the area of climate change. In 2024, the *United Nations Global Principles for Information Integrity* were presented [13]; that year also witnessed the launch of the Global Initiative for Information Integrity on Climate Change, spearheaded by Brazil and coordinated through UNESCO [14]. The *Global Principles* highlighted the need for "independent, free and pluralistic media" around the world as vehicles of information and opinion formation. They also called for more "transparency and research" into whether and how traditional media and online communication platforms maintain information integrity in the public interest. That publication, however, stopped short of offering an explicit or operational definition of information integrity.

A UN policy paper preceding and preparing the *Global Principles* went part of the way by referring to information integrity as "the accuracy, consistency and reliability" of information [15]. These three criteria are, in fact, legacies of the information security literature [9], and have significant transfer value for assessments of the information integrity of public forms of communication, too. Further research has considered additional criteria for public communication, including security, fidelity, and, importantly, transparency: the need to establish how a given item or set of information came into existence, holding a particular content in a particular form [16]. The criterion of transparency recalls both standard methodological procedures of scientific research and the normative ideal of public and political debate as the pursuit of the right ends by the right means through the open exchange of arguments among all affected by the resulting decisions [17].

Building on previous scholarship and policy development, the present Synthesis Report departs from four criteria to guide an assessment of the integrity of the information environment regarding climate science:

- **accuracy** – the alignment of the information environment with the findings of climate science,
- **consistency** – the stability of the information available at different times and in different places about the natural and human causes of climate change,
- **reliability** – the explication of the origins of the information in question and its relevance and application to climate change, and
- **transparency** – the possibility for citizens to trace the trajectories of information about climate change from its sources and throughout the infrastructures enabling its communication to recipients.

Together, these criteria delimit a field of four dimensions along which previous research has documented both general challenges to and specific disruptions of information integrity about climate science:

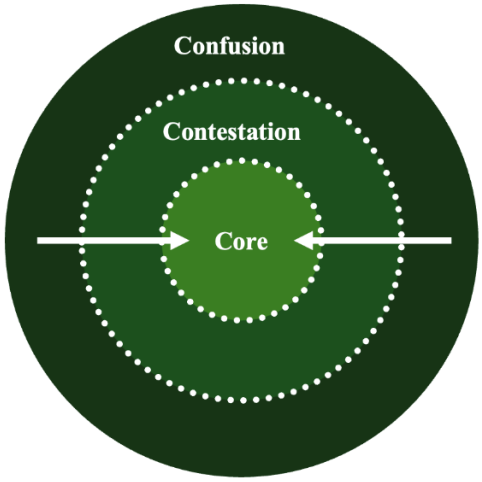
- the **correspondence** of the publicly available information with the current consensus of climate science (accuracy),
- the **coherence** of the information enabling public and policy debate (consistency),
- the **dependability** of the available information for individual and collective opinion formation and agency (reliability), and
- the potential for **reflection and deliberation** through comparing, contrasting, and assessing diverse instances and sources of information about climate change (transparency).

Recognizing that climate change constitutes a contested terrain of national and international public and policy debate, the report delimits challenges to and disruptions of information integrity from the ongoing deliberations and recurring disagreements that are essential features of both science and democracy. A common denominator for the two modern institutions of science and politics is the self-correcting practices they ideally rely on in pursuing knowledge and serving the public interest [18]. It is disturbances of these practices, and of their mutual support through the sharing of scientific information in public forms of communication, that the following Systematic Review of the state of research addresses.

Figure 1 (see p. 11) lays out a heuristic model suggesting the boundaries between legitimate debate and illegitimate disruption. The **core** represents the findings and conclusions delivered through the established practices of climate science, as summarized by the Intergovernmental Panel on Climate Change in assessment reports since 1990 [2]. Practices of **contestation** include doubts, disagreements,

and discussions regarding the nature of climate change, its causes, consequences, and potential solutions, with participation from scientific communities, national and international agencies of governance, civil-society organizations, and the general public. Practices of **confusion**, lastly, introduce information that conflicts with or undermines one or more of the four criteria of information integrity noted above, which serves to delegitimate the products of the core (the validated results of climate science) and/or the processes of legitimate contestation (underwritten by established procedures of scientific inquiry and democratic governance). The dotted lines recognize the fuzzy boundaries between the three domains; the arrows suggest the disturbances of core scientific knowledge and consensual forms of contestation that are introduced by the communication of confounding information.

**Figure 1. Three domains of communication about climate change.**




**Source:** IPIE Panel on Information Integrity about Climate Science.

Two additional specifications of the scope of the Systematic Review should be noted. First, the communication of confusing information can be either intentional or incidental. Here, a distinction is commonly made in research as well

as in public debate between (intentional) disinformation and (incidental) misinformation (*SR2023.1*). Section 3, on Methods, returns to the operationalization of this and other distinctions, while Section 4, on State of Research, considers findings concerning each aspect in previous research. For example, fossil fuel and other companies will intentionally launch campaigns greenwashing—denying or deflecting attention from—the climate impact of their products and services, which may be passed on incidentally or unwittingly by media and private citizens.

Second, challenges to and disruptions of information integrity follow both from the interventions of particular agents and from wider social structures [19], including communication infrastructures, which variously condition the production, circulation, and uptake of information about climate change. For instance, as agents of influence the companies engaging in greenwashing benefit from entrenched structures of ownership and control over economic, organizational, and technological resources. Media and citizens equally depend on legislative structures and educational systems to gain insight into company operations and to recognize instances and practices of greenwashing.

The agent-structure and intentional-incidental spectra intersect in the communication of confounding information. Specific, intentional interventions by particular agents according to their strategic interests produce similarly concrete, identifiable disruptions of information integrity about climate change. Likewise, general communication infrastructures such as contemporary digital platforms and the structures of national and international economy, politics, and culture variously enable and constrain such communicative events. This set of conditions presents long-term challenges for the maintenance of information integrity regarding climate change and other critical issues. Research has examined both

the nature of the crisis of information integrity and a range of potential measures and partial solutions.

## Objectives and research questions

The purpose of the report is to review, synthesize, and assess the current state of knowledge about general challenges to as well as specific disruptions of information integrity about climate science, as they affect public debate and policy development from the local to the global level of human existence and coexistence. Specifically, the report seeks to:

1. Summarize the origins of, backgrounds to, and consequences of the crisis of information integrity in contemporary communication about climate change.
2. Document gaps in previous research that limit the understanding of the crisis of information integrity and delay individual and collective engagement with climate change.
3. Identify ways and means of mitigating the crisis of information integrity.

Following Section 3, on Methods, Section 4 presents the results of a systematic review of previous research on information and communication about climate change. Section 5 addresses additional findings and implications of previous research and the gaps in current knowledge.

To structure the systematic review, the report addresses a set of research questions that cover the elements and steps of a process of communication. The research questions were originally articulated in one of the foundational models of the field of media and communication research [20]. At the same time, the questions reflect the universal human practice of communicating with others, increasingly through technologies from writing through printing to digital devices such as personal computers and smartphones (for a historical overview, see, e.g.,

[21]). And, for present purposes of an interdisciplinary presentation of findings and insights, these questions recognize the common experience of communicating with other people as well as with private organizations and public institutions, through different media and in diverse circumstances, for a wide variety of personal and communal purposes.

The research questions are:

- WHO – who originates information that disregards, circumvents, or otherwise undermines one or more of the four criteria of information integrity regarding climate change? The agents behind the dissemination of such information range from individuals such as the CEOs of corporations and pseudo-scientists, via interest groups and stakeholder organizations, to institutions and officials representing nation-states.
- SAYS WHAT – what categories of information and practices of communication are designed or serve in effect to undermine information integrity? The categories of information include explicit denials of the reality of climate change, as well as skepticism concerning specific findings or potential solutions. Communicative practices range from attempts to obstruct or delay measures to mitigate climate change, to the introduction into public or policy debate of information posing as bona fide scientific findings.
- IN WHICH CHANNEL – which media and other vehicles and venues of communication are the concrete means by which confounding information is distributed? Beyond traditional print and broadcast mass media, the internet and social media have become key public carriers of information about climate change (including a great deal of information generated by bots), to which must be added private,

behind-the-scenes interactions such as interventions by think tanks into political processes.

- TO WHOM – who is addressed and affected by an intentional or incidental undermining of information integrity about climate science? While a great majority of the world's population receives information through digital and analog media on a daily or regular basis, including misleading climate-related information, research has further singled out particular population segments, such as students and older adults, for studies of their access to and uses of this information.
- WITH WHAT EFFECTS – what is the effect, influence, or impact of confounding information on people's understanding of, knowledge about, opinions on, and behaviors relating to climate change? Alongside, for instance, specific studies of effects on political attitudes, research has also considered wider implications for the general public's trust in the institution of science and the results it delivers, as well as people's affective or emotional responses to information about climate change.
- WITH WHAT POTENTIAL SOLUTIONS – amending and adding to Lasswell's [20] original paradigm, the systematic review also incorporated the potential solutions to the undermining of information integrity about climate science that have been explored in previous research. Here, the measures considered range from national and international regulation and legislation, via the moderation of online content by platforms and enhanced public dissemination of scientific findings, to broad-based educational initiatives.

# SECTION 3. METHODS

A systematic review provides one of the most well substantiated and commonly applied approaches to assessing the state of knowledge in a given field of inquiry [22]. Systematic reviews can help identify gaps in previous research that require or invite further inquiry, and they can be used for the development of theory and the identification of policy implications. This Synthesis Report builds on a systematic review of existing research on the production and circulation of information and misinformation about climate change, complemented by a gap analysis of evidence and insights missing in the literature [23]. The present section lays out the elements and steps of the review and analysis.

By way of introduction, we recognize several helpful previous reviews regarding particular aspects of climate change communication, for example focusing on social media [24], conspiracy theories in online environments [25], and the prevalence of climate change denial and potential ways of counteracting this [26], [27]. To the best of our knowledge, the present report constitutes the most comprehensive systematic review to date of the state of research on information integrity about climate science.

## Sampling procedures

An initial challenge of designing the present systematic review followed from the terminologies that are commonly employed across disciplines and fields addressing the domain of interest. Section 1 noted how the term *information integrity* has increasingly come to be employed in both scholarly and policy publications. However, a preliminary review of literatures with a dual focus on climate change and information integrity indicated that publications and their references largely relied on terms deriving from policy and practice regarding

climate change and social responses to the climate crisis (e.g., mis- and disinformation, greenwashing, and conspiracy theories).

Following further exploration of literatures representing a range of social-scientific disciplines and interdisciplinary fields, the primary sampling procedure departed from the following search query, which was applied to titles, abstracts, and authors' keywords:

> (climate change OR climate-change OR global warming) AND (misinformation OR disinformation OR greenwashing OR conspiracy OR denial OR obstruction OR skepticism OR contrarianism).

The following databases were searched:

- Web of Science (https://clarivate.com/academia-government/scientific-and-academic-research/research-discovery-and-referencing/web-of-science/)
- Scopus (https://www.scopus.com/home.uri)
- PubMed (https://pubmed.ncbi.nlm.nih.gov)

The outcomes of the searches were:

- Web of Science: 1,305 publications,
- Scopus: 2,122 publications,
- PubMed: 249 publications,
- Total following removal of duplicates: 2,276 unique publications.

In accordance with the standard PRISMA procedure [22], the first step of the screening reviewed the titles and abstracts of publications for their relevance in terms of the dual focus of the review on climate change and information integrity. This led to the selection of 974 publications.

In a second step, only peer-reviewed publications appearing in 2015 or later and written in English were selected, which produced a set of 625 publications.

The third and final step aimed to select influential publications as measured by their citations to further focus the review on recognized contributions to the literature. Rather than relying on raw citation counts, we employed the Normalized Citation Score (NCS), which adjusts citation counts relative to the average citations of articles published in the same year, taking expected citation rates into account [28], [29]. This approach mitigates biases stemming from year of publication, thus producing a more balanced or fair comparison of citation impact for recent and older publications. With a cutoff of 0.6, the procedure yielded a primary sample of 269 papers representing the highest normalized citation scores for inclusion in the systematic review.

Whereas the three databases employed together deliver a broad base of literatures from different disciplines and fields, for the purposes of the present systematic review two domains could be considered less well represented: law and computer science. The legal literature covers, among other things, the regulation of climate impacts and of communication about climate change; computer science examines both the infrastructures carrying information and communication about climate change and the potential technological responses to the challenges to and disruptions of information integrity.

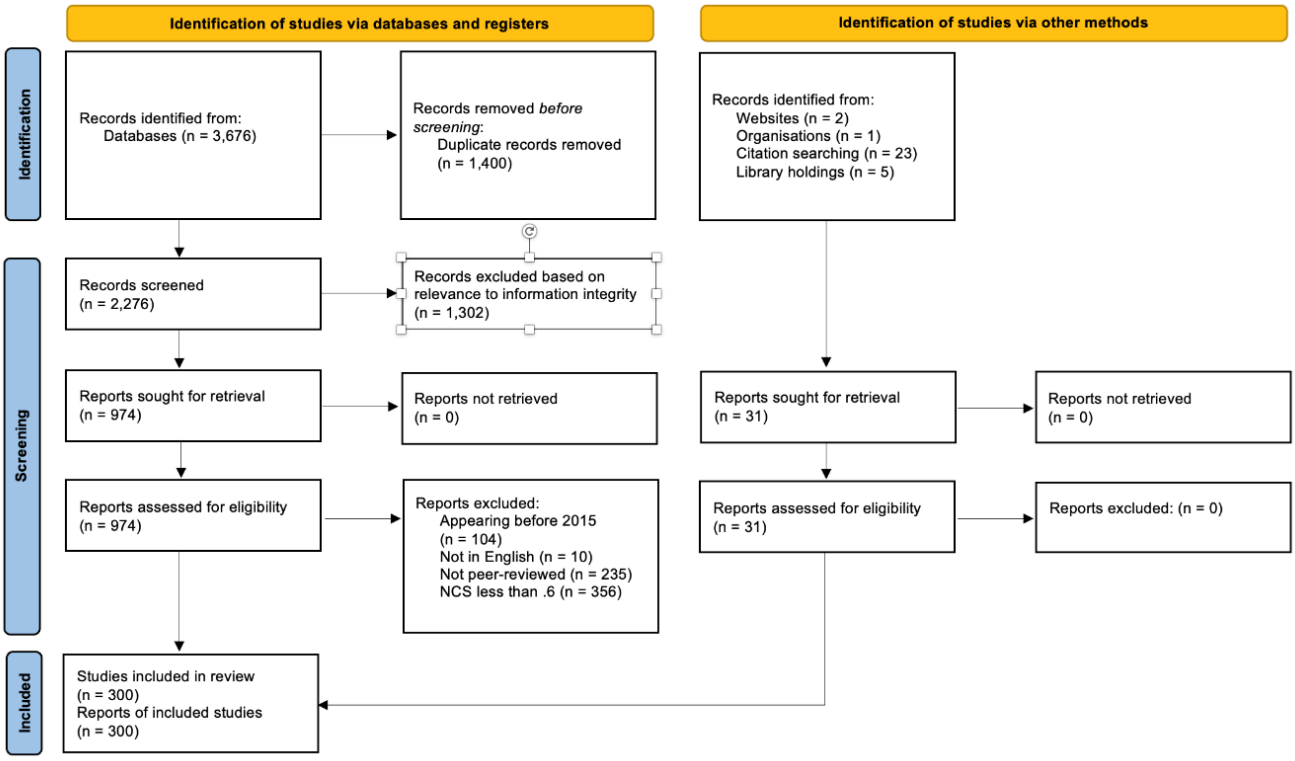
A supplementary review specifically of legal research on the integrity of climate information yielded 13 additional publications.

A supplementary review specifically of computer science publications and conference proceedings on the communication of climate information and technological responses to the undermining of information integrity added 18 publications.

In sum, the systematic review was based on a sample of 300 publications in total.

The steps of sampling are summarized in the PRISMA matrix in Figure 2.

**Figure 2. PRISMA flowchart of the sampling for the systematic review.**

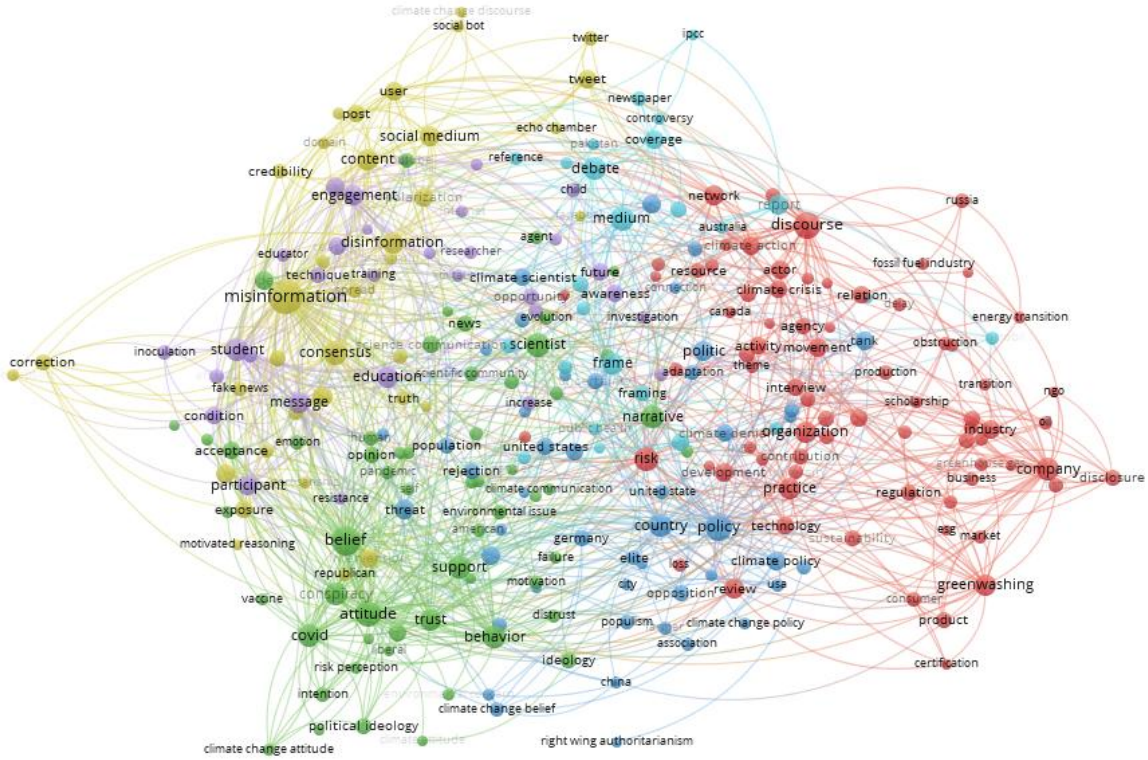



**Source:** Page et al. (2021)

## Analytical procedures

To produce an initial overview of terms and concepts appearing in the sample, a network mapping of title and abstract text data was carried out in the second step of screening the literature (n = 625). Two sets of software were used: Bibliometrix [30] and VOSviewer [31], [32]. A total of 344 keywords were identified and analyzed across the dataset, generating the network map displayed in Figure 3.

**Figure 3. Network map of keywords in the sample (n = 625).**




**Source:** IPIE Panel on Information Integrity about Climate Science.

The network analysis identified six clusters of keywords, which begin to suggest the range of topics and issues addressed in the literature:

**Cluster 1 (red)**, centering on economic agents and practices behind the climate crisis (e.g., fossil fuel industries, emissions, investments, and greenwashing, but also consumers and discourses of communication about climate change).

**Cluster 2 (dark blue)**, centering on political agents and practices variously responding to climate issues (e.g., rightwing authoritarianism, populism, and Trump, but also elections and citizens' political orientation generally).

**Cluster 3 (green)**, centering on perceptions, attitudes, and behaviors relating to climate change (e.g., risk perception, trust/distrust, and conspiracy theories, but also emotions and other cases of information integrity regarding vaccines and Covid-19).

**Cluster 4 (yellow)**, centering on types of misinformation about climate change, especially on social media, and its wider implications (e.g., mis-/disinformation, fake news, social media, echo chambers, and polarization, but also the exposure to and the different users of information).

**Cluster 5 (purple)**, centering on public and regulatory responses to challenges to information integrity about climate science (e.g., children, education, and inoculation, but also in terms of hope and critical thinking).

**Cluster 6 (light blue)**, centering on news coverage and representations of climate change in various traditional media (e.g., newspapers, IPCC reports, and the framing of information, but also controversies concerning the information about and the domain of climate change).

Together, the clusters bear witness to a sustained attention to and examination of how various social, political, and economic aspects of climate change are represented, perceived, and responded to by individuals and collectives. These elements align with a standard model of communication, as introduced in Section 2, which constitute six research questions: who / says what / in which channel / to whom / with what effect [20], with the addition of 'with what potential solutions,' regarding challenges to and disruptions of information integrity about climate science.

As also indicated in Section 2, the systematic review departed from the six research questions. Building on the network analysis and the preceding preliminary review of literatures in the area, we developed a qualitative coding

procedure to identify content related to each of the six research questions (i.e., senders, messages, media, recipients of information, responses, and solutions).

Two research assistants were trained in coding the textual and visual contents of journal articles and other documents [33], [34], [35]. Because the purpose was to identify findings in previous research for each of the six research questions, and to arrive at a synthesis of their implications for further research and policy, the analyses were not designed to quantify the distribution and correlations of various terms, empirical domains, theoretical concepts, or research traditions, or to include measures such as intercoder reliability [34]. The qualitative procedure [36], instead, ensured a consolidation of findings and insights from the publications in the sample with a view to addressing the research questions. A Consulting Scientist performed the training of the coders; supervised and resolved instances whenever the coding of an item was in doubt; and created a first draft of the coding and categorizations of the publications. The Chair of the IPIE Scientific Panel on Information Integrity about Climate Science responsible for this Synthesis Report supervised the Consulting Scientist and further revised both the first draft and subsequent drafts in consultation with the full Panel and the Consulting Scientist. Section 4 presents the results of these analyses for consideration by and among a wider community of researchers and policymakers.

Before reporting the results, two limitations of the systematic review should be noted. First, the systematic review only covered previous research published in English. This is a commonly noted limitation of available accounts of the state of knowledge across diverse disciplines and fields, and it is one that requires action by research communities and funders, not least for domains with global and existential implications, such as climate change and information integrity. Second, and relatedly, the distribution of countries examined in the sample is skewed: While 70 publications in the sample focus on the United States, the entire

continent of Africa and other individual countries are represented in one publication only. This uneven distribution follows from the unbalanced production of knowledge across the globe [328]. In view of the historical responsibility of nations in the Global North for the climate crisis, and for its impacts on the Global South, there is an urgent need for more research regarding the Global South as well as comparative aspects of information and communication about climate change—to which the gap analysis following the reporting of the results from the systematic review returns.

It should be added that, compared to systematic reviews, gap analyses do not represent a clearly delineated or consistently applied methodology. Although many disciplines and fields will refer to gaps in the state of knowledge, including missing empirical evidence or weakly supported theories, it appears that professional and instrumentally oriented areas of inquiry such as medicine and health research come closest to definitions and operationalizations, specifying gaps in terms of knowledge that is required to act on behalf of individuals: "Research needs are those areas where the gaps in the evidence limit decision making by patients, clinicians, and policy makers" [23]. In the broad domain of climate change, gaps in knowledge can be understood, in the first instance, as a need for research to sustain the conditions for life, human flourishing (*eudaimonia*), and biodiversity. In the specific case of information integrity, gaps in knowledge can further be understood as barriers to the translation back and forth between established scientific knowledge and publicly circulated information about climate change.

The gap analysis in Section 5 builds on the systematic review, registering gaps in knowledge for each of the six research questions and adding perspectives arising from the resulting synthesis and its implications for policy development and

practical aspects of the necessary human mitigation of and adaptation to the climate crisis.

## SECTION 4. FINDINGS: STATE OF RESEARCH

### *Current Knowledge*

### Who

Research has indicated that challenges to and disruptions of information integrity primarily originate from actors with an economic or political interest in representing events and issues in ways that disregard, circumvent, or otherwise undermine climate science. At the intersection of economy and politics, moreover, these interests have joined forces in organizations serving to variously deny relevant evidence and delay required actions. A range of other social actors have further contributed to deflecting public attention and awareness from the causes and consequences of climate change. The section 'With what potential solutions' (p. 61) returns to the ongoing struggle between, on the one hand, challengers and disrupters and, on the other hand, agents and institutions seeking to repair and maintain information integrity about climate science.

#### Fossil fuel and other industries

The fossil fuel industry has engaged in a dual deception of the public. Companies in this sector have, on the one hand, employed diverse techniques to deny the reality of climate change, to obscure their own responsibility, and to obstruct or delay mitigating measures. On the other hand, the same companies have deployed so-called greenwashing to portray themselves as environmentally sustainable enterprises (see also the section 'Says what,' p. 35). A substantial body of research has documented how fossil fuel companies such as TotalEnergies, ExxonMobil, Chevron, BP, Shell, and ConocoPhillips—along with coal producers like Peabody, CONSOL, and Arch Coal (the latter two now merged in Core Natural Resources)—have denied or distorted scientific facts, undermining public

understanding of and trust in science [37], [38], [39] by actively promoting misleading narratives regarding their environmental footprints [37], [39], [40], [41], [42]. While much of the available research has focused on the United States, studies have demonstrated similar strategies by the same fossil fuel companies in several other countries, including Australia [43], China [44], and Canada [45].

Beyond the fossil fuel industry, research has identified comparable practices across a range of business sectors. One study illustrated a long-term strategy by American electric utility companies, first through denying or sowing doubt about climate change between 1990 and 2000, and subsequently by obstructing and delaying mitigating solutions, while simultaneously shifting the responsibility for climate change to other sectors of society [46]. Also in the U.S., a recent study showed how animal agriculture companies, in concert with scientific entities, twisted reports to suggest that their carbon emissions were negligible, thus misleading the public and contravening regulation by policymakers [47]. Another study found that 44% of statements by the commercial airline industry about their carbon footprint were misleading [48]; similar findings apply to statements from the tourism [49] and fast-food industries [50].

Technology and artificial intelligence (AI) firms, too, have engaged in deceptive practices. According to one study [51], while tech firms painted an environment-friendly image of “climate AI,” a closer analysis of their material structures and practical operations revealed significant environmental harm resulting from their activities.

Lastly, research relying on computational network analyses has identified a coordinated “climate change countermovement” operating across different industries and sectors [52], [53], including the industries of fossil fuel, plastic, and agrichemical production [54]. A longtime researcher of the climate change

countermovement, Robert J. Brulle [55], summed up the evidence as an indication of the existence of an organized "denial machine."

**Governments and states**

Governments come and go, whereas nation-states have remained the key constituents of the modern world order across centuries. This means that a change of government may bring about changes in a state's climate policy as well as its informational and communicative infrastructures and practices. Nevertheless, research has found that countries in the Global North, as a group and over time, have neglected to assume financial responsibility for their disproportionate effects on global climate change in the context of the 1992 United Nations Framework Convention on Climate Change (UNFCCC), actively delaying and resisting contributions to covering the costs of mitigation in the Global South [56]. Strategies have ranged from hard tactics, including explicit denial of responsibility and open rejection of proposed measures, to soft yet equally effective approaches of designing the language of joint statements to minimize the gravity of past actions, the severity of present effects, and the urgency of climate action in a future perspective [56].

Because the sample of the present systematic review has a clear overrepresentation of studies from and about the U.S., it is not possible to compare and assess the informational and communicative strategies of different nation-states in detail. Still, in the present sample, Russia comes out as a prominent player in recent years. Whereas the Soviet Union and early post-communist Russia acknowledged the importance of climate change as a public issue, particularly the Putin administration appears to have largely disregarded climate change [57]. Studies focusing on the recent past have pointed to a shifting or ambiguous stance on the part of Russia, with the country presenting itself as adhering to international climate policies while failing to live up to these

standards in practice [58]. In advance of the invasion of Ukraine in 2022, to remain a primary supplier of fossil fuels to the European Union through market actors such as Gazprom, the Russian state adopted several narratives—portraying gas as constitutive of national identity; labeling EU policies of transitioning to renewable energy sources (RES) as "hypocritical" and "politically motivated," even claiming that RES are harmful to nature [59].

It should be added that strategic national institutions working in close collaboration with governments have been found to undermine information integrity about climate change. The U.S. Navy, for one, has engaged in greenwashing by presenting itself as the "Great Green Fleet," serving its mission through geopolitical reach, while continuing to rely on nonrenewable resources [60]. The Russian Intelligence Institute (RIA), for another, has used troll farms to disseminate disinformation about climate change on social media [61].

Governments and states, thus, occupy an ambiguous position in contemporary information environments. While ideally ensuring frameworks of education and infrastructures of communication writ large, a range of political authorities and stakeholders have been found to participate in disrupting information integrity about climate science. The section 'With what potential solutions' (p. 61) returns to some of the potential interventions by governments and states to restore and maintain information integrity.

**Political parties and leaders**

In the polarized political landscape of the United States, climate change has become one of the most divisive topics. Whereas the Democratic Party has recognized the urgency of climate action, the Republican Party has employed a variety of countertactics, including denial of the reality of climate change, discrediting climate scientists and climate policy advocates, and rejecting global

solutions to climate change [62]. A comparative analysis of the rhetoric of the two parties showed that while Democrats presented scientific facts, Republicans would rely on anecdotes and storytelling, which may be both more persuasive and more difficult to refute [63].

In the European context, studies have found rightwing populist parties to be actively contravening climate science. Spain's Vox Party, though seemingly acknowledging the reality of climate change, has framed solutions as a matter of local decisions while at the same time reaffirming ideals of traditional lifestyles and rural and national identities [64]. The Swiss People's Party (SVP) has sought to obstruct a transition to renewable energy, arguing that such policies impose an excessive economic burden on the Swiss nation [65].

Research further indicates that the communicative strategies of rightwing populist parties vary considerably across countries as well as contexts. A study comparing Germany's Alternative für Deutschland (AfD) and France's Rassemblement National (RN) demonstrated that, while AfD would emphasize outright denial of climate change, RN pursued an opportunistic approach, shifting its stance across settings and relying on a terminology of "sovereignty" to couple issues of climate change and climate action (or not) to national culture [66]. Another study looking at Germany, Austria, and Poland identified common denominators of opportunism and what was termed "retrogradism" [67]. Whereas the discourses of rightwing populist parties did vary between countries, their shared rhetoric would glorify a past of local, rural lifestyles. The Freedom Party of Austria (FPO), for instance, has supported green energy solutions within that country, but has opposed international agreements that could be seen to threaten national sovereignty. The Law and Justice (PiS) party in Poland, similarly, has projected an image of pragmatically supporting international

agreements even while associating national identity with energy sovereignty through coal supplies, and framing its own carbon emissions as negligible [67].

Individual politicians have also been found to disrupt information integrity about climate science. Based on a network analysis of 7.3 million tweets, one study identified U.S. President Donald Trump as the key influencer of the network, whose logical fallacies, unfounded claims, and cherry-picking of findings were heavily retweeted by other users [68]. Other research on denials, outright lies, and conspiracy theories about climate change has further suggested that Trump, rather than being an exceptional case, could be considered a prominent instance of a wider problem of political figures with climate-contrarian views being elected to top positions [69]. Outside the U.S., a study in the context of Malaysia found that a majority of misleading messages about climate change were being spread by politicians [70]. Research has also noted legal implications of misleading online information presented by politicians and others [71].

**Interest groups, lobbies, and think tanks**

The boundaries between different groups or categories of political and economic actors are frequently blurred in the climate domain. Research has documented extensive organized collaboration among fossil fuel companies, states, and political actors, both when it comes to denying the scientific evidence about climate change [72] and with a view to delaying policies and interventions [73]. Market actors will seek to influence policymaking and the associated political processes through establishing, supporting, and funding diverse interest groups, associations, lobbies, and think tanks—alliances that often work in tandem to resist or slow down mitigating solutions.

By 1980, the American Petroleum Institute (API) was spreading misleading information to cast doubt on global warming and influence public policy with the

aim of slowing down emission controls, carbon pricing mechanisms, and energy transition mandates [74]. Also in the 1980s, ExxonMobil coordinated its activities with the International Petroleum Industry Environmental Conservation Association (IPIECA) to weaken international policies in the climate domain [37]. ExxonMobil continued its efforts as one of the founders of several organizations denying climate change and becoming deeply involved in American political life [75]. Strategic alliances among market actors and decision-makers have further been strengthened by the dependence of U.S. states on these market actors, motivating more lax legislation and weaker environmental policies [76].

Think tanks and other nonprofit civil-society organizations have developed into complex networks influencing climate communication and policy. Portraying themselves as independent and neutral institutions of research and education, think tanks commonly receive funding and other support from market actors to generate policy briefs, recommended strategies, and other knowledge resources serving the interests of these same market actors. As such, think tanks and comparable organizations have come to channel select business interests into policymaking and public debate.

A case in point is The Heartland Institute, a conservative think tank in the U.S., which, in addition to denying the reality of climate change, has framed the costs of climate policies as a burden on the public [77]. A study of the positions promoted by a variety of conservative think tanks demonstrated how their discourses have evolved over time, from outright denial of climate change to skepticism regarding the feasibility and effectiveness of proposed solutions, and increasing attacks on the integrity of climate science and scientists [78]. The authors of the same study found that the think tanks in question, including The Heartland Institute, depended on substantial anonymous external funding, from

obscure entities such as the Donors Trust and Donors Capital Fund, to promote conservative causes.

Conservative think tanks have been active outside the U.S., as well. A study from Canada documented how carbon-based industries have entered into strategic coalitions with think tanks, interest groups, and lobbies to influence and delay policymaking and legislation [45]. Another study from Europe pointed to strong similarities between the rightwing discourses emerging from European and U.S.-based think tanks [79]. A majority of these European think tanks examined in the same study were found to be allied with conservative U.S.-based foundations such as The Heritage Foundation, the Cato Institute, the Competitive Enterprise Institute, and Americans for Tax Reform. These findings were further supported by an analysis of blog posts by think tanks in Germany and the U.S. that showed how they question climate science and evidence-based policies [80].

Studies also show that philanthropic organizations and wealthy individuals have funded the promotion of agendas contrary to climate science. Such interventions have been made possible, in part, through nontransparent and nontraceable funding mechanisms such as the Donors Trust and Donors Capital Fund, thus obscuring the interrelations of funders, the recipients of funds, and the messages and communications being funded [81], [82].

**Media and bots**

In addition to serving as vehicles of information originated by other stakeholders (as addressed in the section 'In which channel'), media and their professional staff have themselves played an active part in challenging information integrity about climate science. Studies show that media outlets associated with conservative or rightwing political ideologies will give priority to and amplify denial, skepticism, and conspiracy theories regarding climate change [83], [84]. An analysis of

newspaper coverage in the United Kingdom indicated a growing prevalence of skeptical narratives, specifically in opinion pieces and editorials authored by in-house nonspecialist columnists, rather than by experts in climate science [85]. Also, individual journalists, along with bloggers, have figured prominently among the various actors accusing climate scientists of spreading hoaxes [86] as well as casting doubt on the entire institution of science, including climate science [87].

Alongside human actors, bots on social media contribute to the undermining of information integrity about climate science. A social bot is a computer algorithm designed to interact with, emulate, and potentially alter the behavior of humans so that bots can be thought of as puppets programmed by human masters [88]. One study concluded that close to 25% of the tweets addressing Donald Trump's announcement of American withdrawal from the 2015 Paris Agreement originated from bot accounts, and further that the suspected bot accounts tended to promote and amplify denialist discourses regarding climate change [89]. Another study of tweets relating to climate change found that 15% of all accounts were bot accounts [90]. One noteworthy feature was that while 83% of these suspected bot accounts supported climate activism, the remaining accounts representing denial and skepticism concerning climate change would pursue active strategies of engagement, such as initiating conversations with non-skeptical human users while amplifying the voices of skeptical users. A study of tweets on Twitter (now X) relating to the 2019/2020 Australian bushfires indicated how some of these tweets were generated by bot accounts. Here, a noteworthy feature was that although, again, bot accounts engaged in climate activism as well as denialism, both categories of bots tended to polarize discussions through evoking emotions [91]. Another study that analyzed 14 million messages spreading 400,000 articles on Twitter showed how bots played a disproportionate role in spreading articles from low-credibility sources [92].

Other agents of misleading communication are trolls [93] and entire troll farms [94] that seek to polarize public opinion, for example, on climate change. Trolls are typically humans who are paid by states.

**Scientists, teachers, and institutions of learning**

While historically a source of accurate and reliable knowledge, institutions of research, teaching, and learning can also be purveyors of misleading information about climate change when private industries fund academic programs and centers [47]. In the field of tourism, for example, some think tanks and interest groups have used tactics such as using non-peer-reviewed literature, outlier studies, and misinterpreting valid research to deny anthropogenic climate change [49]. Contrarian scientists hired by or working in close collaboration with conservative think tanks have authored reports and participated in congressional hearings without possessing the relevant scientific credentials regarding climate change, potentially not only misleading public opinion, but also impacting policy development and regulatory measures [76]. A more wide-ranging critique [95] even went on to suggest that academic communities have been conducting "business as usual" while holding detailed and specific knowledge about the reality and urgency of climate change.

Teachers, too, may compromise information integrity about climate science in the classroom. A study of K-12 teachers in the United States found that while practically all teachers in the sample were aware of anthropogenic climate change, they held unclear or unresolved beliefs regarding the appropriate responses, likely affecting their teaching and students [96].

Fake experts have presented themselves as holding the right professional credentials and meriting scientific credibility in matters of climate change in public formats of communication [68]. Communication of contrarian positions

about climate change has, in turn, been reported to generate both self-doubt and redoubled efforts among bona fide scholars in order to rectify misleading information arising from public debate [97].

### Other challengers of information integrity

A final, diverse group of actors includes, first, *religious figures and institutions*. A study [98] pointed to the disruptive role of conservative Christian organizations, specifically through the Accelerated Christian Education (ACE) homeschool curriculum in the United States, in which fundamentalist interpretations of biblical texts come to infuse curricula, casting doubt on the reality of climate change. Second, famous *businesspeople and celebrities* have been found to challenge information integrity about climate science, even though their activities appear less prominent than those of politicians, organizations, and anonymous agencies [70].

## Says what

This section considers, first, the various categories of information that undermine information integrity, ranging from denial of the reality of climate change to skepticism regarding its nature and the proposed solutions, sometimes articulated as conspiracy theories. Second, it delves into the associated communicative practices, including strategies, tactics, and processes of greenwashing, delay, and obstruction of human responses to climate change.

### Denial

Denial comes out in previous research as one of the most widespread threats to information integrity regarding climate science. While studies point both to the outright rejection of the reality of climate change and to the undermining of its severity as widespread, research has identified further subcategories such as denial of anthropogenic climate change [99] and science denial, i.e., discrediting

science as an institution serving society and the world [100], [101]. Discourses of denial are predominantly employed in—but not limited to—communication by market actors [45], governments and political parties [102], and conservative think tanks [79]. The literature also points to a persistent association of climate denial with rightwing political ideology [103].

Denial of anthropogenic climate change, also referred to as soft denial [104], represents instances where the reality of climate change as such is recognized, whereas the collective contribution of (some portions of) humanity over time is dismissed, labeling climate change instead as a naturally occurring phenomenon. A study from Norway showed that at least 36% of respondents in the sample rejected the human causes of climate change, even while accepting climate change as a fact [105].

Science denial covers a range of positions, including the rejection of the scientific consensus on issues such as climate change, Covid-19, and the effectiveness of vaccines for protecting humans [106]. The literature further indicates that science denial is commonly associated with conspiracy theories [107] and with political movements representing conservative political leadership [108].

**Skepticism**

A second widespread threat to information integrity regarding climate science is skepticism. Although skepticism has family resemblances with denial, it presents itself as more nuanced. Rather than pushing a hard-and-fast rejection of the reality of climate change, skepticism articulates various doubts about the nature of climate change and the contributing factors, as well as the potential effectiveness of proposed solutions. Importantly, research has suggested that skepticism may be gradually taking precedence over denial in public opinion, which has led scholars to refer to “new forms of denial” [75, p. 113].

Research consistently documents strong ties between climate skepticism and political attitudes associated with far-right ideology, nationalist identity, and populism [109] [110] [111]. Studies have highlighted the role of fossil fuel companies, such as TotalEnergies [37] and ExxonMobil [41], in promoting skepticism by casting doubt on the scientific consensus regarding climate change. Equally, U.S. conservative philanthropists including megadonors have been found to disseminate climate skepticism among the public [82].

Similar to climate change denial, climate skepticism comprises several subcategories. While evidence skepticism refers to questioning the reality of anthropogenic climate change, response skepticism revolves around doubts concerning the feasibility and effectiveness of proposed policies and potential solutions. As in the case of denial of anthropogenic climate change, evidence skepticism speaks to the human causes of climate change. While climate change as a naturally occurring phenomenon is recognized, the contributing human factors are questioned [112]. This last form of skepticism, further, has been found to relate to respondents' religiosity [113]. One study found that in U.S. print media coverage, climate change skepticism was being replaced by response skepticism regarding, for example, political regulation [114]. Another study of television coverage of the 2021 IPCC reports in five countries concluded that whereas evidence skepticism was still common, but mostly confined to rightwing channels of communication, response skepticism figured across both mainstream and rightwing media outlets [115].

In a complex domain of interrelated beliefs and attitudes, studies have indicated that climate change skepticism appears rooted in skepticism regarding the science documenting climate change, primarily due to concerns over potential biases in science and the accuracy of scientific data and models. In addition, skepticism is fueled by perceptions that ordinary people—the general public—are

being excluded by climate science and climate scientists [116], [117]. Again, as with denialism, skeptical positions are not limited to climate change, but extend to other scientific matters, such as vaccines and natural evolution, thus registering a wider phenomenon of science skepticism [118], [119].

It is important to recognize national differences in the framing of and discourses about climate skepticism. Whereas in the U.S. climate skepticism has mostly been associated in publicly available information with rightwing populism and conservative politics, research has shown that in Russia skepticism is predominantly promoted by the state as such [58]. In a similar vein, a 2015 study suggested that, in China, climate skepticism has taken the distinctive form of a conspiracy theory about the West, so that climate change has been branded as a Western attempt to obstruct China's economic and social development, again framing climate change as an issue of national identity [120]. In Germany, an analysis of hyperlink networks found that climate skepticism comprised a counterpublic of sorts, only loosely connected to a social mainstream [121]. This counterpublic could be seen to situate itself within an "alliance of antagonism," aligning with other groups supporting conspiracy theories, neglected men's rights, and rightwing agendas [121].

**Conspiracy theories**

Alongside outright denial and generalized skepticism, a specific category of responses affecting information integrity about climate science are conspiracy theories [122]. These theories typically frame climate change as a hoax, i.e., a mistaken premise that has been appropriated and abused by politicians, elite groups in society, and climate scientists to serve their own hidden purposes and agendas [123]. Conspiracy theories in the domain of climate change commonly emphasize the political implications of such presumed practices by hidden forces [124].

Climate-conspiracy theories have translated into attacks on the credibility of climate scientists, for instance, in the online blogosphere, with frequent reference to a terminology of "climategate" (which, referring to information hacked from a university server in the United Kingdom, suggests that climate scientists will manipulate data and mislead the public) [78]. Among several strategies, studies have identified interrelations in YouTube videos between climate-conspiracy positions and assertions about the existence of so-called chemtrails, defined as a secret weather and climate control program [125]. Such conspiracy videos will mimic scientific narratives in a professional style, for instance, by hijacking scientific terms such as geoengineering, which makes it more difficult for members of the public to distinguish these from genuine, authoritative science videos [125].

A specific target of conspiracy theories has been the climate activist Greta Thunberg, who has been framed as a promoter of hidden agendas. Research has established that Swedish rightwing media have circulated manipulated pictures of Thunberg and George Soros, the investor and philanthropist, appearing together, which appeared designed to suggest her deep and problematic engagement with a global economic and political elite [84].

**Greenwashing**

The term greenwashing covers misleading communicative practices and narratives regarding the climate commitments and actions claimed by companies and corporations [126]. The literature has referred to the discrepancy between what commercial and other agents say and what they do, as the 'walk and talk hypothesis.' A study based on 725 corporate sustainability reports concluded that the majority of companies engaged in greenwashing by deploying symbolic narratives rather than documenting concrete mitigating actions [127]. Another study demonstrated that fossil fuel companies, too, will present themselves as

environmentally responsible, making pledges without supporting evidence for their green engagement, and highlighting investments in clean energy while remaining dependent on fossil fuels in their operations [38].

As a wider communicative strategy, greenwashing includes attempts by companies to deflect attention from environmentally harmful actions through a "rhetoric of environmental friendliness" [39]. A study of Total found that this oil and gas company would portray itself through publicity activities as environmentally responsible while in fact engaging in practices harming the natural environment [37]. In a variant of greenwashing, companies underreport their sustainability actions to reduce consumer guilt, also known as greenhushing. With reference to rural tourism businesses, a study concluded that these businesses would only communicate about 30% of their activities relating to sustainability, while simultaneously employing affective language to justify their "customers' hedonistic use of the landscape" [128].

Greenwashing also occurs in the form of shifting responsibility away from one's own organization. A study focusing on energy companies showed that their greenwashing narratives included portrayals of themselves as victims, further emphasizing and exaggerating techno-optimistic solutions, and obscuring their own contribution to global warming [44]. A Swedish fast-food chain was found to engage in greenwashing through net-zero claims by equating emissions reductions and carbon offsets, while simultaneously shifting responsibility for climate impacts to other actors in the economy, such as consumers and even farmers in the Global South [50]. Along similar lines, a study of greenwashing by airlines [48] documented how airlines would shift responsibility away from themselves and onto customers, employing diverse linguistic tactics, from vague language designed to avoid the detection of inconsistencies to misrepresenting scientific facts.

### Delay and obstruction

Delay and obstruction as communicative strategies have predominantly been deployed by economic actors, such as fossil fuel companies, to slow necessary climate action and to block implementation of environmental policies and other regulation. Research has characterized delay as a form of "new denial" because the strategy has consequences comparable to the outright denial of climate change [73]. Fossil fuel companies that are experiencing decreases in stock value due to climate change news are more likely to spend money on lobbying [129].

Studies have documented various categories of narratives and other discourses designed to delay climate action. A study from Australia indicated how the fossil fuel industry has retained its dominant position by delaying action through narratives linking fossil fuels to national identity [43]. These narratives have further suggested that fossil fuels are responsible and reasonable forms of energy, providing more benefits than harms and, therefore, could be thought of as necessary [43]. A comparable tactic, also adopted by fossil fuel companies, has been to link innovations and projects in renewable energy to the continued extraction and consumption of natural gas, suggesting that both forms of energy will be needed in the future [40].

Beyond companies and corporations, governments will also engage in delay and obstruction through a variety of strategies and tactics. Research [56] has identified four main categories of delay and obstruction employed by countries in the Global North: "limiting the scope of the issue, reducing transparency, manipulating concepts, and pushing non-transformative solutions" (p. 97). Another study also condensed discourses of delay into four main types: redirecting responsibility, pushing non-transformative solutions, emphasizing the downsides of climate policies, and surrendering to climate change [130].

### Science misinformation

The literature has referred to a distinctive set of communicative strategies as science misinformation. Whereas the concept of science misinformation extends to other domains such as Covid-19 or vaccines generally [131], it holds specific implications for the domain of climate change because science misinformation has been found to operate in conjunction both with other categories of misleading information about climate change and with additional communicative strategies such as denial, skepticism, and conspiracy theories.

A basic form of science misinformation is generalized misrepresentations of the scientific consensus about climate change and specific false or misleading claims about particular scientific facts and potential solutions to the climate crisis. Such misinformation has a long legacy: It has been employed extensively by economic actors such as fossil fuel companies to mislead the public, both about the reality and urgency of climate change and about the responsibility of this industrial sector for climate change. Although the historical record shows that TotalEnergies, an energy company, had some knowledge about the harmful environmental effects of its products as early as 1971, this and other companies continued promoting doubts about the facts of climate change until the late 1980s by concealing the scientific evidence [37]. Similarly, even when ExxonMobil made investments that could be framed and disseminated as socially responsible through its collaboration with esteemed scientific institutions such as Columbia University and the Massachusetts Institute of Technology (MIT), the company sought to undermine the scientific consensus on climate change by misrepresenting relevant findings [75]. One study [42] highlighted how an early discursive frame mobilized by ExxonMobil in its external communications was the uncertain nature of climate science. Over time, the company shifted its communication strategies toward other frames, including references to climate

change as a "risk" rather than a "reality," framing itself as a "fossil fuel savior" and taking for granted that the world will need fossil fuels for the foreseeable future [42].

The literature has situated misinformation about climate science within a longer and broader trend: Recent science misinformation has come to be dominated by strategies and interventions explicitly aimed at discrediting and delegitimizing climate science, including through direct attacks on individual scientists and scientific institutions [132]. Studies have shown how The Heartland Institute (the conservative think tank covered in the section 'Who', p. 25), while still employing discourses of scientific uncertainty, has shifted its emphasis toward attacks on climate scientists [77], [78].

Misinformation about climate science, then, comes out in studies as one aspect of a wider stream of science misinformation, which further resonates with expressions of distrust of science and scientists among the general public. One analysis found that even people who identify as generally "pro science" would reject the scientific consensus concerning climate change because of a limited understanding or misconceptions of scientific inquiry [133].

Studies indicate that such public distrust reverberates on social media. Research has referred to a "post-truth" era in which user-generated comments about environmental and other social issues, for example, on Facebook, reflect a wider questioning of the role and legitimacy of science in society. Evidence-based facts and arguments are becoming less influential in shaping public opinion than ad hominem attacks and emotional discourses [134]. One study [135] elaborated how Facebook denial groups will adapt scientific evidence about climate change to fit counter-narratives. The same study highlighted how the technological affordances and operations of social media and digital platforms generally can be mobilized to amplify such counter-narratives [135]. Another study of social media

documented the role of Russian trolls in circulating anti-science and pseudoscience content on Twitter (now X), concluding that, in addition to disrupting information integrity about climate science, such trolls could be seen to pursue wider political motives [61].

It should be recognized, lastly, that science misinformation can also originate from science itself in what must be termed scientific malpractice. Research has categorized this kind of science misinformation in variants such as hype, publication bias, citation misdirection, predatory publishing, and scientific filter bubbles [136]. These practices serve to further undermine the scientific consensus and, hence, public trust in actionable climate science.

## In which channel

With the ongoing digitalization of local and global communication infrastructures, the "channels" carrying different types of information and communicative practices have been diversified. Research on media and communication has identified three categories of technologies and institutions, each of which holds distinctive implications for ensuring information integrity about climate science, as addressed in the following subsections: traditional mass media such as the printed press and broadcasting; social media and other online platforms; and a diverse category of source media [137, p. 41], such as press releases and corporate reports, which historically have fed into mass media coverage, but which have increasingly become channels of information and communication in their own right for different stakeholders.

### Traditional mass media

Even while social and other digital media have attracted growing attention both in research and in public debate, traditional so-called legacy or mass media have remained important channels of information for the general public. A recurring

finding has been that especially rightwing and conservative mass media outlets contribute to the disruption of information integrity about climate science. A study of U.K. newspapers indicated that while climate skepticism appeared to be growing across media with different political leanings, uncontested skepticism predominated in opinion pieces and editorials in rightwing media [85]. Similarly, an analysis of 52 newspapers in the U.S. concluded that conservative outlets disproportionately covered the so-called Climategate conspiracy theory already noted [83]. Another study of U.S. print media coverage found that skepticism regarding the impact of climate change was prevalent across different media regardless of their political orientation [114]. Further studies of U.S. print, broadcast, and cable news stories noted how doubts about climate change were being fueled by the political polarization between Democrats and Republicans, so Republicans would take messages from Democrats as cues to situate themselves in opposing positions rejecting climate science [138]. A 2023 publication suggested the complexity of how climate skepticism is being covered and channeled to the public: Skepticism regarding climate science appeared prevalent especially in rightwing news programs in multiple countries, whereas skepticism regarding the possible mitigating responses to climate change was manifest in mass media across the political spectrum [115].

In some instances, mass media have served as willing channels disseminating misleading information advanced by high-profile public figures [70]. For example, one study suggested that news interviews would allow political leaders to spread misleading information unchallenged by journalists [69].

In some countries, including Russia, moreover, state-governed media—from newspapers, documentaries, and national TV talk shows to popular science books—have been found to promote narratives of denial, contrarian discourses, and conspiracy theories [102].

It should be added that commercial messages like advertising remain a staple of mass media content. Historical studies of ExxonMobil's communications strategy [41], [42] documented the systematic use of so-called advertorials—paid editorial statements that have been published in reputable channels such as *The New York Times*—casting doubt on the reality and urgency of climate change, and downplaying the impact of the company's activities on the natural environment.

At the intersection of commercially or politically motivated and independent, journalistic information, some media have been found to serve climate-contrarian interests. One study [139] identified a "climatism cartel" denying climate change, including The Heartland Institute think tank (as referred to in the 'Who' section, p. 25), which also publishes a newsletter, *Environment and Climate News*.

As elaborated below in the section on 'Source media,' corporate actors will employ multiple channels in combination. One example comes from a study of the American electric utility industry, which has employed diverse channels and genres of communication to promote denial, doubt, and delay—from internally oriented shareholder reports to externally targeted periodical publications, complemented by television interviews with industry representatives advancing contrarian positions [46].

**Social media platforms**

Social media and the internet generally have entailed a sea change in information and communication environments. Compared to one-to-many communication through mass media, social media platforms enable many-to-many communication, so that established political and corporate actors and interests, as well as civil-society organizations and members of the general public, may share information and interact online to engage with common concerns such as climate change. While much of the available research has examined social media

use in North America and Europe, some studies have addressed, for instance, China [140] and Latin America [141].

It is well documented that youth are among the primary audiences for information about climate change online [142]. Beyond age, individual factors such as political orientation and trust in science affect people's uses of and responses to information about climate science on social media [143]. An overview of the complex role of social media in the dissemination of misinformation about climate change highlighted how human factors—values and ideologies, social norms and belief systems, and confirmation bias—interact with the features of social media platforms, including the functions of algorithms and the presence of false and malicious accounts [144]. This interplay contributes to homophily, polarization, and echo chambers, which, in turn, increases users' vulnerability to encountering and consuming, as well as further spreading, misleading information online [144] (see also [145]).

In the case of Facebook, research indicates that its affordances for users can be leveraged to strategically promote discourses of denial and skepticism [135]. A study of Italian Facebook groups found that the more active users were within conspiracy echo chambers, the more likely they were to embrace the full range of conspiracy theories [146]. During the 2020 U.S. elections, Facebook was the primary platform on which fossil fuel companies, advocacy groups, and industry associations launched targeted advertisements to reinforce pre-existing beliefs on the importance of fossil fuels in order to protect their industries [147].

A study of the Weibo platform in China found that focusing on the content of messages, rather than on user-based (e.g., comments or likes) or propagation-based features, worked better to identify misinformation [140].

Several studies have identified blogs as a challenge to information integrity about climate science. Blogs are utilized by individuals, institutions, and companies to disseminate discourses of denial, conspiracy, and contrarianism. One study showed blogs to be carriers of conspiracy theories specifically to legitimate a backlash against a scientific study of climate change [107]. Moreover, blogs can contribute to the formation and intensification of polarized public opinion. When blog posts are endorsed by other readers, including those supporting contrarian narratives, users are more likely to similarly endorse this "perceived social consensus" [148]. A study of blogs in Germany demonstrated how climate-contrarian blogs made up clusters, disconnected from the mainstream, but highly active within their own universe, and with further links to misogynistic, men's rights, and rightwing online communities [121]. As such, hyperlinked blogs can nurture a polarized blogosphere of separate publics. More generally, affirmers and contrarians in the blogosphere accuse each other of being untruthful and deploy attacks to vilify the other group rather than debate the science and subject of climate change itself [86]. Such polarization is not limited to discussions of climate change as a general condition, but extends to questions concerning natural facts such as Arctic ice loss or the potential extinction of polar bears, which come to serve as proxies for either acceptance or denial of the climate crisis [149].

Additional platforms such as Reddit and YouTube have facilitated the dissemination of information undermining the integrity of climate science. On Reddit, tourists who feel overwhelmed trying to negotiate the meaning and practice of sustainability may tune out or accept defeat, sometimes turning to conspiracy theories to answer the question of who is responsible [150]. Other research, however, has found little evidence of the presence of polarized echo chambers in Reddit's network structure [151]. On YouTube, comments about a flood in Germany showed a transformation from conflicts about facts to conflicts

of identity and values [152], suggesting a move away from debates about facts to attacks on the other side of the debate [86]. YouTube has also served as a channel through which self-proclaimed experts will seek to mislead the public about climate change [125].

Deepfakes present a specific threat to information integrity regarding climate science. An analysis of climate change on social media concluded that between 27% and 50% of respondents were unable to distinguish deepfake videos from authentic representations [153]. Work has begun in 2025 to explore the implications of generative forms of artificial intelligence for the domain of climate change communication [154].

**Source media**

Source media comprise channels through which various stakeholders are in a position to present their own accounts and promote their own perspectives on climate change. Among the key actors, overlapping with those addressed in the 'Who' section (p. 25), are powerful economic and political interests.

*Economic* or commercial interests are promoted through the publication of *corporate sustainability reports*. Substantial discrepancies between what corporations say and what they do, including exaggerated claims regarding their positive impact on the natural environment, were documented in a study examining 725 corporate sustainability reports [127]. Research [39] has identified three distinctive narratives that fossil fuel companies use to deny or obfuscate the fact that climate change is a problem: ideological denial of its root causes, greenwashing (as reviewed in the section on 'Says what', p. 35), and reification of the status quo as necessary. While disclosures about corporate carbon footprints (sometimes mandatory, sometimes voluntary) represent important sources of information, these disclosures can end up promoting greenwashing instead [155].

Both American and Chinese energy giants have been found to use corporate social responsibility reports for greenwashing purposes [44]. Growing demands for sustainable Environmental, Social and Governance (ESG) investment funds have served as an incentive to greenwash assets by giving them misleading fund names or by inflating their ESG ratings [156]. A study focusing on climate disclosures by the U.S. Securities and Exchange Commission (SEC) suggested that companies may be using these disclosures to obscure their actual environmental impact [157].

Further corporate initiatives in the form of *public relations* bear witness to diverse strategies and tactics of impression management. Canadian industrial emitters, for example, have engaged in greenwashing and denialism through a combination of public consultations, media campaigns, annual reports, company websites, and lobbying [158]. Australian fossil fuel companies, similarly, have been found not only to deny their climate impact, but also to obstruct and delay solutions through a wide range of public relations activities [43]. *Corporate websites and blogs* serve similar ends. Websites in the tourism industry have been found to rely on affective language to legitimize hedonism and eliminate a potential sense of guilt among travelers, without referencing the environmental impact of tourism [128]. A study of the airline industry concluded that close to half of claims about voluntary carbon offset programs published on the websites of 37 companies were misleading [48].

A special case of corporate communication by fossil fuel and other companies is *litigation filings* and related press releases in court cases addressing climate-related issues. Research has indicated that such documents are designed to promote narratives delaying climate action while at the same time downplaying the role of companies in bringing about and exacerbating the climate crisis [159].

At the juncture of economy and politics, the websites of *think tanks* contribute to the spread of misleading information. One study of the websites of contrarian think tanks based in Europe identified discourses aligned with those of comparable organizations in the U.S. [79]. Another study demonstrated how blogs associated with conservative think tanks would employ dedicated communicative strategies and rhetorics targeting particular audiences, from accounts of scientific uncertainty and a dissemination of political ideology to indications of the economic costs of climate action [80].

Last but not least, commercial stakeholders maintain a strategic presence on *social media platforms.* A study of the Twitter accounts of four fossil fuel companies—Shell, ExxonMobil, BP, and TotalEnergies—showed that these are actively employed to channel narratives designed to delay consequential action in response to climate change [40].

A second group of source media serve the interests of *political actors*. At the level of *nation-states*, governments will rely on institutional documents and websites to undermine information integrity about climate science. One study [59] noted how the Russian government would deploy documents regarding energy and foreign policy on the websites of governmental institutions, aligned with statements by businesses in relevant domains, to spread misleading information or justify delays in climate action. However, it was the Putin era that ushered in climate skepticism; despite some climate skepticism advanced by Russian delegations at early COP meetings (1995, 1996), this attitude did not correspond to the position of the Russian government [57]. A study on the U.S. [63] found that speeches by members of Congress have served as an important platform for political actors to present misleading information about climate change. Across several countries, *political parties*, especially those on the right wing, have employed channels such as party manifestos and press releases for similar ends. For instance, Germany's

AfD, Poland's PiS, Austria's FPÖ [67], and Spain's Vox party [64] have leveraged party manifestos, press releases, and public statements, along with mass media coverage, to spread skepticism and promote so-called climate nationalism for purposes of delay and obstruction.

As with commercial interests, political figures and organizations are active on *social media platforms*. One current example is U.S. President Donald Trump, who has utilized social media to advance denialist narratives, which are amplified when shared by his supporters [69]. Political parties such as AfD in Germany and RN in France complement party manifestos and political speeches through their official social media accounts, sharing misleading information and contributing to delay and obstruction of climate action [66].

*Science*, while traditionally grounded in stringent methodologies and substantiated forms of evidence, has also been found to compromise information integrity regarding the climate crisis and the potential solutions. Both *corporations* and *governments* have funded scientists and academic centers that align with their positions or minimized their contributions to the climate crisis. The channels of communication employed here include scientific papers, reports, conference proceedings, and participation at public events [49], [47].

The classic norm of neutrality or balance in *journalism* may end up giving excessive attention to discourses of denialism and delay. A quantitative study comparing the media visibility of climate contrarians and climate scientists concluded that the two groups attained near equal visibility in mainstream media. Still, climate contrarians received up to 49% more visibility than scientists in media outside the mainstream [160]. This discrepancy is attributed, in part, to a lack of rigorous editorial mechanisms for filtering misleading information in non-mainstream channels. In mainstream media, "false balancing" ends up

contradicting the accumulated scientific evidence and international political agreements.

Lastly, studies have indicated that both *interpersonal* [161] and *institutional* [45] networks serve as important channels of communication through which climate skepticism can be disseminated. While less visible than communication carried by either traditional mass media or social and digital media, such interactions can have a significant impact on the attitudes and actions of individuals and on the policies and practices governing key institutions in society. The section on 'Who' above (p. 25) noted how the coordinated activities of certain think tanks and political institutions on policy development unfold without democratic oversight or transparency.

## To whom

Contemporary information environments incorporating traditional mass media as well as social and other digital media typically envelop entire publics, who thus are regularly subject to disruptions of information integrity about climate science. At the same time, research has identified certain groups as particularly susceptible or vulnerable. Beyond the public domain, politicians and other policymakers represent a specific target group for coordinated attempts to obstruct or delay interventions designed to mitigate climate change.

### Politicians and policymakers

As reviewed in the section titled 'Who' (p. 25), powerful economic and political interests will distribute misleading information that affects policies and actions in the climate domain. These efforts are often undertaken through alliances covering market and state as well as civil-society actors, interest groups, lobbies, and think tanks (e.g., [46], [72], [73]). These stakeholders and alliances, thus,

address individual citizens as well as the legislative, executive, and judicial institutions and agencies of public governance.

Because political democracy is everybody's business but also the specific occupation of elected officials, civil servants, and other professional actors, it is important to recognize the strategic place of the latter group in the flows of information and communication that constitute political processes, and their similarly strategic role in the translation of these flows into action (or inaction). The section 'With what effects' (p. 56) returns to some of the ways in which information and opinions travel back and forth between public opinion and political institutions, anticipating and orienting what societies as collectives and communities will be doing about climate change.

**Online publics**

Studies have suggested that people who frequently engage with social media and who rely on online sources for news and information may be especially susceptible to misleading information about climate change. This subgroup of the online public, importantly, is heterogeneous, comprising both individuals whose pre-existing beliefs lead them to actively seek, consume, and disseminate content with little or no information integrity and users who are inadvertently exposed to and influenced by misleading information [162]. A study from China suggested that such susceptibility may follow from limited scientific literacy among average online media users [140]. At the same time, the characteristics of the information presented can contribute to misleading users, including emotionally triggering and manipulative formats of representation [163], [164], polarizing functions of communication [86], and inauthentic [90] and deceitful [125] accounts of events and processes relating to climate change.

**Students and youth**

Reflecting a long-standing concern for children and young people in scholarship and public debate concerning media and communication, research has pointed to students and other youth as specific targets of misleading information about climate change. Even while young people, being future decision-makers regarding climate change and other grand social challenges, are in need of actionable information, they stand out in the literature as vulnerable, partly because of a reliance on social media and other online channels as primary sources of information, partly because of limited experience and information literacy [106]. Studies have suggested that a significant disconnect between scientific communities and media outlets causes uncertainty and mistrust among the general public, and the young (college students) in particular [165].

The literature suggests that students and other youth are exposed to misleading or questionable information to a considerable extent and that, simultaneously, they struggle to assess the quality of the information on offer. One study found schoolchildren to be highly susceptible to misleading information, particularly as they grow older and increasingly rely on social media [142]. A comparable study of students' critical literacy skills found the sample generally unprepared to evaluate the quality of scientific YouTube videos [166].

Education systems, further, may not succeed as a countervailing force. One study [167] argued that narratives advanced by the fossil fuel industry have penetrated education systems, amounting to a "petro-pedagogy" which encourages students to adopt worldviews serving the interests of that industry while discouraging the imagination of alternative futures. Relatedly, another study found that youth undergoing Christian homeschooling were more susceptible to misleading information about climate change [98].

### Other target groups

A variety of studies have indicated that other social groups, too, may be particularly susceptible to misleading information about climate change. Compared to younger segments of the population, *adults and educators*, for one, appear more likely to accept deepfake videos as authentic [153]. Disadvantaged and *underrepresented communities*, for another, have been found to be more susceptible to science misinformation, including about climate change, likely owing to deep-seated structural and institutional power dynamics that generate mistrust in social institutions, as well as to algorithmic structures that entail the selective distribution of information to different sociodemographic segments [168].

Research has further indicated that the combination of specific *personal characteristics* with particular *contexts* of information use can increase a person's susceptibility to misleading information. A comparative study of people's susceptibility in various domains such as climate change, Covid-19, and AI-related misinformation concluded that, whereas some personal characteristics would influence susceptibility equally across domains, other correlations were context-dependent [169]. For example, trust in one's social networks and belief in conspiracy theories affected susceptibility regarding all the contexts examined, whereas susceptibility varied across these domains according to people's risk perception, how open-minded their thinking was, and their political orientation.

## With what effects

Most effects research has examined the short-term impact of media on particular audiences or groups of users. Studies centering on information integrity about climate science have further addressed the effects of communicative processes on both individuals and institutions, including consequences that unfold over time. This section considers the impact of misleading information about climate change

at different scales of social organization, on different time scales, and at different levels of human consciousness.

**Public trust in science**

When the evidence produced by climate science is disregarded, circumvented, or undermined, public trust suffers. Research has produced detailed findings on the ways in which conspiracy theories, in particular, affect people's trust in climate science and science generally [170]. Discrediting the overwhelming scientific evidence about climate change and discouraging relevant actions, these theories promote a rejection of science as a social institution, curb public engagement with the associated political issues, and diminish participation in mitigating, proactive behavior [80], [123], [171]. Conspiracy theories, moreover, have been found to feed sentiments of powerlessness and disillusionment, which in turn contribute to denialism and skepticism regarding climate science [172]. One study showed that exposure to misleading information about climate change negatively affected people's ability to subsequently detect misleading information [173].

The timing of conspiracy theories, as they are received and understood, matters for their impact. A two-phase study indicated that while people are disinclined to believe in conspiracy theories about topics on which they already have knowledge and hold opinions, the effects of conspiracy theories are more pronounced when it comes to, for example, new technological developments [174].

One study identified a "conspiracy gap" between two different subgroups among climate change skeptics. Skeptics who subscribe to conspiracy theories express distinctively low concern for the natural environment and low support for corresponding climate policies, whereas skeptics who, after all, do not believe that climate change is a hoax, are more inclined to support or align themselves with environmental concerns and policies [175].

### Affective responses to (mis)information

Alongside cognitive responses to the reality of climate change and the science accounting for the underlying mechanisms, several studies have examined individuals' affective or emotional responses to both reliable information and misleading information in this domain. Conspiracy theories about so-called chemtrails, for instance, have been found to evoke feelings of anger, sadness, fear, and anxiety in individuals [170]. The media carrying such information and their features and formats also contribute to affective responses. A study of social media headlines noted how contents associated with climate denialism featured emotional expressions and forms of address similar to the attention-grabbing language of clickbait texts and links [164].

Research indicates that cognitive and affective responses interact. A study found that when individuals encounter misleading information dissonant with their earlier beliefs, they experience emotions ranging from anger and hostility to uncertainty and confusion. When the dissonance is resolved, they feel relief and satisfaction. The same study also found that people develop cognitive coping mechanisms including changes in behavior [163]. A follow-up study indicated, importantly, that regardless of their own earlier beliefs, individuals were affected by exposure to misleading information, and would respond by developing coping strategies [162].

### Political attitudes and policies

At the boundary between individual and institutional effects, research has indicated that misleading information about climate change impacts the attitudes and actions of voting publics and policymakers. A comprehensive study of how people perceived various scientific topics, including climate science, found that misleading information not only affects individuals' beliefs but also shapes their

attitudes and behaviors, with potential institutional or structural consequences [101]. Although this same study addressed public distrust in science, it went beyond that and suggested that specific misleading information and general skepticism spread by political figures and other vested interests can have disruptive effects. At the same time, the study recognized that opposition to or distrust of various interests, positions, and institutions in society, rooted in citizens' lived experience, are integral to processes of political democracy [101]. Other studies have cautioned that the concrete effects of misleading information may be more limited than is sometimes assumed [176], [177], [178].

Additional studies have elaborated how skepticism will travel back and forth between public opinion and the institutional processes of political democracy. One study argued that skeptical attitudes on the part of wider publics could be seen to influence concrete policymaking processes [161]. Another study found that skepticism regarding climate change, spread particularly by rightwing parties, obstructed the transition from fossil fuels to renewable energy, in a multi-step process: This particular segment of political elites nurtured public opposition to climate policies, which, next, fed into policy- and decision-making [65]. In a similar vein, an experimental study indicated that whereas messages supporting climate action had little to no effect on anthropogenic climate change views, denial messages did reduce people's belief in anthropogenic climate change [179].

Conspiracy theories, by undermining public trust, have been found to harm both the legitimacy of science among the public and the policy support traditionally offered to science [180]. Moreover, personal attacks on scientists, in a first step, damage their credibility and studies and, in additional steps, erode public trust in science and weaken support for climate policymaking and mitigating action [132]. Such erosion of public support for and policy advocacy of climate action is

deepened by industry-supported research disseminating skewed findings and prejudiced conclusions [47].

**Extended and amplified effects**

Communication effects research has emphasized the importance of considering people's pre-existing beliefs and worldviews when examining and assessing the effects of information, whether they are enlightening or misleading. One study concluded that if misleading information about climate change aligns with individuals' pre-existing beliefs, people will tend both to accept such information as more credible than scientific evidence and to be reinforced in their beliefs through confirmation bias [181]. In comparison, another experimental study found limited to no effects, either of misleading information advanced by fake experts or of interventions designed to inoculate participants in the experiment in question to misleading information [182].

Further research has suggested that not only individual persuasions but also social structures constitute intervening variables in the processes by which communication takes effect. A study found that exposure to misleading news and information appeared less influential than either socio-demographic factors or political ideologies in shaping people's beliefs [183].

At the same time, studies have indicated that online exposure to contrarian arguments regarding climate change can reinforce skepticism when this exposure creates an impression of widespread support for a skeptical position [148]. Additional studies suggest that social media can affirm as well as extend conspiracy theories, so participants come to be exposed to a wider circle of these theories [146], [184].

## With what potential solutions

Studies of interventions designed to strengthen the integrity of information about climate science occupy a spectrum from the institutional to the individual levels—from public governance of online platforms and other media, to education of citizens as critical readers of and active participants in conversations about climate change and climate action. The following sections review findings along this spectrum.

### Governance through public regulation

Governance refers broadly to the principles and procedures by which communities, organizations, and other social entities are regulated. While the following section returns to the internal operations of digital platforms and other media, the present section focuses on their external regulation by authorities representing and serving the public interest.

Studies [185] have identified legislation, coupled with litigation, as key structural measures to counter misleading information originating from both corporate and governmental sources. They further recommend mobilizing international trade regulations, such as the European Climate Law, to penalize agents of misleading and disruptive information and communication regarding climate science. Research has found that greenwashing and other corporate strategies are less prominent in countries with strict climate laws. Uniform and stringent standards for corporate climate reporting can help overcome such malpractices, strengthening stakeholder confidence and motivating corporations to provide detailed and accurate climate information [186]. Another study [127] further underscored the importance of mandatory and standardized corporate reporting, such as that required according to the EU's taxonomy regarding sustainable investment, to ensure transparency, accountability, and accuracy of the claims

made by corporations. This can complement greater vigilance among regulators and investors in scrutinizing corporate claims.

Anticipating policy development, legislative measures, and their enforcement, stakeholders can pursue a variety of political strategies and tactics. One contribution [76] noted a need for climate policy advocates to enhance their political skills and media engagements, while simultaneously leveraging powerful potential political allies such as utilities companies as well as reducing their own internal divisions (see also [73]). Another intervention [187] proposed norm-based and targeted messaging to different stakeholder interests across the climate domain, recognizing the diverse values held by these interest groups but emphasizing the public desirability of pro-environmental behaviors based on credible sources of evidence. Taking the World Health Organization's intervention blocking the lobbying efforts of the tobacco industry as a precedent, one set of authors [185] specifically proposed that a firewall be put in place between governments and climate lobbies.

A study among university students in Taiwan indicated that most are aware of climate change [188]. Therefore, the priority should be placed on leadership through policy rather than on education of the general public. In Switzerland, another study [65] drew attention to "semi-anti" clusters within the public: Although social elites held more clear and consistent attitudes favoring a transition to renewable energy, other groups, while relatively more skeptical, still appeared open to engaging in climate action depending on specific issues and contexts. Research has also suggested that international climate diplomacy can promote cooperation by identifying mutual benefits, for instance, in the case of the fraught relationship between Russia and the EU concerning Russian gas exports during the EU's energy transition [59].

Legal mechanisms of regulation have been the subject of several studies of questionable corporate and political practices such as greenwashing. Referring once again to the historical case of regulation of the tobacco industry, research [189] has proposed litigation against corporations and lobbyists who are repeat offenders, in part to generate media coverage that may contribute to inoculating members of the public against misleading claims (see further the subsection 'Inoculation' below, p. 74). Other research [75] added the argument that given the past record of both their environmental impact and their historical attempts to mislead the public, oil companies have a special moral duty to rectify their past and present harm to the environment.

Studies have proposed more stringent third-party verification procedures regarding companies' net-zero and carbon-neutral claims, including distinguishing between their emission reduction and carbon removal targets, respectively [50]. One study [190] called for companies to commit not just broadly to a green transition, but concretely to accurate disclosure of their fossil fuel dependencies. Research from the United States has suggested that the two reporting systems of the Securities and Exchange Commission (SEC) and the Environmental Protection Agency (EPA) do not deliver precise or transparent measures of environmental impacts, in effect misleading stakeholders, and that this may require their replacement by one integrated system of environmental accounting [157]. Against this background, the study in question recommended a reliance on certification systems supported by state-of-the-art technology to avoid, at once, greenwashing and undue administrative burdens on companies (on certification systems, see also [191]).

Financial mechanisms, lastly, can contribute to ensuring that funds are allocated to their designated climate-related purposes, avoiding greenwashing and other malpractice. One study [192] addressed monitoring and evaluation mechanisms

for the area of climate bonds (CB); another study [193] raised concerns about abusive practices in the wider domain of green finance. Research [156] has further identified risks of greenwashing in the case of ESG (Environmental, Social, and Governance) investments, recommending an open-access real-time tracking system to ensure the accuracy and transparency of accounting for green investments. Demonstrating a high likelihood of greenwashing in the case of ESG bonds, other research [194] added a call for certification of these bonds. A common goal of transparency can be served, on the one hand, by collaborations joining industrial, governmental, and other stakeholders within climate regulation [189]. On the other hand, so-called FinTech (financial information technologies) can be leveraged to track patterns of carbon offsets, sustainability claims, and investment flows [195].

**Governance through corporate policies**

Companies that own and operate digital platforms and other media of communication are left to regulate themselves in many respects. One key practice—content moderation—is designed to remove and/or prevent the spread of misleading content. The literature in the area bears witness to the contested nature of content moderation as market actors from these media have been among the primary disruptors of information integrity about climate science.

In addition to content moderation encouraging or requiring evidence-based information dissemination, research has referred to fact verification mechanisms embedded in search engines and sources for claims made on online platforms as effective means of countering misleading information about climate change [107]. A related practice is the moderation of user comments on the stories published by online newspapers [107]. A further approach to slowing the spread of misleading information online is a modification of the metrics coupling flows of information with levels of user engagement and deploying “virality circuit breakers” [173].

However, citing other research, the authors of this study soberingly noted that it is the same platforms that enable and profit from the dissemination of reliable and misleading information alike, which limits efforts of self-governance.

An additional form of governance is annotation, or the flagging of false or questionable information. While YouTube has sought to counter misinformation by providing annotations to its content from the texts of Wikipedia and Encyclopedia Britannica, the impact of that endeavor remains unclear [125]. Relatedly, a study [68] advocated flagging social media accounts that spread climate misinformation and collaborating on targeted educational campaigns, even while cautioning that such initiatives might end up strengthening skeptical and denialist positions instead.

A further consideration is the efficacy of various correction strategies. A study centering on Instagram [196] concluded that corrections based on logic or reasoning were more effective and resilient than fact-focused corrections, but that fact-based corrections were perceived to be more credible, suggesting a need to combine several practices of content correction (see also the subsection on 'Fact-checking' below, p. 67).

On a positive note, social bots have been found to serve to popularize climate science on behalf of climate stakeholders and platforms [90]. A related study on the role of bots in online debates about climate change suggested deploying networked communication tools, such as dislike buttons, to reduce the disruptive effect of malignant bots [89].

Some contributions to the literature have noted dilemmas of content moderation and other practices of regulation, including their legal implications [197]. One contribution [198] pointed to the potential tension between content moderation and free speech, highlighting the need to conduct content moderation in a

consistent and transparent manner, both to prevent backlash in specific cases and to ensure the general legitimacy and public acceptance of the practice. In a similar vein, a study of online conspiracy communities argued that preemptive moderation may lead members to feel ostracized, calling for balanced interventions to avoid a further marginalization of such groups and their retreat to the fringes of society [199]. A further study of both climate action and obstruction groups on social media recommended targeting both camps to amplify like-minded stakeholders and counteract opposing stakeholders respectively [200].

**Legal strategies and tactics**

In addition to general legislative frameworks and regulatory practices, research has considered specific legal doctrines, strategies, and tactics for safeguarding information integrity about climate science. The United Nations considers access to accurate and reliable information about climate change as a human right [201], referring to a responsibility that states have to proactively collect and disseminate information on climate change and its impact on humans. Moreover, research has addressed disruptions of information integrity in the context of both civil and criminal frameworks. Some scholars have even suggested that the fossil fuel industry's active concealing of essential information about the mechanisms producing global warming constitutes a crime against humanity [202].

Research has explored a range of existing legal doctrines. These include consumer fraud, securities fraud, false or misleading statements, fraudulent and misleading speech, misleading representations, and deceit. Research also emphasizes the need to develop new doctrines supporting strategies to enhance the accountability, primarily of the fossil fuel industry, for undermining the integrity of climate information [203], [204], [197]. Studies of litigation have primarily examined claims against companies involved in climate washing (i.e., greenwashing), by both state and non-state actors, including regulators,

prosecutors, governments, municipalities, NGOs, investors, public interest groups, and consumers [205], [206], [207], [197].

A further line of legal inquiry has addressed the shaming of firms that misrepresent their carbon footprint or other direct and indirect contributions to the climate crisis, most notably as a potential regulatory tactic, employed by governments to equip stakeholders ranging from consumers, investors, and employees to NGOs and media outlets with actionable information on corporate transgressions [208]. Capitalizing on corporate reputational vulnerabilities, and carried out through labels, databases, press releases, social media posts, rankings, ratings, and corporate disclosures, this informational and nudging tactic can be employed by civil-society actors, even without government involvement [209]. Relatedly, the legal literature has examined other disclosures of information, typically regarding firms' climate impacts, through labels (usually for consumers), greenhouse gas (GHG) databases, and corporate disclosures of climate risks to investors in their filings with securities regulators [210].

**Fact-checking**

While overlapping with other practices of corporate, platform, and media governance, fact-checking represents a wider endeavor performed by several social institutions. The agents, formats, and target audiences of fact-checking, further, vary. One study [211] found that the correction format does not matter much as long as the correct facts are presented; another study [212] highlighted the importance of targeting individuals particularly susceptible to misleading information through fact-checking.

Research has noted the potential of fact-checking regarding climate-related information, with cross-national research suggesting both its effectiveness and its lasting impact [213]. One study [214] found that warning labels reduced the

perceived credibility of misinformation and decreased the likelihood of it being shared with others, but also that additional measures, such as enhancing media literacy, improving critical skills, and inoculation (see further the subsections on 'Inoculation' and 'Education', p. 74 and 76, respectively) would be needed to consolidate information integrity about climate science at the receiving end.

Regarding the senders of news and other information, some research [215] has reported that although journalists were aware of the tools available for fact-checking, they commonly lacked institutional support in the form of editorial policies promoting climate-related fact-checking and attention to local circumstances. Another potentially scalable source of fact-checking is crowdsourcing, even though experts and laypeople have been found to differ in their assessments of the correctness and credibility of news and other forms of information [216].

The potential of fact-checking depends on individual as well as institutional factors. A study in the U.S. [217] found that corrections made by Republican politicians acknowledging climate science were more persuasive to conservative audiences than those coming from either neutral experts or Democrats. An additional study [218] suggested that while misleading information about climate change that is advanced, for instance, by a president can also be corrected through fact-checking, such correction does not override the president's capacity to shape policy.

National and international institutions have a public responsibility to intervene through fact-checking and official corrections, for instance, when media misrepresent a scientific report or other publications. One contribution [219] specifically suggested that the IPCC has failed to counter misleading information in various media about its consensual findings, instead favoring political

neutrality and avoiding confrontation. This may have detrimental long-term effects on the integrity of information and communication about climate science.

**Science communication**

Alongside fact-checking calling out incorrect information, the communication of science, by scientists, has an important role to play in building and maintaining public trust, in the institution of science, its findings, and the individuals and groups accomplishing science on society's behalf. Studies have pointed to the clear and direct communication of scientific facts [175], including to climate skeptics [116], as avenues toward repairing and maintaining trust as well as engaging in broad-based dialogue about climate change.

Research has further recognized the need to relate scientific facts to the diverse social and cultural contexts in which different audiences and publics live their lives. A study of why a sample of individuals considered themselves "unconcerned" about climate change [220] found that this was due not so much to a deficit of information or lack of knowledge as such, but rather to a disconnect between natural-scientific facts and people's lived experience.

One of the challenges facing science communication is the continuous and concerted circulation of misleading information by stakeholders with either commercial or political interests, or both, who command considerable economic resources (as reviewed in the 'Who' section above, p. 25). Research has recommended a similarly coordinated response, across political allegiances and grounded in climate science [89]. Here again, clear communication about the concrete activities of climate-change deniers may help avoid confrontational interactions and, in turn, further polarization of public debate [106].

It should be recognized that science, being grounded in epistemologies historically articulated by intellectual elites in the Global North, represents a

structural challenge, not least for underrepresented groups in the Global South relying, in part, on indigenous knowledge for leading their lives. According to one study [221], state authorities in the Indian Himalayas have wrongfully labeled local environmental narratives as conspiracy theories. To share the available scientific solutions as well as to counter misleading information, one intervention [168] proposed a respectful communicative configuration in which trusted local figures would occupy the role that Western communication research has dubbed opinion leaders [158]. Another contribution [222] concurred in referring to a fundamental paradigm of "human cooperation" for mitigating the collective crisis humans face. An integration of spiritual perspectives into climate communication practices could also enhance engagement specifically among conservative and religious audiences [103], [223]. In a future perspective, research [224] called for more intersectional as well as interdisciplinary research to recognize the partially local solutions to the global climate crisis.

For science communication to and with youth, social media and online information environments are evidently key. Social media can engage young people in discussions about climate change and associated misleading information, supported by collaborations among scientific institutions, health organizations, and youth-led initiatives [225]. Across age groups, as well, scientists' engagement with the general public serves to disseminate scientific facts and counter misleading information [149]. And across liberal and conservative media as well as tabloid news formats, climate scientists' interactions with diverse publics are needed to counteract the persistence of so-called niches of denial [99].

**Young people on social media**

It should be added that, more than being receivers of science communication about climate change, young people have also been found to increasingly engage

in climate activism by reaching out to others through social media [226], [227], relying in part on the visual affordances of platforms such as Instagram [228], [229]. A noteworthy feature of this climate activism has been its articulation of "climate optimism" and "ecocentric" identities among participants [230]. At the same time, studies on the social media impact of perhaps the most well-known of these young climate activists, Greta Thunberg, have identified a range of positive as well as negative responses to the person and her activism [227], [231].

**The fine print**

Research has examined how the texts and images carrying climate-related information can aid public understanding of and engagement with climate change. Studies have included experimental research assessing the impact of lexical choices in misleading information about climate change [232], research on discursive conventions affecting attention over time to particular aspects of climate change [233], and how-to guides with recommendations for ways of addressing the general public about climate change [234]. Research has further explored the complex interpretive processes in which recipients make sense of climate change and their own climate agency [235].

A case in point is advertising, which contributes to consumerism and, hence, to climate change. Research has also suggested, however, that if deployed in appropriate forms, "green advertising" can stimulate recipients to engage in responsible consumer behaviors, as well as to promote narratives of climate protection [236].

Recognizing the polarized nature of some information environments, several studies have pointed to the importance of securing bipartisan or nonpartisan support for a common ground of scientific consensus among political leaders and elites, who are primary influences on the attitudes and actions of voters and wider

publics [63], [138]. Such political messaging could highlight the dramatic social consequences of climate change [237] and its very real local effects, bridging psychological distances experienced by publics vis-à-vis a global condition [238].

As noted in the sections 'Says what' (p. 35) and 'With what effect' (p. 56), the framing of climate change has significant implications for public understanding of and engagement with the climate crisis [239]. Considering the potential of tailored forms of messaging, one intervention [185] argued that to address conservative and skeptical audiences, climate issues could be framed in accordance with conservative values such as national security, sovereignty, and economic independence, further utilizing a "co-benefit" framing of the diverse advantages generated by climate measures. In a similar vein, another contribution [240] referred to "adaptive" framing as a way to avoid explicitly challenging skeptics' ideological positions, instead emphasizing practical solutions delivering autonomy and control to all.

Because people's beliefs about climate change and their ideological values are closely entangled, messaging should carefully consider the values of different target groups [241]. One study covering the U.S., China, and Germany found that while political orientation was a strong predictor of beliefs and attitudes regarding climate change in the U.S., environmental norms and values were more predictive in all three countries, leading the authors to conclude that the framing of climate change through broad and shared environmental concerns promises more effective communication and public engagement [242]. Another study argued that spiritually and morally framed messages could serve to reduce resistance to climate measures among conservatives and rightwing individuals [103].

Just as climate (mis)information elicits affective responses, so emotion may become part of the necessary solutions to the climate crisis. Challenging linear

notions of communication, one contribution [234] presented a model for environmental communication based on principles of accessibility, balanced messaging, and clear action strategies, which further took into account recipients' emotions and cognitive frameworks. Relatedly, another study [175] suggested activating personal experiences and emotions such as nostalgia into actions that entail caring for the climate. A further study [243] noted that whereas both positive and negative emotions can drive climate engagement, emotional forms of messaging appeared especially well suited for addressing skeptics and conservatives. Referring to visual communication, another study [241] suggested that positive images with vivid content can help turn negative perceptions into constructive engagement.

More generally, language use, including narrative structures, is an important tool for addressing diverse audiences [244], rendering climate change personally relevant and emotionally compelling. Personal narratives and localized stories can be leveraged to induce feelings of closeness, relatability, and urgency [245], [243]. Storytelling, further, can be utilized to bridge the gap between scientific knowledge and spirituality or religiosity in engagements with the natural world [223]. One study [246], however, cautioned that such creative practices may end up reinforcing ideological polarizations, calling instead for communication of the facts of climate change.

Visual communication in still and moving images is a key feature of contemporary information environments and can be mobilized to stimulate engagement and effect. One contribution [101] argued that well-supported arguments and accessible forms of communication are not mutually exclusive for enhancing public engagement. For example, images of retreating glaciers can be more effective than abstract statistics in conveying the reality of climate change [101]. In a similar vein, one study [247] highlighted visual storytelling through art and

media as a mode of nurturing audiences' long-term emotional involvement in the natural environment.

At the intersection of media governance and discursive conventions, lastly, research [248] has criticized a false balance between "warners versus deniers" in mainstream news coverage of climate change, calling instead for interpretive forms of journalism avoiding polarizing narratives.

**Inoculation**

A specific solution examined in research on audiences and publics has been inoculation—preemptively exposing people to misleading contents and forms of information in order to generate lasting immunity. Although one concern has been that this strategy might backfire, reinforcing opinions that are out of step with the scientific consensus, a range of studies have found inoculation to be an effective approach to countering misleading information [249], [189], [101]. Research has further suggested that communication of the scientific consensus, in combination with warnings about the circulation of politically and commercially motivated misleading information, helps support information integrity about climate science [250], [251].

Different types of inoculation—fact-based and technique-based—have been employed [252]. Where fact-based inoculation informs individuals about misleading claims concerning specific topics, technique-based inoculation calls out the various techniques utilized to mislead people, such as false balance and fake experts, which makes the approach transferable across topics [252]. Inoculation may also focus on the reasoning behind the claims being made, so that even individuals without scientific expertise will be in a better position to assess the information being offered and detect misleading elements [249], [252]. Research has found that not only the "prophylactic" (preemptive) but also the

"therapeutic" (retroactive) methods of inoculation, following exposure to misinformation, can serve their purpose [253]. Findings from one study suggested that the impact of inoculation may be durable, even if the effects of the mere representation of a scientific consensus appear to decay over time [250].

In the context of crisis communication responding to misleading information seeking to damage the credibility of a movement or organization, one study found that inoculation is more effective when specific details are offered, which allows audience members to form their own opinion and, thus, feel empowered rather than manipulated [254]. Another study examined the impact of inoculation against greenwashing by companies, finding that consumers were less likely to hold positive perceptions of a company or to intend to purchase its products following inoculation against its greenwashing activities [255]. In an educational setting, technique-based inoculation has been shown to work well for future teachers in identifying and countering misleading information [256].

Beyond advancing cognitive understanding of the processes or outcomes of science, communication about climate change can draw on emotion, affect, and social elements such as gamification to serve inoculation. One group of scholars [257] described how the deployment of a climate negotiations simulation game, *World Climate*, had multiple positive outcomes, not only by providing individuals with reliable information about climate change, but also by stimulating a sense of urgency and hope, as well as motivating people to consider their personal contribution to the mitigating solutions. The *Cranky Uncle Game*, similarly, combined humor and gamification to accomplish inoculation and education of otherwise disengaged or discouraged and self-censored students [258]. Heightened engagement with inoculation interventions can also be supported through the visual and interactive formats of digital media: One study found that

interactive documentaries and immersive forms of journalism helped to inform and inoculate individuals regarding the nature of climate change [259].

It should be noted, however, that other research has questioned the effectiveness of inoculation, depending on the issues and domains in question. One study showed that while corrective messages influenced individuals' perceptions of HPV vaccination, there was no evidence of an effect on more partisan or polarizing issues such as gun control and climate change [260]. Moreover, a recent study reported little evidence of an inoculation effect while, to the contrary, finding misleading information to be effective in shaping participants' beliefs about climate change; the authors, accordingly, argued that more systemic interventions, for example, by platforms through content moderation and fact-checking, are necessary to complement inoculation [173]. Similarly, a study seeking to replicate an earlier experiment [249] in a different country did not find evidence of inoculation, instead affirming a relationship between participants' worldviews and their climate-specific attitudes, which likely limits the efficacy of inoculation strategies, not least in polarized information environments [182].

**Education**

As a long-term and broad-based strategy, education comes out in research as one of the most important enablers of information integrity about climate science [142]. Under a wide umbrella of educational interventions, studies have pointed to a variety of approaches, including enhancing general scientific literacy, correcting specific misinformation, recognizing emotional responses and diverse worldviews among students and wider publics, and avoiding an acceleration of polarization in the design of communication techniques [106]. At the same time, individuals' social and cultural backgrounds and contexts have been found to condition the impact of any intervention [245]. For example, a study [261] concluded that the uptake of climate education was contingent on levels of

religiosity as well as political orientation, so the benefit of education countering climate skepticism was more limited among highly religious individuals and people with rightwing political views.

Regarding specific strategies for stimulating climate agency, research [262] has further indicated that so-called free riders (who benefit from climate mitigation actions but do not contribute actively themselves) constituted two separate subgroups, cynics and doubters. Whereas cynics acknowledge the importance of climate action and are open to community-driven motivations for action, doubters dismiss the issue's importance altogether, even when demonstrating an interest in incentives such as financial rewards. However, since education represents a long-term strategy, some authors have proposed that interventions with more immediate outcomes should be prioritized in a matter as urgent as climate change [185].

When it comes to enhancing media users' and citizens' literacy, research has pointed to two separate, if complementary, aspects: media and information literacy, and scientific and environmental literacy.

Digital media and information literacy has been subject to extensive research, not least because of the increasingly central place of digital media and communication in the lives of publics around the world. Studies on youth suggest that they are often hesitant to trust news coverage on climate change, even when it aligns with the scientific consensus. This reluctance may stem from an abundance of online misinformation, young adults' dependence on cognitive heuristics, and the influence of anti-intellectual currents in the information environment [165]. Training to critically assess the information on offer through digital media platforms can help raise awareness of misleading content [153]. Importantly, not only textual content but also visual materials such as YouTube

videos should be part of digital literacy curricula to train students' skills of evaluating the information they encounter on a daily basis [166].

Scientific literacy, equally, aids publics in distinguishing between truth and falsehood, and in recognizing manufactured doubts about the reality of climate change [87]. Diverse studies have shown that the general educational level and specific scientific literacy of respondents explain the degree to which they accept anthropogenic climate change (ACC) [263]; that a grasp of how science works is an important step toward recognizing ACC [133]; and that scientific literacy similarly empowers people to differentiate between real science and pseudoscience [106]. Research has laid out various concrete techniques for teaching and enhancing science literacy [264]. In the long term, the future existence and contribution of scientific research on climate change and other critical domains will depend on continued public trust and support, which begins with an understanding of how science operates and contributes to society [136]. Similarly, enhanced scientific literacy regarding concrete causes and effects could help generate public support for the policies responding to climate change. People inhabiting regions in China with high levels of air pollution have been found to associate this state of affairs with climate change—a relationship that could be articulated by policymakers en route to reducing emissions and, thus, alleviating both conditions [245].

Curriculum development comes out in research as an important tool for building scientific literacy. A major reason for denial, doubt, and skepticism in domains such as vaccines and climate change is a generalized lack of trust in the institution of science, which can be mitigated by integrating basic practices of scientific research into school curricula as well as following up by displaying the same practices in public information campaigns [131]. Just as importantly, studies have indicated that "inculcating intellectual virtues," i.e., prioritizing reflexivity among students, helps them develop capabilities of critically assessing false or

misleading information and accepting correct and substantiated information even when it initially conflicts with their own worldviews [265, p. 873]. A comparable study found that persons with a disposition for analytical thinking were more likely to embrace scientific evidence, which led the authors to call for the cultivation of general reasoning skills through tailored curricula [246]. Similarly, a third study suggested that, beyond scientific facts, curricula should integrate interdisciplinary perspectives to consider the ways in which information about climate change comes to be produced, used, and applied across a variety of social and cultural contexts [266]. One challenge of designing such broad-based curricula is the danger of intensifying existing polarization within a student body or having an articulation of the issues at stake backfire; this challenge calls for curricula that are sensitive to the worldviews represented among students [267].

Beyond education conceived as a practice promoting primarily cognitive competences, research has documented the role played by emotions, including hope and a sense of urgency, in learning about the reality of climate change, motivating meaningful changes in behavior, and recognizing the tangible outcomes of one's own actions [257]. Hope, in particular, stands out as a potentially helpful component of education about climate change. Highly negative representations fuel hopelessness and have been found to deactivate and demotivate students and young people [268], [269]. Importantly, however, studies of hope and climate agency have identified two varieties: constructive hope, recognizing the outcomes of taking action, and denial hope, implying that climate change does not represent a significant human problem. More than mere optimism or wishful thinking, constructive hope is associated with a sense of responsibility and active engagement with potential interventions counteracting climate change [268], [269]. A meta-analysis of studies in this domain indicated an association of constructive hope with greater climate engagement [270]. A further study found a large majority of students in the sample entertaining constructive

hope, which, along with respondents' gender and knowledge about climate change, was a significant predictor of actions mitigating climate change. These findings led the authors to recommend special mindfulness among teachers of the different varieties of hope and the designing of activities to strengthen constructive hope among students [271]; see also [268], [269].

In higher education, research has pointed to the relevance of mandatory courses about climate change across different fields of study [245]. Having identified a so-called selective exposure bias—a deliberate avoidance of information challenging one's own skeptical position—among self-defined conservative students, a study found that after completing such a course, as much as one third of conservative students in the sample shifted their position from one of skepticism or uncertainty to acceptance of the reality of climate change [272].

At the juncture of interventions focusing on individuals and carried by institutions, research has highlighted the potential and responsibility of universities for restoring and reaffirming information integrity about climate science through research and education. As institutions serving humanity, part of the mission of universities is to share actionable knowledge in critical domains such as climate change with the general public [134]. And to accomplish this aim, universities need to actively engage with the societies and cultures of which they are a part, avoiding impressions of isolation, elitism, and the exclusion of laypeople, which can lead to public distrust of universities' activities and outputs [117]. One criticism has been that mainstream sustainability education and efforts by universities may be too narrowly conceived in natural-scientific terms, with limited attention being paid to conflicting perspectives and interests across different social groups and world regions regarding the origins of and potential solutions to the problem [273]. Another criticism has been that as universities

increasingly orient themselves to market demands, they may jettison their role in leading a green transition through research and education [95].

One role of educational institutions in the chains of communication about climate science is "to train the trainers"—so-called stakeholder training, particularly of teachers and journalists [215]. Research indicates that as students grow older, they increasingly rely on social media and other online sources, rather than on school learning [142]. For that reason, it is incumbent on teachers to assist students in developing skills of assessing the information presented and identifying misleading variants. Unfortunately, studies suggest that teachers may lack the necessary training to guide their students regarding climate change. For one thing, some teachers themselves hold skeptical or denialist opinions, which may influence their students [96]. For another thing, many teachers lack hands-on and technology-enhanced skills to help students engage actively with the variety of misleading information they will be encountering in their lives [256]. In this regard, research has underscored the importance of teachers mastering not only specific scientific knowledge but also general reasoning skills so that they may effectively guide their students to tackle encounters with a range of reliable as well as unreliable information about climate change [266].

## SECTION 5. ADDITIONAL FINDINGS AND IMPLICATIONS

The sampling procedure for the systematic review returned a variety of studies that did not specifically address challenges to or disruptions of information integrity about climate science, or potential solutions to the crisis of information integrity. Nevertheless, these studies hold findings and implications for further research and policymaking in the wider domain of information and communication about climate change. The present section, accordingly, summarizes the studies in the sample that have not been cited so far with reference to the above systematic of research questions guiding the Synthesis Report.

The additional studies could be grouped into four categories:

- Research on public opinion as it relates to climate change,
- Research on individual-level psychological processes shaping conceptions of and responses to climate change,
- A diverse set of studies including theoretical, methodological, and normative treatments of climate change, and
- A set of incidental references to informational and communicative aspects of climate change.

**Public opinion**

The first subgroup of studies addressed patterns in and variations of *public opinion* regarding climate change. While mostly relying on survey methodologies, research has also considered the contents of blogs as indicators of the constituents of public climate skepticism [274].

Studies have suggested that political polarization of the information environment tends to constrain communication about climate change [275]. One study [276]

pointed to a historical development in the United States in this regard, meaning that the primary predictors of public concern about climate change have shifted from respondents' socio-demographic background features to their political orientations. Here, climate change denial has been found to correlate with favorable attitudes toward U.S. president Donald Trump, with an aversion to wealth redistribution as a mediating factor [277]. White evangelical Christians, further, have come out as the religious group in the U.S. holding the most skeptical positions regarding climate change [278]. Moreover, research has indicated that rightwing populism feeds skepticism because of a lack of trust in the institutions delivering climate science [279].

In the European Union, too, research has indicated that views on climate change correlate with respondents' political ideology along a classic right–left divide, but only in the western portion of the E.U., not within member countries of the former Communist bloc [179]. A related study suggested that different socioeconomic resources and conditions help to explain this difference, since denial of and uncertainty about climate change were found to be more common in rural and less prosperous regions of Europe [280].

Studies have identified additional variations, for instance, in beliefs and attitudes regarding climate change adaptation among farmers and the general public [281]. Recognition of global warming, further, has been found to depend on personal experience from specific locations with distinctive climate conditions [282]. And although political ideology and degrees of trust in science tend to drive attitudes toward contested phenomena such as climate change and Covid-19, research indicates that distinctive features of each of these topics also contribute to variations in public opinion [283]. One study found that, in the end, actions in response to climate change may be undertaken without recognizing its anthropogenic causes [284].

### Individual psychology

A smaller subgroup of studies explored some of the psychological mechanisms accounting for denial of or skepticism regarding climate change at the individual level. A large-scale survey experiment found "no evidence that motivated cognition can help to explain widespread climate change denial and environmentally harmful behaviour" [285]. Studies have pointed to an interchange between cognitive styles and ideological beliefs as drivers and shapers of climate skepticism [286], specifically that such skepticism can be driven by a "social dominance orientation" [287], [288]. Further research has suggested that people are able to reconcile contradictory positions in the climate domain through abstraction and "conspiracism" [289].

Regarding solutions at the level of individual psychology, one study called for greater attention to be given to the lived contexts of everyday experience in which people encounter climate change [210]. Another study pointed to a potential for nudging climate skeptics toward recognizing the reality of climate change: An experiment indicated that asking participants first about their belief in science in general, and only then about their belief in *climate* science, produced higher levels of belief in climate science, arguably because participants were seeking to maintain cognitive consistency [290].

### Theoretical, methodological, and normative contributions

The third subgroup of studies variously offered theoretical specifications of climate change and human responses, methodological approaches, and normative assessments of the origins of and potential solutions to climate change.

The theoretical contributions included a taxonomy of climate change skepticism [291] and definitions of "green growth" [292]. Specific analyses addressed

conceptions of the psychology of collectives [293] and of political-institutional barriers to achieving energy efficiency [294]. A wider invitation suggested that sociologists in particular should reinvigorate ”the sociological imagination” [295] in the face of the climate crisis [296].

Another set of publications occupies an overlapping domain of conceptual analysis and normative argument. One contribution interrogated the term “eco-fascism,” suggesting it serves to obfuscate the issues linked to the climate crisis [297]; another contribution investigated green initiatives by the state of Israel as instances of “settler colonialism” [298]. Other publications have referred to a “petro-masculinity” combining climate change denial with racism and misogyny [299] and to “toxic masculinity” as a gendered response to ontological insecurity arising, in part, from climate change [300]. One study identified a wider “British war on woke” premised on the protection of the white race and the working class [301]. Another study pointed to “racial resentment” in the U.S. fueling anti-science views on climate change and other contested issues [302].

A final set of studies in this subgroup addressed methodologies and policies for engaging with the climate crisis. One methodological contribution suggested the importance of considering the potentially adverse, discouraging consequences of “mortality-laden messaging” in both study designs and communications about climate change [303]. In contrast, another contribution advocated for the development of “education for the end of the world as we know it” [304]. A policy-focused publication cautioned against the “greening of grey infrastructures” as part of coastal development reconfiguring natural environments [305]. Lastly, one contribution advocated for “Green New Deal” policies, not only for ethical and political reasons, but because a coupling of climate action with strategies for greater social equality could prove more effective in achieving decarbonization than “carbon-centric” policies in themselves [306].

### Incidental references to information, communication, and climate change

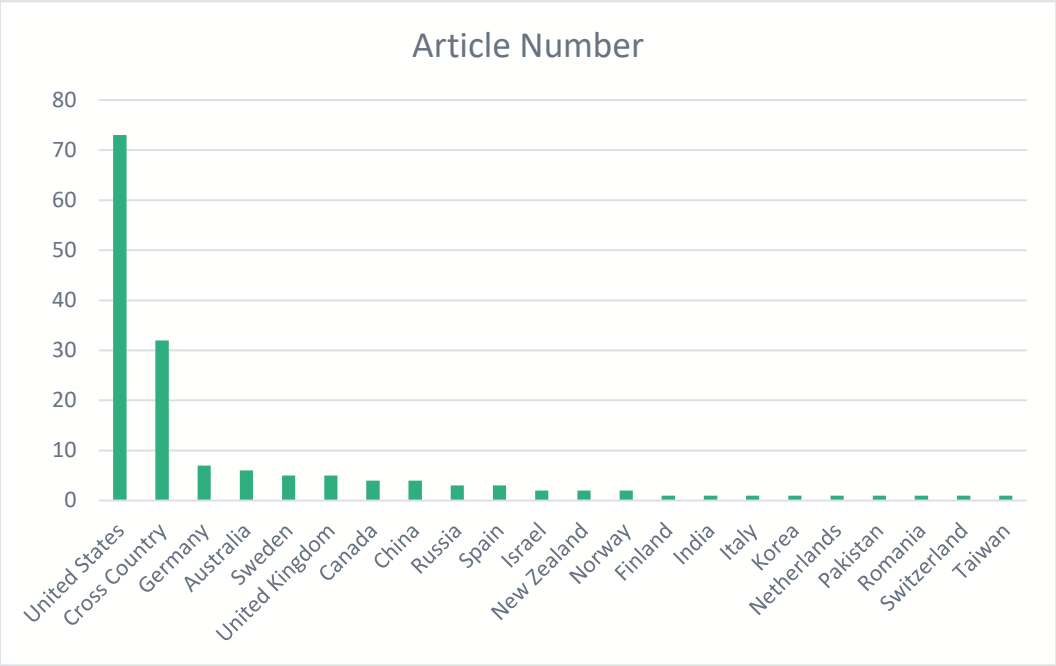
The final subgroup of studies includes relatively few incidental references to aspects of either climate change or information and communication. One publication presented a general account of the implications of climate change for societies and humanity [307]. The other contributions addressed various business-related activities, including the responsibility of oil and gas companies for leaving fossil fuels underground [308], practices of climate information disclosure by companies [155], and the state of sustainable finance research [309].

## Gaps in scholarship

### An elephant in the room

Before reviewing specific gaps in previous research, as registered through the preceding systematic review, it is important to recognize what is commonly referred to in the English language as “the elephant in the room”—an evidently important issue that, nevertheless, is not being talked about or, in this case, hardly being studied. Overshadowing other gaps is the dearth of studies addressing information integrity about climate science in the Global South, and in globally comparative perspectives. Figure 4 reiterates the skewed distribution, noted in Section 3, of the countries and world regions examined in the sample of studies included in the present systematic review. Mirroring other structural divides in global access to material and immaterial resources, this gap presents a particularly pressing problem at a time when humans everywhere find themselves face to face with variable degrees of the existential risk [1] of climate change [2] as intensified and exacerbated by a crisis of information integrity.

**Figure 4. The distribution of countries in the sample of the systematic review.**




**Source:** IPIE Panel on Information Integrity about Climate Science.
**Note**: Sample covers the period 2015–2025.

Whereas some research has addressed challenges to and disruptions of information integrity beyond North America and Europe (e.g. [310], [311], [312]), it is incumbent on scholarly communities and funding agencies to start filling this first gap in knowledge as a matter of priority. As noted in Section 2 of this Synthesis Report, in 2024 the United Nations launched the Global Initiative for Information Integrity on Climate Change, to be supported through further research. Section 6 of the present report (p. 96) returns to the implications of the state of knowledge for further scholarly initiatives and policy interventions.

**Who**

Because so much research has focused on conditions in the United States and, to an extent, the European Union and other parts of the Global North, relatively little

is known about the role of governments and states or of companies and corporations in other world regions as disrupters of information integrity about climate change. Comparative studies, which could help to identify mitigating global strategies adapted to local circumstances, are similarly scarce; in the sample of studies included in the systematic review for this report (n = 300), only 32 publications adopted a cross-country perspective.

Furthermore, the sort of alliances integrating interest groups, lobbies, and think tanks into strategic entities obstructing climate action in the United States and Europe have also been identified elsewhere, constituting "transnational business coalitions" that operate across diverse aspects of the climate crisis. An early publication [313] indicated that such coalitions had "emerged in virtually all the major environmental policy fields, including ozone, biosafety, and climate change" (p. 28). The local embedding and policy impact of these entities, however, as well as their sources of financing are not well understood.

Regarding particular purveyors of misleading information about climate change, little is known, first, about the role of religious figures delivering their messages at churches and temples across rural and urban areas. The present review noted the alignment of religious and rightwing institutions and communities in the U.S. with denialism and skepticism. Also in the Global South and elsewhere, religious actors can serve as "hinges" opening diverse doors to such influences on the public. Second, there is a need for further research on the relative contribution of human stakeholders and their automated puppets (bots) to the amplification of extreme positions; this is of particular interest at a time when artificial intelligence (AI) is reconfiguring the agency of humans and machines in producing and circulating (mis)information.

**Says what**

The findings concerning the messages of disruptive communications about climate change noted an apparently widespread shift from denialism toward skepticism regarding climate change, specifically a "response skepticism" [114] regarding the feasibility and effectiveness of proposed policies and potential solutions. At the same time, the identification and interpretation of expressions of skepticism present practical as well as methodological difficulties, more so than denials of the reality of climate change. 'The fine print' of texts and images, referred to in the section 'With what solutions,' matters a great deal for the messaging of misleading information about climate change. This complexity calls for the development of methodologies combining the nuance of qualitative content studies with the scope of computational and other quantitative approaches.

Alongside the need to track other key developments in climate messaging—the prevalence of conspiracy theories, the prominence of information posing as scientific evidence, and the waves of attacks on climate science and scientists—the systematic review indicated the emergence of what has been referred to as "climate nationalism" or "eco-nationalism" narratives and arguments relating climate change to issues of national identity and reemphasizing national sovereignty as a bulwark against external influences, including international traffic consisting of people and goods. More research is needed to monitor the development of such nationalism as it relates to climate policies in different countries and world regions. Eco-nationalism may further strengthen existing barriers to global cooperation in the response to the global climate crisis.

**In which channel**

The findings of previous research indicated that traditional mass media remain important sources of information and opinion, including for the climate domain, even while the internet and social media have been attracting growing attention from publics and scholars alike. But, despite a growing number of studies on media systems outside the Global North and some comparative research [314], the relative importance of mass media in disseminating skepticism, greenwashing, policy obstruction, and other delay tactics regarding climate change in different countries and world regions is not well understood. An early study comparing print news media in Brazil, China, France, India, the United Kingdom, and the United States found that coverage of climate skepticism was largely limited to the U.K. and the U.S. [315]. Updated research is needed to assess the place of mass media in current information environments and within public and private chains of communication regarding climate change.

Information about climate change is typically presented in traditional journalistic genres of news and current affairs. Here, research has drawn attention to the phenomenon of "false balancing" between scientific evidence and denialist or skeptical statements. In the coming pivotal years and decades, it will be important for more studies to assess whether and how journalism serves the public interest by moving beyond this practice to maintain information integrity about climate science.

So-called source media, through which various stakeholders present their own accounts and promote their own perspectives, have come out in previous research as an important and underestimated carrier of misleading information about climate change. Cases in point are corporate sustainability reports and official documents issued by governments. Source media are of special interest for further research, not only because they represent strategic communications by

partisan actors, but also because they disseminate information in formats different from those of mainstream media and away from the public eye.

**To whom**

Earlier research has noted that in current information environments, anybody and everybody is likely to encounter misleading information about climate change. This is in spite of the fact that public concern about groups that may be especially vulnerable or susceptible, not least children and young people, has motivated studies dedicated to these groups. In a future perspective, studies should seek to clarify the extent to which exposure to misleading information is incidental, and whether and how selected social groups are targeted by specific stakeholders.

The literature has drawn attention to the strategic place of certain individuals—elected officials, civil servants, and other professional actors—in the flows of information and communication that constitute the political processes that lead to climate policy development, legislation, and action by executive agencies. While some research has addressed the coordinated strategies of obstructing evidence-based climate communication in institutional and organizational settings [316], [317], further studies of these processes, in national and comparative perspectives, are of special interest for a better understanding of how and why climate action is being opposed and delayed.

**With what effects**

It has been a recurring finding that the effects of media and communications on attitudes and behaviors are rarely direct or strong and that they move in multiple steps conditioned by citizens' pre-existing beliefs and worldviews as well as the social and cultural contexts of information use (for an overview, see [318], [319]). New computational methodologies are being developed for studying at scale both the available information menus and the distinctive information diets of different

segments of national and international publics. Employing such methodologies, one study [320] identified the existence of online disinformation campaigns that were coordinated across multiple platforms, which calls for future corresponding studies of the public exposure to such campaigns in the domain of climate change (relying on costly research infrastructures that will require substantial public or private funding of scholarship).

Studies have suggested that the speech of political elites is a leading influence on public concern over climate change [321], [322]. To account for the complex chains of communication in which information integrity about climate science is being undermined, further sustained research is needed on the communication of both publics and policymakers, as well as into the cumulative impact on key institutions of scholarship and governance. First, the literature indicates that public trust in the institution of science and in other social institutions supporting science suffers under the influence of misleading information about climate change, conspiracy theories in particular. More research is needed on public trust as it relates to climate science and develops in different national contexts. Second, the systematic review indicated how, for instance, skepticism regarding climate science travels back and forth between public opinion and policy development within formal political institutions. Further studies of this juncture are of special importance for understanding whether and how opinion and policy translate into individual and collective climate action.

**With what potential solutions**

Research has indicated that governance through public regulation represents a primary avenue for repairing and maintaining information integrity about climate science, including the introduction of standardized procedures for the corporate reporting of climate impacts and the allocation of adequate resources for enforcing climate-related legislation.  Comparative studies of current regulatory

approaches and outcomes in different countries and world regions can help to specify policy options in a future perspective. It should also be noted that at the time of writing this report, internal as well as external regulatory practices may be changing in response to shifting political leadership at the national level as well as geopolitical developments, including the second term of U.S. president Donald Trump and the different regulatory philosophies of the United States, the European Union, and China.

For communication in the wider public domain, the balance between external, public regulation and internal, corporate regulation is key. While research [323] has indicated that online platforms and communication services have a commercial incentive to disseminate information regardless of its accuracy, consistency, reliability, or transparency—the four criteria of information integrity laid out in Section 2 of this report—studies have identified ways of reining in this practice, for example, by restricting the merging of data sets [324]. Such merging allowed, for instance, the Cambridge Analytica consultancy to deanonymize personal data and profile millions of voters in several national contexts in the 2010s.

Research has also pointed to how an information resource such as Wikipedia is potentially a double-edged sword, since its resilience against the strategic manipulation of politically charged content appears to be limited by its reliance on automated processes of curating information [325]. The Digital Services Act of the European Union, further, includes provisions for researchers to gain access to the data held by platforms and search engines as one way of monitoring their compliance with legislation as well as assessing their service to the public. Further studies should track the mechanisms and outcomes of existing legislation and explore additional regulatory and technological measures to enhance information integrity about climate science.

Across corporate reporting of the climate impacts of material production and the public dissemination of climate science, research has pointed to the potential of litigation initiated by a range of stakeholders, across the Global South and North, for repairing the integrity of the available information. Studies in this area, however, are still relatively scarce and should be complemented by national as well as comparative studies.

The literature has noted how the disrupters of information integrity about climate science will join forces through think tanks and other civil-society organizations, further suggesting that, similarly, the necessary responses to disruption need coordination. The recent launch of the Global Initiative for Information Integrity on Climate Change, coordinated through UNESCO [14], is one example of international collaboration in this domain. Research and public debate have also addressed issues of whether and how the authoritative reports of the IPCC [2] could and should be leveraged through additional public and policy efforts [326]. More studies are needed to better understand the potentials and limitations as well as the complementarity and overlaps of these initiatives, including the interfaces between science communication, fact-checking, activism, and other interventions.

Finally, citizens constitute pivots in the translation of climate science into wider public awareness and concrete political action, even if climate change appears to be "out of scale—incommensurable […] with common frames of human cognition and communication" [327, p. 439]. Whereas studies have indicated the potential of inoculation against misleading information, despite mixed empirical findings, education comes out in research as one of the most important, if long-term, strategies of enhancing information integrity about climate science. Here, more research is needed to assess interchanges between the development of science literacy and media or information literacy among learners, further taking into

account the different social and cultural backgrounds and contexts that condition learning and, hence, the application of global lessons learned about climate change by citizens in local contexts. Studies should also explore how students and other citizens engage with accurate, consistent, reliable, and transparent information to support education and public information campaigns in a future perspective.

## SECTION 6. CONCLUSIONS

Building on a systematic review of previous research on information integrity about climate science, the present Synthesis Report had three main objectives:

1. To summarize the origins of, backgrounds to, and consequences of the crisis of information integrity in contemporary communications about climate change.
2. To document gaps in previous research that limit understanding of the crisis of information integrity, and which further delay individual and collective engagement with climate change.
3. To identify ways and means of mitigating the crisis of information integrity.

This conclusion offers a summary of the present state of knowledge, including gaps and needs for further research, complemented by policy recommendations regarding potential interventions by national and international agencies into the current information environment as it conditions communication about climate change. The summary and recommendations are structured with reference to the research questions and criteria of information integrity laid out in Section 1.

### Summary of the state of knowledge

**Who**. The primary actors behind the diverse challenges to and disruptions of information integrity about climate science have been powerful economic and political interests, from fossil fuel companies to governments and nation-states. These interests, moreover, have joined forces in alliances designed to obstruct and delay timely climate action. Among other actors, scientific hired hands have aided and abetted the dissemination of inaccurate information, while many media have not filled their classic role of providing consistent and reliable information to the public. Further research is needed, particularly about the

activities of such actors in the Global South and about the alliances operating at national as well as international levels.

**Says what**. The focus of communications undermining information integrity about climate science appears to have shifted from denialism toward skepticism, covering a variety of messages questioning the relevance, feasibility, and effectiveness of potential solutions. Methodological development and additional empirical studies are required to track this complex messaging about climate change. In addition, "climate-nationalist" narratives and arguments have emerged that may impede global collaboration in the climate domain and that call for attention from the scientific community through comparative research.

**In which channel**. While social and other digital media of communication have been attracting growing attention from citizens and scholars alike, traditional mass media remain important carriers of information disregarding, circumventing, and undermining climate science. Particularly for the Global South and in comparative perspective, more studies are needed of the place of social media as well as mass media in society-wide chains of communication. Most important perhaps, source media—the means through which stakeholders promote own their positions regarding climate change—constitute strategic links in the chains of deliberation and decision-making, often outside public scrutiny, and call for more sustained research in the coming years.

**To whom**. Given the ubiquitous and pervasive nature of contemporary media and communications, everyone is a potential target of misleading information about climate change. Further studies, however, should seek to establish the extent to which the public's exposure to such information is incidental or targeted through specific strategies and tactics of interaction. It is important to note, moreover, that some stakeholders will be targeted specifically for structural reasons: Research has pointed to the pivotal position of elected officials, civil servants, and

other administrative personnel in the chains of climate policy development and decision-making, which calls for more focused and comparative studies.

**With what effects**. Research has indicated that, rather than changing climate-related attitudes and behaviors in the short term, media and communications influence public opinion and policymaking over time and in multiple steps. Studies have found that conspiracy theories and other misleading information have undermined public trust in climate science and other key social institutions, a pattern calling for continuous monitoring. A second strategic juncture to be addressed in further research is the interchange between public opinion and policy development, which orients decisions and actions that end up affecting human livelihoods and the living conditions on Earth.

In the introduction in Section 1 and the presentation of findings in Section 4, this report added a sixth element to the five paradigmatic questions [20]: with what potential solutions? Previous research has identified ways and means of responding to the crisis of information integrity. The following, final section of the report presents findings and insights regarding potential solutions in the form of policy recommendations for consideration by national and international policymakers and other climate stakeholders.

**Policy recommendations**

A near-universal scientific consensus has indicated that anthropogenic sources are key to the accelerating climate crisis [2]. To respond to this existential risk [1], it is essential that citizens, publics, policymakers, and political establishments around the world have access to and act on the findings of climate science. As documented in the present Synthesis Report, however, the integrity of the information representing climate science in a wide variety of public and private contexts of communication, has been and is being challenged and disrupted.

Building on earlier theoretical and empirical contributions, Section 1 introduced four criteria of information integrity, each of which has been found in research to be disregarded, circumvented, and undermined:

- **accuracy** – publicly available and politically influential information about climate change is, to a significant extent, inaccurate by the established standards of climate science,
- **consistency** – widely disseminated information about the causes and consequences of climate change is inconsistent across time, place, and means of communication,
- **reliability** – substantial portions of the available information about climate change is unreliable as a guide to individual and collective climate action, and
- **transparency** – the senders, interests, and sources of funding behind much of the available information about climate change is not transparent to its recipients.

Studies have identified four avenues toward repairing and maintaining climate integrity about climate science in the interest of humanity and biodiversity:

**Legislation and regulation**. Legislation represents collectively agreed rules of social and human coexistence, including principles and procedures governing the exchange of information and the expression of opinion. While digital platforms and other media of communication, to an extent, regulate themselves internally and in dialogue with their users, the record regarding information integrity about climate science, as documented in this report, indicates the need for enhanced governance in the public interest.

**Litigation**. Litigation refers to the possibility of taking legal action in response to, for example, a violation of rights or a breach of contract. Whereas the literature on

litigation regarding information integrity about climate science is still relatively limited, studies have pointed to the potential for a range of actors, from governments and prosecutors to NGOs and individual citizens, to bring lawsuits, so far primarily against private companies engaging in greenwashing.

**Education**. Education constitutes a broad-based and long-term strategy of enabling people to access, process, and apply information about climate change, empowering them to respond both to the crisis of information integrity about climate science and to the climate crisis as such. Research has indicated the need to cultivate, at once, science literacy and media literacy among citizens at large, so that they may secure conditions of survival and flourishing (*eudaimonia*) for themselves and others.

**Counterpublics**. Counterpublics constitute ad hoc and shifting alliances of strategic and tactical collaboration, among peoples, communities, and political and civil-society entities at local and global levels, against the alliances built by powerful economic and political stakeholders to obstruct and delay climate action. Research has suggested that counterpublics can contribute to challenging and disrupting the challengers and disrupters of information integrity about climate science.

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## Contributors

Drafting authors: Ece Elbeyi (Consulting Scientist, Türkiye), Klaus Bruhn Jensen (Panel Chair, Denmark), Melissa Aronczyk (Canada/United States), Jusen Asuka (Japan), Gizem Ceylan (Türkiye/United States), John Cook (Australia), Gabor Erdelyi (Hungary/New Zealand), Heather Ford (South Africa/Australia), Carlos Milani (Brazil), Eni Mustafaraj (Albania/United States), Fredrick Ogenga (Kenya), Sharon Yadin (Israel), Philip Howard (IPIE President, Canada/UK), Sebastián Valenzuela (IPIE Chief Science Officer and Chair of the Science & Methodology Committee, Chile). Coders: Mara Günther and Maria Florencia Nebreda. Independent General Reviews: Robert Brulle, Jennifer Jacquet, Stephan Lewandowsky and Timmons Roberts. Fact-checking: Heidi Schultz. Design: Domenico Di Donna. Copyediting: Beverly Sykes. We gratefully acknowledge support from the IPIE Secretariat: Lola Gimferrer, Egerton Neto, Wiktoria Schulz, Donna Seymour, Anna Staender, and Alex Young.

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Seefeldstrasse 123
P.O. Box 8034 Zurich
Switzerland

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