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Journal of the European Meteorological Society

journal homepage: <https://www.sciencedirect.com/journal/journal-of-the-european-meteorological-society>

Bridging science and society: Key communication points for climate experts

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ARTICLE INFO

Keywords:

Science communication
Climate communication
Climate change
Interdisciplinarity
Dialogue model

ABSTRACT

In 2023 and 2024, record global temperatures and numerous extreme weather events underscored the urgency of addressing climate change and its far-reaching environmental, social, and economic impacts. As these changes intensify, it is more important than ever for the scientific community to effectively communicate their findings to society and decision-makers. Bridging the gap between scientific knowledge and public understanding is essential for favoring informed decision-making and meaningful action on climate issues. Although scientists are among the most trusted professionals, inter- and transdisciplinary collaboration with communication experts is essential to improve scientific outreach on this critical issue. At the 2024 Annual Meeting of the European Meteorological Society (EMS) in Barcelona, we organized a workshop targeted to climate scientists to address challenges in climate science communication. Featuring experts from neuroscience, communication studies, activism, and journalism, the workshop fostered cross-disciplinary dialogue to identify strategies to raise public awareness of the climate crisis. This paper summarizes the key insights of the workshop, emphasizing the importance of training climate scientists in effective communication, enlarging networks for collaborative communication efforts, and integrating neuroscientific knowledge about cognitive biases and attitude change into messaging. Key takeaways from the workshop include: 1. recognizing and valuing the expertise and perspectives of the other party in the dialogue (dialogue-model), 2. understanding the influence of cognitive dissonance and biases in climate science communication, and 3. developing compelling research-based narratives that address both problem and solution through collaboration with communication professionals, such as journalists. These recommendations aim to empower the next generation of climate scientists to engage with society as trusted and impactful communicators.

1. Introduction

The years 2023 and 2024 have been the hottest on record. In 2023, the global average 2-m air temperature surpassed pre-industrial levels by 1.48 °C (Cattiaux et al., 2024), setting a new record. However, 2024 exceeded this milestone, with temperatures rising approximately 1.55 °C above pre-industrial levels, making it the warmest year ever recorded. Notably, 2024 also became the first year in which the annual

average temperature exceeded the critical 1.5 °C threshold, highlighting the escalating urgency of addressing climate change (ECMWF, 2025). Drummond et al. (2018) found that in countries where mitigation efforts are ambitious, awareness of climate change is relatively high. Furthermore, Doran et al. (2023) found that awareness of the reports of the Intergovernmental Panel on Climate Change (IPCC) among people in Norway is positively correlated with climate protests and mitigation policies in Norway. This highlights the tight links between

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<https://doi.org/10.1016/j.jemets.2025.100012>

Received 27 December 2024; Received in revised form 7 March 2025; Accepted 16 March 2025

the opinion of the general audience and the political address on climate change-related issues, in which science can play a very interesting role.

A large number of scientists consider themselves responsible for mitigating climate change and advocate taking action personally (Dablander et al., 2024). Today, many scientists, spanning from early-career researchers to experienced senior professors, engage in public communication and create their own communication spaces in a variety of forms including public events, and the standard media (televisions, printed journals, etc.) as well as on social networks. Scientists are also among the most trusted professionals in our global society. The survey of Cologna et al. (2025) in 68-countries with 71922 participants shows that scientists are trusted by the majority of people in the majority of countries. According to the Ipsos Global Trustworthiness Index 2023 (IPSOS, 2023), they are considered trustworthy by 57% of the people surveyed, and rank second after medical doctors (58%) and preceding teachers (53%). In contrast, journalists are in the lower end of the distribution (25%), followed by politicians, who are ranked lowest (14%). This is thought-provoking, as journalists and politicians are key voices in shaping social dynamics and, in particular, in communicating about environmental and climate changes. Such a high level of trust strongly calls for scientists to make their research accessible and understandable to society. Science communication can be a very challenging task, especially on socially and politically important topics like climate change. Climate experts, however, are often not trained to do public communication. An interdisciplinary cooperation between climate scientists and researchers in the field of humanities (e.g., communication studies, psychology, sociology), and communication and engagement experts (e.g., journalists and activists) bundles expertise to enable professional, effective and trustworthy climate communication. Moreover, while conveying scientific messages it is important to consider the audience, the communication format and framing of the message (Nisbet, 2009; Torok et al., 2020; Myers et al., 2023).

During the Annual Meeting of the European Meteorological Society (EMS) in Barcelona in September 2024, we organized a workshop on the topic of climate communication supported by COST Action FutureMed,² an international transdisciplinary network aimed at bridging climate science and its impacts on society. The workshop was addressed, but not limited to early-career climate scientists. The workshop featured speakers from neuroscience, science communication, activism, and journalism. These disciplines and professions were selected to enable exchange between communication experts from practice (journalism, activism) and the climate-science-community with a discourse on science communication and human behavior (neuroscience). Neuroscientists are increasingly interested in the climate crisis because it has emerged as one of the most compelling case studies for exploring human reasoning, the impact of cognitive biases on decision-making, and the processes of belief and attitude change (for example, see Nature Human Behavior's Special Issue on "Climate change and human behavior",³ and the article published in Trends in Cognitive Sciences by Aron (2019)). Neuroscience is an essential discipline for advancing our understanding of human reasoning and attitude change, and interdisciplinary collaboration is crucial to support collective actions to mitigate the climate crisis. This boundary-breaking exchange between disciplines and professions represented fertile ground to explore not only the success of climate communication in making science accessible to all, but also its capability to consider the perspective of diverse audiences in a thoughtful way. The workshop was structured as following: 1. presentations by the speakers with open discussion (2 h), 2. Group activity with a practical exercise for the participants (persona groups and gallery walk, see the Supporting Material; 45 min), and 3. a panel discussion organized as a fish-bowl with both speakers and workshop participants on the panel (1 h).

In this meeting summary, we present the key points that emerged from the workshop and highlight the main insights for climate scientists who want to improve their science communication skills. Considering the high level of trust accorded to scientists, their involvement in communication is important to add credibility to climate information. With this in mind, the training of climate scientists, especially at an early-career stage, is relevant for the progress of communicators with high potential. The paper describes the most relevant psychological mechanisms for climate science communication in Section 2, strongly calls for the development of networks of people to create new ways of communicating climate science in Section 3 and outlines some practical suggestions in the concluding Sections 4 and 5.

2. Psychological aspects

Climate science communication is not only a transfer of knowledge from an expert to a receiving audience. Differently from communication of technical scientific concepts, communication on the climate crisis requires conveying complex information that spans various disciplinary fields, from technical and scientific domains to those more typically socio-economic. Additionally, it often involves communicating bad or unwelcome news, which tend to be rejected or completely ignored by involved individuals (Sharot et al., 2011). However, climate crisis communication has the potential to counteract the negative information by motivating concrete reactions at personal and collective levels. Because of its strong interference with rooted behaviors and beliefs, the reception of climate communication may be hampered by cognitive biases (Zhao and Luo, 2021), namely psychological processes that determine how human reasoning operates.

Here we present the types of cognitive biases and human reasoning modalities which are most relevant in the context of climate information. Cognitive dissonance, first conceptualized by Festinger (1954), is the feeling of discomfort that arises when a new piece of information clashes with previous personal beliefs or behaviors. Individuals thrive to solve this dissonance using different strategies, for example changing the conflicting belief or behavior, or more often ignoring, denying or avoiding exposure to the new conflicting information. Other types of cognitive biases, such as confirmation and attentional bias, may be implicitly activated to solve cognitive dissonance. Confirmation bias is the automatic tendency to select information which confirms one's views and to disregard opposing information (Kappes et al., 2020). It can apply to biased search and memory recall, but also to interpreting ambiguous evidence in support of previous convictions. A recent study by Wang and Jaidka (2024) demonstrated that the words employed to search for climate related information on the internet are significantly different and may successfully predict personal political orientations, thus confirming that individuals' divergent opinions actively modulate the exposition to different information. Similarly, attentional bias is the automatic, perceptual ability to attend to information differently according to one's previous beliefs, devoting greater attentional resources to topics better aligned with our interests and opinions (Luo and Zhao, 2021). For example, the smell of cigarette smoke arouses the smoker's urge to light a new cigarette, or climate change-related images are more effective at capturing the attention of individuals with a pro-environmental disposition (Carlson et al., 2019).

A different type of bias which concerns the human's response to climate information is temporal dissonance (e.g., Weber, 2006; Pahl et al., 2014). This applies to a reduced perception of danger from climate change, due to the delay between problems in day-to-day life and the multi-decadal time scales on which the increase in climate-related risk evolves. For this reason, the climate crisis is not generally perceived as an urgent societal issue, at least not before direct exposure to climatic disasters. The perception of temporal and geographical vicinity to climate-change impacts is thus important for activating a feeling of urgency towards the climate crisis. In fact, direct experience, or empathy towards those that encounter the experience directly, may

² <https://futuremedaction.eu/en/>

³ <https://www.nature.com/collections/icdbbbibg>

reduce psychological distance thus supporting change in behaviors and ideas (Keller et al., 2022). Based on this, we highlight three crucial strategies within climate communication:

1. emphasizing urgency by revealing the connection of environmental changes and extreme events with climate change, e.g., through rapid attribution studies (e.g. Stott et al., 2016; Faranda et al., 2024; Clarke et al., 2022).
2. storytelling as a means of creating emotional attachment to the issue. This is particularly relevant in an urban society, where obvious changes in the natural environment and its biodiversity are hardly perceived (Pahl et al., 2014). In the context of storytelling, the framing of the issue makes a big difference. Catastrophe framing, often employed by journalists, is effective at increasing an audience's attention on the topic of climate change (Boykoff, 2024; O'Neill and Nicholson-Cole, 2009), but on the long term may be detrimental, as it promotes a feeling of helplessness and fatigue, and triggers defensive reactions related to cognitive dissonance (O'Neill and Nicholson-Cole, 2009).
3. conveying both problem and solution to empower people instead of overwhelming them (Merkel et al., 2020).

Although it would be naive and inaccurate to depict climate change as an all-positive story, communication strategies as those published by the United Nations⁴ encourage to transmit hopeful messages showing stories of effective climate adaptation and mitigation. Conveying not only the problem but also solutions can help to empower people for taking action. Optimistic, solution-based messaging might be more effective in promoting pro-environmental behavior compared to fear-based or guilt-driven approaches. They also suggest addressing temporal dissonance by focusing on the urgency of immediate action. For example, showing achievable short-term objectives and opportunities is expected to overcome the temporal delay separating our daily lives from such a long-ranging issue. Regarding cognitive dissonance and confirmation and attentional biases, recent scientific literature promotes the importance of taking into account the interests and political views of each specific group of people when communicating information about climate change. Goldberg et al. (2021), for example, demonstrated that tailored advertising about climate change in the US, thanks to the choice of trusted messengers for the targeted community (e.g., a retired Air Force General for a campaign directed to US conservatives), show better chances in raising the interest towards climate crises.

3. Find allies

The field of climate science has urgent political implications on actions to be taken (e.g., Isopp, 2015). However, many scientists working on climate change feel unheard seeing that their work often goes unnoticed and fails to strengthen efforts on climate change mitigation (Carrington, 2024; Dablander et al., 2024) While many consider moving to or engage in politics or activism to foster acceptance of the current knowledge and according actions (Isopp, 2015; Dablander et al., 2024), getting science closer to the public is also very effective. The interactions with professional communicators may be complicated by differing objectives, lack of scientific training among communicators or missing communication skills among scientists. Therefore, we believe it is crucial for scientists to avoid handling communication efforts alone. Scientists may look for skilled allies in the public sphere and build a wide, inter- and transdisciplinary network of experts when engaging in climate communication. In this network, potential allies like activists, journalists, or educators contribute their professional competence in conveying messages to different target groups using

specialized communication strategies. Further allies are found among fellow scientists and the audience itself. Scientists in turn bring their science-based expertise, latest scientific insights, credibility, and authenticity to the allies. At best, the exchange between scientists and allies is beneficial for both sides, e.g., by merging networks and thence coverage.

A strong relationship between science and activism may play a vital role in implementing the solutions to climate change. In fact, through activism climate change issues reach a wide geographical and generational coverage (Lee et al., 2020), as well as putting pressure on politics and hence opening opportunities for climate advocacy. Activist movements exist in manifold forms with differing strategies and objectives in the field of climate and environment. For instance, Fridays For Future diversify the message according to their mostly young audiences through local groups. Their focal claims include immediate climate justice, adherence to science, and stopping fossil fuels. Another activist group, Extinction Rebellion, is mainly targeted towards young adults (30–40 years of age) and communicates a strong sense of urgency. As Fridays For Future, they also demand immediate action, adherence to “the truth” (which corresponds to scientific knowledge on impacts of climate change), and shared decision-making on climate policies. Their general narrative fueled the “Green Wave” (2018–2019) during which science, media, activism and politics aligned into a socio-political climate cause (Rödter and Pavenstädt, 2023; Zamponi et al., 2023). Climate movements have contributed to shifting the public opinion and to making climate policies acceptable, with the total number of pledges increasing from 2018 (IEA, 2021). The COVID pandemic reduced the enthusiasm of the Green Wave which lead, for example, in Italy, to the creation of other places of dialogue and gathering around the topic, such as Ci Sarà Un Bel Clima (CS1BC, There will be a good climate, <https://unbelclima.it/>). CS1BC is a collective of activists, coming from different academic and professional backgrounds, who promote the exchange of science-based, clear and honest messages on climate change with the goal of activating citizens and communities to properly tackle the climate crisis. As an example of their work, CS1BC has recently developed a collaborative process called “General Convention of Climate Action”. They have elaborated a list of propositions addressed to the Italian government in different sectors (e.g., energy, education, transportation) with a bottom-up approach that included numerous environmental associations and a decision-making method based on scientific training. Aside from those organized groups, activism has a more general meaning, which refers to being active citizens who look for reliable information, engage in public debates, look for bottom-up solutions and propose new approaches to the emerging challenges. Science-backed activists can raise their credibility by joining forces with scientists, without losing their authenticity.

Journalists have different priorities than scientists: often, quick publishing of good stories that raise attention is the focus. A synergy between science and journalism can help improving science communication by jointly developing a science-based story. To facilitate collaboration, scientific content can be prepared in a compelling way by respecting the “five W” of journalism: (1) Who is the protagonist of the story?, (2) What happens in the story?, (3) When is the story told?, (4) Where does the story take place?, and (5) Why does the story happen? (Singer, 2008). Another idea for creating good stories is to invite journalists to accompany scientists in their work. Often, journalists show a high interest in natural sciences, which can be met by inviting them to join fieldwork campaigns. Cooperation with scientists also provides journalists with newsworthy topics with the potential for appealing illustration or in-depth expertise on complex subjects, thus raising their credibility.

For scientists, the closest allies may be their colleagues and their institutions. While exchange among peers can raise the motivation for communication, having the chance to engage with scientists with a longer experience in communication might be very helpful and inspiring. In addition, communication activities can increase or strengthen

⁴ <https://www.un.org/en/climatechange/communicating-climate-change>

Practical advice for communication



Fig. 1. Practical advice for climate scientists to start engaging in science communication.

established research networks. The media offices of universities and research centers could also provide significant support in shaping the messages and amplifying the impacts of communication activities. Communication also highlights the relevance of an institution's research output.

Lastly, the audience can constitute a major ally. Usually inhomogeneous, the audience can include interested, enthusiastic, alarmed, concerned, disengaged, and doubtful people, who cannot be reached in the same way (Leiserowitz et al., 2023). Our workshop was dedicated to a way of climate communication that considers the specific perspective of the audience, including their personal, professional, social or educational backgrounds. These backgrounds shape how messages are interpreted, acknowledged or refused. Preparing the workshop, we spread out different climate communication materials, ranging from traditional formats such as newspaper articles and scientific journal to art performances, cartoons etc. With the subsequent hands-on activity, we aimed at raising awareness of divergent perceptions of different climate communication strategies between scientists and the general public. Participants of the workshop were asked to take on “personas” (Nielsen, 2019; Cooper, 1999) with different backgrounds and views on climate change. With that perspective, they individually viewed all exhibited materials. In the concluding group reflexion, they evaluated the different examples of climate science communication through their persona-perspective regarding 1. if the communication example raises their attention, and 2. if and to which extent it motivates them to take action. The group activity is fully described in the Supplementary Material. Due to its generic blueprint character, the workshop can be transferred to other contexts. In general, the audience profits from educational components of communication efforts, but also from bringing relevant topics to the attention of scientists and thus shaping future research questions (e.g., via co-creation).

4. Practical advice

Against the backdrop of the above-mentioned challenges, we last address actionable options for climate researchers who wish to engage in climate communication. Given the relevant cognitive processes mentioned in Section 2, climate communication should (1) use authoritative

scientific information, (2) exploit solution-based approaches when addressing problems or challenges instead of catastrophe-framing, and (3) call for actionable tasks to reach short-term objectives. In practice, this translates to the following advice for scientists (Fig. 1).

- **Be prepared for communicating:** To ease communication, e.g., with journalists, a simple toolbox may be effective. This includes: a biography, a summary of research and main interests, pre-made graphics, contact information, answers to frequently asked questions. Aside from responding to queries, scientists are encouraged to pro-actively reach out to editors-in-chief, public or private actors, or to engage in social media.
- **Get support from your institution:** Communication should be a valued part of academic work. Scientists may ask their institutions for support or actively engage with their media center. Institutions may organize training courses for communicators (e.g., journalists) to convey climate change-related messages accurately, but also train academics in communication. More actions by institutions are proposed in Gardner et al. (2021).
- **Get organized:** Organizing covers (1) encouraging and connecting with fellow scientists (also interdisciplinary) and allies from the public, (2) the definition of common goals in communication, (3) including dedicated resources and time for communicating new findings in the workflow or in projects, and (4) selecting topics and target groups you feel comfortable with.
- **Cooperate with allies:** Cooperation with allies, e.g., educators, journalists, activists and fellow scientists allows for synergies in the communication process. The choice of allies may be guided by shared values or available resources.
- **Shape your message:** When messages are defined, it is important to consider correct scientific information, the framing (e.g., solution-based when raising problems), the objective (e.g., triggering and maintaining discussion), the audience, the media of communication, and the communicator's attitude (e.g., honesty, accuracy, kindness, own interests). Aggressive communication very likely results in refusal of the message.
- **Tell good stories:** Other than raw data, (human) stories resonate with the emotions of the audience. Therefore, skillful storytelling is key to conveying messages. Adopted from journalism, the “five Ws” (see chapter 3.2.) should be retained.

5. Conclusion

The workshop held at the 2024 European Meteorological Society (EMS) Annual Meeting in Barcelona focused on tackling the challenges of climate science communication. It brought together climate scientists alongside experts from neuroscience, communication studies, activism, and journalism to foster cross-disciplinary dialogue. The objective was to develop strategies that enhance public awareness of the climate crisis. Key takeaways from the workshop highlighted the need to train climate scientists in effective communication, to create collaborative communication networks, and to incorporate psychological and strategic insights into messaging. These efforts aim to empower the next generation of climate scientists to become influential and impactful communicators.

Integrating the communication recommendations from chapter 4, we call for the widespread use of a dialogue-based communication style. Dialogue, as a mutual exchange of at least two actors, favors a chain of interrelated messages and thus interactivity (Hoppe et al., 2018). This form of public engagement allows to create occasions for politicians, educators, journalists, entrepreneurs or activists to engage with scientists, but also with each other. The dialogue model brings scientists with their expertise and scientific facts and results together with target groups with their own knowledge and expertise. By creating these exchange networks, different kinds of valuable knowledge can be passed among scientists and society (Reincke et al., 2020). Furthermore, a dialogue enables a communication format that is interactive, trustworthy, more pervasive, and less “self-selective” than one-sided communication formats.

Our workshop emphasizes that respectful, thoughtful dialogue that incorporates psychological insights and communication strategies like storytelling can effectively inspire climate protection actions and that it is important for climate researchers to expand this form of communication. In this way, climate communication becomes an active piece of the solution of the climate crisis, where solid networks based on trust, mutual interests are identified and supported, and solidarity is at the forefront.

CRedit authorship contribution statement

M. Mittermeier: Writing – original draft, Project administration, Funding acquisition, Conceptualization. **A. Portal:** Writing – original draft, Project administration, Funding acquisition, Conceptualization. **A. Meroni:** Writing – original draft, Project administration, Conceptualization. **A. Böhnisch:** Writing – original draft, Project administration, Conceptualization. **C.E. Carniel:** Writing – original draft, Conceptualization. **I. Hoppe:** Writing – review & editing, Methodology. **I. Ronga:** Writing – review & editing, Methodology. **C. Pogliani:** Writing – review & editing, Methodology. **E. Bompan:** Writing – review & editing, Methodology. **K. Geneuss:** Writing – review & editing, Methodology. **M. Tuninetti:** Writing – review & editing, Methodology. **M.D.C. Llasat Botija:** Writing – review & editing, Methodology. **S. Khodayar:** Writing – review & editing, Funding acquisition.

Declaration of competing interest

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

Acknowledgments

The workshop and the paper were a true group effort by MM, AP, AM and AB. All four authors contributed equally to the work, though at different stages of the process. For this reason first-authorship is shared among them. The authors acknowledge the support of COST

Action CA22162—FutureMed: A Transdisciplinary Network to Bridge Climate Science and Impacts on Society, supported by COST - European Cooperation in Science and Technology (<https://futuremedaction.eu/en/>). MM, AP, AM and AB are grateful to the European Meteorological Society for the financial and technical support in the organization of the communication workshop in Barcelona, which is at the origin of this paper. IR is funded by PON (Programma Operativo Nazionale) project “Ricerca e Innovazione” 2014–2020: D11B21005800007.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.jemets.2025.100012>.

Data availability

No data was used for the research described in the article.

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