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ORIGINAL ARTICLE

A new hope or phantom menace? Exploring climate emotions and public support for climate interventions across 30 countries

Chad M. Baum[1] | **Elina Brutschin**[2] | **Livia Fritz**[1] | **Benjamin K. Sovacool**[1,3,4]

[1]Department of Business Development and Technology, Aarhus University, Herning, Denmark

[2]International Institute for Applied Systems Analysis, Laxenburg, Austria

[3]Bennett Institute for Innovation and Policy Acceleration, University of Sussex Business School, Brighton, UK

[4]Department of Earth and Environment, Boston University, Boston, Massachusetts, USA

Correspondence
Chad M. Baum, Department of Business Development and Technology, Aarhus University, Birk Centrepark 15, 7400 Herning, Denmark.
Email: cmbaum@btech.au.dk

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Abstract

Emotions are central to human experiences of climate change. Empirical research demonstrates their importance for climate perceptions and climate-related behaviors. The intensifying severity of climate change prompts consideration of emerging, potentially controversial technologies. Alongside mitigation and adaptation, climate intervention proposes to remove carbon dioxide from ambient air (carbon dioxide removal, CDR) or reflect sunlight away from the Earth (solar radiation modification, SRM). Although such options arouse emotional reactions of diverse kinds, the intersection between climate emotions and climate intervention has received limited attention. This article employed a unique, global dataset with 30,284 participants across 30 countries (in 19 languages) to provide insights on 3 questions. We first leveraged the global dataset to map the incidence of fear, hope, anger, sadness, and worry across countries—the first time the climate emotions of adults are investigated on this scale. We also identified significant differences in emotions by level of development, with those in advanced economies reporting weaker levels of climate emotions. Second, using multiple linear regression analyses, we explored the relationship between climate emotions and support for climate-intervention technologies. We determined that the emotions of hope and worry seem to be the most consistently (positively) correlated. Third, we explored if reading about technology categories differentially affected climate emotions. Individuals randomly assigned to read about ecosystems-based CDR were significantly more hopeful about climate change (those about SRM the least). Together, our results provide the first global-level evidence of the relationship between discrete climate emotions and perceptions and support of climate interventions.

KEYWORDS
carbon dioxide removal, climate change, emotions, global south, negative emissions, solar geoengineering

1 | INTRODUCTION

Few things seem to divide human opinion as much as the emotion of hope and its role in human experience. Proposing that hope can be maladaptive, there is the familiar dictum, "it's the hope that kills you." Alternately, there is Emily Dickinson: "Hope" is the thing with feathers/That perches in the soul/And sings the tune without the words/And never stops – at all –.'' In this telling, hope pushes us to persevere, despite doubt and uncertainty.

Hope resonates with equal complexity in the context of climate change—with this also true of emotions in general. On the one hand, there are the ever-increasing disasters, economic losses, and impacts on human mortality (Lenton et al., 2023). Such tragedy is deepened by its heavier burden in the less wealthy, privileged sections of the world, which have contributed least to the problem (Carleton et al., 2022; Kotz et al., 2024). Attempts to detail the depths of the challenge at hand and the major changes required to our collective way of life (Scranton, 2015; Wallace-Wells, 2019), however, run the

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risk of de-motivating individual and collective action. Maybe unsurprisingly, skepticism of hope is deeply present in popular discourse and among scientists (Carrington, 2024). That is, given the scale of the climate catastrophe, what reason is there for hope? Admonishing the inaction of politicians, Greta Thunberg has argued: "You can't just sit around waiting for hope to come; then you're acting like spoiled, irresponsible children; you don't seem to understand that hope is something you have to earn."

On the other hand, there are emerging proposals, for example, climate-intervention technologies, which aim to expand the toolbox available to deal with climate impacts. In addition to types of climate action like mitigation and adaptation, climate intervention is receiving greater attention due to the greater evidence of climate disasters and insufficient pace of emissions reductions (National Academies of Sciences, Engineering, Medicine [NASEM], 2018, 2021; United Nations Environment Programme [UNEP], 2023). From this perspective, prospective solutions may prompt reasons for hope, or at least to avoid despair. Climate intervention consists of two broad types: carbon dioxide removal (CDR), where carbon dioxide is removed directly from the atmosphere in familiar "ecosystems-based" forms like afforestation and "novel," engineered approaches like direct air capture; and solar radiation modification (SRM), like stratospheric aerosol injection (SAI), which aims to reflect sunlight away from the Earth and into space.

Both CDR and SRM have their downsides, risks, and potential for unforeseen consequences (Honegger et al., 2021; Ricke et al., 2023; Sovacool et al., 2023). They provoke controversy as well, in part because they are seen to distract from necessary mitigation efforts and questions about their triggering "false hope" (McLaren, 2016; Preston, 2013). Given the damages to natural ecosystems and costs of human suffering, there are however increasingly strong arguments that we may not have the luxury to ignore climate intervention (Parson & Keith, 2024; Smith et al., 2024).

On the whole, this demonstrates that the topic of climate intervention represents rich emotional terrain. The intersection of climate emotions and climate intervention nevertheless remains an underexplored topic.

1.1 | Climate emotions and the incidence of climate action

The emotionality of climate change in general has received more attention. According to one analysis of Google Trends data (Gilder, 2023), search interest related to "climate anxiety" has grown around the world—with queries in English 30 times higher in 2023 than 2017. Similarly, we observe greater attention in the scientific literature to the relationship between anxiety and climate change (Marczak et al., 2023; Sangervo et al., 2022; Swim et al., 2022; Whitmarsh et al., 2022). Looking at generational cohorts in the United States, Swim et al. (2022) documented higher levels of worry about climate change and, to a lesser extent, anger and guilt among the younger participants. In general, the extent of mental-health issues and of research devoted to their study is sufficiently large to merit mention in the Intergovernmental Panel on Climate Change (IPCC) (2023) AR6 report on "Impacts, Adaptation, and Vulnerability." B4.4 stresses the stakes involved: "Mental health challenges, including anxiety and stress, are expected to increase under further global warming in all assessed regions, particularly for children, adolescents, the elderly, and those with underlying health conditions (very high confidence)."

Recent empirical research has consistently established that emotional reactions rank among the central predictors of climate perceptions, support for climate-mitigation policies, and climate-relevant behaviors (Brosch, 2021; Geiger et al., 2023; Myers et al., 2023; Smith & Leiserowitz, 2014). Various attempts to improve the effectiveness of climate communication thus adopt a deeper focus on engaging emotions rather than stressing the role of knowledge (Brosch, 2021; Chapman et al., 2017; Leiserowitz & Smith, 2017). This builds on growing evidence that emotional reactions can signal an issue or information that is deserving of priority (Marcus et al., 2000; Nabi, 2003, 2018). It therefore makes sense that distinct emotions would prove variously responsive to information content (Feldman & Hart, 2018; Hornsey & Fielding, 2016; Myers et al., 2023). Increasing attention to discrete emotions (e.g., fear, anger, hope, and sadness) has revealed their varying impacts on climate change perceptions and behaviors (Chapman et al., 2017; Myers et al., 2024). For instance, Myers et al. (2023) established how differently focused video messages (on consensus around climate change, its causes, impacts, and potential solutions) provoke distinct emotions (guilt, anger, hope, sadness, and fear). Each of these in turn affected support for climate policies to a variable extent. However, it can by no means be expected that messages influence emotions in any kind of straightforward manner. Providing a "cautionary note" here, Hornsey and Fielding (2016) revealed that a message intended to increase optimism about climate change ended up undercutting mitigation intentions. This unintended effect emerged from the message having decreased perceived risks and felt distress. Instead, it was the negative emotions (anxiety, sadness, and shame), which were more relevant for behavioral intentions and feelings of efficacy.

Given their different roles and tendencies, we briefly review the literature on discrete emotions. Anger, as an emotion that is broadly directed at something or someone externally to blame, can be associated with retribution-seeking—in the climate context, this seems to foster participation in collective action and personal behaviors, support for regulatory policies, and better mental health outcomes (Chu & Yang, 2019; Myers et al., 2024; Sabherwal et al., 2021; Stanley et al., 2021). Using a nationally representative survey in Norway, Gregersen et al. (2023) found that the effect of climate anger on climate activism was seven times greater than the effect of hope. Conversely, anger was not significantly relevant for intentions to engage in climate mitigation; sadness, fear, and hope were all positively related.

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The authors also identified distinct relationships depending on the content of anger: Those angry about humanity's inaction or unwillingness to take responsibility were more likely to engage in climate behaviors; the opposite was true for those whose anger stemmed from "contrarian" beliefs on the existence of climate change. Focusing on motivations of climate demonstrators, Lorenzini and Rosset (2024) identified a notable pattern: Senior (>60) protestors were angrier, whereas younger protestors (<35) were more fearful. Greater fear and anger corresponded to stronger motivation to take part in climate strikes across all ages.

Hope, representing a positive evaluation of an uncertain situation or motivating action to escape an unwanted outcome, is postulated as a key—missing—ingredient for climate attitudes and engagement, including by young people (Nabi et al., 2018; Ojala, 2012, 2023; Geiger et al., 2023; Myers et al., 2024). Sangervo et al. (2022) found that climate hope (and anxiety) was positively and diversely correlated with types of climate action (lifestyle changes, activism, volunteering, etc.). The role of hope is however contested: If hope is founded on denial of climate change, it prompts less engagement (Geiger et al., 2023; Marlon et al., 2019; Ojala, 2023). Distinguishing "false" versus "constructive" forms of hope, Marlon et al. (2019) established positive, significant effects of constructive emotions on support for climate policies and behavioral intentions; there were countervailing effects for false hope.

Sadness, grounded in experiences of loss and inciting a desire for restoration, has received less attention. Perhaps this reflects the focus on respondents in the global north less likely to bear the brunt of climate damages. It has been speculated that sadness in such contexts, as it is felt more at a psychological distance, is rather on behalf of people or species more directly affected (Leiserowitz & Smith, 2017; Spence et al., 2012). Moreover, there is preliminary evidence of sadness having a key role vis-à-vis attitudes and policy support for climate justice (Myers et al., 2024).

Lastly, fear (or anxiety), as prompted by a discerned threat to oneself or significant others, can trigger protective action (Marcus et al., 2000; Smith & Ellsworth, 1985). The potential for a counterproductive effect of fear as a motivator for climate change has been mooted (e.g., Lucas, 2022); the relationship between fear and climate change is however ambiguous (Chapman et al., 2017). For instance, the effectiveness of fear-based messaging is found to be ineffective at motivating engagement (Bilfinger et al., 2024; Ettinger et al., 2021; O'Neill & Nicholson-Cole, 2009). But other studies demonstrate the potential for fear to promote certain pro-environmental behaviors, depending on fear intensity (Meijnders et al., 2001), together with its significant linkages with support for climate policies (Myers et al., 2024).

One key shortcoming in this literature is the lack of non-western perspectives (Lawrance et al., 2022, 2024; Pearson, 2024). By centering those in rich Western countries, the result is a narrow depiction of the relationship between emotion and climate change. There are only a few articles examining climate emotions in the global south; even so, they offer a relevant, complementary perspective (Abunyewah et al., 2023; du Bray et al., 2019). There is one cross-country (survey) exercise looking at the emotionality of climate change, focusing on young adults (Clayton et al., 2023; Hickman et al., 2021 also conducted a secondary analysis of age and gender). Surveying more than 10,000 participants (aged 16–25) in 10 countries, Hickman et al. (2021) found that at least half reported feeling (in descending order) sad, afraid, anxious, angry, powerless, helpless, or guilty—only 30% reported feeling indifferent or optimistic. The authors established that almost 60% of respondents were very or extremely worried about climate change, particularly in the global south (Brazil, India, and the Philippines). Feelings of betrayal with governments (their own and generally) were also higher in the global south, except for Nigeria—such perceptions were positively linked with negative thoughts about climate change.

1.2 | Intersection of climate emotions and climate interventions

The literature on the emotionality of climate interventions is growing. Most of the focus has been on the affective evaluations of technologies like enhanced weathering (Pidgeon & Spence, 2017), bioenergy with carbon capture and storage (BECCS) (Klaus et al., 2020), marine cloud brightening (Bartelet et al., 2025), SAI (Fenn et al., 2023; Hussain et al., 2024; Klaus et al., 2020; Merk & Pönitzsch, 2017), and CDR as a category with BECCS, direct air capture with carbon storage (DACCS), biochar, afforestation, and soil carbon sequestration (Wenger et al., 2021). Of note, the literature consists of only: four studies examining perceptions in Germany, two in the United Kingdom, two in Switzerland, one in Australia, and one in Pakistan, Kenya, and Nigeria (Hussain et al., 2024). To date, public perceptions in only seven countries have been examined; only Hussain et al. (2024) have surveyed publics in the global south.

One way in which affect has been examined is to inquire of the positivity or negativity of affect toward technologies—in a way that corresponds to outcome variables, such as support and balance of benefits to risks (Hussain et al., 2024; Pidgeon & Spence, 2017; Sütterlin & Siegrist, 2017; Wenger et al., 2021). For instance, Pidgeon and Spence (2017) found that positive feelings held the strongest predictive value of support for enhanced weathering (an example of CDR)—above prior knowledge, climate beliefs, trust in scientists, and the perceived balance of risks and benefits.

Other studies examined discrete emotional responses (e.g., angry, happy, sad, afraid, and hopeful) (Braun et al., 2018; Fenn et al., 2023; Klaus et al., 2020; Merk & Pönitzsch, 2017). Asking how strongly individuals felt 11 positive/negative emotions about SAI, Merk and Pönitzsch (2017) established that: "affect is the strongest driver in attitude formation," that is, more than risk and benefit perceptions (a finding supported by Bartelet et al., 2025; Fenn et al., 2023). Using a longitudinal design (two waves), Braun et al. (2018) have also illustrated a "cooling-off effect,"

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whereby negative emotional reactions toward SRM tend to decline over time. This decline was linked to increasing acceptance—the trend for positive reactions was ambiguous.

Lastly, only one study explored how affect about climate change impacts climate intervention (Sütterlin & Siegrist, 2017). Portraying intensity of feelings on a range from "very negative" to "very positive," the authors found that participants who were more negative about climate change were inversely more positive about SRM—but only for those individuals who did not receive information about SRM. If individuals received such information, no such relationship existed. This led the authors to conclude that affect towards climate change was only influential in the absence of information about SRM.

1.3 | Current article

Although the literature on discrete climate emotions features growing nuance, some relevant gaps remain. First, given that most of the research has focused on the United States and other western countries, there is limited understanding of emotions across the global south (cf., Clayton et al., 2023; du Bray et al., 2019; Hickman et al., 2021). Second, although the relationship of climate emotions and climate perceptions and behaviors has received attention (for western countries), this is not yet true for proposed climate-intervention approaches—in the one case this is done, it focuses on SRM and for one country at a time (Sütterlin & Siegrist, 2017).

Given the lack of research on the intersection of climate emotions and perceptions and support of climate-intervention technologies, this article employed a unique, global dataset with 30,284 participants across 30 countries (in 19 languages) to undertake an exploratory analysis and give insights on three research questions.

- What is the global incidence of climate emotions (fear, hope, anger, sadness, and worry), and how does this vary among countries, including at different levels of development?
- What is the relationship between climate emotions on the one hand, and support for and perceptions of climate-intervention technologies on the other? Does the importance of climate emotions vary depending on the type of climate intervention?
- Does learning about SRM and CDR technologies differentially influence the expressed strength of climate emotions?

To answer these questions, we first leveraged the global nature of this dataset to map the incidence of the five climate emotions (fear, hope, anger, sadness, and worry). Second, using multiple linear regression analysis, we explored the relationship between the climate emotions and perceptions and support for climate-intervention technologies. The technologies were divided into three categories, with participants randomly assigned to one of the following: ecosystem-based CDR (afforestation and reforestation, soil carbon sequestration, marine biomass, and blue carbon), engineered CDR (BECCS, DACCS, biochar, enhanced weathering), and SRM (SAI, marine cloud brightening, space-based geoengineering). Similar analyses were conducted for climate emotions vis-à-vis perceived risks and benefits of the technologies. Third, leveraging the use of random assignment to the categories, which preceded items on climate emotions, we also examined the existence of quasi-experimental effects: if randomly assigned information on technologies in a category had a relative impact on the strength of climate emotions. This analysis, facilitated by our comprehensive examination of SRM and CDR, lends alternate insights into the potential "moral hazard" of climate intervention (Campbell-Arvai et al., 2017; Satterfield et al., 2023). In particular, we wished to examine if information about the different technologies might affect the strength of climate emotions (see Sütterlin & Siegrist, 2017), for example, if reading about SRM might inflate the public's optimism about climate change.

2 | RESEARCH METHODS

As a starting point, our survey instrument focused on 10 climate interventions. We selected the interventions to reflect the diversity of approaches that have been proposed, within each of the three categories described above, and to represent those which have received the most attention in the literature (NASEM, 2018, 2021; Smith et al., 2024; Sovacool, 2021). These are as follows:

- **SAI**, which aims to limit the effects of climate change by using planes or balloons to spray small particles (aerosols) into the upper atmosphere;
- **Marine cloud brightening**, which aims to limit the effects of climate change by spraying small particles, such as sea salt, into the air over the oceans, to make clouds brighter;
- **Space-based geoengineering**, which aims to limit the effects of climate change by putting a giant mirror or other reflective material in outer space between the Earth and the sun;
- **Afforestation and reforestation**, both aim to limit the effects of climate change by planting trees;
- **Soil carbon sequestration**, which aims to limit the effects of climate change by changing agricultural techniques to store more carbon dioxide in soils;
- **Marine biomass and blue carbon**, both aim to limit the effects of climate change by improving how much carbon dioxide is stored in the oceans;
- **DACCS**, which aims to limit the effects of climate change by using very large fans to remove carbon dioxide from the air;
- **BECCS**, which aims to limit the effects of climate change by growing and harvesting plants as a source of energy and then storing the emissions permanently in rocks or underground reservoirs;

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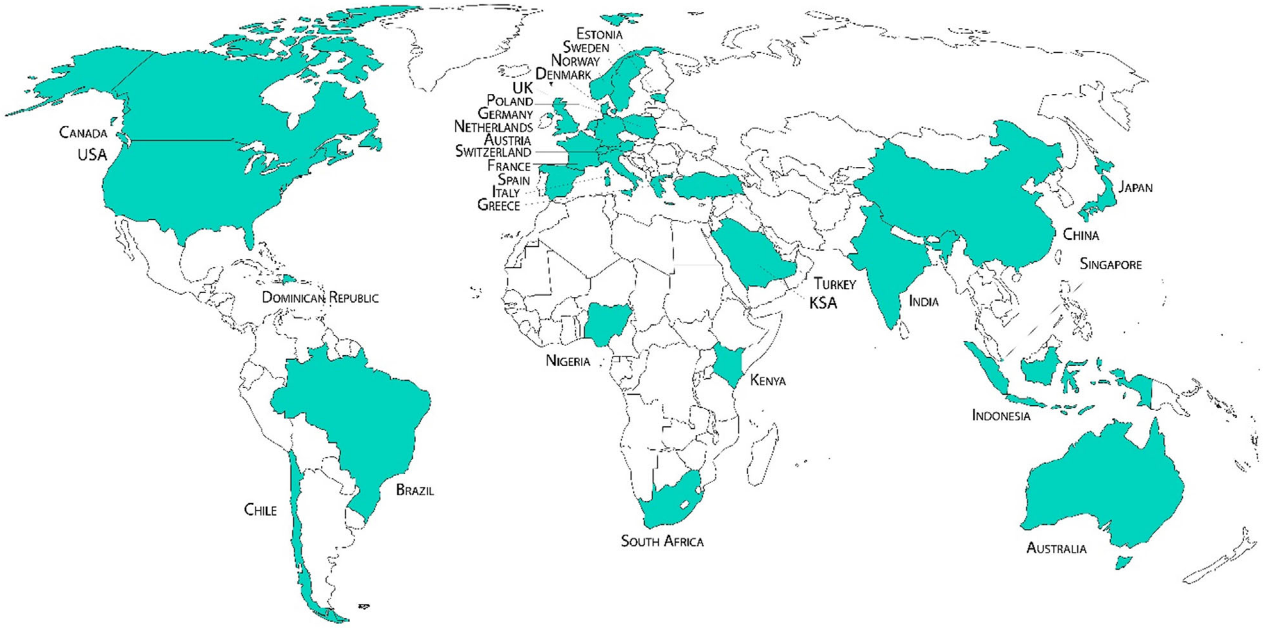

FIGURE 1 **Geographic representation of 30 countries surveyed on climate-intervention technologies**. Nationally representative surveys of support for climate intervention in 30 countries and 19 languages (at least 1000 participants in each). Samples representative in terms of age (between 18 and 74), gender, and geographic region, and with broad quotas (equal split above and below median) for education and income; *Source*: Authors.

- **Enhanced weathering**, which aims to limit the effects of climate change by increasing the ability of rocks to absorb carbon dioxide from the atmosphere;
- **Biochar**, which aims to limit the effects of climate change by heating organic material, such as tree branches and cornstalks, inside a container with no oxygen.

2.1 | Procedure and sample

The survey of the 10 interventions was conducted online, with alternate templates designed for handheld mobile devices and desktop use, in 30 countries and 19 languages (see Table A1, and $N = 30{,}284$ participants spread evenly across the countries [Figure 1]). Countries were selected according to several criteria: to ensure representation of the global south, so far lacking in the climate-intervention literature (Baum et al., 2024a; Carr & Yung, 2018; Contzen et al., 2024; Hussain et al., 2024; Sugiyama et al., 2020; Visschers et al., 2017); to engage small island (developing) states (Dominican Republic and Singapore), given the severity of climate threats and damages in these countries; and to include countries where research, trials, or deployment into climate-intervention technologies is ongoing (e.g., Low et al., 2022).

Data collection was administered online, from August to December 2022, by a professional survey firm (Norstat) using quota sampling, with prior and informed consent by all participants. Data were delivered to researchers in a de-identified and anonymized form. Having established criteria for exclusion of respondents (e.g., comprehension checks, instructed response items, and speeder checks), the sample of participants was subjected to various quality checks to produce the final dataset (Appendix 1). Further information on socio-demographic characteristics (age, gender, country region, and geographic area (e.g., urban and rural), educational attainment, household income, political views, religiosity, occupational category, and membership in ethnic minority or indigenous groups) for countries can be made available on request from authors. Though a few studies have drawn on the same global dataset (Baum et al., 2024a; Brutschin et al., 2024; Fritz et al., 2024), the relevance of climate emotions has not been examined. Moreover, since Fritz et al. (2024) investigated climate worry, though using a different analytical approach, this factor is assigned less emphasis in the current article—we ultimately decided to include it to facilitate comparisons with the climate emotions, as well as with reference studies (Hickman et al., 2021).

2.2 | Questionnaire/Dependent variables

The set of surveys aimed to investigate public perceptions and support of climate-intervention technologies using several items on risks and benefits, support for technology-related activities, items on socio-demographic factors, and covariates on climate beliefs, environmental identity, and aversion to tampering with nature. Survey materials were prepared in English and then translated (by professional translators contracted by Norstat) into localized forms of the language(s) most often spoken in the target countries. Further information on survey procedure, including issues of translation, can be found in Appendix 1 (see also Baum et al., 2024a).

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2.2.1 | Information on climate-intervention technologies

Full information texts for the background information given to all participants and information texts on each technology (grouped into three categories) are presented in Appendix 1 (Figures A1 and A2). This background information was used to promote a cursory awareness of climate change and introduce participants to climate intervention as a potential suggestion. Crucially, this text explicitly acknowledged that adaptation and mitigation strategies were also available, to avoid the conclusion that climate intervention measures were the only ones available.

Individuals were then randomly assigned to read about three or four technologies (presented in randomized order) in one of the categories: SRM; engineered CDR; ecosystems-based CDR. We opted for this approach so participants would have to jointly evaluate multiple technologies that were broadly similar, thereby reducing cognitive load. Each information text followed the same format, starting with a broad description of how they would (or do) work, more detail on potential benefits, followed by prospective risks or limitations. Our aim, given the anticipated novelty of most options, was to offer a balanced presentation of risks and benefits so individuals could draw their own inferences. Texts were constructed to explain how technologies function, rather than give a detailed account of risks and benefits—and thus avoid "hint of risk" or other priming effects (Gregory & Lichtenstein, 1994; Satterfield et al., 2023). To ensure a systematic approach for designing information texts, we oriented these around, for example, the negative impacts listed in Fuss et al. (2018), with one socio-economic and one environmental risk—the same was done for SRM options. Moreover, all texts were accompanied by graphics designed (by a professional designer) in the same style to ensure consistency in terms of quality and tone.

Two comprehension-check questions followed the information texts. Next, we asked questions relating to perceptions of risks and benefits and support for climate-intervention technologies. After these came questions about climate emotions as well as covariates, including climate and environmental beliefs. The survey concluded with socio-demographic questions.

2.2.2 | Independent variables: Emotions toward climate change

To assess emotions toward climate change, we drew on validated scales from the literature on climate change and, if possible, climate intervention. We used the four-item scale on *affect related to climate change* by Feldman and Hart (2021) and one item on *worry over climate change* by Steentjes et al. (2017). These emotions were identified as those most discussed in relation to climate change as well as offering insight into potential diversity in emotional experience in this context. A*ffect related to climate change* (1–5 scale, 1 = Not at all, 5 = Extremely) consists of four items on discrete emotions: hopeful, afraid, angry, and sad. Individuals were asked how much they felt "each of these emotions when thinking about climate change." Individuals were also asked about their *worry over climate change* (1–5 scale, 1 = Not at all worried, 3 = Somewhat worried, 5 = Extremely worried, with a "don't know" option). Although a type of emotion with cognitive and affective components, we examined worry with its affective counterparts given its wide use to understand climate-intervention perceptions (Braun et al., 2018; Campbell-Arvai et al., 2017; Merk et al., 2019; Pidgeon & Spence, 2017; Sweet et al., 2021).

2.2.3 | Dependent variables: Technology support and perceived balance of benefits and risks for climate intervention

Two different dependent variables were employed for multiple linear regression analyses. First, we examined *technology support* for each CDR and SRM option (1–5 scale: 1 = Strictly reject, 3 = Neither reject nor support, 5 = Fully support, and a "don't know" option). This measure was assessed using three questions about support for different activities: "How much do you support further research (e.g., through modeling of effects on climate and lab experiments)?"; "How much do you support small-scale field trials?"; "How much do you support the broader deployment to limit the effects of climate change?" Items always appeared in this order, whereas the order of technologies was randomized. These questions were adapted from Pidgeon and Spence (2017) and Jobin and Siegrist (2020), along with a new item distinguishing support of small-scale field trials. Because the three types of support were strongly correlated (Spearman's $\rho > 0.95$), we constructed a composite measure by taking their average. Principal component analysis (varimax rotation) extracted one factor for all technologies; reliability was also more than sufficient: Cronbach's α (for all technologies) > 0.90.

The second set of dependent variables was the *perceived balance of benefits and risks* of each CDR and SRM option (1–5 scale: 1 = Risks far outweigh the benefits, 2 = Risks slightly outweigh the benefits, 3 = Benefits and risks are about the same, 4 = Benefits slightly outweigh the risks, 5 = Benefits far outweigh the risks). Participants were asked to make a summary evaluation of the technologies, responding to the question: "Which of these statements best reflects your own view on the balance of the potential risks and benefits?" This item was adapted from Pidgeon and Spence (2017) as well. We also conducted regression analysis regarding the importance of climate emotions for a set of international and domestic policies relevant for CDR and SRM. Since the standardized effects are relatively small, we decided to remove this analysis from the main text (see Appendices 6 and 7).

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2.3 | Analysis

Data were analyzed using SPSS v28.0. We conducted descriptive statistical analysis, including frequency distributions and correlation analysis (Spearman's ρ). Nonparametric testing is used, given the non-normality of variables, to test for significant pairwise and group-wise differences. We utilized independent-samples (two-tailed) Kruskal–Wallis H tests for significant differences ($p < 0.05$) in discrete climate emotions across country cohorts. Significance values for the testing of pairwise differences were adjusted by the Bonferroni correction for multiple comparisons. Moreover, we conducted exploratory analysis in the form of a series of multiple linear regressions to examine the influence of the set of emotions on, first, support for each climate-intervention technology and, second, the perceptions of their balance of risks and benefits. Each regression included an intercept and covariates related to climate and environmental beliefs (full results in Appendix 7; details on covariates in Appendix 2). Covariates included: aversion to tampering with nature; environmental identity; perceived climate harm; science and technology as solutions to climate change; personal experience with natural disasters; and belief in climate change. We included dummy variables related to the country cohort from which a respondent originated: "developing" for developing economies in the global south or "advanced" for advanced economies in the global north, with BASIC and emerging economies as the reference category.

Finally, we examined the existence of quasi-experimental effects stemming from randomized assignment to the technology categories. We specifically tested for significant differences for each of the discrete climate emotions, depending on category assignment, using nonparametric independent samples (two-tailed) Kruskal–Wallis H testing. For the emotions where significant differences were identified, we explored pairwise differences between technology categories using independent samples (two-tailed) Kruskal–Wallis H testing, with the significance values adjusted by Bonferroni correction for multiple comparisons.

3 | RESULTS

3.1 | Descriptive statistics and correlations among climate emotions and between climate emotions and climate beliefs

3.1.1 | Descriptive statistics

On average, participants reported feeling all the emotions at least somewhat. In the ascending order of their mean values, the sample was slightly less angry ($M = 3.17$, $\sigma = 1.28$) or hopeful regarding climate change ($M = 3.17$, $\sigma = 1.28$). Being afraid ($M = 3.35$, $\sigma = 1.27$) or sad ($M = 3.47$, $\sigma = 1.24$) was more common. The most reported emotional reaction, however, was worry about climate change ($M = 3.80$, $\sigma = 1.09$)—the most common response was "Extremely worried" (32.2%). Nearly four out of five participants reported being at least "somewhat" worried about climate change.

3.1.2 | Correlations among climate emotions

Some of the affective reactions toward climate change are, unsurprisingly, correlated with one another. We identified positive and significant correlations (Spearman's $p < 0.01$) among angry, afraid, sad, and worried (Figure 2). Hopeful is an exception, which is significantly correlated (negative) with angry and sad as well as (positive) worried, but not with afraid—all correlations are relatively small.[1]

3.1.3 | Correlation between climate emotions and climate perceptions

We identified strong relationships between emotional reactions toward climate change and a variety of climate perceptions (Figure 2). The strongest correlations are present between the negatively valenced reactions (afraid, angry, sad, and worried) and perceptions of climate harm, environmental identity, experience with natural disasters, and aversion to tampering with nature. All correlations are positive and significant, indicating a closer relationship to nature or being more directly impacted by climate change engenders negative affective responses. Curiously, we identify positive and significant correlations between being hopeful toward climate change and these factors as well, but such correlations are consistently smaller. "Hopeful" is found to correlate more strongly with belief in science and technology as a solution to climate change and be inversely correlated with beliefs that climate change exists.

3.2 | Mapping of climate emotions across countries

Clear differences in climate emotions emerged across countries. Looking at the country-level means, we can identify both a degree of heterogeneity and the greater preponderance of certain emotions in specific regions (Figure 3, Table 1; see Figure A2 for worry). Starting with hope about climate change, the most "hopeful" countries were generally developing economies in the global south, or BASIC, and emerging economies. Such countries, only 12 out of 30,

[1] We examined correlations between the climate emotions and socio-economic and demographic variables (age, geographic region, educational attainment, household income, political views, and level of religiosity). Because the size of the correlations was rather small (i.e., $\rho < 0.1$) and there is little variation in the direction of effects across emotions, we opt to focus on the other relationships. We do highlight the relatively strong (positive) correlation between being hopeful and having a higher level of religiosity ($\rho = 0.331$) and more conservative political views ($\rho = 0.171$). Being worried about climate change is positively correlated with higher religiosity ($\rho = 0.189$).

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	Hopeful	Afraid	Angry	Sad	Worried	Aversion to tampering with nature	Environmental identity	Perceived Climate harm	Experience with Natural disasters	Science and tech as solution	Belief in climate Change (Yes)	Belief in climate Change (Yes but)	Belief in climate Change (No)
Hopeful	X	0.00	**-0.04**	**-0.05**	**0.10**	**0.05**	**0.24**	**0.12**	**0.11**	**0.34**	**-0.05**	**0.07**	**-0.03**
Afraid	0.00	X	**0.55**	**0.60**	**0.56**	**0.19**	**0.28**	**0.48**	**0.20**	**0.08**	**0.23**	**-0.17**	**-0.15**
Angry	**-0.04**	**0.55**	X	**0.62**	**0.48**	**0.23**	**0.30**	**0.39**	**0.18**	**0.03**	**0.23**	**-0.19**	**-0.12**
Sad	**-0.05**	**0.60**	**0.62**	X	**0.51**	**0.20**	**0.31**	**0.41**	**0.18**	**0.03**	**0.26**	**-0.20**	**-0.15**
Worried ("don't know" coded as missing)	**0.10**	**0.56**	**0.48**	**0.51**	X	**0.23**	**0.46**	**0.62**	**0.27**	**0.18**	**0.32**	**-0.24**	**-0.20**

FIGURE 2 **Correlations (Spearman's ρ) among and between climate emotions and other factors**. Bold font indicates significance at $p < 0.05$. Colors become golden orange as correlations become more strongly positive and bluer when more strongly negative. ATNS stands for aversion to tampering with nature.

TABLE 1 Significant differences ($p < 0.05$) in climate emotions among country cohorts. Standard deviations are in parentheses.

	Developing economies/global south ($N = 3016$)	**BASIC/Emerging economies ($N = 9091$)**	**Advanced economies/global north ($N = 18{,}177$)**
Hopeful	3.83[a] (1.16)	3.57[b] (1.23)	2.90[c] (1.15)
Afraid	3.53[b] (1.32)	3.64[a] (1.26)	3.18[c] (1.23)
Angry	3.03[c] (1.37)	3.33[a] (1.29)	3.12[b] (1.25)
Sad	3.42[b] (1.32)	3.59[a] (1.26)	3.42[b] (1.21)
Worried ("don't know" coded as missing)	4.11[a] (0.96)	4.09[a] (0.99)	3.60[b] (1.11)

Note: Responses for "Hopeful," "Afraid," "Angry," and "Sad" on a 1–5 scale (1 = not at all, 5 = extremely) to the question "How much do you feel each of these emotions when thinking about climate change?". Ordering of items was randomized. Responses for "Worried" on a 1–5 scale (1 = not at all worried, 5 = extremely worried) to the question "How worried, if at all, are you about climate change, sometimes referred to as 'global warming'?". Individuals could also select "don't know"; this was coded as missing data. Different letters denote significant pairwise differences ($p < 0.05$) between the country cohorts for a given emotion, according to independent-samples Kruskal–Wallis H test analysis, with significance valued adjusted by Bonferroni correction for multiple comparisons. For instance, if different letters appear in all columns, then all country cohorts significantly differ for the emotion—with "a" denoting the one highest in that emotion. If the same letter appears in two columns, there is no significant difference between these country cohorts. Means (rather than mean ranks, on which tests are based) reported. Full details on significance testing in Appendix 5.

occupied 11 of the 12 most hopeful: Indonesia ($M = 4.13$), Nigeria ($M = 3.96$), and India ($M = 3.94$). The one representative from the global north was the United States ($M = 3.46$), whereas European countries ranked among the least hopeful—notably, those in western and northern Europe like Germany ($M = 2.56$), Austria ($M = 2.58$), and Sweden ($M = 2.60$).

Conversely, regarding being angry or sad about climate change, we observe a similar pattern, where these emotions are more reported by those in countries more exposed and vulnerable to climate change. For anger, participants in the three southern European countries of Spain ($M = 3.70$), Italy ($M = 3.70$), and Greece ($M = 3.67$) reported the strongest emotions here, followed by a cluster of emerging economies: Chile ($M = 3.59$), Turkey ($M = 3.55$), Indonesia ($M = 3.46$), India ($M = 3.44$), and Brazil ($M = 3.38$). Most of these same countries were among those expressing sadness about climate change, that is, Greece ($M = 3.92$), Indonesia ($M = 3.90$), Italy ($M = 3.87$), and Spain ($M = 3.84$). At the bottom end of the range, however, there are several countries in Northern Europe (specifically, Scandinavia), along with the United States and the Netherlands.

When it comes to being afraid and/or worried about climate change, we again observe that it is advanced economies

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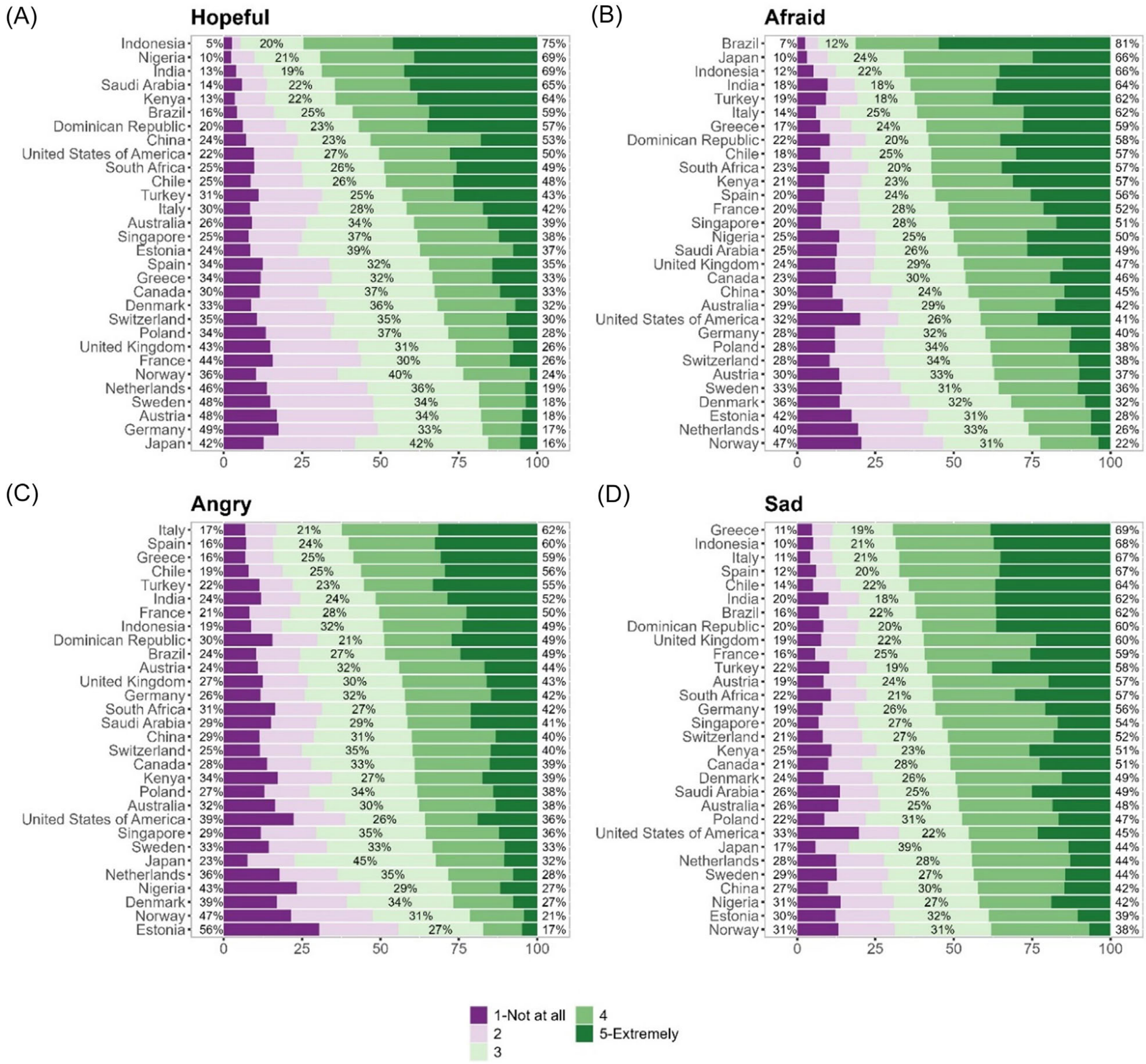

FIGURE 3 **Emotions about climate change (hopeful, afraid, angry, and sad) across 30 countries**, on a 1–5 scale (1 = not at all, 5 = extremely) with $N = 30{,}284$ participants (at least 1000 participants in each country); Numbers to the left reflect those answering "1" or "2," in the middle "3," and to the right "4" or "5." Panel (a) shows the results for "hopeful"; Panel (b) for "afraid"; Panel (c) for "angry"; and Panel (d) for "sad".

in the global north at the lower end of the range—particularly those in Scandinavia (Norway, Sweden, and Denmark), on the Baltic Sea (Estonia and Poland), and the Netherlands. Expressing both the greatest degree of fear ($M = 4.27$) and worry ($M = 4.37$) about climate change were the participants in Brazil—indeed, in terms of being afraid, Indonesia was a distant second ($M = 3.84$), such that the Brazilians in the sample stand out in this regard. Other countries ranking highly in both emotions included BASIC and emerging economies across the world (such as Turkey, India, Chile, and Indonesia), developing economies in the global south (Dominican Republic and Kenya), and Southern European countries (Spain, Italy, and Greece).

Independent-samples (two-tailed) Kruskal–Wallis testing determined that there were significant differences ($p < 0.001$) by country cohort for all climate emotions (details on significance testing in Appendix 5). Those in developing countries in global south were significantly more hopeful, and those in the advanced economies the least hopeful. Those in advanced economies expressed significantly less fear, sadness, and worry than other cohorts—the level of sadness expressed was similar in advanced and developing economies. Anger was the only emotion more weakly expressed by another cohort: developing economies. Otherwise, those in emerging economies expressed the strongest feelings of anger, fear, sadness, and worry—developing economies were worried

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to a similar extent (see Table A2, Appendix 4 for cohort differences for the covariates).

3.3 | Regression analysis of the influence of discrete climate emotions on perceptions and support of climate interventions and support for climate-intervention policies

We conducted a series of multiple linear regressions to understand how the strength of climate emotions is (diversely) related to perceptions and support of climate-intervention technologies. Reflecting our focus on the interrelationships among climate emotions and climate perceptions, these variables are included as covariates in the regression analysis; the results are not reported here (see Appendix 7 for full regression results). Looking at Table 2, we identified that being hopeful or worried about climate change is consistently positively and significantly related to support for all climate-intervention options. The one exception for hopeful relates to support for afforestation, which is not significant—the effect of being worried on support for this option is also the lowest. In contrast, being afraid was positively related to support, but only for SRM and engineered CDR categories—this effect is also rather smaller. Being angry, if significant, is negatively related to support—but only for ecosystems-based CDR options, BECCS, and biochar. Being sad is positively related to support for ecosystems-based CDR and biochar; this emotion was, however, negatively related to support for space-based geoengineering. Accordingly, it is the only one of the climate emotions that relates to support for climate-intervention options in both a positive and negative direction.

Focusing on the technology categories, climate emotions assume different roles. Being more hopeful, afraid, or worried is consistently related to higher support for SRM or engineered CDR options. Regarding ecosystems-based CDR, being afraid fails to have a significant relationship. In contrast, being sad about climate change is (positively) related to this category, whereas being angry is negatively so. These two emotions (angry, sad) have a less consistent (but more often negative) relationship with support for SRM and engineered CDR options.

3.4 | Climate emotions vis-à-vis perceived risks and benefits of climate intervention technologies

Next, we repeated the set of multiple linear regressions with the perceived balance of benefits and risks as the dependent variable. Though this variable is strongly correlated with support of all technology options (Spearman's $\rho \geq 0.45$), it was important to consider how strength of climate emotions was related to such perceptions. In fact, prior research on public perceptions of SAI indicates that determinants can have a more divergent influence on the perceived balance of bene-

TABLE 2 Standardized coefficient estimates for climate emotions vis-à-vis support for 10 climate-intervention options.

	Stratospheric aerosol injection	Marine cloud brightening	Space-based geoengineering	Afforestation reforestation	Soil carbon sequestration	Marine biomass and blue carbon	Direct air capture	BECCS	Enhanced weathering	Biochar
Global mean	3.33	3.50	3.40	4.43	4.16	4.13	3.73	3.73	3.48	3.85
Hopeful	**0.126**	**0.112**	**0.129**	0.018+	**0.049**	**0.053**	**0.121**	**0.116**	**0.129**	**0.096**
Afraid	**0.041**	**0.047**	**0.052**	−0.012	0.002	0.006	**0.055**	**0.034**	**0.043**	**0.046**
Angry	−0.012	−0.019	0.021+	**−0.040**	**−0.031**	**−0.027**	−0.013	**−0.028**	−0.010	**−0.039**
Sad	−0.010	0.006	**−0.044**	**0.056**	**0.035**	**0.043**	0.001	0.019	−0.023+	**0.045**
Worried	**0.109**	**0.099**	**0.087**	**0.036**	**0.077**	**0.091**	**0.087**	**0.071**	**0.056**	**0.056**

Note: "+" reflects coefficient estimates significant at a level of $p < 0.10$. Responses to the dependent variable (*technology support*) on a five-point scale (1 = strictly reject, 3 = neither reject nor support, 5 = fully support, with "don't know" option) were combined into a single factor for the three items on support. Multiple linear regressions also included the set of covariates (and intercept). Full regression results, one for each of the ten technologies, can be found in Appendix 7. As a robustness check, we ran a series of generalized estimating equations (GEEs), one for each technology, where participants were nested at country level and with a normal distribution with an identity link function along with an exchangeable structure for the working correlation matrix (Contzen et al., 2024; Horton & Lipsitz, 1999). Results were substantially unchanged in terms of the size of coefficient estimates and findings of significance. As such, we retain the linear regression results with confidence. Bold font indicates that an effect is significant ($p < 0.05$). Positively significant effects shaded in blue; negatively significant effects in orange.

Abbreviation: BECCS, bioenergy with carbon capture and storage.

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fits and risks than support (Baum et al., 2024a). Comparing Tables 2 and 3, we could identify several points of divergence, notably related to the effect of being angry and sad about climate change. Being angry only has a significant (positive) relationship with the positive balance of benefits and risks of enhanced weathering. Being sad is significantly related, always negatively, to three options: SAI, space-based geoengineering, and enhanced weathering. More generally, the extent to which the strength of climate emotions is significantly related to perceived benefits and risks of climate-intervention options is reduced compared to support. Being hopeful, for instance, is no longer significantly related to perceptions of two ecosystems-based CDR options—and for afforestation and reforestation, the relationship is in the opposite direction. The strength of fear toward climate change is also negatively related to positive perceptions of two ecosystem-based CDR options—this relationship is strongest for afforestation. At the same time, being afraid is positively related to perceptions of two SRM options: SAI and marine cloud brightening. And finally, although being worried about climate change is significantly (positively) related to support for all options, this emotion is not significant for perceptions of risks and benefits for four (of seven) CDR options: afforestation, soil carbon sequestration, enhanced weathering, and biochar. For perceptions of afforestation, climate emotions (hopeful, afraid), where significant, are negatively relevant. No emotion is found to be significantly related to perceptions of benefits and risks for soil carbon sequestration.

3.5 | Quasi-experimental effects of randomized technology category assignment on discrete climate emotions

Having randomly assigned participants to receive information on one technology category, we examined whether being informed about one category versus another influenced one's affective reactions toward climate change (Table 4). It has been surmised that learning about potential solutions to climate change could impact how one perceives the problem (e.g., McLaren, 2016).

Independent-samples (two-tailed) Kruskal–Wallis testing found significant differences between technology categories vis-à-vis being hopeful ($H(2) = 43.740$, $p < 0.001$) or worried ($H(2) = 6.492$, $p = 0.039$). No significant differences for being afraid ($H(2) = 1.715$, $p = 0.424$), angry ($H(2) = 2.869$, $p = 0.238$), or sad ($H(2) = 2.908$, $p = 0.234$) could be identified.

We then investigate pairwise differences between technology categories for the emotions where significant differences could be identified—adjusting significance values using the Bonferroni correction for multiple comparisons. Starting with hope, we establish that those reading about ecosystems-based CDR reported being the most hopeful about climate change, whereas those who received information about SRM were the least hopeful: ecosystems-based CDR versus SRM, $H = 784.196$, $Z = 6.548$, $p < 0.001$; engineered CDR versus

TABLE 3 Standardized coefficient estimates for climate emotions vis-à-vis the perceived balance of benefits and risks for 10 climate-intervention options.

	Stratospheric aerosol injection	Marine cloud brightening	Space-based geoengineering	Afforestation reforestation	Soil carbon sequestration	Marine biomass and blue carbon	Direct air capture	BECCS	Enhanced weathering	Biochar
Global mean	2.71	2.89	2.76	3.87	3.59	3.52	3.11	3.10	2.86	3.25
Hopeful	**0.081**	**0.076**	**0.069**	**−0.036**	−0.011	0.002	**0.045**	**0.053**	**0.065**	**0.030**
Afraid	**0.045**	**0.045**	0.017	**−0.079**	-0.026^{+}	**−0.036**	0.011	−0.006	0.022	−0.003
Angry	0.020	0.011	0.020	0.008	−0.005	−0.001	−0.009	−0.010	**0.030**	−0.014
Sad	**−0.050**	−0.022	**−0.036**	0.023	0.011	0.026^{+}	−0.007	−0.018	**−0.070**	0.019
Worried	**0.084**	**0.078**	**0.073**	−0.004	0.029^{+}	**0.053**	**0.058**	**0.059**	0.020	0.022

Note: "+" reflects coefficient estimates significant at a level of $p < 0.10$. Responses to the dependent variable (*perceived balance of benefits and risks*) on a five-point scale (1 = Risks far outweigh the benefits, 3 = Benefits and risks are about the same, 5 = Benefits far outweigh the risks) to the question, "Which of these statements best reflects your own view on the balance of the potential risks and benefits?". Multiple linear regressions included the set of covariates (and intercept). Full regression results, one for each of the 10 technologies, can be found in Appendix 7. Bold font indicates that an effect is significant ($p < 0.05$). Positively significant effects shaded in blue; negatively significant effects in orange.
Abbreviation: BECCS, bioenergy with carbon capture and storage.

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TABLE 4 Significant differences ($p < 0.05$) in climate emotions resulting from randomized assignment of information about ecosystems-based carbon dioxide removal (CDR), engineered CDR, or solar radiation modification (SRM). Standard deviations are in parentheses.

	Ecosystems-based CDR (1) (N = 10,105)	Significant difference	Engineered CDR (2) (N = 10,095) (1) vs. (2)	Significant difference (2) vs. (3)	SRM (3) (N = 10,084)	Significant difference (1) vs. (3)
Hopeful	3.25 (1.22)	*	3.21 (1.24)	*	3.14 (1.23)	*
Afraid	3.36 (1.26)		3.34 (1.28)		3.36 (1.27)	
Angry	3.19 (1.28)		3.16 (1.29)		3.17 (1.27)	
Sad	3.49 (1.23)		3.46 (1.25)		3.46 (1.24)	
Worried	3.83 (1.08)		3.79 (1.10)		3.79 (1.09)	

Note: Responses for "Hopeful," "Afraid," "Angry," "Sad" on a 1–5 scale (1 = not at all, 5 = extremely) to the question "how much do you feel each of these emotions when thinking about climate change?". Ordering of items was randomized. Responses for "Worried" on a 1–5 scale (1 = not at all worried, 5 = extremely worried) to the question "how worried, if at all, are you about climate change, sometimes referred to as 'global warming'?". Individuals could also select "don't know"; this was coded as missing data. Asterisks denote significant pairwise differences ($p < 0.05$) between technology categories, according to independent-samples Kruskal–Wallis H test analysis, with significance values adjusted by Bonferroni correction for multiple comparisons. Means (rather than mean ranks, on which the tests are based) are reported.

SRM, $H = 488.803$, $Z = 4.081$, $p < 0.001$; ecosystems-based versus engineered CDR, $H = 295.393$, $Z = 2.467$, $p = 0.041$.

Regarding being worried about climate change, we could not find evidence for any significant differences once we applied the Bonferroni correction for multiple comparisons: ecosystems-based CDR versus SRM, $H = 270.002$, $Z = 2.299$, $p = 0.065$; engineered CDR versus SRM, $H = 23.330$, $Z = 0.199$, $p = 1.00$; ecosystems-based versus engineered CDR, $H = 246.672$, $Z = 2.100$, $p = 0.107$. There may be (group-wise) differences in how worried individuals report being about climate change, but these are small enough to not be robust to the Bonferroni correction.

4 | DISCUSSION AND CONCLUSION

Drawing on a unique, global-level dataset ($N = 30{,}284$ across 30 countries, in 19 languages), the relationships between climate emotions and the perceptions and support of climate-intervention technologies are explored for the first time. Benefitting from the global-level dataset, our most direct contribution is to give insight into the broad incidence of climate emotions (fear, hope, anger, sadness, and worry) in advanced, emerging, and developing countries. These results are the first, to our knowledge, to provide insights on such a scale of climate emotions for adults. A global study by Hickman et al. (2021) identified sad, afraid, anxious, and angry as the most reported emotions among young adults. Among adults, we identified that feelings of sadness were relatively stronger, followed by afraid and angry (Table 1; see also Appendix 3)—worry had the highest mean, but it should be noted that this excluded those participants (0.95% of the total sample) who answered "don't know."

Given the representation of advanced, emerging, and developing countries in our sample, we examined significant differences in the emotional experiences of the participants within these cohorts (Table 1). Those in BASIC and emerging economies (Indonesia, India, Saudi Arabia, Brazil, Chile, China, South Africa, Turkey, and Singapore) related that they were the most worried (joint with developing economies), sad, angry, and afraid about climate change. Those in developing economies (Nigeria, Kenya, and Dominican Republic) said they were the most hopeful about climate change—and disparities across the cohorts were the greatest for this emotion. In total, these results illustrate the divergence of climate emotions at a global level and, crucially, the adverse impacts of not engaging with diverse perspectives on climate change (and proposed solutions) in the global south (IPCC, 2023; Lawrance et al., 2022, 2024). Saliently, this reveals, regarding anger and sadness about climate change, that such emotions appear stronger in the countries more exposed and vulnerable—the strength of such emotions reported by Southern European countries (Spain, Italy, and Greece) is telling in this respect (see Table A2, Appendix 4).

And yet, nuance also emerges once we engage with those across the global south. Interestingly, one of the countries in which the lowest levels of sadness ($M = 3.16$) and anger ($M = 2.72$) were reported is Nigeria—the country-level means of Kenya are also below the grand mean. This is despite both being developing economies in the global south, which are the most vulnerable to climate change in our survey (see Table A2, Appendix 4; Nigeria is also 132nd (of 185) and Kenya 144th, according to the Notre Dame Global Adaptation Index).

One implication, as these countries also ranked among the most hopeful, is the relevance of cultural expectations and norms for the expression of emotions. In the first place, this undercuts any kind of clear-cut link between objective assessments and emotional experiences of climate change. If the most hopeful when thinking about climate change (but afraid,

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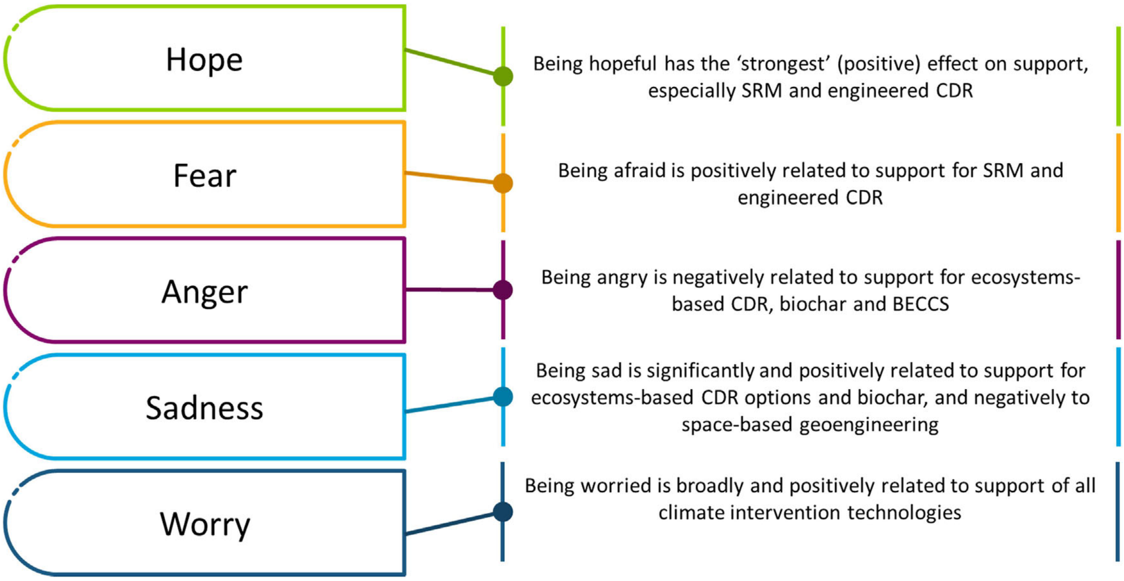

FIGURE 4 **Visualizing the complexity of climate emotions and public support for climate intervention technologies**. *Source*: Authors, based on Sections 3.1–3.4.

sad, and worried nonetheless) are also the ones most vulnerable, we urgently need a much better understanding of what sustains such hope, notably, beyond western contexts. Confronting the factual reality of climate change in the United States and similar countries is often accompanied by a "doom and gloom" narrative (Wallace-Wells, 2019) and skepticism of hope (Carrington, 2024). Survey responses outside of such contexts, however, signal a distinct relationship between hope and climate vulnerability, particularly in Africa.

The fact that hope emerges as a key predictor of support for climate intervention is also indicative of its deeper, mostly unexplored role—further buttressed by countries in the global south appearing more supportive of climate intervention (Baum et al., 2024a, 2024b; Contzen et al., 2024; Hussain et al., 2024; Sugiyama et al., 2020; Visschers et al., 2017). In contrast to some approaches being dismissed as offering "false hope" (McLaren, 2016; Preston, 2013), it might be that western-centered understandings of hope are insufficient. More research into the emotional contours of climate change—of a qualitative, contextually deep character in a non-western context—and their relationship to perceptions and support of climate intervention is thus greatly needed.

Turning to the predictive value of climate emotions for support of climate intervention, we used a set of multiple linear regression analyses to provide comparative insights, at global level, for the first time in the literature. Accordingly, the current research is the first that could reveal the relative effects of discrete climate emotions (fear, hope, anger, sadness, and worry), which we also summarize in Figure 4. The strongest effects were identified for those more hopeful or worried about climate change, each broadly positively related to support for climate intervention (Table 2). The finding that being worried about climate change corresponds to greater support reflects this emotion's tendency to focus attention on potential threats and its positive influence on climate action in general (Marczak et al., 2023; Sangervo et al., 2022; Whitmarsh et al., 2022). Those more hopeful about climate change tended to be more supportive precisely for SRM and engineered CDR categories. Given the relevance of hope for evading unwanted outcomes (Geiger et al., 2023; Nabi et al., 2018; Ojala, 2012, 2023), this suggests the more technical options may be viewed as more efficacious among the more hopeful.

Indeed, the standardized effects of hope on support were consistently among the highest of the variables considered for SRM and some engineered CDR options (Appendix 7). We underline this finding given that the effects of hope (and the other emotions) represent its influence after controlling for the set of covariates on climate and environmental beliefs. Indeed, *science and technology as solution* is the only variable whose standardized effect was consistently stronger, whereas, for many technologies, *aversion to tampering with nature* and *belief in climate change* had greater or proximate effects as well—*environmental identity* exercised a particularly strong impact on ecosystems-based CDR, BECCS, and biochar. The fact that the set of emotions, and hope in specific, is significantly related to support for and perceptions of climate interventions, even after controlling for such factors, demonstrates their relevance in this context. It could be, in fact, that controlling for these covariates in our regression analyses risks understating the role of climate emotions. We decided to include the covariates to minimize the potential for omitted variable bias, given the inter-relationships among these factors (see Figure 2). Further research is in any case worthwhile to more fully establish the importance of climate emotions.

As evidenced by the climate engagement literature (Geiger et al., 2023; Ojala, 2023), the sources of hope are central. We

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indeed found (using further nonparametric Kruskal–Wallis *H* testing for group-wise comparisons) significant differences in levels of hope, depending on one's belief in climate change. Most hopeful are those espousing the (incorrect) belief that natural processes are more impactful than human activities ("Yes, but"; $M = 3.33$), followed by those who fully acknowledged climate change ("Yes"; $M = 3.17$). Those denying climate change were the least hopeful ("No" or "don't know"; $M = 3.02$). Thus, the most hopeful are those somewhat in doubt of anthropogenic climate change—not denying it exists at all. The proportion of participants with such beliefs of "climate delay" (Lamb et al., 2020) in our sample was sizable ($N = 8237$, 27.2%) and spread evenly across countries, never falling below 20%. Again, such findings highlight the need to closely excavate the sources of hope, including how the sources interrelate with support for climate intervention. Given our focus on climate emotions in the present study, we were not able to examine such questions, also not in a way that directly centered the relationship between emotional responses and support for climate intervention.

Still, our results indicate it could be more productive to move beyond debates of whether a given technology portends "false hope" on its own. Instead, future research could examine hope, in its diverse forms, as the product of the interaction between technology and individuals, notably their beliefs and experiences with climate change. Similar to how discussions of hope and climate change have become richer (Geiger et al., 2023; Marlon et al., 2019; Ojala, 2023), such a change would enable an understanding of how and why certain technologies prompt individuals to become more (or less) hopeful, as well as the extent to which this undercuts motivation and support for climate mitigation more broadly.

The other discrete emotions (afraid, angry, and sad) prove not to be as broadly and deeply impactful as hopeful (or worried) for support of climate-intervention technologies. Importantly, however, the divergent directions and patterns of their effects offer further evidence for the distinct roles and "signatures" of climate emotions (Myers et al., 2024). Being afraid, for example, is broadly positively related to support for climate-intervention technologies, though with a smaller effect than hopeful or worried, and just for the SRM and engineered CDR categories. Together with hope and worry, this suggests that fear, and its desire for protective action (Smith & Ellsworth, 1985), is positively linked to support for more controversial forms of climate intervention. The significant findings of being afraid (and other emotions) are also present after controlling for the covariates, including perceived climate harm and personal experience with natural disasters (Table 2, see also Appendix 7). Hence, the emotionality of climate change signifies a separate, added impact to these rather more objective aspects of climate harm and vulnerability.

Being angry, however, exerts a significant, exclusively negative effect on support, but only for ecosystems-based CDR and two engineered CDR options (biochar, BECCS). Considering what they have in common, all are similar in their requirements for land (or ocean) use—such options are broadly also those with which the typical individual may be most familiar. As such, we might surmise that anger, owing to its external assignment of blame and desire to seek retribution (Sabherwal et al., 2021; Stanley et al., 2021), could lead to their being singled out as insufficient to address climate change, acting as a stand-in for the status quo. Insofar as the consequences of such activities may be easier to visualize, due to their familiarity and use requirements, this could also explain why anger about climate change is more closely (and inversely) related to support.

Being sad, lastly, is significantly and positively related to support for ecosystems-based CDR options (and biochar) and negatively to support for space-based geoengineering. Tying this to sadness and its desire for restoration (Myers et al., 2024), it makes sense that it is exactly options more firmly grounded in ecosystems that would be involved. These results make evident how the role of climate emotions depends on the emotion in question and the climate-intervention technology being investigated.

Comparing the influence of climate emotions on support vis-à-vis perceived benefits and risks, there are several points of divergence, though it is generally true that climate emotions have a reduced relationship to the latter (Tables 2 and 3). This is reflected through the prevalence of insignificant results in Table 3 and because standardized effects are nearly uniformly smaller. Although hopeful or worried remain the emotions most significant for perceived benefits and risks—again, mostly for SRM and engineered CDR categories—anger has a limited effect. Recall anger, where significant, had an exclusively negative relationship with support. Such a reversal in the direction of the effects, while unexpected, is also apparent for sad and, somewhat, afraid. Notably, being afraid was mostly positively related to SRM perceptions and negatively so for ecosystems-based CDR. It is not entirely clear why the relevance of climate emotions should deviate so much for perceived risks and benefits versus support—the measures are quite highly correlated (Spearman's $\rho \geq 0.45$ for all technologies). One possibility might be that individuals' perceptions of benefits and risks are linked to evaluations of the technologies, whereas expressions of support encompass a broader range of factors (Baum et al., 2024b). Closer consideration of the manifold roles of discrete climate emotions in this space would therefore be of interest.

Finally, making use of the random assignment of participants to the technology categories, we analyzed if being informed about SRM or CDR had a differential effect on climate emotions. Such differences were only confirmed (for group-wise comparisons of technology categories) for hopeful and worried—significant pairwise differences for levels of worry could not, however, be confirmed. Participants who read about ecosystems-based CDR options were more hopeful about climate change than those assigned to other categories; those reading about SRM were less hopeful overall. We had intended to see if reading about one of the technology categories (e.g., SRM) had a differential impact on the strength of climate emotions, notably, providing reason for individuals to report being more hopeful (McLaren, 2016; Preston, 2013). We found no evidence of this kind,

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however. If anything, reading about SRM appeared to have an adverse impact on how hopeful individuals were about climate change.

However, the quasi-experimental effects of information were generally small: the differences (for hope) amounted to, at most, 0.11 between ecosystems-based CDR and SRM (on a 1–5 scale). Indeed, the fact that receiving SRM information resulted in individuals being less hopeful is at odds with the positive relationships between the two emotions and support for and perceptions of SRM (and engineered CDR) options (see Tables 2 and 3). One possible explanation may be that emotions differed in their responsiveness to the information provided. For instance, as reading about ecosystems-based CDR rendered individuals more hopeful, maybe the greater familiarity of these options mattered. That is, texts on more familiar options were easier to grasp, making it more straightforward to affect emotional responses. Conversely, information texts may not have been of a suitable character to affect the other emotions (afraid, angry, and sad), or a short survey was inadequate to engender any such effect. In the end, the limited nature of the results suggests that they are best understood as a manipulation check on how climate-intervention information differentially affected the climate emotions (or not).

The contributions of the current research to the understanding of climate emotions and climate intervention need to consider some limitations. First, the explanatory power of the regression analysis is not particularly high, with the (adjusted) R-squared of the models for support of the technologies never above 0.23—the values were lowest for the ecosystems-based CDR options and lower overall in the models for perceived balance of benefits and risks (see Appendix 7). Maybe this reflects the unfamiliarity of most climate-intervention technologies; if so, this may change in the future—such unfamiliarity is itself a crucial limitation, as it means that responses to the survey could reflect "pseudo-opinions" that are not well-informed or highly malleable to further information and experience (Bishop et al., 1980; Fischhoff & Fischhoff, 2002). Caveats aside, our models reveal climate emotions have less explanatory power regarding perceptions and support of climate intervention versus climate mitigation and environmental behaviors (Brosch, 2021; Geiger et al., 2023; Myers et al., 2023; Smith & Leiserowitz, 2014). This reinforces the need for further research building on our exploratory analyses of climate emotions and climate intervention, as these options become more widely discussed in the media and among publics.

Regarding the measures we employed for climate emotions, we reiterate that this is the first time emotions have been measured this way in the (nascent) literature on climate interventions—though common in the wider climate literature. Hence, we adopted a broad notion of emotions for our analysis, rather than distinguishing between constructive and false forms of hope (Marlon et al., 2019; Ojala, 2023). Such distinctions would, however, be interesting for future research on the emotionality of climate interventions. Similarly, we decided to focus on a core set of emotions representing those featured most in the literature (or popular media). Future research should nonetheless consider a wider palette of emotions: guilt and powerlessness, for instance, would also seem relevant to perceptions of climate intervention.

As a final point, we also adopted validated measures that had been used to examine emotions in other contexts, such as climate change. Accordingly, this led to some differences between worry and the other emotions in terms of the wordings of the question and the set of responses: Notably, worry alone had a "don't know" option. Though less than 1.0% of respondents selected this response (N = 292, of a total of 30,284), the lack of such an option for the other emotions could have introduced some bias in the results. In addition, generalizability of the current results was likely influenced by the type of information presented to participants. Given the novelty of the topic, we devised the information texts to describe how technologies would work, accompanied by examples of some risks and benefits. The intention was not to give a detailed account of risks and benefits to avoid individuals echoing this information back to us. That being said, information that was principally focused on risks (or benefits) would likely have a different relationship with climate emotions. The same may also be true if details of actual projects were given, instead of a broad description of the technology. In all these respects, there are many avenues for future research to explore on the intersection between climate emotions and climate intervention.

AUTHOR CONTRIBUTIONS

The study was conceived by Chad M. Baum. The detailed design and materials were developed by Chad M. Baum, Elina Brutschin, Livia Fritz, and Benjamin K. Sovacool, with Chad M. Baum and Livia Fritz facilitating data collection. Chad M. Baum analyzed the data and wrote the article with contributions from Elina Brutschin, Livia Fritz, and Benjamin K. Sovacool. Figures and tables were developed by Chad M. Baum, with assistance from Elina Brutschin and Benjamin K. Sovacool.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the current study are not publicly available at present, given that the peer-review process is underway and out of respect for the other articles drawing on it to have the chance to clear peer review. We are in the process of making the data publicly available in full, preferably in a peer-reviewed journal. At the moment, the dataset is available from the corresponding author on reasonable request.

ORCID

Chad M. Baum https://orcid.org/0000-0002-6513-5518

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Additional supporting information can be found online in the Supporting Information section at the end of this article.

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