Support for the deployment of climate engineering: A comparison of ten different technologies

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Abstract

Due to the renewed increase in CO_2 emissions seen in recent years, the deployment of climate engineering technologies is likely to be necessary if the global temperature increase is to be kept within 1.5°C. If climate engineering is to be deployed, however, public support is required. The present study hence compared public support for a broad range of climate engineering technologies. Further, the factors that drive public support were investigated and compared across the technologies. In an online survey conducted in Switzerland, respondents (n=1575) were randomly allocated to the description of one of ten climate engineering technologies, of which seven were specific carbon dioxide removal measures and three were solar radiation management measures. The results show that the level of public support for afforestation was the highest. The levels of public support for the other climate engineering technologies were relatively similar, although a tendency for solar radiation management to have a lower level of support was identified. Across all the investigated climate engineering technologies, the perceived benefits were the main driver of public support. Additionally, for all the technologies but afforestation, a higher level of trust in industry/science/government increased the level of public support, whereas the factor perceived risks & tampering with nature was found to be a negative predictor of support. The present findings suggest that there are opportunities available for the deployment of several climate engineering technologies in combination with other mitigation measures. Focusing on the benefits of such technologies appears beneficial in terms of fostering increased support.

Keywords

Technology acceptance, climate engineering, benefit perception, trust, tampering with nature

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1 INTRODUCTION

High CO_2 emissions, as well as the fact that they are continuing to increase (Jackson et al., 2018), put climate engineering technologies on the agenda to tackle climate change, since decreasing CO_2 emissions through mitigation measures alone will likely not prove sufficient. Different climate models suggest that without the use of climate engineering technologies it will likely not be possible to limit global warming to 1.5°C (Fuss et al., 2018). Hence, it appears that the significant up-scaling of climate engineering technologies will be necessary in coming years (Nemet et al., 2018). To achieve the necessary cooling effect, different types of climate engineering techniques will have to be combined (Fuss et al., 2018; Minx et al., 2018). Yet, if the large-scale implementation of climate engineering technologies is to be achieved, public support is a precondition (Nemet et al., 2018).

To better understand people's reactions to different climate engineering technologies, the present research compares the levels of public support for the deployment of ten climate engineering technologies. For a successful implementation, it is further important to generate an understanding of the influential determinants of public support. We therefore compare the effects of a set of factors previously identified to be influential in the literature (e.g. Corner, Parkhill, Pidgeon, & Vaughan, 2013; Mercer, Keith, & Sharp, 2011; Merk & Pönitzsch, 2017; Pidgeon & Spence, 2017; Visschers, Shi, Siegrist, & Árvai, 2017), namely trust, perceived benefits and perceived risks, as well as tampering with nature.

1.1 Acceptance of climate engineering technologies

The public's acceptance of climate engineering technologies varies according to the type of use (i.e., further researching the technology vs. deploying the technology) and between the different types of technologies available to regulate the climate. Public support has previously been found to be higher for conducting further research on climate engineering technologies than for their deployment (Merk, Pönitzsch, Kniebes, Rehdanz, & Schmidt, 2015; Merk, Pönitzsch, & Rehdanz, 2016; Pidgeon & Spence, 2017; Scheer & Renn, 2014). Often, high levels of concern regarding climate engineering persist, for example, in relation to stratospheric aerosol injection, although there remains a certain degree of reluctance to discard such technologies altogether (Pidgeon, Parkhill, Corner, & Vaughan, 2013). This conditional support for climate engineering could be related to a fear of redirecting funds earmarked for climate change mitigation toward research concerning climate engineering (Wibeck et al., 2017). This finding also supports the notion that climate engineering is reluctantly accepted as a "plan B" in case mitigation efforts do not prove sufficient to tackle climate change (Amelung & Funke, 2014; Corner et al., 2013). Regarding the level of support for the different climate engineering technologies, previous research suggests that carbon dioxide removal (CDR) technologies are generally preferred over solar radiation management (SRM) technologies (Pidgeon et al., 2012; Scheer & Renn, 2014). Focusing on attitudes toward specific climate engineering technologies, Gregory, Satterfield, and Hasell (2016) found that mirrors in space were considered preferable to both stratospheric aerosol injection and cloud brightening, while reforestation was preferred over other CDR measures, such as ocean fertilization.

1.2 Drivers of support for climate engineering technologies

The public seems to react differently to various applications of climate engineering (Pidgeon et al., 2012; Wright, Teagle, & Feetham, 2014). Different perceptions of and support for climate engineering technologies can be explained by a set of factors. In the following we introduce trust, perceived risks and benefits and tampering with nature as relevant determinants of the acceptance of climate engineering technologies.

1.2.1 Trust

It is important to recognize that climate engineering technologies are emerging technologies. Climate engineering is still unfamiliar to the general public, who tend to report fairly low levels of knowledge regarding such technology (Corner & Pidgeon, 2014a, 2014b; Mercer et al., 2011; Pidgeon et al., 2012). When knowledge is lacking, trust is a relevant factor that influences people's perceptions of emerging technologies (Siegrist, 2000). The more people rely on trust in responsible actors, the more they tend to accept a technology or hazard (Siegrist & Cvetkovich, 2000). In the case of climate engineering, trust in different types of actors has been found to be relevant. For instance, trust in scientists or scientific institutions was positively associated with support for both research and deployment (Merk et al., 2015; Pidgeon & Spence, 2017), and it was mentioned to be important in terms of evaluating different climate engineering technologies in relation to mitigation efforts (Amelung & Funke, 2014). Trust in political institutions (Amelung & Funke, 2014), such as the federal government (Mercer et al., 2011; Merk & Pönitzsch, 2017), was found to exert a strong positive effect on the level of support for SRM measures. Finally, trust in the companies that operate climate engineering technologies was also found to be positively related to people's support for deployment (Merk et al., 2015).

1.2.2 Perceived risks and benefits

How people perceive the risks and benefits of a technology is relevant for its acceptance (Huijts, Molin, & Steg, 2012). In general terms, the more risks people perceive, the less benefits they associate with a technology or hazard (Alhakami & Slovic, 1994). This was found for climate engineering technologies as well, for which the public perceives few benefits but high risks (Gregory et al., 2016), although supporters of SRM have been found to value its benefits more strongly than people who oppose the technology (Mercer et al., 2011). The perceived benefits have been consistently found to represent a positive predictor of support for climate engineering, while the perceived risks are known to be negatively related to support (Burns et al., 2016; Harnisch, Uther, & Boettcher, 2015; Visschers et al., 2017; Wibeck et al., 2017). Further, when the benefits of enhanced weathering were perceived to outweigh the risks, or when the risks were perceived to be acceptable, both were found to be related to higher levels of support (Pidgeon & Spence, 2017). The types of risks and benefits associated with climate engineering in general were investigated in a cross-country study that included Australia and New Zealand (Wright et al., 2014). The climate engineering technologies were most often associated with attributes such as “unknown risks” or “risky.” These negative associations were most pronounced in relation to mirrors in space and stratospheric aerosol injection, while biochar and air capture evoked comparatively more positive associations, such as “environmental friendliness” or “long-term sustainability.” In terms of enhanced weathering and cloud brightening, people’s perceptions were neither strongly negative nor strongly positive (Wright et al., 2014).

1.2.3 Tampering with nature

When people are informed about climate engineering, the associated technologies evoke a sense of worry regarding their potential interference with nature (Pidgeon et al., 2012). Climate engineering is seen as something that tampers with nature, meaning that nature should not be manipulated in such as way (Corner et al., 2013). For this reason, some people are convinced that plans to address climate change should only be adopted if they do not excessively manipulate nature (Gregory et al., 2016). In that sense, the deployment of climate engineering prompts people to re-examine the relationship between nature and human actions. If such technologies were deployed, the impact on nature would no longer simply be a side effect of human activity, since nature would instead be actively shaped and controlled by humans (Corner et al., 2013). This has been suggested to represent a possible obstacle to the acceptance of SRM measures, since they are perceived to be unnatural, which triggers very negative affective reactions toward this type of technology (Sütterlin & Siegrist, 2016). This is also linked to the worry that the ways in which climate engineering tampers with nature could have unintended and uncontrollable consequences in the longer term (Corner et al., 2013; Pidgeon et al., 2012). However, a counterargument has been raised that people have intervened with nature for hundreds of years, which accounts for the imbalance created in relation to CO_2 emissions, and hence there is actually a moral imperative to deploy climate engineering so as to preserve nature for future generations (Corner et al., 2013). Previous studies have found that those people who more strongly oppose SRM hold stronger beliefs that it is tampering with nature when compared to those who support the technology (Mercer et al., 2011). Tampering with nature was also found to be a negative predictor of people's acceptance of climate engineering in general (Corner & Pidgeon, 2014b), as well as of SRM (Visschers et al., 2017) and stratospheric aerosol injection (Merk et al., 2015) in particular.

1.2.4 Study set-up and aims

Prior research concerning people's perceptions of, or support for, climate engineering technologies has tended to focus on either the term "climate engineering" or "geoengineering" in general (Corner & Pidgeon, 2014a; Cummings & Rosenthal, 2018; Scheer & Renn, 2014; Wibeck et al., 2017), specific types of climate engineering technologies, such as SRM or CDR (Braun, Rehdanz, & Schmidt, 2017; Mercer et al., 2011; Pidgeon et al., 2012; Sütterlin & Siegrist, 2016; Visschers et al., 2017), individual technologies (Merk & Pönitzsch, 2017; Merk et al., 2015; Merk et al., 2016; Pidgeon & Spence, 2017), or limited subsets of technologies (Corner et al., 2013; Wright et al., 2014). To the best of our knowledge, no previous research has compared the public's support for a broad range of climate engineering technologies as well as the drivers of that support. Therefore, to obtain a better understanding regarding public support for different climate engineering technologies,[1] the present study addressed two main questions: What are the differences in people's perceptions and levels of support for the various

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[1] Although these technologies differ in respect to the mechanisms used to regulate the climate, we use the term "technology" in a broad sense to include "devices or hardware but also practices and behavior", in accordance with the approach of Minx et al. (2018, p. 5).

climate engineering technologies? What drives support for the different climate engineering technologies?

To answer these questions, we investigated ten different climate engineering technologies, that is, seven CDR and three SRM technologies, which are currently being discussed in other research fields (Jones, Haywood, & Boucher, 2011; Jones et al., 2017; Lawrence et al., 2018; Minx et al., 2018; Moore, Jevrejeva, & Grinsted, 2010; Proctor, Hsiang, Burney, Burke, & Schlenker, 2018; Rahman, Artaxo, Asrat, & Parker, 2018) or considered in relation to their potential implementation (Field & Mach, 2017; Intergovernmental Panel on Climate Change [IPCC], 2018; Nemet et al., 2018). The technologies that were included in the survey, were two mineralization-based CDR technologies, namely i) enhanced weathering and ii) direct air capture and storage (DACCS), and five biomass-based CDR technologies, namely iii) ocean fertilization, iv) afforestation (including reforestation),[2] v) biochar, vi) soil carbon sequestration, and vii) bioenergy with carbon capture and storage (BECCS). Further, we included three different SRM technologies, namely viii) cloud brightening, ix) stratospheric aerosol injection, and x) mirrors in space.

2 METHODS

The data for this study were collected in the German-speaking part of Switzerland in November 2018 using a market research company. The final sample included 1575 respondents, of whom 50% were women. The average age of the respondents was 44 years. Quota sampling was used to ensure an appropriate gender and age balance in the sample, with five equally distributed age groups (between 18 and 69 years) being formed based on census data collected from Eurostat (Eurostat, 2018).

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[2] While afforestation is considered to involve the planting of trees in areas that have not been recently afforested (most often, for 50 years), reforestation describes the replanting of trees in areas that were deforested more recently. These two measures are often jointly categorized in the literature (Fuss et al., 2018). For reasons of simplicity, we use the term “afforestation” throughout the present study.

The respondents were asked to complete an online survey programmed in Unipark (Questback Ltd, 2015). First, the respondents answered socio-demographic questions (age, gender, level of education). The survey also measured their political orientation on a scale ranging from 1 “left” to 10 “right” (Breyer, 2015). Subsequently, they were asked to indicate their level of concern regarding climate change for items such as “I worry about the climate’s state” on a scale from 1 “do not agree at all” to 7 “fully agree” (Shi, Visschers, & Siegrist, 2015; Tobler, Visschers, & Siegrist, 2012). All the included items are presented in Appendix Table 1A.[3]

All the respondents then read the same introductory text on “Limiting the effects of climate change.” The text stated:

> *Through human activity, carbon dioxide (CO_2) and other greenhouse gases are released into the atmosphere, where such emissions contribute to the global increase in the Earth’s temperature and to changes in the climate. Different measures have been suggested to deliberately limit the effects of climate change. In the following, we present one of these measures to you.*

The respondents were then randomly allocated to one of ten groups.[4] Of the ten groups, seven received information regarding a specific CDR measure, namely either i) DACCS, ii) enhanced weathering, iii) afforestation, iv) biochar, v) BECCS, vi) ocean fertilization, or vii) soil carbon sequestration. The three remaining groups received information about SRM measures, namely either viii) stratospheric aerosol injection, ix) cloud brightening, or x) mirrors in space. All the descriptions are presented Appendix Table 1A.

In the case of direct air capture and storage, the text stated:

> *The main idea behind this measure is to lower the Earth’s temperature by removing carbon dioxide (CO_2) from the atmosphere.*
> *With multiple large fans, CO_2 is removed from the atmosphere. With a filter, the fans withdraw CO_2 from the air. The CO_2 molecules in the air attach to the material in the*

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[3] At this point, further questions were included to assess each respondent’s knowledge regarding climate change. These questions did not form part of the current analysis and, therefore, they are not described here.

[4] The random assignment of respondents to the information texts on technologies worked as intended. The ten groups did not differ in terms of age ($F(9,1565)=0.77$, $p=0.64$), gender ($F(9,1565)=0.32$, $p=0.97$), education ($F(9,1565)=1.11$, $p=0.35$), political orientation ($F(9,1565)=0.99$, $p=0.44$) and concern about climate change ($F(9,1565)=0.64$, $p=0.77$).

> *filter, while other molecules, such as oxygen or nitrogen, pass through the fan. By heating up the filter, the* CO_2 *molecules are released, and they can be compressed and stored underground.*
> *This effect is stable when the captured* CO_2 *is stored underground in adequate geological formations, where it permanently remains.*

The next set of questions specifically assessed each respondent's perception of the particular CDR or SRM measure they were informed about. The respondents indicated their level of subjective knowledge concerning the technology (i.e., their awareness) by answering the question "How much do you know about #technology#?"[5] on a scale ranging from 1 "I have never heard about it" to 6 "I know a lot about it" (Pidgeon et al., 2012; Pidgeon & Spence, 2017). The risks and benefits perceived by each respondent were assessed on a scale ranging from 1 "do not agree at all" to 6 "fully agree" based on a set of items derived from the work of Wright et al. (2014) and Visschers et al. (2017), for which we randomized the order of appearance in the questionnaire. The respondents were questioned as to the extent to which they agreed with statements such as "The deployment of #technology# is an eco-friendly measure for reducing the Earth's temperature" so as to assess their benefit perception. The perceived risks were assessed using items such as "The deployment of #technology# leads to unintended side effects". Further, we measured the degree to which the technology was perceived to tamper with nature using the scale introduced by Visschers et al. (2017). The items, for example, "Trying to influence the climate system by #technology# reflects human arrogance", were measured on the same scale as the perceived risks and benefits. Lastly, we asked the respondents "How much trust do you have in the following institutions when it comes to their responsibility to use #technology# to lower the Earth's temperature?". Their level of trust in different institutions (industry, science, government) was measured on a scale ranging

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[5] #technology# serves as a placeholder for the CDR or SRM technology description that each respondent was randomly allocated to in the questionnaire.

from 1 “no trust” to 6 “very high trust” (Mercer et al., 2011; Siegrist, Cousin, Kastenholz, & Wiek, 2007). All items are listed in Appendix Table 1A.

In the final part of the survey, the respondents’ support for further research being conducted into the particular climate engineering measure, as well as their support for the deployment of that technology, were assessed on a scale ranging from 1 “I strictly reject” to 6 “I fully support”. The items were based on the work of Pidgeon and Spence (2017), and they asked the respondents “To what extent do you support further research regarding #technology#?” and “To what extent do you support the deployment of #technology# to reduce the Earth’s temperature?”.

3 RESULTS

3.1 Support for the ten CDR and SRM technologies

One-way ANOVAs were conducted to test whether there were different levels of support for further research regarding ($F(9,1565)=20.39$, $p<0.001$), as well as for the deployment of ($F(9,1565)=21.60$, $p<0.001$), the different CDR and SRM technologies. The means and the 95% confidence intervals are shown in Figure 1. In terms of the public support for deployment, the Bonferroni post-hoc test revealed that the respondents showed a significantly higher level of support for the deployment of afforestation ($M=4.57$, $SD=1.28$) when compared to all the other technologies. The respondents indicated a significantly higher level of support for the deployment of biomass-based technologies, such as biochar ($M=3.98$, $SD=1.16$), soil carbon sequestration ($M=3.85$, $SD=1.20$), and BECCS ($M=3.79$, $SD=1.15$), together with mineralization-based technologies, such as DACCS ($M=3.78$, $SD=1.23$) and enhanced weathering ($M=3.87$, $SD=1.22$), when compared to the deployment of mirrors in space ($M=2.92$, $SD=1.43$) and stratospheric aerosol injection ($M=3.23$, $SD=1.32$). However, the support for the deployment of ocean fertilization ($M=3.52$, $SD=1.25$) did not significantly differ from the support for either stratospheric aerosol injection or cloud brightening (M=3.35, SD=1.21). Further, the support for cloud brightening did not significantly differ from the support for either BECCS or DACCS (see Figure 1, for all the test statistics see Appendix Table A2).

When considering the technologies separately, the paired-samples t-tests showed that the respondents supported research significantly more than they did deployment, except for in relation to biochar ($t(158)=1.52$, $p=0.13$), soil carbon sequestration ($t(152)=1.50$, $p=0.14$), and cloud brightening ($t(160)=1.29$, $p=0.20$) (see Appendix Table A2). However, the differences in the levels of the two types of support were only small ($0.07 \leq |M_{Resarcht}\text{-}M_{Deployment}| \leq 0.30$) (Figure 1).

Insert Figure 1 around here

3.2 Correlations between the explanatory factors

The product-moment correlations were calculated for each condition subsample so as to assess the relationship between the measured scales at the level of the climate engineering technologies.

We found that perceived risks and tampering with nature were strongly correlated in all the conditions ($0.57 \leq r \leq 0.74$, $p_s<0.01$). It appears that respondents assessed tampering with nature similarly to perceived risks of climate engineering technologies. For the subsequent analysis, we combined perceived risks and tampering with nature into one scale, which we term perceived risks & tampering with nature.

For the remaining scales we found moderate correlations between trust and perceived benefits in all the conditions ($0.32 \leq r \leq 0.50$, $p_s<0.01$), as well as small to moderate negative correlations between trust and perceived risks & tampering with nature ($-0.40 \leq r \leq -0.21$,

p_s<0.01) in all the conditions, except afforestation, cloud brightening, BECCS, soil carbon sequestration. In turn, small to moderate correlations were found between perceived risks & tampering with nature and perceived benefits in all the conditions ($-0.46 \leq r \leq -0.26$, p_s<0.001). Climate change concern was further found to be correlated with trust in the BECCS, afforestation, DACCS, and cloud brightening conditions ($0.16 \leq r \leq 0.31$, p_s<0.05). This was also the case between climate change concern and the perceived benefits of BECCS, afforestation, biochar, and DACCS ($0.21 \leq r \leq 0.34$, p_s<0.01). Finally, a small correlation between climate change concern and perceived risks & tampering with nature was found in the case of afforestation (r=-0.19, p=0.02).

We checked the reliability of the measured scales (i.e., climate change concern, perceived benefits, perceived risk & tampering with nature, trust) and found them to be within the acceptable ranges for all the conditions (see Appendix Table A1). We, therefore, computed the mean values across the items.

3.3 Differences in subjective knowledge, perceived benefits, tampering with nature, and levels of trust across the climate engineering technologies

With regard to the perceptions of the different climate engineering technologies on the part of the respondents, one-way ANOVAs were conducted concerning the degree of subjective knowledge, risk/tampering perception, the benefit perception, and the trust in institutions. The Bonferroni post-hoc test showed that the respondents' subjective knowledge was significantly higher for afforestation (M=3.15, SD=1.19) when compared to all the other measures, being just above the mid-point. Their subjective knowledge concerning the other CDR and SRM measures was generally low. The self-reported levels of knowledge concerning BECCS (M=2.22, SD=1.24), soil carbon sequestration (M=2.07, SD=1.06), and stratospheric aerosol injection (M=1.96, SD=1.38) were significantly higher than those concerning ocean fertilization (*M*=1.64, *SD*=1.13), cloud brightening (*M*=1.54, *SD*=0.91), and mirrors in space (*M*=1.52, *SD*=1.02), *F*(9,1565)=27.83, *p*<0.001 (Figure 2, Appendix Table A3).

For the perceived risks & tampering with nature, the Bonferroni post-hoc test revealed that the respondents perceived mirrors in space (*M*=4.00, *SD*=1.06) to be more risky and tampering with nature to a significantly greater degree than the other measures, except for stratospheric aerosol injection (*M*=3.89, *SD*=0.99) and ocean fertilization (*M*=3.71, *SD*=0.89). Afforestation (*M*=2.56, *SD*=1.08) was considered to be significantly less risky and tamper less with nature than all the other measures. Smaller differences were present for the other measures (*F*(9,1565)=29.32, *p*<0.001) (Figure 2, Appendix Table A3).

The perceived benefits were significantly different across the ten climate engineering technologies (*F*(9,1565)=26.71, *p*<0.001). The Bonferroni post-hoc test revealed that the perceived benefits were significantly higher for afforestation (*M*=4.38, *SD*=1.01) than for all the other measures, while they were significantly lower for mirrors in space (*M*=2.92, *SD*=1.04) when compared to the other CDR technologies. For the remaining measures, the respondents indicated that the perceived benefits are situated closer around the mid-point (Figure 2, Appendix Table A3). The Bonferroni post-hoc test revealed no differences between the conditions in terms of the levels of trust, although the overall one-way ANOVA was significant (*F*(9,1565)=16.62, *p*=0.05).

Insert Figure 2 around here

3.4 Predicting public support for the deployment of climate engineering technologies

To predict the public support for the deployment of climate engineering technologies, we conducted separate multiple regression analyses for each of the ten investigated technologies. The model included socio-demographic variables, climate change concern, trust, perceived risks & tampering with nature, and perceived benefits. The latter three variables were measured at the technology-specific level. All the multiple regression models were significant, and they explained between 48% and 65% of the variance in support. The regression coefficients can be found in Table 3.

The main predictor of support for the deployment of CDR and SRM measures was the respondents' benefit perception, that is, the higher the perceived benefits, the higher the support for deployment. In the case of ocean fertilization, biochar, and stratospheric aerosol injection, perceived risks & tampering with nature was nearly as strong a predictor. Support for the technologies decreased, the more they were perceived to be risky and tampering with nature. This relationship was found for all the CDR and SRM measures, except for afforestation, in which case perceived risks & tampering with nature had no significant effect. Trust in in responsibility of science, government, and industry to use a CDR or SRM technology was also a consistent predictor, again with the exception of afforestation, for which there was no significant relation to support. In the case of afforestation, ocean fertilization, DACCS, and stratospheric aerosol injection, the respondents' climate change concern was significantly positively related to their support for the deployment of these technologies. Further, a higher education level was related to increased support for ocean fertilization, age was positively related to support for BECCS, while being a man was related to increased support for stratospheric aerosol injection and DACCS.

4 DISCUSSION

Climate engineering technologies will most likely have to be deployed in the coming decades so as to limit the negative effects of climate change (Fuss et al., 2018; IPCC, 2018). However, public support will be a precondition for the widespread adoption of these technologies and, therefore, should be taken into account. The present study examined the levels of public support for ten different climate engineering technologies in Switzerland, as well as the factors that predict public support. This extended the prior research in two key ways. First, we widened the scope of investigation and compared the public support for a broad set of climate engineering technologies that are frequently discussed in relation to their potential to tackle climate change in the near future. Second, we expanded on those factors that predict public support and compared their effects across the climate engineering technologies.

Our results show that public support for climate engineering varies across technologies. Generally, the CDR measures received a higher level of support when compared to the SRM measures, although the difference between the CDR technologies and cloud brightening was not as strong. This aligns well with the findings of previous research (Pidgeon et al., 2012; Scheer & Renn, 2014) and with the scientific consensus. SRM measures are not part of the IPCC scenarios, since they are considered to involve substantial risks as well as large uncertainties and knowledge gaps (although they may be effective in reducing average temperatures) (IPCC, 2018). The levels of public support were clearly lower for mirrors in space and stratospheric aerosol injection, closely followed by cloud brightening and ocean fertilization, which are also often considered by the scientific community to be associated with too many unknown effects and potentially high risks (Fuss et al., 2018; Lawrence et al., 2018).

Three factors consistently predicted the levels of support for the climate engineering technologies, namely i) trust in science, industry, and government to deploy the technology responsibly; ii) the perceived risks & tampering with nature; and iii) its perceived benefits. The models all explained high shares of the variance, ranging between 48% and 65%. Benefit perception was the main driver of support for all the technologies. When more benefits are perceived, the support for all types of climate engineering technologies increases. The importance of the perceived benefits has previously been found in relation to attitude formation concerning stratospheric aerosol injection (Merk & Pönitzsch, 2017). We found that for stratospheric aerosol injection, ocean fertilization, and biochar, perceived risks & tampering with nature was nearly as strongly, albeit negatively, related to support when compared to benefit perception. These results are in line with the findings of previous studies regarding the negative impact of a given technology's perceived degree to be tampering with nature (Corner & Pidgeon, 2014b; Mercer et al., 2011; Visschers et al., 2017). The results further show a positive relationship between trust in science, industry, and governmental institutions and acceptance of climate engineering technologies, as has been found in previous studies (Mercer et al., 2011; Merk & Pönitzsch, 2017; Merk et al., 2015). In contrast to the findings of Braun, Merk, Pönitzsch, Rehdanz, and Schmidt (2017), trust was not relevant to the support for afforestation as a climate engineering technology. As members of the public perceive themselves to be more familiar with afforestation, they may rely more on their own knowledge rather than their trust in institutions or industry when evaluating the technology. It is, therefore, important to note that afforestation showed a different model of support, in which increases in both perceived benefits and concern about climate change led to a higher level of support. No consistent relationship was found between concern about climate change and support across the investigated climate engineering technologies. Further, in contrast to the results of Pidgeon et al. (2012), who found that concern about climate change in the UK was negatively related to support for SRM measures, we note that it is a positive driver of support for stratospheric aerosol injection.

Although afforestation received comparatively the highest level of support, that support was not located at the highest point on the utilized scale. Hence, the public might still have certain reservations concerning the deployment of any climate engineering technology. The levels of support for the remaining technologies were located within the medium range of the scale. This is a positive finding in the sense that no form of climate engineering investigated in this study evoked extreme opposition, which leaves room for the possibility of deploying them in combination to reach the 1.5°C target, as has previously been suggested (Fuss et al., 2018; Minx et al., 2018). Mid-range levels of support could also indicate that climate engineering technologies are not the preferred option for tackling climate change. As has been suggested in prior studies, climate engineering is often conditionally accepted as a secondary measure for limiting the effects of climate change, together with mitigation measures (Corner et al., 2013; Wibeck et al., 2017). The public might implicitly compare a given climate engineering technology to measures they already know about so as "to make sense of an unfamiliar issue" (Pidgeon et al., 2012, p. 4191). This also suggests that climate engineering technologies are not assessed in isolation. The study by Amelung and Funke (2014) found that some people prefer to exclusively make use of mitigation measures to curb greenhouse gas (GHG) emissions, while others favor the combining of mitigation measures with CDR or with SRM as a "plan B" strategy to hedge the risks associated with mitigation (i.e., not achieving the necessary GHG reductions). Moreover, others indicate a preference for tackling the impacts of climate change by means of climate engineering alone (Amelung & Funke, 2014). Informing the public about the different climate engineering technologies can have an impact on their preferences concerning how best to tackle climate change. The type of effect is, however, somewhat ambiguous. It was previously suggested that climate engineering might pose a moral hazard, since it could be seen as a simple solution to climate change, which could serve to undermine mitigation or adaptation efforts (Lin, 2013). In some investigations, reactions toward information concerning CDR were, in fact, found to reflect a risk compensation strategy (except in the case of afforestation), in which learning about CDR technologies reduced the perceived risk of climate change, which was in turn related to reduced support for mitigation measures (Campbell-Arvai, Hart, Raimi, & Wolske, 2017). Yet, no risk compensation was found when information was provided concerning a SRM technology, but rather an increase in mitigation behavior was observed (Merk et al., 2016).

The present study was designed to compare the levels of support across different climate engineering technologies. This approach allowed us to compare a wide range of technologies, as well as to determine the level of public support of each technology individually. The employed design did not allow the *respondents* to compare the different types of climate engineering technologies, since this would have proved very taxing for them. For joint evaluations of climate engineering technologies, a study would need to be limited to a smaller set of technologies. In such a case, the research would forgo the benefit of assessing the main available climate engineering technologies in terms of their potential for future deployment. Joint evaluations, however, do help with contextualizing information when compared to the evaluation of single options (Hsee, 1996). The preferences regarding climate engineering technologies could differ if the respondents were given the opportunity to compare them, in contrast to what was reported here. In a survey in which certain climate engineering technologies were evaluated together with current climate change policies, the preference structures differed for the SRM measures (i.e., preference for mirrors in space) from the findings presented here, although they concurred relatively well with the preferences across the CDR measures (Gregory et al., 2016).

Some limitations of the present study need to be addressed. The information we provided on climate engineering technologies focused on the description of the technologies and how their use is a possible action to tackle climate change. The type of information provided to the public can influence people’s emotional responses, while emotions, in turn, have an effect on people’s support for climate policies (Feldman & Hart, 2018). Based on the findings from Feldman and

Hart (2018), describing the use of climate engineering technologies as a way to tackle climate change could have increased people's emotions of hope, thereby increasing the support for these technologies, compared to information that would have focused on the impacts of the technologies. The communication of impacts, in terms of the risks and benefits of climate engineering technologies, has been associated with lower levels of acceptance in previous research (Braun, Merk, et al., 2017; Sütterlin & Siegrist, 2016). Hence, information about additional risks and benefits is crucial, and the discourse on the risks and benefits associated with the technologies will shape future levels of support. Based the benefits and risks of climate engineering technologies as understood today, we assume that soil carbon sequestration might be better accepted if the public is informed about the co-benefits of increased soil fertility and protection against soil erosion (Rumpel et al., 2018). The same goes for biochar, which is also known to enrich the soil (Lawrence et al., 2018). Due to land-use competition with food safety (Torvanger, 2018), a decrease in support could be expected in the case of BECCS. As has been called for in previous research (Visschers et al., 2017; Wolske, Raimi, Campbell-Arvai, & Hart, 2019), it would further be beneficial to disentangle the effect of informing the public on risks and benefits. That is, the levels of support across climate engineering technologies should be examined, when both specific benefits and risks, when only risks, and when only benefits are mentioned.

Not providing information on additional risks and benefits could further have impacted how people rated both tampering with nature and the risks of the different climate engineering technologies. As we found a very strong correlation between perceived risks and tampering with nature, it seems that respondents in our sample did not distinguish between the risks they associated with the technology and the degree to which they thought it was interfering with nature. Additional information on risks would be expected to increase the gravity of the risks rather than the degree to which it is seen to be tampering with nature, which would indicate that the two concepts are different. However, this is not yet entirely clear. In a previous study, information on additional risks and benefits increased the perception for some technologies (i.e. afforestation and BECCS) that they were tampering with nature (Wolske et al., 2019). Therefore, how different types of information (i.e. benefits or risks) affect the perception of the technologies to have risks, but also to tamper with nature should be considered in further research.

As the present study was conducted in Switzerland, the generalizability might be limited to that country. However, the results align well with the findings of previous research, and we would hence expect to find similar results in other Western countries in which research on climate engineering has mostly been conducted. The public in Western countries often share the belief that technologies will evolve and ultimately lead to a better standard of living (Pidgeon et al., 2012). Still, the specific siting of certain climate engineering technologies might be an issue in the future. We know from the research on other technologies, that the siting of new nuclear power plants proved difficult (Greenberg, 2009), and that people living near a CCS site were less accepting of the technology compared to people living further away (Braun, 2017). The deployment of climate engineering could therefore engender higher levels of opposition with their large-scale deployment.

Furthermore, there is still a need to investigate support in those countries in which the implementation of the technologies is most effective and where vulnerable populations live. Afforestation, for example, offers the highest net benefit in tropical regions, since there is a limited negative impact in terms of the changed albedo effect (Fuss et al., 2018). Low- and middle-income countries might be the ones to lose or gain the most from SRM measures due to the unequal distributions of side effects and benefits (Rahman et al., 2018). Further, recent findings show that climate engineering seems to be accepted only reluctantly in such countries (Carr & Yung, 2018).

The present study has two encouraging implications. First, focusing on benefits can foster public acceptance, since benefit perception was the most important predictor across all the investigated technologies. Second, the differences in support are relatively small and the support for the technologies is generally neutral, although afforestation is better accepted. This implies that there is potential for the simultaneous deployment of different climate engineering technologies, mainly CDR measures, as we do not find very strong opposition towards them. Further, it allows us to address the question of which technologies are the most efficient in terms of tackling climate change and to deploy them as a priority. At this stage, the use of climate engineering to tackle climate change in addition to mitigation measures seems conceivable from the point of view of public support.

Figures and tables

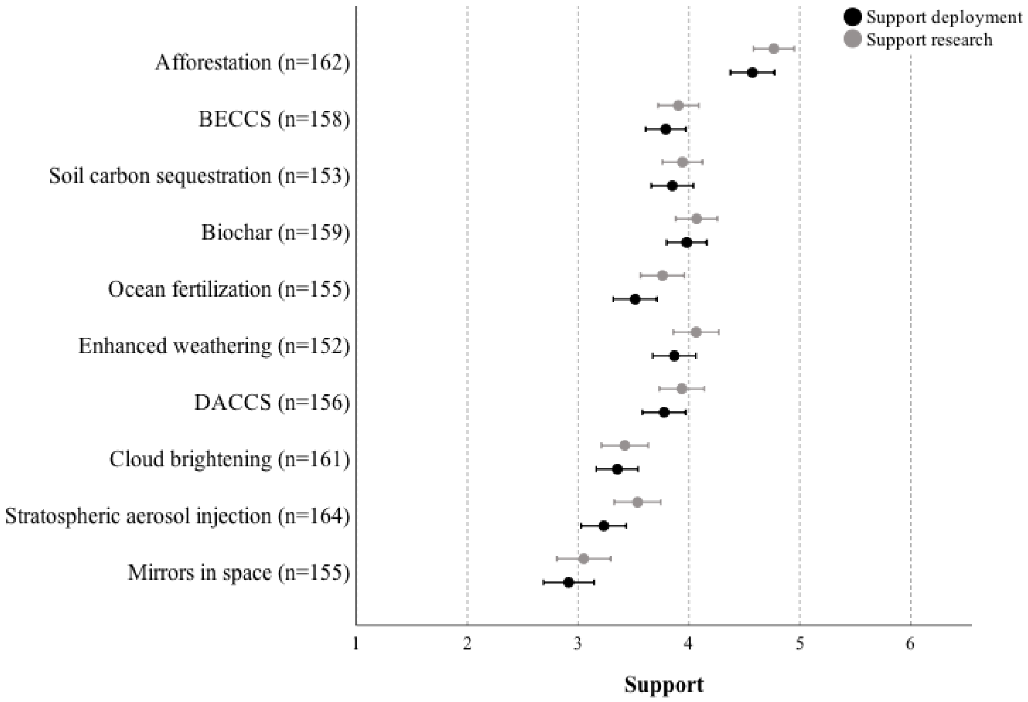

Figure 1. Differences in levels of support across the CDR and SRM technologies for research and deployment. Means and 95% CIs are shown.

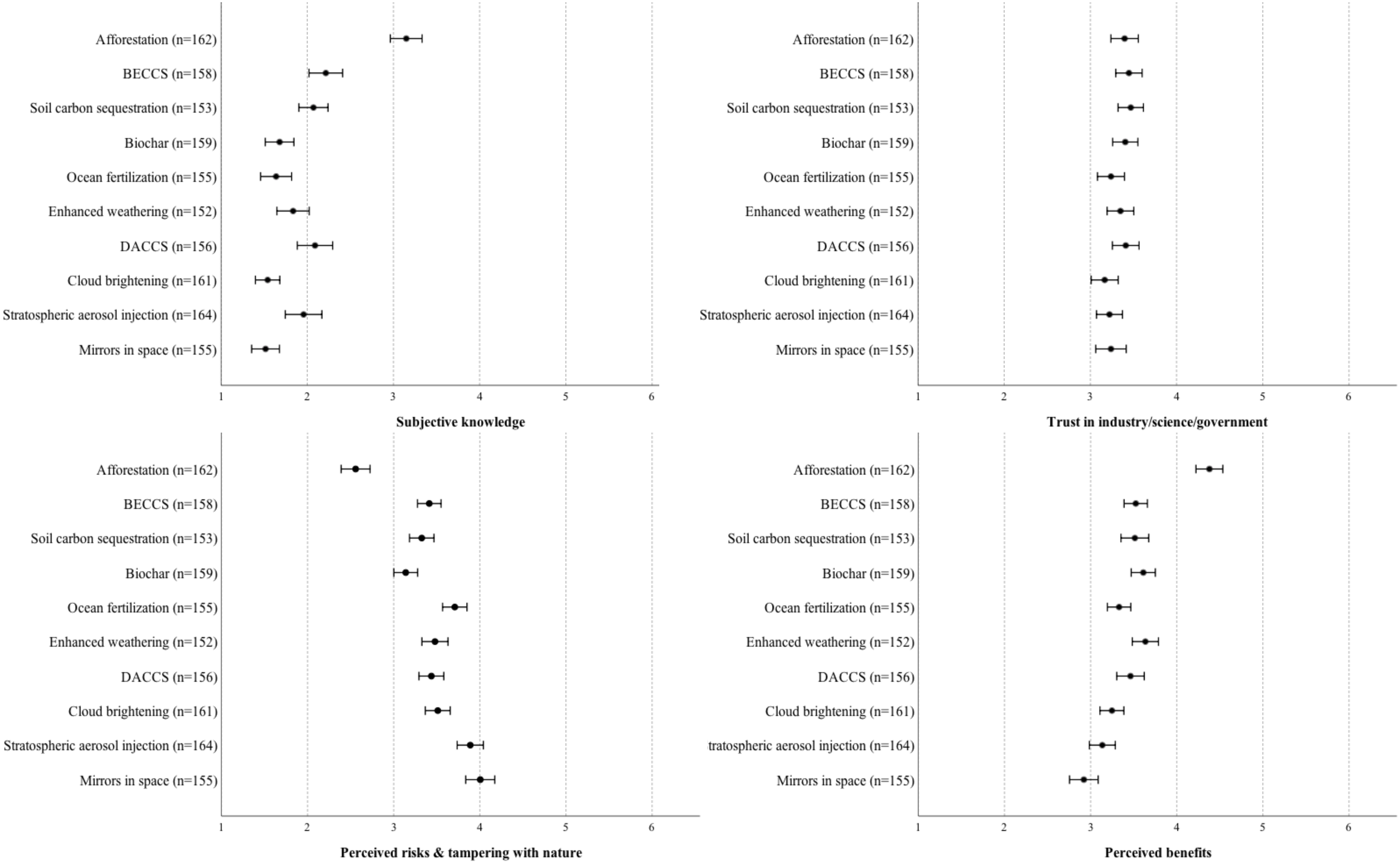

Figure 2. Differences in subjective knowledge, levels of trust, tampering with nature, and perceived benefits across the climate engineering technologies. Means and 95% CIs are shown.

Table 1

Predictors of support for the deployment of different SRM and CDR measures

	Solar radiation management			**Mineralization-based carbon dioxide removal**		**Biomass-based carbon dioxide removal**				
	Mirrors in Space	**Stratospheric aerosol injection**	**Cloud brightening**	**DACCS**	**Enhanced weathering**	**Ocean fertilization**	**BECCS**	**Soil carbon sequestration**	**Biochar**	**Afforestation**
	B [95CI]	B [95CI]	B [95CI]	B [95CI]	B [95CI]	B [95CI]	B [95CI]	B [95CI]	B [95CI]	B [95CI]
Constant	0.18 [-1.31, 1.67]	1.41 [-0.14, 2.96]	0.37 [-0.87, 1.61]	-0.51 [-1.68, 0.67]	1.02 [-0.33, 2.37]	0.98 [-0.75, 2.71]	1.14 [-0.23, 2.52]	1.35* [0.10, 2.59]	1.95** [0.64, 3.27]	-0.23 [-1.59, 1.13]
Gender[a]	0.26 [-0.01, 0.54]	0.33* [0.03, 0.64]	0.26 [0.00, 0.53]	0.27* [0.02, 0.53]	0.03 [-0.22, 0.29]	0.07 [-0.22, 0.36]	-0.01 [-0.26, 0.24]	0.12 [-0.15, 0.38]	0.15 [-0.11, 0.41]	0.20 [-0.09, 0.48]
Age	0.00 [-0.01, 0.01]	-0.01 [-0.02, 0.01]	0.00 [-0.01, 0.01]	0.00 [-0.01, 0.01]	0.01 [0.00, 0.02]	0.00 [-0.01, 0.01]	0.01* [0.00, 0.02]	0.00 [-0.01, 0.01]	0.00 [-0.01, 0.01]	0.00 [-0.01, 0.01]
Education	-0.03 [-0.12, 0.07]	-0.03 [-0.13, 0.07]	0.05 [-0.04, 0.14]	0.05 [-0.03, 0.13]	-0.02 [-0.11, 0.06]	0.13* [0.03, 0.23]	0.08 [-0.01, 0.17]	0.04 [-0.05, 0.13]	0.03 [-0.05, 0.11]	0.03 [-0.07, 0.13]
Concern about climate change	0.11 [0.00, 0.22]	0.14* [0.01, 0.27]	0.06 [-0.05, 0.18]	0.20*** [0.09, 0.31]	0.05 [-0.07, 0.17]	0.18** [0.05, 0.31]	0.08 [-0.03, 0.19]	0.05 [-0.07, 0.17]	0.12 [0.00, 0.24]	0.26*** [0.14, 0.38]
Trust [technology]	0.20** [0.06, 0.34]	0.36*** [0.19, 0.53]	0.26*** [0.12, 0.41]	0.18* [0.03, 0.33]	0.48*** [0.33, 0.63]	0.31*** [0.14, 0.48]	0.24** [0.09, 0.39]	0.30*** [0.13, 0.46]	0.21* [0.05, 0.37]	0.03 [-0.12, 0.18]
Perceived risks & tampering [technology]	-0.26*** [-0.41, -0.11]	-0.43*** [-0.60, -0.25]	-0.31*** [-0.45, -0.16]	-0.18* [-0.32, -0.03]	-0.31*** [-0.46, -0.17]	-0.42*** [-0.61, -0.23]	-0.40*** [-0.55, -0.24]	-0.31*** [-0.47, -0.14]	-0.48*** [-0.63, -0.33]	-0.11 [-0.26, 0.04]
Perceived benefits [technology]	0.81*** [0.65, 0.97]	0.44*** [0.26, 0.62]	0.70*** [0.53, 0.86]	0.68*** [0.53, 0.83]	0.49*** [0.33, 0.64]	0.44*** [0.25, 0.64]	0.58*** [0.40, 0.75]	0.57*** [0.41, 0.73]	0.50*** [0.33, 0.67]	0.70*** [0.53, 0.87]
R^2 adjusted	0.65	0.49	0.53	0.61	0.59	0.48	0.53	0.54	0.51	0.53
F(df1, df2)	42.59*** (7, 147)	23.62*** (7, 156)	26.58*** (7, 153)	34.90*** (7,148)	32.25*** (7,144)	21.59*** (7, 147)	26.55*** (7, 150)	26.25*** (7, 145)	24.87*** (7,151)	26.74*** (7,145)

Note. * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

[a] Gender: 1 = female, 2 = male.

DACCS stands for direct air capture and storage, BECCS stands for bioenergy with carbon capture and storage.

5 APPENDIX

Table A1

Questionnaire and items

Scales and items	**Prefacing text and response categories**
Political orientation (Breyer, 2015) Thinking of your own political views, where would you place these on this scale?	Many people use the terms "left" and "right" when they want to describe different political views. Here we have a scale which runs from left to right. *[1 = "left" to 10 = "right"]*
Concern about climate change ($\alpha = 0.93$) (Shi et al., 2015; Tobler et al., 2012) Climate change has severe consequences for humans and nature. Climate protection is important for our future. We must protect the climate's delicate equilibrium. I worry about the climate's state.	Please indicate to what extent you agree with the following statements. *[1 = "do not agree at all" to 7 = "fully agree"]*
General information **Limiting the effects of climate change** Through human activity, carbon dioxide (CO_2) and other greenhouse gases are released into the atmosphere, where such emissions contribute to the global increase in the Earth's temperature and to changes in the climate. Different measures have been suggested to deliberately limit the effects of climate change. In the following, we present one of these measures to you.	*Note. All the respondents received this information.*
Enhanced weathering The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. When rocks weather on soils, CO_2 is removed from the atmosphere. The minerals in the rocks absorb CO_2 from the air and together they form a new solid material (bicarbonate). This material is stored in the ocean. Enhanced weathering speeds this process up by grinding rocks (silicate) and distributing it onto soil, beaches, or river catchments. The ground material has more exposure to the air and, through this, more CO_2 from the atmosphere can be absorbed, which is ultimately stored in the oceans. This effect is stable and, therefore, the captured CO_2 permanently remains in the ocean.	*Note. The respondents were randomly allocated to one of the ten technology descriptions given on the left.* *The informational texts on the CDR technologies were based on the work of Field and Mach (2017); Minx et al. (2018); Moore et al. (2010); and Strefler, Amann, Bauer, Kriegler, and Hartmann (2018).* *The informational texts on the SRM technologies were based on the work of Jones et al. (2011); Jones et al. (2017); Moore et al. (2010); Proctor et al. (2018); Rahman et al. (2018); and Trisos et al. (2018).*
Direct air capture The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. With multiple large fans, CO_2 is removed from the atmosphere. With a filter, the fans withdraw CO_2 from the air. The CO_2 molecules in the air attach to the material in the filter, while other molecules, such as oxygen or nitrogen, pass through the fan. By heating up the filter, the CO_2 molecules are released, and they can be compressed and stored underground. This effect is stable when the captured CO_2 is stored underground in adequate geological formations, where it permanently remains.	
Afforestation The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. Through afforestation, CO_2 is removed from the atmosphere. This means that the number of trees or other plants is increased. Plants use CO_2 for photosynthesis in order to gain energy for their growth. Hence, when trees grow, CO_2 is stored in the wood, leaves, and roots. This effect is reversible. When wood or plant material is burned or decomposes, the CO_2 is released into the atmosphere again.	

Biochar The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. By producing a specific charcoal known as biochar, CO_2 is removed from the atmosphere. Biochar is generated when plant material, for example, organic waste, is heated without oxygen. Biochar contains CO_2 from plants, and it can be added to the soil. This effect is stable. The CO_2 remains bound in the soil for between decades and centuries.	
Bioenergy with carbon capture and storage The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. Plants are cultivated and then burned to produce electricity. The CO_2 released through burning is captured and stored by a system known as carbon capture and storage (CCS). In that way, CO_2 is removed from the atmosphere. This effect is stable when the captured CO_2 is stored underground in adequate geological formations, where it permanently remains.	
Ocean fertilization The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. When the oceans are fertilized with nutrients, CO_2 is removed from the atmosphere. One proposal is to introduce iron, a scarce nutrient in the oceans, into the upper water layer. This triggers an algal bloom, which absorbs CO_2 from the atmosphere through photosynthesis. The algae are either used as food by other animals in the ocean or they sink to the bottom of the ocean, where the carbon is finally stored in sedimentary rocks. This effect is usually stable. However, there are uncertainties as to whether it will last for only a few months or days in some cases.	
Soil carbon sequestration The main idea behind this measure is to lower the Earth's temperature by removing carbon dioxide (CO_2) from the atmosphere. CO_2 is removed from the atmosphere by means of modified agricultural methods and then bound in the soil. This means that the growth of cultivated plants promotes the formation of humus. In humus, which is the uppermost layer of the earth, the carbon of the CO_2 remains bound. This effect is reversible when agricultural practices change, leading to soil degradation and CO_2 emissions.	
Could brightening The main idea behind this measure is to lower the Earth's temperature by deflecting part of the sun's rays and reflecting them back into space. By spraying a fine dust of seawater into the air above the ocean, sunlight is deflected. The droplets of seawater evaporate and then form additional clouds reflecting sunlight. One proposal is to spray seawater into the air with the help of automated ships. This effect is reversible. If the spraying of the seawater is stopped, the cooling effect subsides.	
Stratospheric aerosol injection The main idea behind this measure is to lower the Earth's temperature by deflecting part of the sun's rays and reflecting them back into space. Small particles (aerosols) are sprayed into the upper atmosphere, which deflect part of the sunlight. One proposal is to spray the small particles using balloons. This effect is reversible. If the spraying of the particles is stopped, the cooling effect subsides.	
Mirrors in space The main idea behind this measure is to lower the Earth's temperature by deflecting part of the sun's rays and reflecting them back into space.	

Sunlight is deflected by placing mirrors in space. The mirrors work as an artificial shade for the Earth. One proposal is to launch one million extremely thin discs into space every minute over a period of 30 years. This effect is stable, so long as the mirrors remain in space.	
Subjective knowledge (based on Pidgeon et al., 2012; Pidgeon & Spence, 2017) How much do you know about #technology#?	*[1 = "I have never heard about it" to 6 = "I know a lot about it"]* *Note. #technology# is a placeholder for the particular CDR or SRM technology description that the respondent was randomly allocated to in the questionnaire.*
Perceived benefits (*$0.79 \leq \alpha \geq 0.89$*) (derived from Wright et al., 2014) The deployment of #technology# … … is controllable. … is effective in terms of reducing the Earth's temperature. … is a cost-efficient measure for reducing the Earth's temperature. … is an eco-friendly measure for reducing the Earth's temperature. … is sustainable in the long term. (… is reversible.)* new	To what extent do you agree with the following statements? *[1 = "do not agree at all" to 6 = "fully agree"]* *item not included in the scale, since it reduced the reliability of the scale in all conditions (*$0.77 \leq \alpha \geq 0.85$*)
Perceived risks & tampering with nature ($0.87 \leq \alpha \geq 0.91$*)* *Items perceived risks* (derived from Wright et al., 2014) … blemishes the surrounding area. … leads to unintended side effects. … has unknown risks. … leads to an unequal distribution of risks. … is a threat to humans and nature. (Visschers et al., 2017) *Items tampering with nature* (Visschers et al., 2017) (The use of #technology# is natural.)* (Corner & Pidgeon, 2014b) #technology# disturbs the order of nature. Trying to influence the climate system by #technology# reflects human arrogance. Human's goal to change the climate system by #technology# is immoral. #technology# is contrary to nature.	Note. All the items concerning the risks and benefits were asked jointly and assigned a random order. To what extent do you agree with the following statements? *[1 = "do not agree at all" to 6 = "fully agree"]* *item not included in scale, since it reduced the reliability of the scale in all conditions (*$0.84 \leq \alpha \geq 0.90$*)
Trust (*$0.67 \leq \alpha \geq 0.76$*) (based on Siegrist et al., 2007) Industry in the field of climate technology Science/research Government and official agencies	How much trust do you have in the following institutions, when it comes to their responsibility to use #technology# to lower the Earth's temperature? *[1 = "no trust" to 6 = "very high trust"]*
Support (based on Pidgeon & Spence, 2017) To what extent do you support further research regarding #technology#? To what extent do you support the deployment of #technology# to reduce the Earth's temperature?	*[1 = "I strictly reject" to 6 = "I fully support"]*

Table A2

Differences in the levels of support across the CDR and SRM technologies (test statistic 1) and between deployment and research (test statistic 2)

		Mean (SD)		
Technology	**N**	**Support research**	**Support deployment**	Test statistic 2
Afforestation	162	4.77 (1.18) a	4.57 (1.28) a	*t*(161)=3.52, *p*=0.001***
BECCS	158	3.91 (1.17) b c	3.79 (1.15) b c	*t*(157)=2.03, *p*=0.04*
Soil carbon sequestration	153	3.94 (1.13) b c	3.85 (1.20) b	*t*(152)=1.50, *p*=0.14
Biochar	159	4.07 (1.20) b	3.98 (1.16) b	*t*(158)=1.52, *p*=0.13
Ocean fertilization	155	3.76 (1.24) b d	3.52 (1.25) d e	*t*(154)=3.78, *p*<0.001***
Enhanced weathering	152	4.07 (1.27) b	3.87 (1.22) b d	*t*(151)=3.15, *p*=0.002**
DACCS	156	3.94 (1.28) b c	3.78 (1.23) b d f	*t*(155)=2.61, *p*=0.01**
Cloud brightening	161	3.42 (1.35) d e	3.35 (1.21) c e f	*t*(160)=1.29, *p*=0.20
Stratospheric aerosol injection	164	3.54 (1.36) c d	3.23 (1.32) e g	*t*(163)=4.20, *p*<0.001***
Mirrors in space	155	3.05 (1.52) e	2.92 (1.43) g	*t*(154)=2.18, *p*=0.03*
Test statistic 1		*F*(9,1565)=20.39, *p*<0.001	*F*(9,1565)=21.60, *p*<0.001	

Note. Means and standard deviations are given for the support for further research and the support for the deployment of the given technology. Test statistic 1 shows the one-way ANOVA result. It indicates significant differences in the level of support across the technologies (for research and deployment, respectively). Pairwise comparisons between the technologies were performed using the Bonferroni post-hoc test. Different letters indicate significantly different levels of support for the technologies across research and deployment, respectively. Test statistic 2 shows the result of the paired-samples t-test for the difference between the support for research and the support for deployment for each technology.

Table A3

Differences in awareness, perceived benefits, tampering with nature, and levels of trust across the CDR and SRM technologies

		Mean (SD)			
Technology	**N**	**Subjective knowledge**	**Trust**	**Perceived risks & tampering**	**Perceived benefits**
Afforestation	162	3.15 (1.19) a	3.40 (1.02) a	2.56 (1.08) a	4.38 (1.01) a
BECCS	158	2.22 (1.24) b d	3.45 (0.97) a	3.41 (0.87) b c d	3.52 (0.86) b c
Soil carbon sequestration	153	2.07 (1.06) b d g	3.47 (0.92) a	3.33 (0.89) b d	3.51 (1.01) b c
Biochar	159	1.68 (1.06) c e f g	3.40 (0.93) a	3.14 (0.88) b	3.61 (0.90) c
Ocean fertilization	155	1.64 (1.13) c	3.24 (0.99) a	3.71 (0.89) c e h	3.33 (0.86) b c g
Enhanced weathering	152	1.84 (1.17) b c e	3.35 (0.97) a	3.48 (0.95) b c d	3.64 (0.95) b
DACCS	156	2.09 (1.30) d e	3.41 (0.98) a	3.44 (0.91) b c d	3.46 (1.01) b d
Cloud brightening	161	1.54 (0.91) c g	3.17 (1.01) a	3.51 (0.93) d e	3.25 (0.89) c d e
Stratospheric aerosol injection	164	1.96 (1.38) b d f g	3.22 (0.98) a	3.89 (0.99) h	3.14 (0.98) d e g
Mirrors in space	155	1.52 (1.02) c	3.24 (1.11) a	4.00 (1.06) h	2.92 (1.04) e
Test statistic		*F*(9,1565)=27.83, *p*<0.001	*F*(9,1565)=16.62, *p*=0.05	*F*(9,1565)=29.32, *p*<0.001	*F*(9,1565)=26.71, *p*<0.001

Note. Means and standard deviations are shown. The one-way ANOVAs indicates significant differences in terms of the subjective knowledge, trust, perceived risks/tampering, and perceived benefits across the technologies. The pairwise comparisons between the technologies were performed using the Bonferroni post-hoc test. Different letters indicate significant differences across the technologies.

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