# Using Cultural Theory to Explain Support for Solar Radiation Management

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## Abstract

The vast majority of climate policy is focused on preventing greenhouse gas emissions, and in devising strategies and infrastructure to adapt to a changed planet. A third strategy, geoengineering, involves planet-scale responses to attempt to reverse the effects of climate change. Solar radiation management (e.g. creating clouds to reflect solar energy before it reaches the earth) is the most contentious geoengineering strategy. Solar radiation management (SRM) technology is largely experimental and strategies to research SRM are extremely controversial in the scientific community; yet the general public remains generally removed from this debate. Partisanship traditionally provides a clear lens through which to view favorability to climate change policies with Republicans generally less in favor of climate policies because of perceived impacts on business. However, the lack of partisan attention to SRM suggests other belief systems may be better explainers of SRM attitudes. Previously, scholars (Jones 2011; Kahan et al. 2015) have found climate attitudes to vary based upon cultural types which are a function of how individuals see the role of authority in policymaking and the extent to which individuals see themselves as part of a social unit.

Our work utilizes a national survey of 2,210 adults in the United States to investigate the role of cultural theory in explaining SRM attitudes. We find that most adults in our survey have no knowledge of SRM. After describing SRM to respondents, we find that the majority of respondents are supportive of SRM research in laboratory settings; less supportive of field trials and the use of SRM in the case of emergency; and least supportive of immediate deployment. Further, we find that partisanship is a weak predictor of SRM attitudes, while cultural affinities provide strong influences over SRM attitudes. Specifically, we find strong group affinities to lead to more favorable impressions of SRM research and deployment in the case of climate emergencies. Attitudes toward hierarchy, specifically, cultural affinities that disfavor hierarchy, explain hostility to SRM. We contrast these results with a separate analysis of more widely known mitigation policies: carbon taxes, regulations on carbon emissions, taxes on higher income earners for green investment and carbon cap and trade. For these better-known policy positions, partisanship is far more important. Our work contributes to the application of cultural theory to policy attitudes as well as the shifting landscape of attitudes toward geoengineering.

## Introduction

Geoengineering is an under-researched, controversial and largely unknown solution to an already politically fraught problem in climate change where, particularly in the United States, partisanship determines support for policy tools. Geoengineering encompasses planetary scale interventions in the earth's climate system taking two general forms: carbon dioxide removal (CDR) and solar radiation management (SRM) whereby solar energy is reflected back to space before it can head the planet's surface. The vast majority of people in the world know little to nothing about geoengineering – even if they are climate aware.

Research understanding the foundations of geoengineering opinion is still largely in early days in no small part due to the fact that the vast majority of individuals who are surveyed about geoengineering learn about it for the first time from survey researchers. The general lack of awareness of geoengineering provides opportunities to study a response to climate change that has yet to become an ideologically polarized issue (Long and Scott 2013) in contrast with other policies such as regulations on greenhouse gas (GHG) emissions or green taxes. The geoengineering literature suggests a potential for attitudes that cut across partisan attitudes, with interventions that may prevent climate harms while maintaining the current fossil fuel status quo.

Belief structures outlined within cultural theory have provided additional and distinct purchase in scholarship assessing variation in climate policies. Cultural theory foundational elements of grid - attitudes about the role of authority in policymaking - and group - attitudes toward social solidarity - have been found to influence attitudes toward the severity of climate risks and preferences for specific actions for mitigation tools. In general, this literature notes that individuals more strongly aligning with the group dimension of cultural theory are more likely to identify climate risks and favor interventions, while the grid dimension is more variable. However, policy scholars have yet to assess the impact of cultural theory specifically on geoengineering attitudes. In this paper we broadly investigate variation in geoengineering attitudes and we specifically ask: how does cultural theory explain geoengineering attitudes?

To solve this puzzle, we investigate a range of policy responses to the more controversial form of geoengineering: solar radiation management. Solar radiation management techniques include such technologies as cloud enhancement (Pope et al. 2012) and mirrors in space. Current discussion of SRM revolves around the capacity of SRM to serve as an emergency intervention in the earth's climate system, but one that could have catastrophic consequences. Because of the potential for harm, even researching SRM has proved controversial. We investigate the effects of partisanship and cultural theory types on a range of SRM policies: an outright ban, laboratory research, field experiments, deployment in the case of emergency, and deployment now.

Our work utilizes a national survey of 2,210 adults in the United States. We find that the vast majority of adults in our survey have no knowledge of SRM. After describing SRM to respondents, we find that the majority of respondents are supportive of SRM research in laboratory settings. We find that respondents are less supportive of field trials and use in the case of emergency and least supportive of immediate deployment. Further, we find that partisanship is a weak predictor of SRM

attitudes, while cultural affinities provide strong influences over SRM attitudes. Specifically, we find strong group affinities to lead to more favorable impressions of SRM research and deployment in the case of climate emergencies. Attitudes toward hierarchy, specifically, cultural affinities that disfavor hierarchy, explain hostility to SRM. We contrast these results with a separate analysis of more widely known mitigation policies: carbon taxes, regulations on carbon emissions, taxes on higher income earners for green investment and carbon cap and trade. For these better-known policy positions, partisanship is far more important. Our work contributes to the application of cultural theory to policy attitudes as well as the shifting landscape of attitudes toward geoengineering.

## Perceptions of Geoengineering and Solar Radiation Management

Geoengineering as a climate change strategy and many of the specific tools that geoengineers would use often are received as science fiction. Carbon dioxide removal (CDR) on a small scale is relatively well understood (e.g. afforestation), but large scale, technology-heavy forms of CDR such as direct air capture whereby carbon dioxide is extracted from the atmosphere and deposited deep within the earth (ironically, often in old oil and gas sites) are still in their nascent form. However, both the Trump (the "Trillion Trees" initiative) and Biden (the 2021 Inflation Reduction Act's $3.4 bn to construct four direct air capture plants) administrations have made policy rumblings about large-scale CDR. But, suffice to say, these technologies are unproven at scale. Even more technologically challenging and environmentally risky are solar radiation management (SRM) techniques which include such technologies as marine cloud seeding, stratospheric cloud creation, and mirrors in space. Similar to CDR, very small-scale SRM strategies have been successfully attempted, but nothing approaching the scope required to change the global climate, not to mention the (in some cases, literal) environmental fallout associated with their global deployment. Solar radiation management in large part is an unregulated and controversial field to those who know about it and has largely been ignored by policymakers globally.

Geoengineering is not well known (Corner, Pidgeon, and Parkhill 2012), except for particular populations most interested in climate change. Surveys often find that the general public knowledge of geoengineering, across multiple countries, is less than 10 percent (Mercer, Keith, and Sharp 2011; Corner and Pidgeon 2015). This number increases when respondents are given some context for geoengineering, such as relating geoengineering to climate change or mentioning specific tools associated with geoengineering. Within geoengineering, carbon dioxide removal benefits from greater public awareness than solar radiation management owing to overlaps between CDR and better known mitigation techniques such as afforestation and, more recently, direct air capture (Carlislie et al. 2020).

Support for geoengineering ~~in general~~ is highly variable in part because of the technical nature of its use, but this is largely a function of extremely low awareness. Within the issue network of climate change policy advocates, there is real reluctance to support SRM specifically, though CDR enjoys more support. Again, some of this variation may be due to the technological challenges associated with SRM in comparison with CDR (though, CDR at the planetary scale required for geoengineering presents significant technical and governance challenges, too).

Surveys show a mixed picture with respect to the effect of geoengineering knowledge on support for geoengineering. Individuals who claim to be the most informed about geoengineering are often heavily engaged in the politics of climate change adaptation and mitigation or are conspiracists concerned about powerful individuals or countries intentionally toxifying the atmosphere. Thus, it is perhaps not surprising that some studies (Cummings and Rosenthal 2018; Cummings, Lin, and Trump 2017) find that familiarity with geoengineering leads to less support. Relatedly, Braun (2017) finds that informing people of geoengineering also leads to less support in the short-term, but this opposition wanes over time. Informing individuals of SRM has been shown to shape perceptions of other climate solutions, particularly for populations that are less likely to support other climate tools. Skeptics (The Royal Society 2009), individuals who favor markets over equality (Kahan et al. 2015), and conservatives (Fairbrother 2016) have been shown to increase their support for mitigative actions as they are informed of geoengineering. Solar radiation management is an extremely low-knowledge, low-salience issue for most people. In such scenarios, any information offered to individuals about SRM can be counted on to influence attitudes; and, as we show, the literature generally shows new information to put downward pressure on attitudes, leading to the following hypothesis:

**H1: Knowledge of SRM leads to less support for SRM.**

Attitudes toward SRM are a function of perceptions of obvious, knowable harms (e.g. less sun, acid rain, etc) and benefits that appear to be fantastical (e.g. setting a global temperature). However, if the harms of climate change are perceived to be large, soon, and proximate, attitudes about SRM that emerge from concerns over SRM harms may be offset by perceptions of climate catastrophes. Thus, attitudes toward climate change are crucial to determining attitudes toward geoengineering (Visschers et al. 2017; Mahajan, Tingley, and Wagner 2019). Individuals who do not believe that climate change is occurring certainly will not see the benefits of engaging in solar radiation management because for many potential reasons (e.g. the wrong belief that humans can't affect global climate or simply geoengineering addresses a non-existent problem with no other concomitant benefits). Belief in climate change enhances an interest in solar radiation management, but so, too, do opinions that climate harms may be soon and catastrophic. The preceding analysis motivates the following hypothesis:

**H2: Belief in climate change leads to greater support for SRM.**

Attitudes towards science and scientists are particularly important in discussions of climate policy and this is ~~particularly~~ pronounced in the case of SRM's unproven and unclear technology. Solar radiation management relies upon confidence in climate change predictions to characterize climate risk, which itself depends upon trust in scientists that study climate change. Further, scholars (Cummings and Rosenthal 2018; Raimi 2021) have found support for SRM to be driven by trust in scientists given the extreme technological advancements required for solar radiation management to be effective, leading to the following hypothesis:

**H3: Trust in science leads to greater support for SRM.**

## Cultural Theory and Solar Radiation Management

Solar radiation management represents a 'clumsy solution' to climate change that may not map onto existing polarized partisan positions regarding solutions (Verweij et al. 2006; Nowlin 2022; Thompson 2003). In addition, the lack of broad salience of SRM in political discourse writ large suggests that it is a policy option yet to be linked to a particular partisan valence. Thus, we look to cultural theory as an alternative value structure to explain policy preferences.

Cultural theory posits that individual attitudes toward social and political phenomena are a function of how individuals view both the role of authority in motivating their decision-making and the "degree to which people affiliate themselves with a bounded social unit (McNeeley and Lazrus 2014)". Wildavsky (1987) and coauthors (Dake and Wildavsky 1991; Wildavsky and Dake 1990) initially described these characteristics along four dimensions; Jenkins-Smith and co-authors (2011) refined the measure to the more widely utilized 'grid' and 'group' (Johnson and Swedlow 2021). Grid and group are generally understood to represent a continuum of worldviews informed by (Nowlin and Rabovsky 2020) and informing social interactions (West, Bailey, and Winter 2010). Individuals that score high on the grid dimension are more accepting of externally imposed rules on social behavior, individuals that score lower on the grid dimensions more likely to favor autonomy from authority. Individuals who score higher on the group dimension are likely to engage in behaviors motivated by a desire to contribute to and maintain group benefits. Individuals who score lower on the group dimension are not inherently against groups, but are not compelled by group benefits.

Solar radiation management requires significant confidence in the role of expertise, specifically scientific expertise, in both the identification of climate change and in the (incredible) interventions in the earth's climate system. Solar radiation management presents serious risks in deployment, risks that find themselves in competition within risks to the planet that result from climate change now and in the future. While regional SRM strategies do exist, the broader debate about SRM is largely framed as a planet-wide set of impacts with benefits of successful SRM felt across the globe (the same goes for burdens). Thus, we posit that individuals who are motivated by group affiliations are more likely to favor SRM, particularly in the case of climate change.

**H4a: Individuals scoring higher on the group dimension will support SRM**

The collective action problems associated with many climate solutions make large-scale policy efforts challenging. Mitigation policies require that individual people, governments, or countries make significant investments that ultimately amount to fractional contributions to the stock of GHGs in the atmosphere despite individually born costs. Adaptation policies often provide benefits for the entities engaging in the costs of adaptation, but this limits the global reach of policy activities. Geoengineering, and particularly SRM, are technologies where one individual, government, or country can potentially affect the entire globe. Thus, the research, development, and ultimate deployment of SRM technologies are heavily dependent upon centralized powers in the form of government and private entities. Prominent skeptics of SRM include a broad ideological range of individuals, from philosophers to conspiracy theorists, however a uniting theme is a

skepticism of SRM because of concerns that policy choices will be made by elites – e.g. billionaires, particular industries, technocrats, big government, etc – without sufficient democratic input. Thus, we posit that individuals that have less affinity for authority are more likely to oppose SRM.

**H4b: Individuals scoring higher on the grid dimension will support SRM**

When grid and group are overlaid, four categories of worldview emerge: individualism (low group, low grid), egalitarianism (high group, low grid), hierarchism (high group, high grid), and fatalism (low group, high grid). Scholars (Hulme 2009; Wildavsky 1987) have produced numerous two by two charts to describe this relationship (see ours in Figure 1), though the methodological manifestation of this relationship does not typically identify a specific individual as one of these categories (e.g. a person is a "hierarch") but the extent to which individuals hold beliefs relative to each of these categories (e.g. a person has a number of tendencies that are common to a hierarchism). These worldviews manifest in significant differences in thinking through the role of governments and public policy in motivating behavior. Individualism is generally market oriented, preferring structures that enable competition and freedom of choice. Egalitarianism is similarly interested in self-determination in governance, but does favor political arrangements where group considerations constrain individual behaviors. Hierarchism has a similar affinity for governance that produces group benefits at the expense of individual freedoms, but also in favor of an ordering of society where expertise is favored over participation. Fatalists generally envision a world in which they are not strongly part of a general group (either in a participatory or beneficial way), but also exist in a world in which their decisions are constrained.

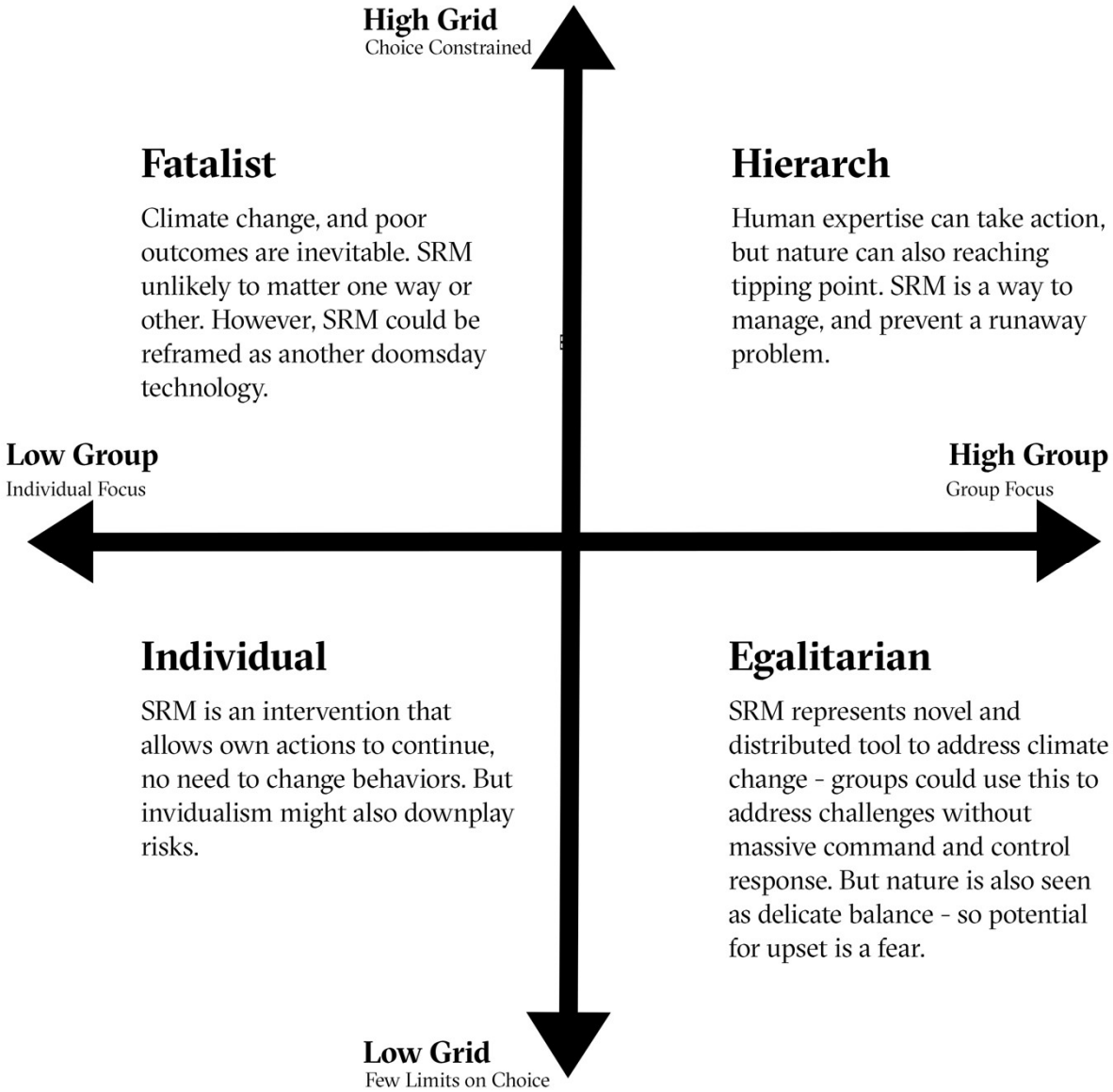



Figure 1. 2 by 2 cultural theory grid

Perhaps the most common application of Cultural Theory is the investigation of risk perception as a function of cultural theory type (Wildavsky and Dake 1990; Dake and Wildavsky 1991; Johnson and Swedlow 2021; Kiss, Montpetit, and Lachapelle 2020). In particular, studies examine the role that cultural type plays in attitudes toward policies that intervene in the natural world. Multiple scholars (Halik, Verweij, and Schlüter 2018; Price, Walker, and Boschetti 2014; McNeeley and Lazrus 2014; Thompson 2003; Hulme 2009) match cultural types to myths of nature for the purpose of determining attitudes toward environmental policies (Grendstad and Selle 2000; Timmerman 1986). Individualists view nature as a benign phenomenon that will adapt or bend to human actions, while the egalitarian cultural typology leads to a view of nature as existing in a fragile balance with society. Hierarchs view nature as both somewhat tolerant of human action as

well as manageable by humans; however, hierarchs are also aware of specific points of no return regarding environmental systems. Fatalists believe that nature is capricious and ultimately outside of the realm of human control, rather, that nature exerts influence over humanity regardless of human actions.

Nowlin and others (Nowlin and Rabovsky 2020; Nowlin 2022; Ripberger et al. 2012) have specified relationships between cultural theory types and climate attitudes with the starkest contrast existing between egalitarians and individualists. These ideologies, too, best map onto ideologies, particularly in the US context. Egalitarians, with their concept of nature as fragile, see the natural world as critical for human development and, thus, are most likely to support climate change policies. Believing that nature is resilient and that societal growth comes through idiosyncratic expression, individualists are the least likely to support climate policies. Cultural theory scholars have noted that the grid dimension is ultimately bound up with other notions of ideology. In other words: people often don't mind authority so long as it enforces their fundamental beliefs. Thus, hierarchs, in Nowlin's (2022) words, tend to have "muddled" views on climate change. Fatalists, in broad strokes, generally are less interested in the government doing much of anything and this is specifically true in the case of climate change (Jones 2011).

The cumulative knowledge of the benefits and burdens of SRM coupled with research matching cultural theory types with conceptions of nature and climate attitudes lead us to believe that the group dimension is more important than the grid dimension in determining SRM attitudes. Thus, we posit that egalitarians are most likely to be in favor of SRM. Further we posit that hierarchs are also favorable toward SRM, albeit with less fervor compared with egalitarians. Fatalists are less likely to favor SRM in part because of their lack of group affinity, but also given previous findings in the literature that fatalists in general are less favorable toward climate policy at all. Finally, individualists are the least likely to favor SRM given attitudes that are less favorable to centralized authority as well as have low group affinity. Our propositions are summarized in Table 1.

| **Hypothesis** | **Cultural Type** | **Favorability toward SRM** |
|---:|---|---|
| H5a | Egalitarians (high group, low grid) | Most positive |
| H5b | Hierarchs (high group, high grid) | Positive |
| H5c | Fatalists (low group, high grid) | Negative |
| H5d | Individualists (low group, low grid) | Most negative |

Table 1. Direction and magnitude of general expected relationships between cultural types and SRM attitudes.

Still, it may be possible for lower group cultural types to favor SRM, though for different reasons. While SRM may be an externally imposed climate solution, geoengineering may supplant many other more invasive climate policies that constrain individual behavior. It is possible, then, that individualists might particularly prefer a policy where climate change is addressed with little impact to their current routine. The potential for catastrophe looms over all discussions of SRM - e.g. technological failures can cause rapid warming and runaway greenhouse feedback effects. Fatalists might see the earth as doomed in either case and thus might not resist SRM elements.

## Governance Challenges and Policy Options: Choices between Research and Use

Thus far we have constructed an understanding of SRM attitudes based upon knowledge of SRM as well as underlying beliefs in the form of cultural theory, but we also consider support for SRM policy tools. In what sometimes feels like a cart-before-the-horse discussion, a significant portion of the SRM literature considers policy designs (or, lack thereof) as part of the potential challenges associated with governance (Preston 2013; McLaren and Corry 2021). Considerable debate exists regarding the ethics of even talking about SRM, much less the technological challenges associated with development and the logistical challenges associated with continued deployment. Even if these issues are addressed, some scholars understand solar radiation management to be inherently anti-democratic (Szerszynski et al. 2013).

In spite of this considerable theoretical debate, or perhaps because of it, SRM is currently undertheorized, largely unregulated, and many of the potential technologies associated with SRM are untested. In broad strokes, governments have not taken particularly strong measures to encourage or regulate SRM which creates a nascent governance regime for which any policy step would be significant. Among the range of options governments can consider, the following emerge from the literature: ban, encouraging more research in a lab, allowing for field experiments, deployment in the case of emergency, and immediate deployment (see Merk et al. 2015). Attitudes toward the low-salience issue of SRM depend upon individual risk perception regarding climate change versus the outcomes of these various policy interventions.

H6: Support for solar radiation management policies decreases as tools move from laboratory research to deployment.

There is some empirical evidence to suggest that each of these steps represents a different level of commitment to geoengineering and an enhanced risk associated with potential environmental or social calamity that might result. In their (2015) article, Merk et al find general support for laboratory research, less support for field research (see also Carlisle 2020), and rejection of immediate deployment suggesting that we can expect variation in levels of support for these options based upon the potential risks associated with each. However, this finding is not universal as Jobin and Siegrist (2020) find no difference in support between research and deployment. The general consensus among most empirical studies is that the public hold serious reservations about ever doing SRM (Corner and Pidgeon 2015; Macnaghten and Szerszynski 2013; Corner, Pidgeon, and Parkhill 2012). While SRM is seen as risky (certainly more than CDR), favorability toward deployment increases among those that see it as a quick fix to an even worse climate problem (Carlislie et al. 2020; Mahajan, Tingley, and Wagner 2019).

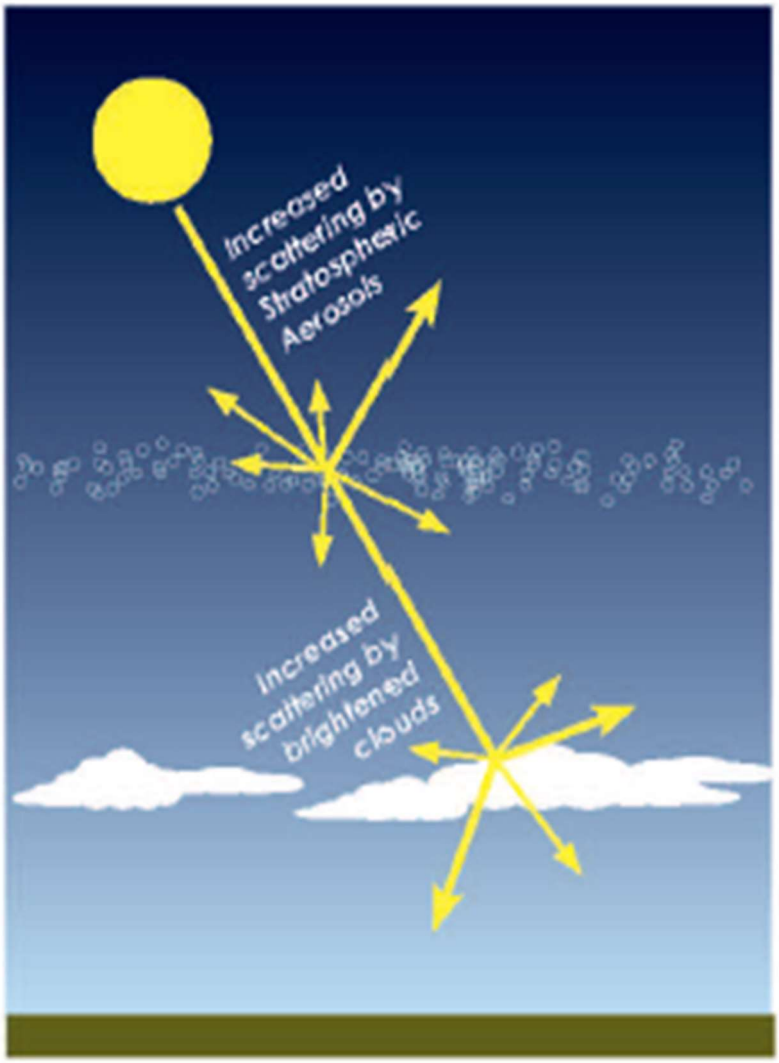
## Methods

To investigate our hypotheses, we conduct a national survey in the United States. We present respondents with information about SRM after asking them how much they have heard of the topic. We then conduct analyses of these data using ordered logit regression and logistic regression..

*Survey Design*

The survey was developed as a part of an ongoing research project at Reed College under the Northwest Policy Priorities Project (NWPP). This survey was developed with a focus on climate change perceptions, environmental attitudes, opinions on SRM, and finally trust in science and institutions. We first asked respondents about their familiarity with SRM. Response options allowed for never having heard of it, and having heard a little or a lot about SRM. Next, we introduced SRM using a vignette found in Figure 2 which provided a common introduction to all respondents. The vignette included a visualization developed by the National Research Council. Respondents were given the following to read before answering questions regarding SRM.

Existing tools to address climate change include reducing fossil fuel consumption or responding to rising seas or hotter climates with changes in where or how people live. These tools have many costs and challenges. New technologies are being proposed to prevent a fraction of the solar energy from reaching the planet through the introduction of reflective substances in the atmosphere which scatter light energy before it reaches the surface of the earth as illustrated in the figure below. The scientific community refers to this as Solar Radiation Management or SRM.




Citation: National Research Council 2015.

Spraying or releasing these substances would likely need to occur annually. The substances would be distributed at an altitude of twice the height that commercial airliners

use. This approach mimics an effect created by large volcanic eruptions. There are potential benefits and risks to this approach.

*Benefits*

SRM would cost less than any other existing proposal to address climate change and global warming. It has the potential to reduce the rate of warming on Earth by 50% in the next 50 years. SRM allows for humankind to address climate change with very limited economic impacts and no change to our lifestyles or communities.

*Risks*

There is a possibility that these substances could damage the ozone layer or produce harmful acid rain. It is not certain that these technologies would work as planned or that it would benefit all of the planet the same way. There is also a potential that the reduction in heating created by SRM could invite some nations to increase their carbon emissions if they believe there is now a permanent solution.

FIGURE 2: SURVEY VIGNETTE INTRODUCING SRM

After presenting the vignette we asked five questions regarding opinions on SRM using a four-point scale to rate their agreement, from strongly disagree to strongly agree. The five SRM policy options presented (from Merk et al. 2015): scientists should research SRM using theoretical models, simulations, and lab experiments; scientists should test SRM using field trials, that is, experiments in the real world outside the laboratory; SRM should be used when massive and irreversible changes in the climate system are approaching which cannot be averted otherwise; SRM should never be used no matter the situation; and if SRM was possible today, we should use it immediately. Statements were randomly rotated when presented to respondents and shown in two blocks of dynamic grids. We also ask respondents to rate whether the following mitigation policies are a good idea or a bad idea (not sure is also an option): a tax on emissions of carbon based fuels such as coal, oil, and natural gas; increasing taxes on high income earners to invest in green jobs and energy efficient infrastructure; strict limits and enforcement on carbon emissions; and using permits for carbon emissions in a cap and trade market.

Following SRM and mitigation questions we asked respondents to respond to questions developed in previous work on cultural theory (Jenkins-Smith et al. 2011; Jones 2011) using a five-point scale for respondents to rate agreement or disagreement: strongly agree; somewhat agree; neither agree nor disagree; somewhat disagree; and strongly disagree. The final questions included in this analysis asked about confidence respondents had in climate scientists,[1] how likely new

[1] The confidence in climate scientists question we used the following scale: a great deal of confidence, only some, hardly any, and no. For analysis this item was recoded into a dummy variable using the "a great deal".

technology will solve most of the problems from global climate change,[2] and the belief that humans can or could take action on climate change.[3] We also ask about educational attainment, recoding into a dummy variable that includes college or higher. Tables 2 and 3 share the summary statistics for these variables. Table 2 presents the four indices, each constructed from three items. The Cultural Theory battery contains twelve questions in total.

| **Variable** | **Mean (Std Deviation)** | **Min** | **Max** |
|---|---|---|---|
| Individualism Index | 3.16 (1.07) | 1 | 5 |
| Hierarch Index | 2.84 (1.02) | 1 | 5 |
| Egalitarian Index | 3.31 (1.12) | 1 | 5 |
| Fatalism | 2.88 (0.95) | 1 | 5 |

TABLE 2: SUMMARY STATISTICS OF COMPOSITE CULTURAL THEORY INDICES

| **Variable** | **n (Percent)** |
|---|---|
| Awareness of SRM* | 944 (30%) |
| Great deal of confidence in scientists that study climate change | 1190 (38%) |
| New technology will solve most of the problems from global climate change in next 50 years | 1679 (53%) |
| Humans could (or can) reduce climate change** | 2210 (70%) |
| Republican | 811 (29%) |
| Four year college degree or more | 1083 (34%) |
| * Two response levels are combined here, "Yes, I have heard a lot about SRM" and "Yes, I have heard a little about SRM". ** This item has three response levels combined that reflect respondent belief that humans can act to change the climate. Responses include perspectives that humans could, but are unwilling or uncertain on how to act. | |

TABLE 3: SUMMARY STATISTICS OF VARIABLES RECODED FOR USE AS COVARIATES IN MODELLING

[2] For the technology item the question asked how likely technology would solve problems from climate change in the next 50 years. We used the following scale: very likely, somewhat, not very, very unlikely; recoded into a dummy variable for technological optimism using the "very likely" responses.

[3] The climate action item provided five statements about the possibility that humans could act to address climate change. This included two statements in the negative: that climate change was not happening and that no action was possible. Two positive responses shared that action was possible but limited by uncertainty or political commitments. The fifth stated it was and possible and humans can today take action. These final three statements were recoded in together.

*Survey Administration*

We conducted an online survey using an opt-in panel administered by YouGov. The survey was conducted by using a representative sample of 2,210 adult US residents interviewed online between August 8 - August 15, 2022. Respondents were selected from YouGov's opt-in panel to be representative of adult US residents based upon their age, gender, race and education. The survey sample was weighted according to gender, age, race, education, state and geographic region within the state based on the U.S. Census American Community Survey, and the U.S. Census Current Population Survey, as well as data from self-reported turnout and presidential vote. The state level weights were trimmed to have a range of 0.4 to 4.1. The margin of error (MOE) for estimates is 1.8 percent. These reported measures of error do not reflect non-sampling errors, including potential selection bias in panel participation or in response to a particular survey.

*Analysis*

For the SRM research questions, we conduct an ordered logit given the ordinal structure of the data. For the mitigation questions, we conduct a logistic regression given the binary structure of the response data. We employ the same binary regressors for all models: awareness of SRM, confidence in climate scientists, ability of technology to solve problems of climate change, ability of humans to take action to address climate change, Republican party identification, and college education (see Tables 1 and 2 for summaries).

## Results

Affinities for different dimensions of cultural theory produce different levels of support for SRM across a range of commitments (See Figures 3 and 4 as well as Table 4). Egalitarian beliefs (low grid, high group) lead to increased support for all SRM questions (lab research, field research, deployment now, and deployment in times of emergency) except never using SRM. Respondents with hierarchical affinities (high grid, high group) favor field experiments, the use of SRM now, and the use of SRM as a last resort. Individuals scoring higher on individualism (low grid, low group) are more likely to favor SRM field experiments, the use of SRM if it were possible right now, but are, curiously, also more likely to favor never using SRM. Finally, individuals with more fatalistic view (high grid, low group) offer the least enthusiasm for SRM, favoring SRM as a last resort but also supporting that SRM never be used.

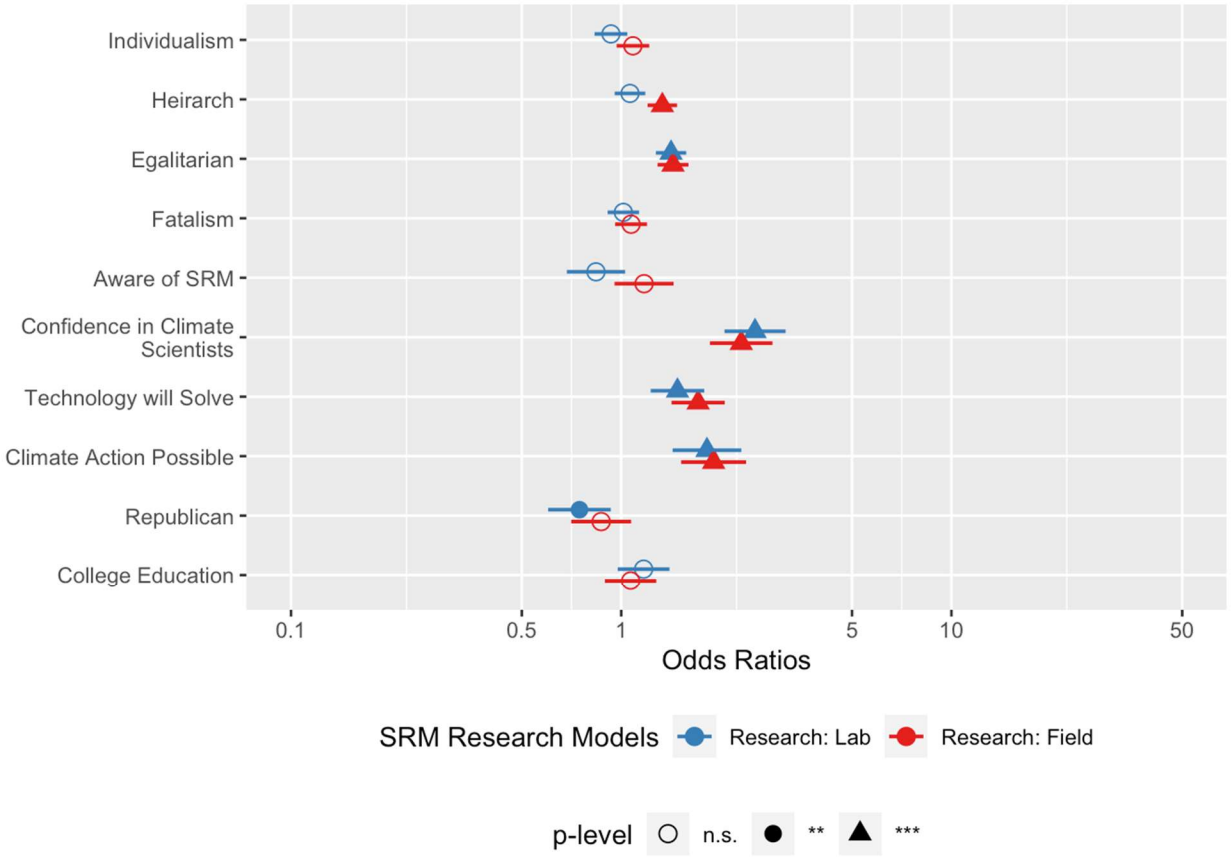



FIGURE 3: ODDS RATIOS FOR SRM RESEARCH MODELS

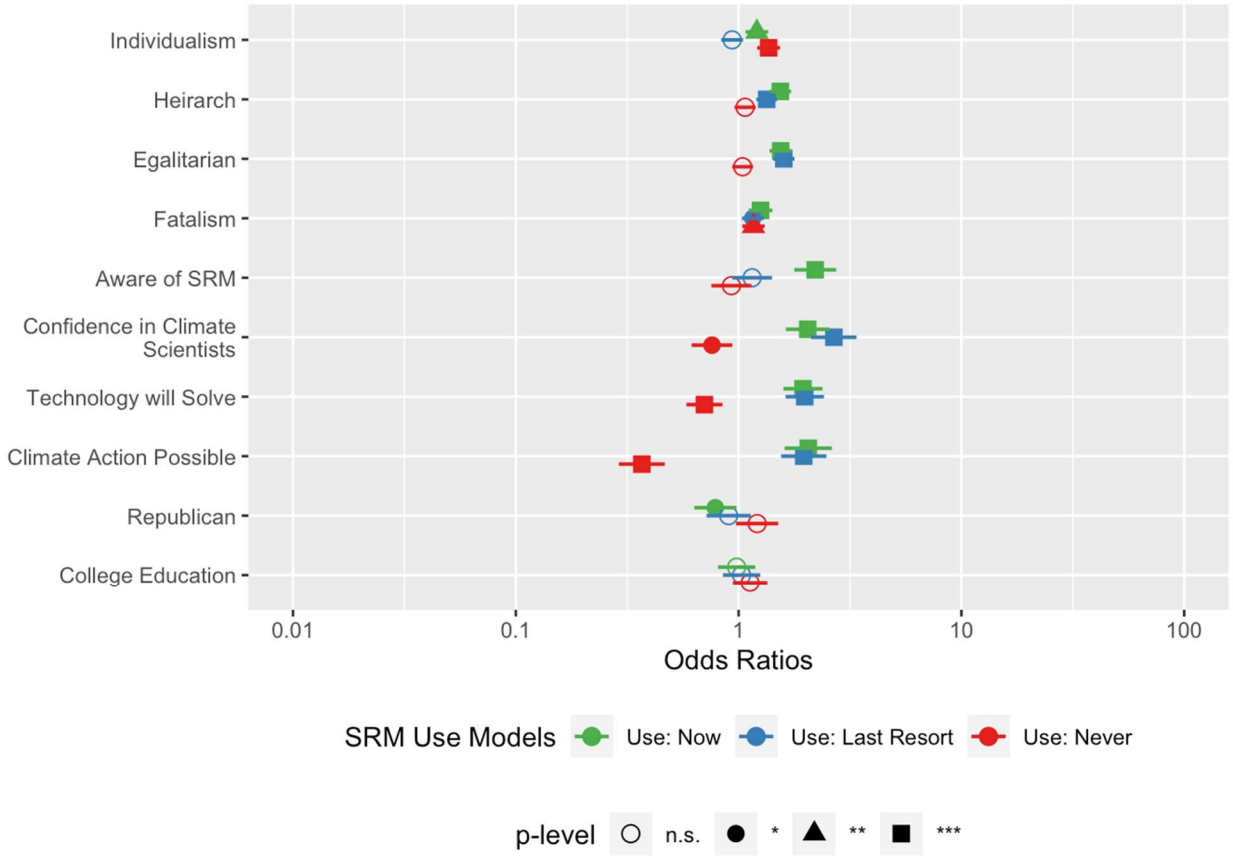



FIGURE 4: ODDS RATIOS FOR SRM USE MODELS

| **Variable** [1,2] | **Research in Lab** | **Research in Field** | **Use: Now** | **Use: Last Resort** | **Use: Never** |
|---|---|---|---|---|---|
| CT: Individualism | *0.93* | *1.08* | 1.21** | *0.94* | 1.36*** |
| CT: Hierarch | *1.06* | 1.33*** | 1.54*** | 1.34*** | *1.07* |
| CT: Egalitarian | 1.42*** | 1.43*** | 1.54*** | 1.59*** | *1.04* |
| CT: Fatalism | *1.01* | *1.07* | 1.25*** | 1.16* | 1.17** |
| Aware of SRM | *0.84* | *1.17* | 2.21*** | *1.15* | *0.93* |
| Confidence in Climate Scientists | 2.54*** | 2.31*** | 2.04*** | 2.68*** | 0.76* |
| Technology will be Able to Solve Climate Problems | 1.48*** | 1.71*** | 1.94*** | 1.98*** | 0.70*** |
| Humans can Take Action on Climate Change | 1.82*** | 1.90*** | 2.05*** | 1.96*** | 0.37*** |
| PID: Republican | 0.75** | *0.87* | 0.79* | *0.90* | *1.21* |
| Education: College or more | *1.17* | *1.07* | *0.98* | *1.03* | *1.13* |
| [1] *p<0.05; **p<0.01; ***p<0.001 | | | | | |
| [2] OR = Odds Ratio | | | | | |

TABLE 4. ORDERED LOGISTIC REGRESSION OF SRM POLICY ATTITUDES

The results indicate stronger support for SRM from respondents who have closer affinities to cultural types that score higher on the group dimension (egalitarians and hierarchs). While it is true that there is also support from low group cultural types (individualists and fatalists), it is less consistent and of a lesser magnitude. The grid dimension explains SRM skepticism as respondents scoring highly on individualism (low grid) and fatalism (low grid) are in favor of never using SRM.

Respondents that have prior knowledge of SRM are consistently more likely to support the research and immediate deployment of SRM. There is no relationship between SRM awareness and deploying in the case of emergency or never using. One inference from these findings is that SRM awareness is linked in some part with a positive familiarity with SRM. Given that there are relatively few SRM evangelists in comparison with what appears to be a strongly cautious academic community coupled with lay conspiracists this finding is notable, particularly so given other academic research that finds knowledge of SRM decreases positive attitudes towards use.

Our work broadly finds that individuals who are engaged in climate change on multiple dimensions are more likely to favor SRM research and deployment. We specifically find that trust in climate scientists, beliefs that technology can solve climate issues, and a desire for actions to address climate change are all associated with stronger support for SRM. The magnitudes of these effects, particularly in support of climate scientists, are quite pronounced.

Finally, partisanship does not serve as a particularly strong indicator of support for SRM. Republicans are less likely to support laboratory research of SRM techniques and are less likely to support the immediate use of SRM. However we find no relationship between partisanship and key dimensions of never using SRM or using SRM in times of a climate emergency.

We understand that solar radiation management is a niche issue in the world of climate change politics and policy. Our findings have value on their own simply to gauge attitudes toward SRM and we offer unique findings that cultural types higher in group offer support for SRM, cultural types lower in grid offer skepticism, knowledge of SRM increases support for its research and deployment, and partisanship has limited influence. In addition to asking respondents about SRM, we also asked about better known climate issues, specifically: cap and trade, emissions regulation, carbon taxes, and taxes on the wealthy to fund climate initiatives. These policies are far better known than SRM and have been the subject of considerable partisan debate at the state and federal level in the United States. We use the same independent variables to predict support for these mitigation policies in Table 5.

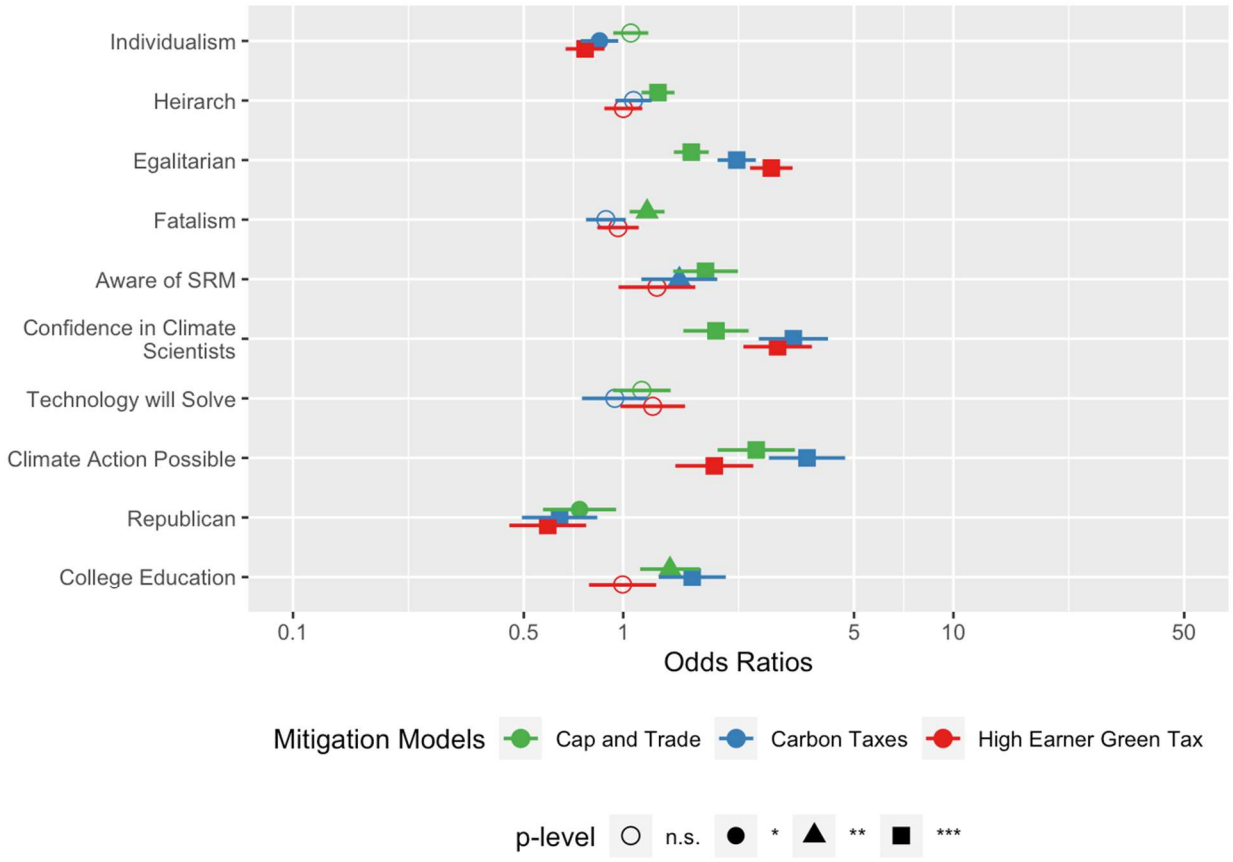



FIGURE 5: ODDS RATIOS FOR CONVENTIONAL MITIGATION POLICIES

| Variable [1,2] | Cap and Trade | Carbon Taxes | High Earner Green Tax |
|---|---|---|---|
| CT: Individualism | 1.05 | 0.85* | 0.77*** |
| CT: Hierarch | 1.27*** | 1.07 | 1.00 |
| CT: Egalitarian | 1.61*** | 2.21*** | 2.81*** |
| CT: Fatalism | 1.18** | 0.89 | 0.96 |
| Aware of SRM | 1.78*** | 1.48** | 1.26 |
| Confidence in Climate Scientists | 1.91*** | 3.28*** | 2.93*** |
| Technology will be Able to Solve Climate Problems | 1.14 | 0.94 | 1.23 |
| Humans can Take Action on Climate Change | 2.53*** | 3.60*** | 1.89*** |
| PID: Republican | 0.74* | 0.64*** | 0.59*** |
| Education: College or more | 1.39** | 1.62*** | 1.00 |
| [1] *p<0.05; **p<0.01; ***p<0.001 | | | |
| [2] OR = Odds Ratio | | | |

TABLE 5. LOGISTIC REGRESSION OF MITIGATION POLICY ATTITUDES

The results in Figure 5 and Table 5 provide similar findings on the role of group in attitudes toward mitigation policies, though with the distinction that certain cultural affinities actually *reduce* support for particular climate initiatives. In general, low group (individualists and fatalists) affinities are far less in favor of top-down policies such as carbon taxes, regulations, and taxes on the wealthy. Egalitarian affinities (high group) are strongly in favor of all mitigation measures while hierarch affinities are only associated with support for cap and trade. While grid was important in understanding opposition to SRM, grid does not seem to be as influential over different mitigation strategies. Also similar to our SRM models, trust in science and respondents' individual desire for climate action contribute to more support of mitigation measures.

Climate change mitigation is a highly partisan issue and our findings bear this out for mitigation in ways that are not seen in SRM. Republicans are consistently against all mitigation policies. Other relationships, too, are distinct between traditional mitigation policies and SRM. Faith in technology to solve climate problems does not influence attitudes toward mitigation policies, with the exception of a tax on high income earners to fund green investment which is related to future technology. Finally, education does not influence SRM attitudes, but does increase support for all mitigation policies (taxes on higher income earners excepted).

## Conclusion

In this paper, we have investigated attitudes toward solar radiation management. We show that the concept of solar radiation management is not particularly widely known, that individuals with strong faith in science are much more likely to favor SRM in all its forms, that partisanship is a weak predictor of SRM attitudes, but that cultural types - particularly group affinities - are better predictors of SRM attitudes. Our results show the utility of applying cultural theory to nascent policy issues and offer a number of opportunities for future research.

First, the landscape of SRM is one of uncertainty for most individuals. Indeed our research finds that the vast majority of respondents have never heard of solar radiation management at all. Solar radiation management depends upon significant advances in science and strong government intervention in supporting research, implementing solutions, and governing the final outcomes. Our research shows faith in science and technology are crucial determinants of support for SRM. Solar radiation management, even in the rosiest scenarios, will come at a significant cost to the environment; thus, even thinking about deploying this technology requires a significant commitment to addressing climate change.

Second, unlike other climate issues, SRM does not follow traditional partisan patterns. As we have discussed previously, there are numerous governance challenges that emerge with respect to SRM goals (how cool?) and management (who decides to deploy?). Republicans may not like centralized government intervention, but may like the lack of serious climate regulation at the individual level. Climate conspiracists are largely Republican and specifically see one of the prime tools of SRM - stratospheric aerosol injection - as part of a grand "chemtrails" plot to spread toxic chemicals. Democrats are certainly keen on government actions related to climate change; however, the potential harms caused by SRM may be a bridge too far. Further, Democrats have

ideological fealty to other goals associated with some climate change solutions such as redistribution of monies from wealthy firms to lower-income individuals. While Republicans are consistently against mitigation measures, we find less opposition among SRM strategies.

We find that, in general, partisanship is not a particularly powerful predictor of SRM attitudes. In our analysis, Republicans are against current deployment, but they are not ruling it out, either. Solar radiation management is an issue, thus, in a rare pre-partisan stage. As a solution that is simply not considered, parties have not engaged in the kind of position-taking that hardens attitudes along dogmatic lines. Future studies might follow the evolution of partisan attitudes toward SRM and other geoengineering strategies as solutions become more salient, investigate party attitudes toward SRM in other governments countries where SRM and related technologies (e.g. cloud seeding) are more salient, or specifically probe partisan beliefs to varied messaging regarding SRM.

Third, while members of parties are equally skeptical of radical changes to the planet as a response to radical changes to the planet, underlying cultural beliefs about humanity's sense of agency in the form of cultural theory provides a powerful way to understand SRM attitudes. In general we find that individuals with a strong group affiliation are more likely to favor SRM research and deployment. Future research might identify the reasons for this, but we speculate that high-group individuals have a sense of loyalty to nature and to their fellow humans. Insofar as climate change approaches a tipping point to fundamentally disrupt nature and the lives of their fellow humans, SRM represents a kind of commitment to the notion that "we're all in this together". This finding is particularly the case for egalitarians, who are generally the strongest advocates of mitigation policies of all cultural theory types. Given the characterization of egalitarians as concerned about the delicacy of nature and potential risks that SRM poses to the environment, the finding of strong support for most SRM tools is particularly striking. In addition, along with other studies that use cultural theory to understand mitigation policy, we find that individuals with hierarchical beliefs are supportive of SRM, but that this support is somewhat muted. The takeaway is that these populations are broadly concerned about the environmental harms from climate change to roll the dice with SRM technologies, but this support is likely contingent upon who is deploying the technology. Future research might investigate this relationship further given that hierarchs tend to be more bipartisan than egalitarians or individualists and, thus, represent a population that has the capacity to swing support from or to SRM (or other geoengineering for that matter). This finding is buttressed by our other observation that low-grid respondents, particularly individualists, is key to understanding support for never engaging in SRM.

Our research does not attempt to solve the significant and important debates asking why we would consider SRM, how it might be done, and who will be involved in its implementation. Instead, we offer insights into how individuals are making sense of the evolving set of solutions associated with the increasingly dire climate crisis. And therein we can say any support for such wild solutions is a commentary on the seeming intractability of the current set of solutions in the current political environment in the United States. According to our data, for now, and in contrast to other studies conducted globally, the more Americans know about the radical solution (SRM), the more they support it - more so if they have concerns for others.

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