Title: 'Maintaining Planetary Systems' or 'Concentrating Global Power'? High Stakes in Contending Framings of Climate Geoengineering.

Citation: Cairns, R. & Stirling, A. (2014) 'Maintaining Planetary Systems' or 'Concentrating Global Power'? High Stakes in Contending Framings of Climate Geoengineering. Global Environmental Change, vol.28, pp 25-38.

Official URL: http://www.sciencedirect.com/science/article/pii/S0959378014000715

More details/abstract: 'Climate geoengineering' is becoming an increasingly prominent focus for global discussion and action. Yet, in academic, policy and wider political discourse, the frequent shorthand term 'geoengineering' is routinely used in very broad, ambiguous and multivalent ways. This study aims to contribute to understandings of these divergent current framings of 'geoengineering' and their implications. It asks not only about disparate understandings of geoengineering itself, but also what these reveal about deeper political dynamics around climate change, science and technology. To this end, the paper applies Q methodology to analyse geoengineering as a subjective discursive construct, the bounds of which are continually negotiated and contested. 35 participants from a variety of political and institutional backgrounds in the UK, US, Canada and Japan undertook a 'Q sort' of 48 statements about geoengineering between December 2012 and February 2013. Four distinctive framings emerged from this analysis, labelled: 'At the very least we need more research'; 'We are the planetary maintenance engineers'; 'Geoengineering is a political project'; and 'Let's focus on Carbon.' Results indicate a strong polarity around divergently-construed pros and cons of geoengineering as a whole – underscoring the political salience of this term. But additional axes of difference suggest a more nuanced picture than straightforward pro/anti positioning. The ambiguity of the term is argued to offer interpretive flexibility for articulating diverse interests within and across contending framings. The paper questions whether increasing terminological precision will necessarily facilitate greater clarity in resulting multivalent governance discussions and public engagement. It argues that the merits of any given form of precision and their policy implications will depend on particular framings. Much ambiguity in this area may thus be irreducible, with the challenges lying perhaps less in the ordering of discourse and more in reconciling the wider material political pluralities that this suggests.

TITLE PAGE

'Maintaining Planetary Systems' or 'Concentrating Global Power?' High Stakes in Contending Framings of Climate Geoengineering.

Dr. Rose Cairns[a]*
r.cairns@sussex.ac.uk
Tel: 0044 (0)1273 678350

Prof. Andy Stirling[a]
a.c.stirling@sussex.ac.uk

[a.] SPRU – Science and Technology Policy Research
University of Sussex, Falmer, Brighton, UK, BN1 9SL
*Corresponding author

Abstract

'Climate geoengineering' is becoming an increasingly prominent focus for global discussion and action. Yet, in academic, policy and wider political discourse, the frequent shorthand term 'geoengineering' is routinely used in very broad, ambiguous and multivalent ways. This study aims to contribute to understandings of these divergent current framings of 'geoengineering' and their implications. It asks not only about disparate understandings of geoengineering itself, but also what these reveal about deeper political dynamics around climate change, science and technology. To this end, the paper applies Q methodology to analyse geoengineering as a subjective discursive construct, the bounds of which are continually negotiated and contested. 35 participants from a variety of political and institutional backgrounds in the UK, US, Canada and Japan undertook a 'Q sort' of 48 statements about geoengineering between December 2012 and February 2013. Four distinctive framings emerged from this analysis, labelled: 'At the very least we need more research'; 'We are the planetary maintenance engineers'; 'Geoengineering is a political project'; and 'Let's focus on Carbon.' Results indicate a strong polarity around divergently-construed pros and cons of geoengineering as a whole – underscoring the political salience of this term. But additional axes of difference suggest a more nuanced picture than straightforward pro/anti positioning. The ambiguity of the term is argued to offer interpretive flexibility for articulating diverse interests within and across contending framings. The paper questions whether increasing terminological precision will necessarily facilitate greater clarity in resulting multivalent governance discussions and public engagement. It argues that the merits of any given form of precision and their policy implications will depend on particular framings. Much ambiguity in this area may thus be irreducible, with the challenges lying perhaps less in the ordering of discourse and more in reconciling the wider material political pluralities that this suggests.

Keywords: geoengineering; climate engineering; framing; Q method; discourse

Word count: 9728

Acknowledgements:

We would like to like to extend our sincere thanks to all of the participants in this study who gave generously of their time and shared their views on this complex topic very openly. The paper benefitted from comments and discussions from a number of individuals including Nils Markusson, Javier Lezaun, Steve Rayner and Peter Healey. We would also like to thank participants of a workshop on Geoengineering Governance that took place at St Annes College, Oxford, who commented on an earlier presentation of these findings. This work was funded by the ESRC and AHRC as part of the Geoengineering Governance Research Project (CGG).

'Maintaining Planetary Systems' or 'Concentrating Global Power?' High Stakes in Contending Framings of Climate Geoengineering.

Abstract

'Climate geoengineering' is becoming an increasingly prominent focus for global discussion and action. Yet, in academic, policy and wider political discourse, the frequent shorthand term 'geoengineering' is routinely used in very broad, ambiguous and multivalent ways. This study aims to contribute to understandings of these divergent current framings of 'geoengineering' and their implications. It asks not only about disparate understandings of geoengineering itself, but also what these reveal about deeper political dynamics around climate change, science and technology. To this end, the paper applies Q methodology to analyse geoengineering as a subjective discursive construct, the bounds of which are continually negotiated and contested. 35 participants from a variety of political and institutional backgrounds in the UK, US, Canada and Japan undertook a 'Q sort' of 48 statements about geoengineering between December 2012 and February 2013. Four distinctive framings emerged from this analysis, labelled: *'At the very least we need more research';* '*We are the planetary maintenance engineers'; 'Geoengineering is a political project';* and *'Let's focus on Carbon.*' Results indicate a strong polarity around divergently-construed pros and cons of geoengineering as a whole – underscoring the political salience of this term. But additional axes of difference suggest a more nuanced picture than straightforward pro/anti positioning. The ambiguity of the term is argued to offer interpretive flexibility for articulating diverse interests within and across contending framings. The paper questions whether increasing terminological precision will necessarily facilitate greater clarity in resulting multivalent governance discussions and public engagement. It argues that the merits of any given form of precision and their policy implications will depend on particular framings. Much ambiguity in this area may thus be irreducible, with the challenges lying perhaps less in the ordering of discourse and more in reconciling the wider material political pluralities that this suggests.

1 Introduction

Concepts of 'climate geoengineering' implicate a diverse array of technologies, in the broadest sense of this term (Jasanoff 1995) – including radically new forms of social practice, institutional culture and political relation, as much as potentially enormous innovations in artefacts and worldwide infrastructures. Commonly referred to as 'geoengineering', these include technologies variously aiming at 'solar radiation management' (such as stratospheric aerosol injection and marine cloud brightening), and those aiming at 'carbon dioxide removal' (such as ocean iron fertilization, or direct air capture) (Shepherd et al. 2009). Although the term geoengineering has become increasingly prominent in discussions of these approaches in scientific, policy, and civil society circles, there is evidence of a growing sense that the label itself may be so broad and ambiguous as to be unhelpful, or even incoherent. Thus the recent report from the IPCC 'expert meeting on geoengineering' draws attention to what it holds to be a 'fuzzy' boundary between geoengineering and other approaches to dealing with climate change, and suggests that 'because of the longstanding ambiguity surrounding the term geoengineering … the individual methods discussed might be referred to more specifically' (Edenhofer et al. 2012, p.3). This refrain about the need to look at different technologies and approaches separately runs through many other reports on geoengineering, and yet many of them (like the IPCC report) retain the word geoengineering in their titles (Shepherd et al. 2009; GAO 2010). In one such report by the US think tank, the Bipartisan Policy Centre (Long et al. 2011), debates around whether the term geoengineering 'was too imprecise…[or] too controversial' (Sarewitz 2011, p.7), actually resulted in the appearance of the additional (equally imprecise) term 'climate remediation' being used alongside geoengineering in the title.

Given the widespread awareness of the ambiguity of the term, and the difficulties this poses for meaningful (or accountable) governance interventions, is it the case that the term geoengineering can be said to have simply outgrown its usefulness? Or is it that, as has been argued to be the case for terms such as 'sustainability' or 'sustainable development' (Baker et al. 1997) it is the very ambiguity of the terms that provides the 'interpretive flexibility' (Pinch & Bijker 1984) enabling them to serve as 'boundary objects'

(Gieryn 1983) around which contending actors can co-ordinate (Stirling 2006). In this latter event, ostensibly negative properties of 'ambiguity' (unclear or uncertain meaning) and 'multivalence' (clearly contending meanings) may – provided other conditions are also satisfied – instead emerge (at least under some views) as potentially more positive. That an otherwise contending diversity of actors may in certain moments find such qualities 'useful' may lend such ambiguous and multivalent terms a surprising degree of resilience.

Rather than seeing either ambiguity or multivalence as 'a linguistic veil which can be lifted to reveal the truth' (Rydin 1999, p.468), and attempting to remove this by carrying out our own 'boundary work' (Gieryn, 1983) to define a sub-set of technologies or approaches as our object of study, a starting point is to adopt a more neutral position with respect to these properties. This study is thus distinct from previous work on frames and framing of geoengineering, much of which starts by offering a definition of geoengineering as the object of study (Sikka 2012a; Luokkanen et al. 2013; Huttunen & Hilden 2012; Scholte et al. 2013; Nerlich & Jaspal 2012). Rather than treating geoengineering *a priori* as an object, a 'novel controversial technology' (Luokkanen et al. 2013) – or even a set of technologies about which there exists an array of sometimes conflicting opinions, or for which there is support or opposition – this study treats geoengineering as a discursive phenomenon, the bounds of which are continually being negotiated. This is in line with insights in much recent policy analysis, which draws attention to the fact that environmental conflict should not be understood as 'a conflict over a pre-defined unequivocal problem with competing actors pro and con,' but seen rather as 'a complex and continuous struggle over the definition and meaning of the environmental problem itself' (Hajer 1997, p.14). Focusing analytical attention on the inherently ambiguous, undifferentiated category 'geoengineering' (a term that has been referred to as a 'quasi-stable meta-label' (Porter & Hulme 2013, p.3)), is argued to be the best way to identify (rather than impose) the most significant axes for distinction, as these relate to key differences in divergent perspectives.

Rather than working to remove ambiguity and multivalence from the term geoengineering, then, this study shifts the focus to that of exploring the kinds of work that this term performs. Whether in spite, or because of, associated ambiguities and multivalence, this discursive function forms an important object of policy

74 analysis in its own right – with potentially deeper and broader material political implications. The result is a
75 perspective on the kinds of wider politics in play around contemporary debates concerning the role of
76 knowledge and innovation under climate change.

77 ***1.1 Framing geoengineering***

78 There exists a small but growing body of academic literature examining discourses and framing of
79 geoengineering. This includes work focused on media framings (Porter & Hulme 2013; Scholte et al. 2013;
80 Luokkanen et al. 2013); framings in the academic literature (Bellamy et al. 2012; Huttunen & Hilden 2012);
81 framings within public discourse (Macnaghten & Szerszynski 2013); the use of metaphor (Nerlich & Jaspal
82 2012), and within particular influential texts (Gardiner 2011). A number of common themes have emerged
83 in this work, for example the importance of 'climate emergency' as a framing device (Nerlich & Jaspal 2012;
84 Sikka 2012b; Gardiner 2013). But there also arise a diversity of findings regarding the relative openness or
85 otherwise of the discourse around geoengineering, or the relative importance of strategic framing to the
86 issue. Given that the term is arguably still unfamiliar to many people, some have argued that the 'first
87 impression, frame, and narrative has yet to be set' (Leiserowitz 2010, cited by Buck 2013), or that there is a
88 *need* for more active and strategic framing of the issue by scientists in particular ways (Buck 2013). Others
89 argue that the ways appraisals of geoengineering options have been carried out to date, provide evidence of
90 a premature 'closing down' around particular 'sets of values and assumptions with respect to the
91 instrumental framing effects of contexts, methods and criteria and options' (Bellamy et al. 2012, p.28). In
92 similar vein, others cite evidence from analysis of the metaphors used to describe geoengineering as
93 indicative of 'restrictions in the interpretative flexibility' of the term (Luokkanen et al. 2013). Sikka takes a
94 particularly strong view of the strategic nature of the framing of geoengineering to date, arguing that 'special
95 interests, including private corporations, conservative think tanks and scientists affiliated with both have
96 drawn on a variety of discursive frames to limit, shape and mould the current debate surrounding
97 geoengineering' (Sikka 2012a, p.173). Conversely others have drawn evidence from an analysis of the
98 changing frames of geoengineering apparent in English speaking newspapers in recent years, to argue that

there is evidence of a progressive 'opening up' (Stirling 2008) of the debate around geoengineering (Scholte et al. 2013).

This study falls broadly under the description of a frame-reflective analysis, as outlined by Schon and Rein (Schön & Rein 1995). As such, it complements and builds upon the corpus of work on framing of geoengineering by bringing a distinctive focus on the ambiguity and multivalence of the term, as outlined above. Within this study, frames are understood as 'schemata of interpretation' (Goffman 1974, p.21), or narratives of understanding that 'help to render events meaningful and thereby function to organize experience and guide action' (Benford & Snow 2000, p.614). Through selectively emphasizing certain facets of a given issue over others, and linking interpretation with action, frames in and of themselves can be understood to perform particular functions (c.f. Entman 2004). Crucially, frames have both ontological and normative dimensions in that they 'link causal accounts of policy problems to particular proposals for action, and so link accounts of 'is' and 'ought' (Rein and Schon cited in Fischer and Forester 1993, p. 11). Hoppe (1999) emphasises that frames are *necessary* for judgement and action, acting as 'a sort of mental grappling hook' (p.207) to enable people to make sense of and act on a given situation. By thus deeply conditioning understandings of the fundamental entities, uncertainties, interests and values in play, the significance of these dynamics can extend far beyond discourse alone. By variously driving and shaping actors' appreciations of the implications of their own commitments and those of others, as well as the broader possibilities and what may be at stake, these framings also shape ontologies of action. It is in such ways, that these discursive phenomena can hold powerful material implications for the exercise of social, political and economic agency towards the structuring of relations and deployment of various kinds of resource (Lukes 2004; Gramsci 1971; Foucault 2002; Bourdieu 1984).

2 Material and methods

This study used Q methodology, a form of discourse analysis with roots in social psychology (Stephenson 1953), to examine framings of geoengineering. Q is an intensive, 'small n' methodology in which a limited

number of purposively selected participants (usually between 20 – 40 people), rank order a selection of subjective statements about the topic of interest. These 'Q sorts' are then compared with one another, and groups of similarly performed sorts are revealed using factor analysis. These clusters of sorts represent shared framings of the topic of interest. The methodology proceeds in three stages: 1. A selection of statements reflecting the diversity of opinions about the subject of interest is collected (the concourse), and a sub-set of these are selected (the Q sample) in order to be administered to participants; 2. participants are selected and carry out the Q sorting process; 3. results are statistically analysed, and the resulting patterns are interpreted with the aid of comments made by participants.

2.1 Building the concourse and selecting the Q sample

Subjective statements about the topic of geoengineering were sought from a diverse range of sources, including: academic papers, government policy documents, NGO reports, scientific and popular news media sources, television and radio interviews, blog posts and comments on online news sites. The aim of statement selection was to gather together as comprehensive as possible a selection of opinions about geoengineering. The final concourse consisted of 322 statements, after which it was decided that the addition of further statements did not add to the diversity of opinions present, and that a 'saturation point' (Eden et al. 2005) had been reached. To narrow down the concourse to the sample of statements to be presented to participants (the 'Q sample'), a structured approach was adopted whereby statements were categorised into a number of themes that were observed in the concourse as a whole. These were: 1) context (the nature of 'the problem'); 2) definitions and characteristics of geoengineering; 3) appraisals of geoengineering; 4) the relationship between science/research and deployment; and 5) governance concerns. Approximately equal numbers of statements from each category were sought, with the aim that each would capture a particular dimension of the issue around which opinion might be divided. In line with a rule of thumb that suggests a Q sample size of between 20 – 60 statements (Webler et al. 2009, p.15), the final sample consisted of 48 statements. A pilot was carried out with 7 individuals (colleagues from the Universities of Sussex, UCL, Oxford and the University of Waterloo, Canada, who were not subsequently

involved as participants in the study), in order to test the clarity of the statements, the comprehensiveness of the themes and topics covered by the statement sample, and the ease with which it was possible to sort them. Following the pilot, a number of statements were removed because they were felt to be confusing or to duplicate existing themes in the sample, others were paraphrased for greater clarity, and a number of additional statements were added to cover themes that were felt by pilot participants to be missing. For example the statement: '*Decisions based on knowledge are better than those based on ignorance, and public policy on geoengineering should be based on the best evidence we can get,*' was removed from the final sample as it was felt to duplicate statement 33 ('*Government support for geoengineering research is important, because good policy decisions depend on good science*'). Statement 46 ('*It's not a question of if but when humanity will be compelled to use geoengineering*') was suggested by a pilot participant in order to cover the theme of inevitability that was felt to be missing from the existing sample. The final set of 48 statements is listed in Table 2.

2.2 Selecting participants and carrying out the Q sorts

The aim of participant selection was not to try 'representatively' to elicit the views of some imagined wider publics as such (Warner 2010; Dewey 1927; O'Neill 2001). Rather, participants were selected on the basis that it was felt that they had the potential to reveal something interesting about the ways in which debates around geoengineering are structured and the existing frames and framing strategies that are being employed. The priority here was exploring the hermeneutic degrees of freedom of a multidimensional discursive constellation (Feenberg 2010), rather than establishing a set of notionally 'representative' centres of gravity. Based on an initial review of the academic and non-academic literature on the topic, a list of participants was drawn up to encompass as diverse as possible a range of people making statements about geoengineering from different disciplinary backgrounds, sectors, nationalities and genders. Participants in geoengineering discourse were identified as being associated with a number of broad 'sectors', identified as: academia (broadly divided into natural/physical sciences and social sciences/ humanities), industry, government, NGO's/civil society, and the media. In order to ensure diversity in the sample, at least two

individuals from each of these sectors were selected. It has been previously observed that the discourse around geoengineering is dominated by 'a very small elite of Caucasian male scientists' (Hulme 2012), and since the aim of this study was to examine extant framings it was expected that this group would predominate in the participant group. However, attempts were also made to increase the gender diversity, and number of nationalities involved in the sample through efforts to actively seek out female voices in the geoengineering debates, and through circulating the invitation to participate as widely as possible via the internet, to the geoengineering Google list (an online forum for discussion on geoengineering: https://groups.google.com/forum/#!forum/geoengineering), Geoengineering Net Forum (a Japanese discussion forum on geoengineering: http://geoeng.brs.nihon-u.ac.jp/) and the African Technology Policy Studies Network. In order to maximise the diversity of opinions, a snowballing approach was also adopted, whereby participants were asked to identify other possible recruits with opinions that might differ from their own. In order to enhance the reflexivity and transparency of the project to which this research contributes (the Climate Geoengineering Governance Project), individuals associated with the wider project were also invited to participate. Following good practice guidelines in scholarship on Q methodology (Robbins & Krueger 2000; Swedeen 2006), the lead author also carried out a Q sort. These sorts can be distinguished in the results by the letters CGG.

Participants were asked to sort the statements into a grid along a scale from +4 (most like their point of view) to -4 (least like their point of view). As is common in Q studies, the grid had a pyramidal or 'quasi-normal' shape, which limited the number of statements that could be placed in each category (See Figure 1). Although the imposition of this distribution shape is not necessary for the technique to work (Brown 1971; Burt 1972; Barry & Proops 1999), it is considered good practice as it encourages the participants to consider the relative placement of the statements more carefully and hence to reveal their preferences more thoroughly (Webler et al. 2009).

The majority of sorts were carried out during face-to-face interviews. In addition, in order to maximise the diversity of the participant group and facilitate international participation, there was an option for

participants to take part via an online interface using the Q-Assessor software (http://q-assessor.com), a tool specifically designed for online Q studies. The use of a combination of face-to-face Q sorts and online sorts has precedents in the literature on Q method (e.g. Gruber 2011) and is supported by empirical work which has shown there to be no apparent difference in the reliability or validity of face-to-face sorts and those carried out remotely by mail (Van Tubergen & Olins 1979); between paper sorts and online sorts in general (Hogan 2010); and between paper sorts and the specific online sorting program we applied in this study, Q-Assessor (Reber et al. 2000).

2.3 Statistical analysis and interpretation

Q sorts were analysed with the freely available software PQMethod (Schmolck 2002). Each sort was correlated with every other sort, and a correlation matrix was generated. Principal components analysis was then used to identify clusters of similarly performed Q sorts, and the resulting factors were rotated using a varimax rotation that aimed to find the simplest structure in the data and to explain the greatest amount of variance. It is important to bear in mind that there is not just one objectively 'correct' or 'mathematically superior' solution regarding the number of factors that emerge from a Q study (Watts & Stenner 2005, p.80). Rather, although the data itself is 'fixed' in the sense that the correlation scores between individual Q sorts do not change, there could be many vantage points from which to view and describe the similarities and differences between views, that are largely dependent on what one is interested in (for example, whether one is interested particularly in revealing minority views, or examining more dominant discourses). In this study a solution was sought that maximised the simplicity, clarity, distinctness and stability of the emerging framings (Webler et al. 2009, p.31), and ensured that at least 2 individual Q sorts correlated uniquely with each factor (cf. Brown, 1980 p. 293). Correlations between an individual's Q sort and a given factor were deemed as being statistically significant at the $p<0.01$ level, if they exceeded a factor loading of +/-0.38, based on the relation: $2.58/\sqrt{n}$), where n = the number of statements in the Q sample: $2.58/\sqrt{48} = 0.3723$ (Brown 1980). Sorts that were significantly correlated with a factor (i.e. those that load at +/- 0.38 for that factor) were considered indicative of that view, and the weighted average of those sorts were used to

calculate an idealised sorting pattern for that factor along the original response scale (-4 to +4). Narrative descriptions of each factor were drafted by examining these idealised sorting patterns and analysing the interview comments made by those people whose sorts were significantly correlated with that factor. Draft descriptions of these factor narratives were sent to all participants, who were asked to comment on whether they felt that their views had been appropriately interpreted. These comments were used to test the validity of the views described.

[Insert Figure 1: The distribution shape onto which participants were asked to sort the statements in the Q sample.]

3 Results

Thirty-five diverse participants carried out a Q sort, thirteen of whom carried out the sort online. Twenty-seven of the participants were male and eight female. Twenty-seven of the participants were from the UK, four were from the U.S., two from Canada, and two from Japan. The sectors with which participants were associated are given in Table 1. With participant permission, the full list of participants and their institutional affiliations (where applicable) is given in the appendix. Based on the criteria listed in section 2.3, three factors emerged from the analysis. One of these was a 'bipolar' factor (certain individuals' sorts were highly positively correlated with this factor, while others were highly negatively correlated), indicating the presence of two groups of people who sorted the statements in more or less opposite ways. Following standard practice in Q studies (Brown 1980), the bipolar factor was split into two separate factors, which resulted in a final solution consisting of four factors. The idealised sorting pattern for each factor is given in Table 2. The degree to which each participant's sort correlated with each factor described is given in Table 3. Participants who carried out a web-based sort are distinguished in Table 3. by the letter W, while individuals associated with the Climate Geoengineering Governance project, including the lead author, are distinguished

by the letters CGG. The degree of correlation between factors is given in Table 4. Narrative descriptions of the four factors follow.

[Insert Table 1: Sectors with which participants were associated (for details see appendix)]

[Insert Table 2: Statements sorted by participants, and the idealised sorting pattern (from -4 to +4) for each factor]

[Insert Table 3: Degree to which each participant's sort correlated with each factor]

[Insert Table 4: Correlations between factors]

3.1 Narrative descriptions of the factors/framings

The factors represent different framings of geoengineering, and were assigned names drawn from statements that were ranked highly for that factor. The numbers in square brackets within the text refer to the statement upon which the interpretation is based (see Table 2). It will be noted (in Table 3) that a number of individuals' Q sorts correlated with more than one factor which suggests that there is not necessarily radical discontinuity across framings (c.f. Dryzek & Berejikian 1993), and that many individuals have access to, and may move between discourses or framings (c.f. Collins & Yearley 1992).

This kind of dynamic is common in Q studies which examine distributed societal, rather than individual psychological, phenomena (Stainton Rogers & Stainton Rogers 1990). In other words, there is no presumption of immutable one-to-one matches between individual positions and particular framings. Nor is there any prior assumption that framings are immutable or that any given individual will engage with only one in any given context. This enables the method to identify a relatively high number of individuals whose views in different ways span between what are otherwise established to be quite discretely stabilised discourses. Again, this might be interpreted as illustrative of the fundamentally ambiguous nature of the term geoengineering. It might also perhaps be suggestive that (as described below), the discursive landscape is characterised by a high degree of ambivalence around and between contrasting stabilised framings. Individuals are thus evidently not only contending with the many ambiguities in play, but actively struggling to formulate opinions incorporating contradictory normative positions. Such individual ambivalence provides a potentially interesting illustration of the distinction drawn at the outset between the ambiguity and multivalence of the geoengineering discourse as a whole. A consequence of this, however, is that although the framings will be described below as discrete in order to facilitate an exploration of some of the different tensions within and between them, it should be remembered that each is also profoundly interlinked with others by means of these continuously actively-mediated discursive relations.

3.1.1 Factor 1: "At the very least we need more research"

Ten participants' sorts were correlated significantly with this factor, including six individuals from academic (natural/physical science) backgrounds, one journalist, one government employee, one non-governmental organisation professional, and an individual from an industrial background. The present authors summarise this framing as follows:

Action on climate change is clearly urgent [39], but arguments that frame the need for geoengineering in terms of an emergency are unhelpful and counterproductive [48]. Geoengineering is certainly not the most revolutionary new idea in climate policy [14], however we shouldn't rule any options out, and at the very least we need more research in this area to understand what approaches won't work and should be avoided at all costs [12]. Research is the only way to determine the potential impacts of different technologies, and we have now achieved the level of scientific sophistication to make research in this area worthwhile [5, 17]. Research is clearly distinct from deployment, and if carried out in a responsible manner, should not be overly controversial [16]. Indeed, if responsible parties don't carry out research, it will be done by less responsible parties [37]. Furthermore, the technical community has a responsibility to explore back-up strategies for dealing with possible future climate emergences [19]. Now is the time for a serious societal conversation about if and how we want to develop these different technologies [38], and public involvement in choices about directions of research and development in this area are crucial [13, 41]. Regulation of research is important, but should be undertaken carefully, as there is a risk that hastily developed regulation might be counter-productive and stifle innovation and scientific freedom [4]. Given the variety of different research activities that might take place, a moratorium on all activities outside the laboratory doesn't make sense [25, 47]. Although the deployment of geoengineering is by no means inevitable [46], and we already have all the technology we need to reduce emissions [45], some kinds of geoengineering will probably be a necessary part of any solution [39]. Geoengineering technologies that are likely to be more ethically preferable are 'encapsulated technologies' such as air capture, rather than non-encapsulated techniques such as stratospheric aerosols or iron fertilization [28]. Commercial involvement in geoengineering might be helpful

[27], but we should probably be wary of claims of technologies to provide win-win solutions allowing economic growth and mitigation to proceed hand in hand [23].

3.1.2 Factor 2: "We are the planetary maintenance engineers"

Two participants' sorts were correlated significantly with this factor, both of whom were associated with non-governmental organisations. The framing has been summarised as follows:

We are currently in an unprecedented planetary emergency brought about by climate change [4], immediate action is urgent [32], and it is likely to be only a question of time before humanity is compelled to use geoengineering [46]. Geoengineering is an important part of the solution to climate change [35, 40], hence, research on geoengineering is both crucial and worthwhile [5, 17], and should be supported by governments as the best basis for sound policy making [33]. Humans have demonstrated their ability to build functioning complex control systems [30], and now need to apply that knowledge to the task of planetary maintenance engineering that (like it or not) now falls upon us [6]. Given the dire state of the climate, neither research nor deployment of geoengineering should be overly controversial [16]. Although there might be some risk associated with research, not carrying out research given what we know about climate change would be riskier [3]. Only through research can we learn what technologies might be helpful, and conversely which shouldn't be deployed [12]. Investment in geoengineering research isn't likely to have a significantly negative impact on policies towards mitigation and adaptation, especially when one considers the dire state that mitigation policies are in already [36], and while the governance of geoengineering brings particular challenges, these are likely to be less difficult to overcome than the challenges of transforming the global energy system [42], which so far appears to have failed. Indeed geoengineering has the potential to revolutionise climate policy [14], opening-up possibilities for economic growth and climate change mitigation to proceed hand in hand [23]. We should not be too hasty in pursuing regulation, which might be stifling to innovation and research [4]. A ban on geoengineering would just be counterproductive [25], likely resulting in

research being carried out in secrecy or by less responsible parties [34, 47]. Those carrying out research are motivated by a desire to find solutions to the climate change problem, and for developing 'back-up' strategies for dealing with a possible future climate emergency [19], rather than any other motivation [8, 7]. Given the urgency of the problem, commercial involvement in geoengineering might be positive in terms of mobilizing innovation and capital investment, possibly increasing the speed with which these technologies could be developed [27].

3.1.3 Factor 3: "Geoengineering is a political strategy"

Five participants' sorts were significantly correlated with this factor, including 3 individuals from academic (social science/ humanities) backgrounds, one journalist and one individual associated with a non-governmental organisation. This framing has been summarised as follows:

Geoengineering won't solve climate change, but is likely to cause unpredictable and irreversible damage to the planet [35]. Attempts to control the climate through geoengineering are neither feasible [30], nor inevitable [46], and would likely lead humanity to a dystopian future in which we would find ourselves trapped by the consequences of our hubristic actions [21]. Geoengineering proposals stem from the same mind set of attempting to control nature that got us into the environmental mess we are in today [1], and are built on the dangerous illusion that complex social problems can be solved with technology [9]. The idea that all of the proposed technologies can be defined as geoengineering because their stated intent is to deal with climate change, is misleading [22]. More than as a set of technologies defined by a stated shared intent, geoengineering can be thought of as a political strategy [24] that serves the interests of the status quo. The commercial interest in some of these technologies only serves to highlight this, and if we were really serious that geoengineering was about 'saving the planet' we wouldn't leave such a task to business [27]. We have all the technologies we need to mitigate carbon emissions effectively; it's just a question of using them [45]. More research into new technologies isn't the most crucial thing [12]; indeed, the risks of doing research

(including the risk of strategic military applications of these technologies [8]) may well outweigh the benefits [3]. It isn't possible to separate out research from deployment in any straightforward way, and both should be considered controversial [16]: carrying out research, especially field trials, is the first step toward deployment, and drawing distinctions between different types of field test only serves to obscure this fact [47]. Since full-scale trials are unethical and small-scale trials can't produce useful data in the noise of global weather [5], it is common sense to institute a moratorium on all testing activities outside the laboratory [25]. The argument that 'someone somewhere will do it, so it might as well be us' [37] is not acceptable, nor are arguments stemming from claims of present day [48] or hypothetical future emergencies [12]. The governance challenges of controlling the global climate through geoengineering would likely be more complex and difficult to overcome than those of transforming the global energy system [42], and given the undemocratic and risky nature of proposals for geoengineering, we shouldn't be going down this path [21]. Publics need to be engaged meaningfully in decisions about research [13], and ultimately have control over which (if any) of these technologies are to be pursued [41]. However, much talk of governance seems to see deployment as inevitable, and is hence a purely instrumental exercise for smoothing this process, rather than allowing genuine dissent to emerge [26].

3.1.4 Factor 4: "Let's focus on carbon"

Four participants' sorts were significantly correlated with this factor, including two individuals from industrial backgrounds, and two individuals from academic backgrounds (one social scientist, one natural scientist). The framing has been summarised as follows:

Action on climate change is urgent [32], and is likely to require the development and deployment of new technologies [45], including some that might be labelled as geoengineering [39]. However, the definition of geoengineering is slippery and after realising that our actions en masse affect the climate, anything we do to address it (including nothing) might be considered geoengineering [18]. Although ambiguous, the concept of

geoengineering might be useful as a political strategy to help open up the solution space available to us for dealing with climate change [24]. There is nothing wrong with a technological fix per se [40, 20], but it's important to remember that technology alone will not 'solve' the climate change problem [35]. It is important to ensure that the direction of development of these technologies is the subject of public deliberation and control [41], so that, appropriately managed, Geoengineering does not have to be fundamentally undemocratic [2]. We clearly need research into new technologies, if only to be able to rule out those that shouldn't be deployed [12], but some research is more morally acceptable [31] than others, and the argument that 'someone will do it so it might as well be someone responsible' (i.e. us) is problematic [37]. Research cannot be neatly separated from deployment, and thus it is difficult to defend the idea that only deployment should be controversial [16]. For this reason publics should be engaged 'upstream' in the direction of research in this area [13]. The inherent complexities of the climate system limit the human ability to predict and judge cause and effects of interventions [17]. This complexity, coupled with human fallibility, means that attempts to control the climate system are likely to fail [30]. Hence we should focus our energies on removing carbon dioxide from the atmosphere [43] (an endeavour in which commercial involvement might be helpful [27]), so that with the right technological and social changes, a carbon neutral future for humanity can be achieved [11], and mitigation and continuing economic activity can take place [23].

4 Discussion

For reasons already discussed, no claim is made that the four framings described above, constitute any kind of comprehensive, authoritative or final set of framings. As in any study of discourse (whether acknowledged or not), these might rather be thought of as stylised indications that will hopefully be of heuristic utility in offering 'tools to think with' in processes of further enquiry (c.f. Brand & Fischer 2012). This discussion will draw out some of the tensions between and within the different framings and examining how concepts of control, research, novelty and interests all feature within and constitute the different

framings of geoengineering. In the following discussion quotes are given anonymously in order to preserve participant anonymity, but where the participant in question is associated with the Climate Geoengineering Governance project, the quote is followed by the letters CGG. Quotes taken from online participants are distinguished by the letter W.

Given the existence of campaigns both for and against geoengineering in general (see for example the work of the Arctic Methane Emergency Group, and the Hands Off Mother Earth campaign), one might expect to find that opinion around geoengineering is highly polarised. The emergence of a bipolar factor (split into Factors 2 and 3), indicating highly opposed views, is therefore perhaps unsurprising. The prominence of this axis also confirms the general salience for this purpose of an aggregated concept of 'geoengineering'. However, the existence of a further two factors clearly indicates that the picture is not as simple as a description of a straightforward 'pro' /'anti' axis might suggest. With regard to the coherence or ambiguity of the term geoengineering, it appears that (although the most different in terms of their framing of geoengineering) individuals loading on Factor 2 (broadly in favour of geoengineering), and Factor 3 (decidedly against geoengineering), actually appeared to find it less problematic making statements about geoengineering as a non-differentiated category, than those loading on Factors 1 and 4. Thus for example, within the Factor 3 framing, a total ban on all geoengineering activities outside the laboratory is a necessary and coherent thing to call for [25]. Likewise within the Factor 2 framing, geoengineering (in general) is one of the most revolutionary new ideas in climate policy [14]. Interview data collected at the time of the Q sorts can be instructive in understanding this. Thus a participant whose sort correlated with Factor 2 explained why he considered the term geoengineering to be useful:

> 'The term has proven to be very useful because of the discussions it catalyses. I view the real utility of geoengineering not really as being the technological interventions but as being so extreme as a concept that it actually provokes imagination and the ability to open up discussions that are otherwise mired in more detailed political positions…it opens up new opportunities for reframing how we deal with climate…'

On the other hand the following quote from a participant whose sort correlated with Factor 3 illustrates why he feels it is meaningful to object to geoengineering in general, and why disaggregating the term is not considered to be of primary importance:

> 'I just think there's a broader thing afoot about trying to solve problems through technological solutions rather than the heavy lifting of social change and actually addressing the root causes and so forth, and geoengineering in some way I think is totemic for that… it's not just about a geoengineering solution, it kind of speaks to, we're going to have a technological solution for this, whether its carbon capture and storage or biofuels or air capture or nuclear power, whatever it is, we're going to craft a technological way round this, such that we don't have to significantly disrupt the economy…'

But while this participant appears to be able to object to geoengineering as illustrative of a broader (in his view) problematic attitude towards the application of technology to social and environmental problem solving, participants loading on Factor 1 (supporting more research), appeared much less willing to take such a general or abstract stand. A fairly typical quote from a participant loading on Factor 1 illustrates this:

> 'My reaction to the term is that it isn't particularly helpful because it describes different groups of approaches. So there's negative emissions, taking carbon out of the air, carbon dioxide removal I guess it's called… which is a very different set of interventions than the solar radiation management stuff. So geoengineering is a catch-all term that creates challenges for us to then have a clear position on… and within those there's lots of different approaches which each have their pros and cons and different risk profile.

Another commented:

> 'I don't want to have a debate about the terminology too much, I think I want to have a debate more about what the technologies do to our climate and I don't think having huge arguments about what a term is or not really make much difference to that'.

Interestingly, although the Factor 1 perspective appears to find the 'catch all' nature of the term presents a problem for the making of general statements about geoengineering, and prefers to focus attention on individual technologies, this view is very clear about what geoengineering is *not.* Hence it appears from the negative score awarded to statement 18, that the definition of geoengineering (while encompassing a broad range of technologies) does not include those activities the effects of which were inadvertent.

A different perspective still was offered by Factor 4, whose agreement with statement 18, suggest a distinctive take on the issue of intent, and a broader understanding of what might constitute geoengineering. For example, one Factor 4 participant defined the term to include interventions not generally classed as technological, such as the implementation of a carbon tax:

> 'If you capture carbon from smokestacks in coal plants, or you implement a carbon tax, or you put particulates in the stratosphere, those are all examples of geoengineering.'

While subscribing to a very broad definition of the term itself (to the extent that it might be difficult to differentiate from other categories of effort such as mitigation), Factor 4 participants (focusing on carbon) were also conscious of the possible utility of the term itself as offering something distinctive on the discursive level at least. Hence one participant argued against the so-called 'moral hazard' argument against geoengineering research [36], by referred to the fact that arguments against geoengineering such as this act to prematurely close down 'the solution space, the option space that you want to keep open.'

While the term's ambiguity is clear, it might be said to have 'functional malleability' (Gledhill, 1994 p 216), and there appears to be a sense (particularly expressed by Factor 2 participants – supporting 'planetary maintenance') that the term in all its ambiguity might be politically *useful* in terms of acting as a catalyst for certain kinds of discussions. Ironically the primary discourse of opposition as represented by Factor 3, in its view of geoengineering as emblematic of the fundamentally flawed nature of the global neo-liberal political economy, might actually act to breathe life into it. Within the Factor 1 ('pro research') framing, the desire to disaggregate the term might be read as an opposition to the constraints of the term, or as an example of

boundary work aimed at reducing ambiguity; while the broad definition of geoengineering offered by Factor 4 ('focus on carbon') participants could be read as a different type of boundary work actually aimed at increasing the ambiguity of the term.

Scholte et al (2012) argue that 'ambivalence' about geoengineering is a frame in and of itself (characterised by the presentation of arguments for and against geoengineering within one text), and they suggest that the increasing prevalence of their supposedly unitary 'ambivalence frame' above other framings of geoengineering articles in newspapers, provides hope for increasing reflexivity in the debate. As discussed earlier, we concur that multivalence is a characteristic of the discourse as a whole, as indicated by the co-existence of multiple divergent normative positions within the debate. However, crucial to this multiplicity is that axes of differentiation extend beyond a simple 'pro' versus 'anti' bimodality suggested by the term 'ambivalence'. Also counter to the argument made by Scholte et al, even if only twofold, such multiplicity cannot confidently be understood as a singular way of framing geoengineering in and of itself. The relatively high number of so-called 'confounders' (individuals whose Q sorts correlated with more than one frame), that emerged from the analysis presented here, could be interpreted as revealing different forms of multivalence with respect to these framings. However, multivalence with respect to the framings described here need not correspond to an individual being ambivalent about geoengineering per se. Obviously, this may be the case in some instances. But a more cautiously grounded interpretation is that the existence of these multivalences suggests a degree of instability in the present discourse. In this sense, the meanings attributed to geoengineering overall may still in some important senses be quite negotiable. But this does not mean that the resulting individual political positions taken in respect of particular prospective geoengineering initiatives may be not reasonably be unambiguous.

The existence of the framing exemplified by Factor 4 ('focus on carbon') also problematizes the frequent calls for increasing precision around the term geoengineering as a pre-requisite for effective governance discussion. This is because it highlights how no one framework for partitioning of the term geoengineering into sub-categories can in itself be thought of as final. The most commonly used distinction - for instance

that between carbon dioxide removal and solar radiation management – only makes sense from within particular frames. More specific distinctions at the level of 'individual' technologies are correspondingly more brittle in relation to contrasting ways of partitioning and aggregating multidimensional characteristics. The more "precise" the proposed taxonomy (like that defined under factor 4), the more vulnerable it is to alternative reasonable characterisations and prioritisations of discriminatory criteria. So any one form of precision may reduce particular ambiguities, but leave others unaddressed – or even compound them. Calls for greater precision must therefore be interrogated as to particular axes of precision involved and their implications. And it cannot be assumed that precision is self-evident, or will in and of itself remedy either ambiguity or multivalence.

4.1 Axes of difference

Hulme (2008) argues that the prospective routes held out to us for dealing with climate change all have 'connotations of global control and mastery of the climatic future' (p. 12). This observation is also borne out in the framings that emerge in this study, in which various ideas around the issue of 'control' constitute one of the principal axes of difference between the framings. Unsurprisingly perhaps, the starkest contrast is between the polarised views of factors 2 and 3, although interestingly notions of control are arguably central to both. Factor 2 affirms the notion that 'we can and should control the climate', Factor 3 upholds the idea that 'we can and should control the research.' Salient here is the Factor 2 framing of geoengineering as 'planetary maintenance engineering' [6], and its emphasis on the human ability to create complex control systems [30], building on an ever increasing scientific sophistication allowing greater understanding of complexity [17]. Conversely the Factor 3 framing emphasizes what is perceived to be the self-deception of attempts to control nature [1, 15], the irreducible complexity and chaos of the climate system [17], and human fallibility and social intractability in attempting to create complex control systems in the past [30]. The roles are reversed when the focus becomes control of research and other geoengineering activities, with the Factor 2 framing emphasizing what is felt to be the 'counterproductive' nature of attempts to ban

geoengineering, and the inappropriateness of a moratorium on geoengineering [25], which might result in testing being carried out in secrecy [34]. The Factor 3 framing, on the other hand, emphasizes the perceived necessity of strong controls on research. With regard to the degree to which this control of research is believed to be possible, one participant commented:

> 'It may be true that it's not fully enforceable but it has very powerful norm setting… it's very important to set that as the standard.'

While rejecting the 'planetary maintenance' metaphor, the Factor 1 and 4 framings diverge somewhat in their view of the feasibility of achieving climate control, with more reticence being expressed within the Factor 4 framing, about the possibilities for either knowledge of complexity [17], and control of the climate [30].

The concept of research represents another fault line or tension between the framings. Given that much discussion of geoengineering occurs in academic journals, and much of the discussion is about research of various types and disciplines, Geoengineering is thus framed by many as being 'at the research stage', and in particular Factor 1 participants appeared to adhere to this view. Thus for example, a fairly typical Factor 1 viewpoint was expressed thus:

> 'I would be paranoid and scared of anybody saying we're going to start geoengineering tomorrow, but I'd be just as worried about someone saying we're going to outlaw any research on geoengineering. We need to do this research. Whether or not we actually do anything with the research is another matter. But in case we need to geoengineer, we should do the research now. Because when you're doing it in a panic and you think you've only got 20 years before London is underwater, you're not going to do science as well as when you think we might not need to do this, you can actually sit back and concentrate and take a slightly longer term view of it'.

A positive emphasis on research is broadly shared by Factors 1, 2 and 4, as illustrated by factor scores for statements 3, 12, and 33, but is problematized by Factor 3 in particular, and to a lesser extent Factor 4 (statements 16 and 37). Thus a Factor 3 participant commented about research:

> '[research] creates a dynamic where you're moving towards something, it creates the beginnings of almost an industry of people who have invested in all of that.'

And the same participant was keen to unpick the term, asking 'what's hidden in the term research?' and commenting:

> 'I think it's very deliberate, the term [research] gets kept together, and by being kept together it means that people who actually don't ever want to move to some kind of experimentation should nonetheless feel they have to support that statement [3] … it speaks to scientific freedom and all these kind of things, which of course and if you're in academia are deeply important and rightly so, but I think it's a deliberate strategy to keep that language obscure'.

The way in which geoengineering is framed (particularly but not exclusively by Factor 1 participants) as being at the research stage, also feeds into ideas about the degree to which geoengineering represents something fundamentally new and untried, or is a continuation (or the latest manifestation of) practices and ideas with a long history. Of the four framings uncovered by this study, the emphasis on continuity is most apparent within the Factor 3 and 4 framings, while as outlined above, Factors 1 and 2 appear to emphasize research and novelty. For example, Factor 3 was distinctive among the four factors in assigning neither a positive nor negative ranking to statement 7 (that deliberate geoengineering has been happening for decades and was not all about dealing with climate change). Interview data and comments from participants who loaded on Factor 3 point to a division over exactly what this means. One view was characterised by the following comments:

574 ‘Geoengineering technologies patented decades ago have been and are being used covertly as
575 political/economic/military weapons. This is obvious to anyone who studies the sky and knows the
576 history of weather/climate modification development. Look up!’[W]
577
578 Although not all Factor 3 participants shared this view, the issue of continuity with other technologies and
579 the idea that the issue was broader than the current climate change focus might suggest were shared.
580 Hence another Factor 3 participant commented:

581 ‘I do think there’s other interests in geoengineering other than climate change, particularly
582 commercial interests. I think there’s an attempt to create new markets in the longer term, there is
583 military interest… I don’t think they’ve been spraying but I do think it’s not all about climate change.’
584
585 The distinction between geoengineering, weather modification and so-called ‘chemtrails’ theories is worthy
586 of a brief note at this point. As a subject discussed and debated by governments, think-tanks and academics,
587 geoengineering in all its ambiguity and multivalence appears to have acquired widespread credibility as a
588 ‘serious’ (Keith & Dowlatabadi 1992) scientific subject. Weather modification on the other hand, has a
589 relatively less authoritative status, occasionally presented as a ‘pseudo-science’, associated with an array of
590 more or less credible characters driven by a variety of more or less honourable intentions (Fleming 2006).
591 Finally, the ‘chemtrail’ theory (positing the existence of a global network of weather modification for
592 nefarious ends), lacks general credibility and authority and is widely labelled (dismissively) in the literature as
593 a conspiracy theory (e.g. Brewer 2007). However, as this examination of the multiple framings of
594 geoengineering has revealed, the boundaries around terms and activities are by no means clear cut or un-
595 ambiguous, and on-going boundary work (Gieryn 1983) is required to maintain the distinction between
596 terms in such ways as to maintain the epistemic authority of certain actors.
597
598 Interview comments from a participant associated with Factor 4 reveal a view that is more explicit about the
599 fluid and blurred nature of the boundaries between different activities:

> ‘We’re already geoengineering the climate … I mean we do a lot to try and change the climate system, we dam rivers, we irrigate large parts of farmland that changes the local climate, we deforest. In the western US I think there’s 169 weather modification projects that try to improve rainfall, China does it systematically…’

And when questioned further about the distinctiveness of weather modification from geoengineering, the same participant highlighted the continuum between them and the constructed character of notions of ‘climate’, by commenting:

> ‘Weather is events and climate is statistics…’

The distinction between weather modification and geoengineering is also brought into question by the following comment made by a Factor 1 participant:

> ‘[The Chinese] are raising from 70 million to 500 million a year the amount they’re spending on their weather modification program, and once you get to half a billion dollars a year, you’re actually talking about something that on aggregate could have a significant effect.. Assume it’s effective, you’re now at a stage where you’re modifying local weather sufficiently over a long enough period that it’s kind of like a geoengineering intervention […] I think we’re going to back-step into geoengineering in that way.’[CGG]

The emphasis on novelty or continuity in different framings of geoengineering is intimately connected to different framings of the interests and motivations at play, and this is another axis of difference along which the framings uncovered by this study can be seen to diverge. Again, Factors 3 and 4 are united by a shared framing of the potential for non-climate change related application of geoengineering technologies, including military applications.

But beyond more radical uses of geoengineering technologies for purposes other than combating climate change, a key distinguishing characteristic of the Factor 3 perspective is that geoengineering – both the technologies it comprises and the attitude it is understood to represent – is an explicitly political project. Here, the process of framing of the issue is understood to be a key element of that project. As one participant explained:

> 'On the pro-geoengineering side I think there is a small core of ideologically motivated and politically smart and active people who are moving people intentionally, particularly in the whole framing game in very careful ways … while there is a lot of naivety and good intention throughout the discussion there's also some very active interests… I can see some evidence of that. That sounds conspiratorial, it's not … it's just looking at the political economy of discussions around climate change'.

Finally, various authors have noted the use of a real or hypothetical climate emergency as a powerful framing device within which geoengineering interventions are situated, and similarly the existence of a climate emergency was an important element of one of the framings (Factor 2) that emerged from this study. The following comment typifies this element of the framing:

> 'The risks from the climate are infinitely worse than the risks from geoengineering; I mean that's absolutely obvious. I say infinitely because that means the end of everything, end of civilisation possibly all human life, I mean it's as serious as that […] Long term it's a catastrophe.

However, although interviews reveal that the urgency of the climate predicament is clearly important for many people, it appears that the framing of the issue in terms of emergency is being consciously rejected by all but Factor 2 participants [statement 48]. For example, one Factor 1 participant commented: 'I think the whole idea of a climate emergency is really kind of counter-productive.' Another hinted at a more strategic view of framing by commenting that it was not a question of whether emergency was a reality or not, but whether or not the emergency frame was helpful for achieving particular ends:

649 'I think people are consciously stepping away from [the emergency framing] because it's become
650 clear that different ideas about what emergency means makes the term useless… It's difficult to use
651 emergency to promote particular actions.'

652 However, although emergency was rejected as a valid framing of the issue by participants that loaded on
653 Factors 1 and 4, the idea of a hypothetical future emergency still featured within these views as a rationale
654 for research [statement 19]. Participants loading on Factor 3 rejected any emergency rationale (either
655 present or future) for geoengineering. One Factor 3 participant explained why he considered the climate
656 emergency framing to be problematic:

657 'The dangerous thing to do with geoengineering, is to frame it … only to be a climate discussion,
658 because if you do then it becomes this uni-dimensional, you know, climate change has got terribly
659 bad, we need to have a fix for it, everything gets arbitrated within this very narrow climate thing, but
660 what you're changing is the planet, or you know, large parts of it, which are much more than about
661 climate, climate is just one factor.'

662

663 ***4.2 Significant silences***

664 It is worth noting that a number of people involved with critical environmental NGO's, who were invited to
665 take part in this study did not respond to invitations to participate, and hence it is likely that there may be a
666 number of significant silences or gaps in the research presented. The reasons for individuals' reticence
667 about involvement (whether about the subject matter, this particular study, or the Geoengineering
668 Governance Project more broadly) were not specified and thus can only be the subject of conjecture.
669 However, Walker and Shove point out that involvement of a broad range of stakeholders in participatory
670 projects and processes, can raise a number of issues, with the potential for inclusion to be 're-interpreted as
671 a process of co-option and neutering of dissent, producing deeply problematic tensions for those taking part'
672 (Walker & Shrove 2007, p.221). Indeed the issue of co-option was one that was raised explicitly by a Factor 3

673 participant, who argued that much of the discussion around geoengineering was being manipulated by
674 people interested in slowing down and confusing governance of climate change; and that hence even being
675 drawn into these discussions would be to play into the hands of these interests. He commented:

676 'There are a lot of well-intentioned people, who are caught up in the discussion and I think to some
677 extent are being used, and some of them are letting themselves be used...'

678 If then, one views the conversation itself as a massive distraction from existing governance discussions
679 around climate change, then perhaps silence and non-participation in that conversation, as embodied by
680 refusals to participate in just such processes and projects as this one, can be read both as an effective and
681 reasonable form of dissent (c.f. Whelan & Lyons 2005). It may be significant here, that this study was
682 completed prior to the much remarked-upon (Stilgoe 2013; Cressey 2013) mention of climate
683 geoengineering at the end of the most recent IPCC summary report for policymakers (IPCC 2013).

684

685 **5 Conclusion**

686 Fischer and Hajer (1999, p.2) argued that although conceptually weak, the term 'sustainable development'
687 created a generative metaphor or story-line around which different interests could co-ordinate, and thus
688 proved to be a very functional concept (cf. Stirling 2009). Arguably the same might be said of the term
689 'geoengineering' (albeit on a smaller, subordinate and more idiosyncratic canvas). As this study has
690 illustrated, geoengineering has a fluid, ambiguous and multivalent set of meanings and is framed by different
691 actors in a variety of ways. Interestingly (and unlike 'Sustainability'), the convening power of the term seems
692 equally potent in two opposing directions, for and against the idea of climate geoengineering in general. This
693 evident polarity within the debate as revealed by the existence of Factors 2 and 3, appears to indicate a
694 'framing gulf' across which actors are likely to 'talk past one another' rather than engage meaningfully (c.f.
695 Hoffman 2011).

However, it is also the case that the existence of additional framings not defined purely along this axis of 'pro' / 'anti' difference suggests an emerging resistance among certain actors to the debate becoming polarised in this way. These alternative framings appear to be seeking either to increase (in the case of Factor 4) or decrease (in the case of Factor 1) the ambiguity and multivalence of the term. Given the multiple framings and meanings within the term, this is unlikely ever to be fully realizable. Unlike the picture suggested by Scholte et al. (2013), who suggest that what they call 'the ambivalence frame may prove to be less powerful than other frames that evoke strong positive or negative feelings', our findings suggest that ambivalence is not best seen as a frame in and of itself able to garner or lose support. Encompassing both multi-dimensionally contending, as well as individually unclear, meanings, this indeterminacy is likely to remain a fundamental, pervasive and perhaps unavoidable feature of the discursive landscape of geoengineering.

Interviews have highlighted the diversity of actors broadly subscribing to shared framings of geoengineering. This might suggest the coming into existence around the term of various discourse coalitions (Fischer & Forester 1993), linking otherwise disparate actors and networks through certain shared narratives and the utilisation of certain discursive resources. Possible examples here are: (i) the narrative of the neutrality or normative desirability of 'research' linking disparate groups within Factor 1; or (ii) the narrative of the essentially undemocratic nature of aspirations to engineer climate at the planetary scale, which links groups within Factor 3. It is clear here that the interpretative flexibility opened up by the ambiguous and multivalent nature of the term facilitates this coalition-formation process by allowing individuals with perhaps little in common in other respects, to speak the same language or advance shared interests on a particular issue. The development of other issues in environmental politics illuminates a clear danger here of co-option of certain actors by others – strategically utilizing particular framing devices to garner support for a particular view.

It remains the case in climate geoengineering as elsewhere, that there may exist significant gaps in any picture that can be presented of the governance discourse. Where discourse itself is recognised to display potentially potent path-dependencies it becomes clear that such silences may indicate not indifference or

acquiescence, but strongly held commitments and active strategy. Experience in other areas of controversy suggests it would be as wise to avoid dismissing these silences as over-interpreting them. Where a discourse itself is seen as dangerously self-reinforcing, it seems as reasonable to defend a right to remain silent, as to voice a critical view. But there does appear one general practical implication for geoengineering governance that is consistent with all the perspectives resolved here. This is, that the natures and implications of contrasting forms of climate geoengineering – and of ideas of geoengineering in general – are matters that far transcend technical analysis alone. Each of the broad perspectives resolved here, entails radically divergent implications for what would count as appropriate questions, expertise or analysis. Compounded (rather than diminished) by the gravity and urgency of the climate change challenge, then, the obvious response to such dilemmas is an aspiration to some kind of democracy (Macnaghten & Szerszynski 2013). Equally by provocation and reflection, techniques like Q method may assist in helping to open up more robustly – and multivalently – critical debate.

6 References

Baker, S. et al., 1997. *The Politics of Sustainable Development*, London: Routledge.

Barry, J. & Proops, J., 1999. Seeking sustainability discourses with Q methodology. *Ecological Economics*, 28(3), pp.337–345. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0921800998000536.

Bellamy, R. et al., 2012. Appraising Geoengineering. *Tyndall Centre for Climate Change Research, Working Paper*, (June).

Benford, R.D. & Snow, D.A., 2000. Framing processes and social movements: An overview and assessment. *Annual Review of Sociology*, 26, pp.611 – 639.

Bourdieu, P., 1984. *Distinction: a social critique of the judgement of taste*, London: Routledge.

Brand, R. & Fischer, J., 2012. Overcoming the technophilia/technophobia split in environmental discourse. *Environmental Politics*, (November 2012), pp.1–20. Available at: http://www.tandfonline.com/doi/abs/10.1080/09644016.2012.730264 [Accessed November 1, 2012].

Brewer, P.G., 2007. Evaluating a technological fix for climate. *Proceedings of the National Academy of Sciences*, 104(24), pp.9915–9916.

Brown, S.R., 1980. *Political Subjectivity: Applications of Q methodology in political science*, New Haven and London: Yale University Press.

749 Brown, S.R., 1971. The forced-free distinction in Q technique. *Journal of Educational Measurement*, 8(4),
750 pp.283–287.

751 Buck, H.J., 2013. Climate engineering: spectacle, tragedy, or solution? A content analysis of news media
752 framing. In C. Methmann, D. Rothe, & B Stephen, eds. *(De-)Constructing the Greenhouse: interpretative*
753 *approaches to global climate governance*. London: Routledge.

754 Burt, C., 1972. The reciprocity principle. In S. R. Brown & D. J. Brenner, eds. *Science, psychology and*
755 *communication*. New York: Teachers College Press.

756 Collins, H.M. & Yearley, S., 1992. Epistemological Chicken. In A. Pickering, ed. *Science as practice and culture*.
757 Chicago, USA: University of Chicago Press, pp. 301–326.

758 Cressey, D., 2013. Climate report puts geoengineering in the spotlight IPCC statement suggests tinkering with
759 the atmosphere could be necessary to meet climate goals. *Nature*. Available at:
760 http://www.nature.com/news/climate-report-puts-geoengineering-in-the-spotlight-1.13871.

761 Dewey, J., 1927. *The public and its problems*, New York: Holt and Company.

762 Dryzek, J.S. & Berejikian, J., 1993. Reconstructive Democratic Theory. *The American Political Science Review*,
763 87(1), pp.48–60. Available at: http://www.jstor.org/stable/2938955.

764 Eden, S., Donaldson, A. & Walker, G., 2005. Structuring subjectivities? Using Q methodology in human
765 geography. *Area*, 37(4), pp.413–422.

766 Edenhofer, O. et al., 2012. *Meeting Report of the Intergovernmental Panel on Climate Change Expert*
767 *Meeting on Geoengineering*, Lima.

768 Entman, R., 2004. *Projections of power: Framing news, public opinion, and US foreign policy*, Chicago:
769 University of Chicago Press. Available at:
770 http://books.google.co.uk/books?hl=en&lr=&id=SzG0HkZeoNIC&oi=fnd&pg=PP8&dq=entman+projecti
771 ons+of+power&ots=hvJmg3rIK_&sig=LR4vKOJItCBl6SkjkrYx84Oba0Q [Accessed September 20, 2012].

772 Feenberg, A., 2010. *Between reason and experience: essays in technology and modernity*, Cambridge MA:
773 MIT Press.

774 Fischer, F. & Forester, J., 1993. *The argumentative turn in policy analysis and planning*, Routledge.

775 Fleming, J., 2006. The pathological history of weather and climate modification : Three cycles of promise and
776 hype. *Historical Studies in the Physical and Biological Sciences*, 37(1), pp.3–25.

777 Foucault, M., 2002. *Power*, London: Penguin.

778 GAO, 2010. *Climate Change: A Coordinated Strategy Could Focus Federal Geoengineering Research and*
779 *Inform Governance Efforts. Report to the Chairman, Committee on Science and Technology, House of*
780 *Representatives*, Washington D.C.

781 Gardiner, S.M., 2013. Geoengineering and moral schizophrenia: What is the question? In W. C. G. Burns & A.
782 L. Strauss, eds. *Climate Change Geoengineering: philosophical perspectives, legal issues and governance*
783 *frameworks*. New York: Cambridge University Press, pp. 11–38.

784 Gardiner, S.M., 2011. Some Early Ethics of Geoengineering the Climate : A Commentary on the Values of the
785 Royal Society Report. *Environmental Values*, 20, pp.163–188.

786 Gieryn, T., 1983. Boundary-work and the demarcation of science from non-science: Strains and interests in
787 professional ideologies of scientists. *American Sociological Review*, 48(6), pp.781–795.

788 Goffman, E., 1974. *Frame analysis: An essay on the organization of experience*, Harper & Row.

789 Gramsci, A., 1971. *Selections from the Prison Notebooks of Antonio Gramsci* Q. Hoare & G. Nowell-Smith,
790 eds., London: Lawrence and Wishart.

791 Gruber, J., 2011. Perspectives of effective and sustainable community-based natural resource management:
792 an application of Q methodology to forest projects. *Conservation and Society*, 9(2), pp.159–171.
793 Available at: http://www.conservationandsociety.org/text.asp?2011/9/2/159/83725 [Accessed July 26,
794 2012].

795 Hajer, M. & Fischer, F., 1999. Living with nature: Environmental politics as cultural discourse. In F. Fischer &
796 M. A. Hajer, eds. *Living with nature: environmental politics as cultural discourse*. New York: Oxford
797 University Press, pp. 1–20.

798 Hajer, M.A., 1997. *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*,
799 Oxford: Oxford University Press. Available at: http://dx.doi.org/10.1093/019829333X.001.0001.

800 Hoffman, A.J., 2011. Talking Past Each Other? Cultural Framing of Skeptical and Convinced Logics in the
801 Climate Change Debate. *Organization & Environment*, 24(1), pp.3–33.

802 Hogan, A., 2010. A comparison of offline and online Q factors. *Paper read at the International Society for the*
803 *Scientific Study of Subjectivity (ISSSS) 26th Annual Q Conference, Akron, OH, USA, October 7-9*, pp.1–6.

804 Hoppe, R., 1999. Argumentative turn. Policy analysis, science and politics: from “speaking truth to power” to
805 “making sense together”. *Science and Public Policy*, 26(3), pp.201–210.

806 Hulme, M., 2012. Climate change: Climate engineering through stratospheric aerosol injection. *Progress in*
807 *Physical Geography*, 36(5), pp.694–705. Available at:
808 http://ppg.sagepub.com/cgi/doi/10.1177/0309133312456414.

809 Hulme, M., 2008. The conquering of climate: discourses of fear and their dissolution. *The Geographical*
810 *Journal*, 174(1), pp.5–16.

811 Huttunen, S. & Hilden, M., 2012. Framing geoengineering in academic literature (DRAFT).

812 IPCC, 2013. *Climate Change 2013 The Physical Science Basis. Working Group I Contribution to the Fifth*
813 *Assessment Report of the Intergovernmental Panel of Climate Change. Summary for Policy Makers*,

814 Jasanoff, S., 1995. *Handbook of science and technology studies*, Sage Publications.

815 Keith, D. & Dowlatabadi, H., 1992. A serious look at geoengineering. *Eos, Transactions American Geophysical*
816 *Union*, 73(27), pp.292 –293.

817 Long, J. et al., 2011. *Geoengineering: A national strategic plan for research on the potential effectiveness,*
818 *feasibility, and consequences of climate remediation technologies*, Washington D.C.

Lukes, S., 2004. *Power: a radical view*, Basingstoke, UK: Macmillan.

Luokkanen, M. et al., 2013. Geoengineering, news media and metaphors: Framing the controversial. *Public Understanding of Science*. Available at: http://pus.sagepub.com/cgi/doi/10.1177/0963662513475966 [Accessed March 28, 2013].

Macnaghten, P. & Szerszynski, B., 2013. Living the global social experiment: An analysis of public discourse on solar radiation management and its implications for governance. *Global Environmental Change*, null(null). Available at: http://linkinghub.elsevier.com/retrieve/pii/S0959378012001483 [Accessed January 28, 2013].

Nerlich, B. & Jaspal, R., 2012. Metaphors we die by? Geoengineering, metaphors, and the argument from catastrophe. *Metaphor and Symbol*, 27(2), pp.131–147.

O'Neill, J., 2001. Representing people, representing nature, representing the world. *Environment and Planning C: Government and Policy*, 19(4), pp.483–500. Available at: http://www.envplan.com/abstract.cgi?id=c12s [Accessed August 28, 2013].

Pinch, T.J. & Bijker, W.E., 1984. The Social Construction of Facts and Artefacts : Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. *Social Studies of Science*, 14(3), pp.399–441.

Porter, K. & Hulme, M., 2013. The emergence of the geoengineering debate in the UK print media: a frame analysis. *The Geographical Journal*, online ver. Available at: http://doi.wiley.com/10.1111/geoj.12003 [Accessed March 2, 2013].

Reber, B.H., Kaufman, S.E. & Cropp, F., 2000. Assessing Q-Assessor: A Validation Study of Computer-Based Q Sorts versus Paper Sorts. *Operant Subjectivity*, 23(4), pp.192 – 209.

Robbins, P. & Krueger, R., 2000. Beyond bias? The promise and limits of Q method in human geography. *The Professional Geographer*, 52(4), pp.636–648.

Rydin, Y., 1999. Can we talk ourselves into sustainability? The role of discourse in the environmental policy process. *Environmental Values*, 8, pp.467–484.

Sarewitz, D., 2011. The voice of science: let's agree to disagree. *Nature*, 478(7), p.2011.

Scholte, S., Vasileiadou, E. & Petersen, A., 2012. Opening Up the Societal Debate on Climate Engineering: How Newspaper Frames are Changing. *SSRN Electronic Journal*, pp.1–28. Available at: http://www.ssrn.com/abstract=2161733.

Scholte, S., Vasileiadou, E. & Petersen, A.C., 2013. Opening up the societal debate on climate engineering: how newspaper frames are changing. *Journal of Integrative Environmental Sciences*, (February 2013), pp.1–16. Available at: http://www.tandfonline.com/doi/abs/10.1080/1943815X.2012.759593 [Accessed February 22, 2013].

Schön, D.A. & Rein, M., 1995. *Frame reflection: Toward the resolution of intractable policy controversies*, Basic Books.

Shepherd, J. et al., 2009. *Geoengineering the climate: science, governance and uncertainty*, London: The Royal Society. Available at: http://eprints.soton.ac.uk/156647/1/Geoengineering_the_climate.pdf [Accessed September 20, 2012].

Sikka, T., 2012a. A critical discourse analysis of geoengineering advocacy. *Critical Discourse Studies*, 9(2), pp.163–175. Available at: http://dx.doi.org/10.1080/17405904.2012.656377 [Accessed September 6, 2012].

Sikka, T., 2012b. A critical theory of technology applied to the public discussion of geoengineering. *Technology in Society*, 34(2), pp.109–117. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0160791X12000073 [Accessed March 22, 2013].

Stainton Rogers, R. & Stainton Rogers, W., 1990. What the Brits got out of the Q, and why their work may not line up with the American way of getting into it! *Electronic Journal of Communication/La Revue Electronique de Communication*, 1.

Stephenson, W., 1953. *The study of behavior: Q-technique and its methodology*, Chicago: University of Chicago Press.

Stilgoe, J., 2013. Why has geoengineering been legitimised by the IPCC? *The Guardian*. Available at: http://www.theguardian.com/science/political-science/2013/sep/27/science-policy1.

Stirling, A., 2008. "Opening Up" and "Closing Down": Power, Participation, and Pluralism in the Social Appraisal of Technology. *Science, Technology & Human Values*, 33(2), pp.262–294. Available at: http://sth.sagepub.com/cgi/doi/10.1177/0162243907311265 [Accessed October 5, 2012].

Stirling, A., 2009. Participation, Precaution and Reflexive Governance for Sustainable Development. In A. Jordan & N. Adger, eds. *Governing Sustainability*. Cambridge: Cambridge University Press.

Stirling, A., 2006. Precaution, Foresight and Sustainability: reflection and reflexivity in the governance of technology. In *Reflexive Governance for Sustainable Development*. Cheltenham, UK: Edward Elgar Publishing, pp. 225 – 272.

Swedeen, P., 2006. Post-normal science in practice: A Q study of the potential for sustainable forestry in Washington State, USA. *Ecological Economics*, 57(2), pp.190–208. Available at: http://www.sciencedirect.com/science/article/B6VDY-4GCX0FX-1/2/165342da20838b66efa2598f8ce31af6 [Accessed September 1, 2012].

Van Tubergen, G.N. & Olins, R.A., 1979. Mail vs personal interview administration for Q sorts: a comparative study. *Operant Subjectivity*, 2(2), pp.51 – 59.

Walker, G. & Shrove, E., 2007. Ambivalence, sustainability and the governance of sociotechnical transitions. *Journal of Environmental Policy and Planning*, 9(3-4), pp.213 – 225. Available at: http://www.tandfonline.com/doi/abs/10.1080/15239080701622840 [Accessed February 1, 2013].

Warner, M., 2010. *Publics and counterpublics*, New York: Zone Books.

Webler, T. et al., 2009. Using Q Method to Reveal Social Perspectives in Environmental Research.

Whelan, J. & Lyons, K., 2005. Community engagement or community action: Choosing not to play the game. *Environmental Politics*, 14(5), pp.596–610. Available at: http://dx.doi.org/10.1080/09644010500257888 [Accessed February 25, 2013].