Novel non-state sources of de facto governance in the solar geoengineering governance landscape: The case of SRMGI and C2G

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ABSTRACT

Climate engineering, which comprises a number of proposals for intentionally intervening into the planet's climate system to reduce global warming, has slowly entered mainstream climate policy discussions. Despite lacking formal governance arrangements and the absence of shared norms, climate engineering is not an ungoverned space. On the contrary, there are many academics and some interest groups present that shape the trajectories of these speculative technological proposals. Consequently, climate engineering's re-emergence has rendered discussions on imagined climate futures and their governance even more complex. Especially one group of proposals, solar geoengineering, is heavily contested. Calls for anticipatory governance have been on the rise in discussions on solar geoengineering. Two influential governance initiatives, the Solar Radiation Management Governance Initiative (SRMGI) and the Carnegie Climate Governance Initiative (C2G), intervene in and steer the solar geoengineering governance landscape, thus *de facto governing* it. This research analyses the governance initiatives' interventions and governance effects as it is argued that their steering has major implications, also for how (future) governance options are envisioned and constructed. Results show that the initiatives' interventions in the form of a governance narrative and broadened engagement result in the strategic opening up of the governance landscape by successfully normalising certain governance directions and objects as well as empowering certain actors and knowledge types. The non-state initiatives' steering effects reveal some communalities but also differences. Both initiatives' governance effects have in common that they implicitly support a disconnection of anticipation from decision making in different contexts. This has implications for the construction of anticipatory governance and whether it is practiced well enough to comply with the ideals of deliberative democracy. Hence, it needs to be paid more attention to the ongoing imagination and construction of governance and how certain unfavourable steering effects can be counteracted.

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CDR	Carbon dioxide removal
CE	Climate engineering
COP	Conference of the Parties to the UNFCCC
C2G	Carnegie Climate Governance Initiative
DECIMALS	Developing Country Impacts Modelling Analysis for SRM
EDF	Environmental Defense Fund
IPCC	International Panel on Climate Change
NGOs	Non-governmental organisations
NETs	Negative emission technologies
SAI	Stratospheric aerosol injection
SCoPEx	Stratospheric Controlled Perturbation Experiment
SR15	Special report on the impacts of global warming of 1.5 °C
SRM	Solar radiation management
SRMGI	Solar Radiation Management Governance Initiative
STS	Science and technology studies
UNEA	United Nations Environment Assembly
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

Is the only manner in which humanity can prevent a climate emergency the deployment of highly speculative technologies? The underwhelming climate actions implemented by various actors so far raise fears that the deployment of so-called climate engineering (CE) or geoengineering technologies might be unavoidable. CE is defined as "deliberate large-scale interventions into the Earth's climate system with the aim of reducing global warming" (The Royal Society, 2009). The driving force behind the interest in CE proposals is thus the concern that the ambitious goal set in the Paris Agreement is not achievable anymore without the deployment of these large-scale interventions (IPCC, 2018). The knowledge that even in case of perfect mitigation, the planet would still face decades of warming due to already emitted greenhouse gases is further fuelling the debate around CE proposals, not to mention the increasingly perceptible climate change impacts across the globe. However, the idea to modify the planet's climate system instead of focusing on behavioural changes of humans is a very contested one (Ginzky et al., 2011, p. 41; Möller, 2018). CE technologies are associated with a combination of high stakes and high uncertainty (Foley, Guston, & Sarewitz, 2019). The technologies bear serious risks at a global level such as changing precipitation patterns, biodiversity impacts and unexpected hot and cold spells (Caldeira, Bala, & Cao, 2013). In addition to that, CE proposals raise existential and value questions which manifests themselves in vehement discussions (Baskin, 2016, p. 5). The topic has slowly entered the mainstream climate policy discussions but the CE proposals remain heavily contested and opinions vary widely (Jacobson, 2018).

It is not the first time that these controversial technologies have been considered. At the end of the Second World War and throughout the Cold War, major investments were made by the two superpowers to advance scientific knowledge on climate control in the widespread belief that nearly every natural or man-made problem could be solved with the help of technologies (Baskin, 2019, p. 29). It was in this context that the idea of CE was born. In the mid-1970s the enthusiasm for weather modification and CE came to a halt and the issue disappeared from the public policy agenda (Baskin, 2019, p. 45). However, it should not take long for the topic to re-emerge. Rising pessimism due to the lack of successful regulations to address global warming and environmental degradation led to CE's re-emergence in the mid-2000s (Baskin, 2019, p. 76). In addition to that, the predominant climate policy discourse adopted a more alarming tone based on the growing concerns shared by scientists (Baskin, 2019, p. 80). The first academic who broke the taboo was Paul Crutzen by promoting more research into and debate on a specific CE technology, sunlight reflecting aerosols, to reduce global warming in one of his articles published in 2006 (Crutzen, 2006). Since then, the number of academic publications on and scientific assessments of CE has increased immensely over the last years (Flegal, 2018). Despite steadily increasing academic attention to the field as reflected in the continually rising number of publications, national as well as international political input into the topic remain limited to absent. Also, apart from some public deliberations, public awareness regarding the issue remains low and often based on misinformation.

In contrast to other controversial technologies such as biotechnology and nanotechnology, CE is based on existing knowledge in earth sciences and chemistry and often constitutes a combination of already existing technologies (Baskin, 2016, p. 5). The most referred to authoritative assessments[1] in the CE field divide CE technologies in two broad categories: carbon dioxide removal

[1] Assessments from institutions with a huge influence on climate policy at the domestic and international level

(CDR) or negative emission technologies (NETs) and solar radiation management (SRM), solar geoengineering or albedo modification (Gupta & Möller, 2018). This categorisation has entered the predominant CE discourse (Gupta & Möller, 2018). The first group of CE proposals addresses the capture and storage of carbon dioxide which has been released into the atmosphere and the second technique aims at the reduction of incoming solar radiation. SRM does not address the actual cause of climate change, that of GHG emissions, or ocean acidification, but surface temperatures by reflecting incoming sunlight. This is why even SRM research advocates emphasise that it should always be deployed alongside ongoing mitigation efforts (MacMartin, Ricke, & Keith, 2018).

Although climate scientists welcomed the ambitious 1.5° C warming target in the Paris Agreement, doubts about its feasibility even when deploying NETs at a vast scale were soon on the rise (Möller, 2018b). New voices emerged in climate science and politics that the more ambitious target might require the consideration of SRM technologies (Horton, Keith, & Honegger, 2016; MacMartin et al., 2018). Horton et al. (2016) also argue that the decision to include a temperature goal in the Paris Agreement instead of a specific quantitative mitigation target would facilitate SRM's consideration in the post-Paris era.

The broader category of SRM comprises various techniques, including surface albedo modification (e.g. cultivation of high albedo crops), marine cloud brightening[2], cirrus cloud thinning by injecting ice nuclei as they absorb a lot of long-wave radiation due to their formation at high altitudes and finally the most advanced and discussed SRM technique, stratospheric aerosol injection (SAI). SAI refers to the release of inorganic particles - most often sulphur dioxide - into the (lower) stratosphere which then oxidise into sulphuric acid aerosols which are able to reflect incoming solar radiation, thus reducing or even reversing global warming. Especially SRM attracts firm opposition due to the radical nature of specific proposals. Publics who have been introduced to SRM but also many climate scientists oppose SRM (Baskin, 2019, p. 2). The well-known academics[3] who are generally supportive of SRM and form the epistemic SRM community[4] have been very influential when it comes to the framing of the technology, thus contributing to the proposals' sustained momentum by presenting themselves as reluctant climate engineers.

This research's focus lies on SRM, also due to the attracted research and policy attention. SAI is the most prominent SRM technique which can be traced back to SAI's alleged potential in terms of scale and feasibility as compared to other SRM techniques. The predominant focus on SAI which is noticeable throughout this research is thus a consequence of the SRM discourse. The small number of scientific SAI research which has been funded and conducted to date usually focuses on computer modelling and observations of volcanic eruptions. Circulating promises and perils regarding SAI are thus based on modelling results which do not confirm its actual feasibility (Flegal, 2018, p. 2). In fact, the assumptions and choices which feed into the model runs are admitted by climate modellers themselves but far from clear and transparent to other experts and non-specialist audiences who are not part of this epistemic community (Low & Schäfer, 2019). There exist considerable uncertainties when it comes to the extent of resulting physical climate effects from a potential SAI deployment which might include reduced rainfall, droughts, monsoon disruptions and even the destruction of the ozone layer next to decreasing temperatures (Irvine, Kravitz, Lawrence, &

[2] Describes the process of increased cloud formation through the spraying of seawater into clouds to enhance the reflection of incoming sunlight

[3] According to Baskin, 2019, p. 18: Ken Caldeira, John Shepherd, David Keith, David Victor, Jason Blackstock, Ben Kravitz, Peter Irvine, Andy Jones, Philip Rasch, Andy Parker, Scott Barrett, Gernot Wagner and Michael MacCracken, Douglas MacMartin

[4] Epistemic community is a term first introduced by Haas (2013) to describe an expert network with authoritative knowledge claims and shared research and norms which is characterised by social cohesion.

Muri, 2016). Also, SAI deployment might thus result in potentially unequal climate effects around the globe (Jones et al., 2017; National Academy of Sciences, 2015).

The Stratospheric Controlled Perturbation Experiment (SCoPEx), a project which forms part of a larger solar geoengineering research program at Harvard University might soon become the first officially backed small-scale SAI outdoor experiment (Harvard University, 2019b). Marine cloud brightening is another SRM technique which would be deployed in the global commons and entail spatially heterogeneous effects. This technique has also been imagined extensively with the help of modelling work but the first outdoor research plans were cancelled after some media coverage and the follow-up project scheduled for 2017 has been put on hold due to a lack of funding (Geoengineering Monitor, 2018). Cirrus thinning is modelled as part of the Geoengineering Model Intercomparison Project but constitutes a less popular proposal also due to a potential net warming effect (Kravitz, 2019a). SRM includes also a technique which would be deployed at the national level and is therefore also less controversial, surface albedo modification. So far, this technique has not received any academic, let alone political, attention.

But SRM should not be considered as only posing physical risks but also social challenges. The political and social aspects associated with solar geoengineering as a totalising technology are revolutionary (Baskin, 2016, pp. 5–11; Hamilton, 2011). Many academics fear that the discourses around these speculative technologies might distract policy makers from the urgent necessity to ratchet up their mitigation and adaptation efforts in line with the Paris Agreement (Flegal, 2018; McLaren, 2016; Morrow, 2014). This so-called moral hazard or mitigation deterrence phenomenon describes the situation in which CE might delay, substitute for or discourage increased and accelerated mitigation efforts (McLaren, 2017). In addition to that, the specific nature of SRM technologies also bears the risk of adaptation deterrence (Flegal, 2018, p. 29). According to one of the first studies focusing on developing country experts' attitudes towards the SRM debate, the fear that CE research could "deflect the burden of the Global North for its role in the climate problem", thus neglecting its "moral responsibility" as the principal perpetrator of climate change outweighs moral hazard concerns (Winickoff, Flegal, & Asrat, 2015). Also, the potentially unequal climate effects of SAI deployment raise fears in developing countries about the implications of CE research distribution as they lack research capacity and funding (Flegal & Gupta, 2017). If SRM technologies are put in an overly positive light by industrialised countries, most of them will be accused of not complying with their mitigation responsibilities by developing countries, thus exacerbating tensions between the groups of countries (Möller, 2018b). This suggests that the legitimacy to put the topic on the international agenda lies with the most vulnerable countries in light of climate change (Möller, 2018b). Reservation or reluctance is perceivable among many national governments to address SRM which has also to do with these dynamics between Global North and South (C2G2, 2018b; Möller, 2018b). This reveals that it poses a great political challenge as SRM could result in increasing distrust regarding states' motives. In addition to that, some people fear that research into SRM technologies and their development could steer future decision-making into a certain direction, thus causing a "lock-in" or being on a "slippery slope" (Bellamy & Healey, 2018). These are only some of the social challenges which come along with SRM imaginaries, not to mention the ethical issues they raise.

Despite lacking formal governance arrangements and the absence of shared norms, the CE field is not an ungoverned space (Gupta & Möller, 2018). On the contrary, there are many academics and some interest groups which shape the trajectories of speculative technologies. Discursive steering by scientific assessments has already been subject to research (see Gupta & Möller, 2018;

Owen, 2014; Jacobson, 2018). In this case, internationally leading experts on solar geoengineering exert steering capacity by first normalizing and then institutionalizing CE research (Gupta & Möller, 2018; Stilgoe, 2016). The re-emergence of the CE topic has thus for sure not made the discussions on imagined climate futures and their governance any easier. The multiple, value-laden discursive framings which are circulating in the CE field have demonstrated that CE poses an immense anticipatory governance challenge (Gupta & Möller, 2018). Anticipatory governance is understood as "governance in the face of extreme normative and scientific uncertainty and conflict over the very existence, nature, and distributive implications of future risks and harms" (ESG Task Force on Conceptual Foundations, 2019). Calls for anticipatory governance have been on the rise in debates around CE (Conca, 2018; Gupta & Möller, 2018).

Therefore, other actors step in to close the gap regarding anticipatory governance. Many academics are taking part in the discussions on how appropriate SRM governance should look like as this field is in general very supply-driven in terms of research of social scientific nature (and otherwise), thus having "outpaced any demand function" (Flegal, 2018, p. 2). They propose expert-developed principles or organise engagement exercises with the larger public. Two non-state initiatives are also operating in this space to address the issue of lacking anticipatory governance. However, little is so far known about the nature and implications of the steering by these novel initiatives, a research gap which this research attempts to close.

1.1 Problem statement

Many non-state actors are active in the CE field, taking a rejective or supportive stance on the speculative technologies. There are also informal initiatives active in this field whose steering is less acknowledged. Especially two initiatives can be conceptualised as informal, emerging de facto sources of governance, the Solar Radiation Management Governance Initiative (SRMGI) and the Carnegie Climate Governance Initiative (C2G) (previously Carnegie Climate Geoengineering Governance Initiative (C2G2)). There is little empirical knowledge available about the nature and implications of the initiatives' steering. Both initiatives do not attempt to steer in terms of taking a position in favour or against the deployment of SRM or by supporting any specific governance framework, but instead aim for opening up discussions about SRM and its governance. Whereas SRMGI aims at introducing new actors from developing countries to SRM and its governance, C2G is targeting government actors across the world. Both initiatives are intervening in the governance landscape which is defined as comprising research trajectories and (research) governance discussions. In that sense, both initiatives are quite unique which is why they are referred to as novel non-state initiatives in this study. SRMGI whose foundation dates back to March 2010 has already been subject to some limited scrutiny (see Owen, 2014), whereas C2G's activities have not yet been analysed. One reason for this is that the initiative's launch only took place in February 2017 (Pasztor, 2017a).

Both initiatives have been chosen as empirical cases for this research due to their influential role in discussions on SRM (research) governance. The initiatives are referred to as "NGOs linked to academia"(Zelli, Möller, & Asselt, 2017), "boundary organizations" (Frumhoff & Stephens, 2018) and "policy-oriented and advocacy non-governmental organisations" (Reynolds, 2018). According to Zelli et al. (2017), the initiatives aim "to increase transparency, inclusiveness and public participation in discussions on SRM". Both initiatives hold a certain level of eminence which is recognised by other actors operating in the SRM governance landscape. A recent assessment of funding into solar geoengineering research from 2008 to 2018 highlights the initiatives' influential role by

revealing that private spending is currently mainly focused on Harvard's Solar Geoengineering Research Program, C2G and SRMGI (Necheles, Burns, & Keith, 2018).

Within the scope of this research, the two initiatives' activities shall be scrutinised to get a more comprehensive idea of the manner in which they intervene in and steer the SRM governance landscape and the resulting implications thereof. The steering by both initiatives has thus implications for how governance options are envisioned and constructed. It is important to create this empirical knowledge as the discussions around CE and respective governance calls are only expected to increase in the near future. With increasing average temperatures around the globe and tangible effects of this change, CE proposals will not vanish from the agenda (Möller, 2018b). The calls to not talk about the issue in the hope that it will fade away are not realistic (Reading Conference). Therefore, "it is no longer a question of if we should talk about them, but rather how we do it and whose perspective will shape the direction of the conversation" (Möller, 2018b).

1.2 Research objectives and questions

Emerging from the preceding problem statement, the main objective of this research is to generate empirical and theoretical knowledge on how prominent non-state initiatives are de facto governing the SRM governance landscape. It is important to create this knowledge as the two governance initiatives take an influential position in the SRM governance landscape and their governance effect allows for the drawing of lessons regarding anticipatory governance options. The insights created by this research are of interest to policy makers and the larger public as novel governance approaches in this field are investigated comprehensively.

The research thus aims to answer the following main research question:

1. How are novel non-state initiatives steering the SRM governance landscape and what are the implications thereof?

To answer this main research question, the following sub-questions have been formulated:

1.1. How are the two initiatives embedded in the SRM governance landscape and what are the controversies they are engaging with?
1.2. How does SRMGI intervene in and steer the SRM governance landscape?
1.3. How does C2G intervene in and steer the SRM governance landscape?

The first sub-objective of this research aims at introducing the SRM governance landscape, thus providing the broader context in which the two governance initiatives are embedded. This includes an analysis of how the governance initiatives relate to other sources of governance in this space. Also, controversial issues which are relevant for the SRM governance discussions are introduced which feed into the second and third sub-objective. The second and third research sub-objectives thus build on issues introduced under the first sub-objective.

The second and third research sub-objectives are to empirically explore the SRMGI initiative and the C2G initiative respectively, as well as their influence on the SRM governance landscape.

The fourth sub-objective is to compare the results of the second and third sub-objectives to assess the overall effect on the SRM governance landscape. In addition to that, reflections on the conceptual framework are undertaken to assess the construction of anticipatory governance options.

The first three sub-objectives thus cover the empirical part of this research whereas the fourth sub-objective also reflects on the insights' importance for the anticipatory governance discussion.

1.3 Roadmap

To answer the outlined research questions, the research is structured as follows. After this introductory chapter, the conceptual framework will be introduced in the second chapter. The conceptual framework concludes with the introduction of an analytical lens that allows for the analysis of the initiatives' potential governance effects. The third chapter outlines the research design and provides more details about the two selected cases for this comparative case study analysis. Subsequently, an overview of the used methods and the data analysis process is given.

Chapters 4, 5 and 6 constitute the three empirical chapters of this thesis, thus integrating results from the data analysis which comprises literature review, document analysis, semi-structured interviews and participant observation. Chapter 4 is a mapping chapter that embeds the two initiatives in the SRM governance landscape. Due to the huge supply of research and the many value-driven opinions about CE and SRM in particular, chapter 4 also includes an overview over all identified controversies as it is important to understand the issues the governance initiatives have to deal with. Chapters 5 and 6 focus each on a specific governance initiative and describe the manner in which they de facto govern the space with the help of the analytical lens developed in chapter 2.

In chapter 7, the governance effects of the two initiatives are compared by answering the main research question. Subsequently, it is zoomed out by reflecting upon the ongoing construction of anticipatory SRM governance. Eventually, this study's conceptual approach is reflected upon before segueing into concluding remarks.

2 Conceptual Framework

In this chapter, the conceptual framework of this research is introduced. The first section on the anticipatory governance of emerging technologies serves as an overarching framework which outlines challenges regarding the governance of novel technologies. Subsequently, the concept of de facto governance is outlined and operationalised in the form of an analytical lens which distinguishes between interventions and effect of such governance.

2.1 The anticipatory governance challenge of novel technologies

In this section the governance challenge of emerging technologies is introduced. It is important to mention here, that this section will talk about emerging technologies in generic terms. However, each (socio)technical system entails its own specific problems and challenges. This research uses the term governance in its broadest sense which means that "all structuring of action and interaction that has some authority and/or legitimacy counts as governance" (A. Rip, 2018). Emerging technologies are defined as having the five following attributes: radical novelty, relatively fast growth, coherence, prominent impact as well as uncertainty and ambiguity (Rotolo, Hicks, & Martin, 2015). When a technology is referred to as novel, this does not mean that it entails unprecedented implications. Novelty is context-dependent and "it is precisely that emerging technologies both have antecedents and are new – that they have what we would call a politics of novelty – that makes them interesting and problematic" (Foley et al., 2019).

Emerging technologies constitute an anticipatory governance challenge because their potential risks and benefits are uncertain, highly contested and often simply unknowable which makes the design of formal governance arrangements for research and development a difficult undertaking (Abbot, 2012; Foley et al., 2019; Stilgoe, Owen, & Macnaghten, 2013). The term risks does not only refer to technical but also to the social, economic and ethical risks which emerging technologies entail and all must be acknowledged when aiming for an effective regulatory framework (Abbot, 2012). However, often the actual challenge is the scientific uncertainty about these risks and the probability of unknown risks (Abbot, 2012). These so-called unknown unknowns require a new approach to risks by decision-makers which moves away from recasting uncertainty as risk and faces "the implications, epistemologically, of acknowledging radical uncertainty" (Baskin, 2019, p. 171).

For governments, the entailed risks and uncertainties of emerging technologies constitute a technology control dilemma also referred to as Collingridge dilemma (Oldham et al., 2014). The dilemma describes the problem that uncertainties regarding a new technology's effects prevent the adoption of deliberative governance arrangements at an early stage of its development but that later on the implementation of regulatory control is very difficult once the technology is entrenched, thus locking us into trajectories which we cannot alter afterwards (Oldham et al., 2014; Stilgoe et al., 2013). To overcome this issue and to realise the shift from risk governance to the governance of innovation itself, practitioners make increasingly use of anticipatory modes of governance which allow for flexibility and responsiveness to new knowledge and understanding (Abbot, 2012; Oldham et al., 2014). This shift demands that the scientific process goes hand in hand with the consideration of social dimensions (Stilgoe, 2015; Stilgoe et al., 2013). Stilgoe et al. (2013) argue that merely risk-based approaches are not able to comprehensively pick up concerns at such an early stage and do not allow for flexibility, reflexivity and anticipation in the research and innovation process. An entire interdisciplinary research field, science and technology studies (STS) deals with these issues which are outlined subsequently.

STS scholars argue that the identity of a technology is not only decided upon by scientists through permanent discursive contests and negotiations but also in public, political and economic contexts depending on its nature (McLaren, 2017). Broader governance is thus present in the field of emerging technologies (Rip, 2018). Scientific findings have no impact at all if they are not "made credible through interests and strategies" (Lidskog & Sundqvist, 2015). In the words of Sheila Jasanoff, who has decisively contributed to the formation of the interdisciplinary STS field, science and society are thus co-produced (Jasanoff, 2004). The fact that consent approval beyond the epistemic community is required for the "successful advancement of technological fields in democratic societies" is widely acknowledged (Jacobson, 2018). This is best described with the term "socio-technical imaginaries" which is defined as "collectively imagined forms of social life and social order reflected in the design and fulfilment of scientific and/or technological projects" (Jasanoff, 2015; Jasanoff & Kim, 2009). As this is a collectively-held imagination the need for interactions and public engagement is pivotal. From a socio-constructivist perspective, the future in the form of sociotechnical imaginaries can be considered a discursive field in which (re)framings of the issue and associated notions of political aspects can decisively influence their acceptance and thus also potential actions by decision-makers (Bellamy, Chilvers, Vaughan, & Lenton, 2013; Jansen & Gupta, 2009; McLaren, 2017). STS scholars thus aim at assessing imaginaries of emerging technologies by exposing underlying framings and narratives (McLaren, 2018). The co-production of science and technology is also why STS scholars challenge the widespread assumption that innovation should be considered as natural, inevitable and unstoppable.

In order to address these challenges, a vision for appropriate governance in this space has been developed. The concept of anticipatory governance has emerged since the mid-1970s but was only coherently used around the year 2000 (Foley et al., 2019). David Guston's (2014) definition of anticipatory governance as a "broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible" is widely acknowledged. The idealistic vision of anticipatory governance consists of two concepts, governance and anticipation. Governance is in this case understood as the "broad-based societal capacity to make collective decisions" and anticipation "expresses a particular kind of disposition toward the future governance" (Foley et al., 2019). Governance would include government actions but is not synonymous to it, non-state actions and public-private collaborations (Foley et al., 2019). Anticipation differs decisively from prediction which implies that action is only taken after knowing what is going to happen (Foley et al., 2019). There exist different approaches to anticipate the implications of emerging technologies which comprise foresight methods (e.g. cross-impact & novel technology assessments), scenario development, public deliberation/engagement and vision assessment (Barben, Fisher, Selin, & Guston, 2008, p. 987; Vervoort & Gupta, 2018). According to Foley et al. (2019) an anticipatory perspective "sees the future not as something that can be predicted but as something to be made through encounters among pluralistic worldviews, political action, technological change, and so on". Anticipatory governance builds upon deliberative activities and seeks two additional capacities, anticipatory knowledge which is different from predictions[5] and probabilistic forecasts and the integration of diverse knowledge types (Foley et al., 2019). In contrast to precaution, anticipation does not assume that uncertainty can be resolved through more research into a certain issue (Foley et al., 2019).

[5] Anticipation differs decisively from prediction which implies that action is only taken after knowing what is going to happen (Foley, Guston, & Sarewitz, 2019). Anticipation, on the contrary, is building capacity in the present, thus preparing for possible events in the future (Foley et al., 2019).

Only if anticipatory governance is practiced well enough, "the ideals of deliberative democracy to reflect the values and capabilities of pluralistic societies" is realised (Foley et al., 2019). The concept of anticipatory governance is, however, differently understood and applied within academic communities such as transition studies, risk, STS and responsible research and innovation (ESG Task Force on Conceptual Foundations, 2019). The scholars diverge in their normative standpoints which has implications for the emphasis they put on certain approaches to anticipation and their institutionalisation (ESG Task Force on Conceptual Foundations, 2019). This study will also provide some insights into how anticipatory governance options are envisioned and constructed.

As mentioned above, even though formal governance and shared norms, formal regulations and institutional arrangements are largely absent in the field of emerging technologies, other forms of governance are flourishing. There is a lot of informal governance taking place by all sorts of non-state actors. A theoretical concept which tries to grasp sources of less acknowledged steering, is *de facto governance*. The following section will dive deeper into its conceptualisation.

2.2 De facto governance

De facto means "existing in fact, although perhaps not intended, legal or accepted" (Cambridge Dictionary, 2019). The term is often used in legal contexts when referring to an illegitimate government of a state. The term *de jure* in contrast refers to forms of steering which have "a right or existence as stated by law" (Cambridge Dictionary, 2019). The term governance comprises all forms of steering that aim at providing political order and common goods on different decision-making levels (Andonova, Betsill, & Bulkeley, 2009; Risse, 2004; Rhodes, 1997). A shift from government towards governance has taken place in the last decades, thus moving beyond the sole focus on state-centred activity. The shift thus adds softer and more indirect, widely dispersed forms of steering to formal, state-based governance such as command and control regulation, bans and international agreements (Conca, 2018). Next to governmental action, non-state actors such as private actors, non-governmental organisations (NGOs), industry associations, financial institutions and experts play significant roles in (sub)national but also transnational governance of specific issues. Owen (2014) even talks about naivety in case other governance forms are not considered as important as formal governance arrangements, especially in the case of emerging technologies.

In the context of emerging technologies, the concept of de facto governance has first been introduced by Arie Rip and his research on nanotechnology governance (Kearnes & Rip, 2009; Rip, 2006). According to Kearnes and Rip (2009) de facto governance "is embedded in forms of anticipatory and informal coordination". The inherent structural uncertainties of some emerging technologies are blamed for the existence of de facto governance arrangements (Kearnes & Rip, 2009). Anticipatory modes of governance for emerging technologies would be linked to the development of "the fora for anticipatory coordination between various actors involved in the development" of technologies (Kearnes & Rip, 2009). This would for instance be observable in visions for research or innovation roadmaps and the adoption of voluntary schemes (Kearnes & Rip, 2009). In a more recent piece, Rip (2018) further argues that de facto governance cannot be coordinated from a central point, is defined by a strong bottom-up character and puts governments in a position in which they have to accept that issues are governed outside their power by unrecognised social orders. The direction of this de facto steering by various social orders does not necessarily have to be ideal. Also, the bottom-up character of de facto governance would constitute an important distinction to the simple opening up of centralised top-down arrangements. De facto governance arrangements are based on an accumulated mass of widely dispersed actions and interactions at the collective level.

De facto governance can shape the contexts in which de jure forms of steering have to be developed (Gupta & Möller, 2018). This occurs through "framing technologies, and influencing their directions, trajectories and pace" (Owen, 2014). Owen (2014) specifies that de facto governance can take various forms: "sometimes overt, sometimes tacit, sometimes covert", including sources which cover "a spectrum from strong advocacy to vehement detraction". According to Gupta and Möller (2018), "the steering entailed in de facto governance is not explicitly recognised as an act of governing by others". In other words, people do not recognise that something is actually governing the space. Due to the fact that these sources of steering are not really recognised as such, it is further argued that the nature and implications of their (discursive) activities should be scrutinised (Gupta & Möller, 2018).

In the field of emerging technologies, the concept of de facto governance has been used already to analyse the boundary work by experts and learned societies (Owen, 2014), steering effects of authoritative assessments (Gupta & Möller, 2018) as well as of practices of scientific research and intellectual property acquisitions (Oldham et al., 2014). The analyses' focus was thereby lying on discursive framings. In this research, the concept of de facto governance is used to scrutinise the steering which flows from two initiatives operating in a field of emerging technologies. The initiatives' steering is more overt than the steering by authoritative assessments. However, the potential steering effect is not fully recognised by other actors in the field. Gupta and Möller (2018) operationalised the concept of de facto governance by differentiating scientific assessments' interventions in from the governance effect on the field of inquiry. The following section will provide the study's analytical framework to analyse the de facto steering by the two novel non-state initiatives.

2.3 Operationalisation of de facto governance by novel non-state initiatives

The preceding section made clear that unacknowledged sources of governance in the field of emerging technologies should not be underestimated as they shape the context in which formal governance arrangements emerge by restricting the terms of the debate or pushing it in certain directions. The introduced concept of de facto governance tries to capture less acknowledged sources of steering, focusing on more implicit and networked forms of coordination. The two NGOs focused on in this research are considered sources of de facto governance as they do not attempt to steer in terms of being in favour of or against the use of certain emerging technologies nor support a specific formal governance framework. The outcome they have in mind is process-oriented in terms of steering the type of process which will govern speculative technologies. Due to the institutional context out of which they emerge and the high-ranking political or scientific support they receive, both initiatives hold an eminent position in the respective governance landscape which provides them with legitimacy and steering capacity. So far, both organisations have not been studied through a de facto governance lens and in general little is known about the nature and implications of the initiatives' steering.

The field of emerging technologies is usually dominated by experts and lobby groups. The two non-state initiatives intervene in a completely different manner into the governance landscape than authoritative assessments or scientific practices which have been the focus of de facto governance studies so far. The novel initiatives intervene in this highly speculative field by dealing with the questions how governance should look like in this space (governance narrative) and what needs to be governed (governance object(s)) and by broadening engagement with the topic. These interventions taken together then have a (potential) governance effect, thus steering the governance landscape.

The aim of this study is to scrutinise these novel sources of steering in terms of their interventions in and effect on the respective governance landscape. The current governance landscape comprises research trajectories and governance discussions. Even though the interventions by these novel initiatives might be more obvious than the ones of scientific assessments, the concept of de facto governance is still considered applicable due to the fact that the (potentially) resulting governance effect and its implications are not really acknowledged. For the analysis an analytical lens (Figure 1) was developed which distinguishes between the initiatives' interventions and the potential governance effect which add up to de facto governance.

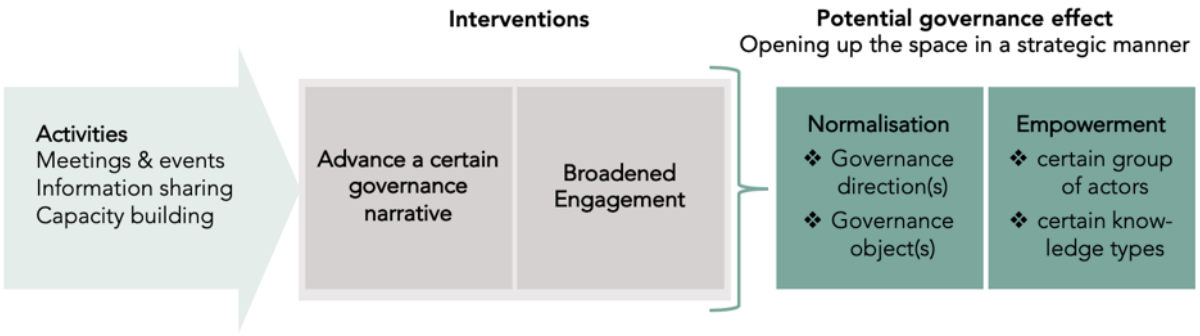

Figure 1: De facto governance by novel non-state initiatives

In the following, the different elements of this study's analytical lens as depicted in figure 1 are explained more thoroughly.

The activities

Activities which are typically undertaken by non-state initiatives include the organisation of all kind of meetings and events, information sharing and capacity building activities. Capacity building activities often involve the provision of funding for the target group. Different types of meetings refer to workshops and (informal) bilateral talks. In the case of a meeting, the active participation by all participants is supported. Events refer to larger gatherings such as a conference with issue-specific sessions. During these gatherings, (panel) discussions with subsequent question-and-answer sessions are a common format. A more flexible format are discussions according to the World Café style which allow for rotating small roundtable interactions. Information sharing activities comprise webinars, briefings and issue-specific publications including blog posts. The produced content is usually disseminated over print or online media, websites and social media channels. Capacity building activities can take different forms as this depends on the issue-specific area and the lacking skills of the respective target group.

Through these activities, the initiatives' two interventions are generated which are further outlined in the following.

The interventions

Both initiatives intervene in the governance landscape by advancing a certain governance narrative and through engagement activities. These interventions shall be further explained in the following.

<u>Advancement of a certain governance narrative</u>

Both initiatives intervene with a certain governance narrative in the space, thereby also determining specific governance objects. A narrative is broadly understood as storytelling which provides

meaning to a certain issue. Narratives can either be used to frame a (policy) problem or to call for some action (Bontje, Gomes, Wang, & Slinger, 2019). Narratives thus involve the use of frames. Frames explicitly or implicitly identify the cause of a rather difficult reality and point towards potential solutions associated with a certain normative standpoint (Dewulf, Boezeman, Vink, & Leroy, 2012; Entman, 1993). Therefore, narratives "provide legitimacy and justification to create and/or maintain processes, structures, and action" regarding governance (Magalhães & Veiga, 2017). Narratives draw on values, principles and "taken-for-granted assumptions stemming from discourses" (Magalhães & Veiga, 2017). A discourse is understood as a specific manner to talk about and understand social reality (Keller, 2011).

In this study, the governance narratives advanced by the initiatives are used as "discursive devices" to study the construction of problems and proposed solutions (Bontje et al., 2019). The space around emerging technologies is usually characterised by discursive battels and controversies. Therefore, it shall be analysed what assumptions are taken up and advanced by the initiatives in form of their governance narrative and what values and principles are referred to.

Broadened engagement

A second intervention by both initiatives is the reaching out to new actors to broaden discussions about controversial technologies and their governance. To what end and in which manner engagement is sought play an important role.

In the field of emerging technologies, the need for public or societal engagement exercises is embraced by many academic communities and supported by different actors. According to STS scholars, in order to reach sociotechnical maturity, deliberative engagement exercises are required to introduce the issue to the broader public (Bellamy, 2016; Bellamy & Healey, 2018; Flegal, Hubert, Morrow, & Moreno-Cruz, 2019). This does not only concern the core technical equipment of emerging technologies but also the understanding of possible governance arrangements (Bellamy & Healey, 2018). Engagement exercises are thus not only an awareness raising exercise but aim at real involvement of the public in the question in what kind of future they want to live in.

The manner in which engagement is broadened is also relevant. Ideally, engagement occurs in a representative manner, involving civil society organisations, private actors, different experts, government representatives and members of the public. Also, attention has to be payed to the integration of diverse knowledge types to advance the public good without causing intolerable trade-offs (Foley et al., 2019). By engaging with stakeholders which have not been familiar with the issue beforehand, it is well-known that framing is everything, especially in the field of emerging technologies (Bellamy, Chilvers, Vaughan, & Lenton, 2012). Deliberative engagement should address means and ends of emerging technologies "in an open-ended, substantive manner, while 'unframing' them as policy objects" (Low & Schäfer, 2019). Therefore, issues should be presented as neutral as possible and participants should be able to ask the questions they consider important. Such an approach needs to take into account for instance that broader questions of overall desirability should be addressed first before the potential pros and cons of certain technologies are addressed (Corner, Parkhill, & Pidgeon, 2011). If these issues are not taken into account, the deliberation process will risk manipulating participants by depicting research into and deployment of controversial technologies in a more socially acceptable manner.

In the case of the two initiatives, it shall therefore be analysed to what end and how they engage with different actors. It could also be that the manner in which they engage is closely related to the

promoted governance narrative which is indicated by the additional grey box around the interventions in the first figure.

The potential governance effect

The described interventions are likely to result in a steering effect on the governance landscape, thus shaping the context for formal, *de jure* governance. The potential governance effect which was identified to be caused by interventions such as the advancement of a certain governance narrative and broadened engagement is the opening up of the governance landscape in a strategic manner by normalising certain governance directions and empowering specific groups of actors or knowledge types.

Normalisation of governance directions

Due to the fact that both initiatives hold an eminent position in this field of emerging technologies, their efforts in advancing a certain governance narrative and the nature of their engagement exercises might result in the normalisation of specific governance directions. Depending on the preceding interventions, different governance and research directions can be normalised by the initiatives. Normalisation is here understood as the process of rendering something more normal or regular. It is argued that in case to be rendered more normal or regular the promoted governance direction needs to be taken up and supported by other actors in the field. The analysis of the potential governance effect will thus reveal how successful the initiatives have been in terms of steering the respective governance landscape by normalising certain elements of their governance narrative or the nature of their engagement approach.

Empowerment of certain groups of actors

Next to the normalisation of certain governance directions, the opening up of the space in a strategic manner also occurs through the empowerment of specific actors. The empowerment can result out of engagement exercises with these actors and the effects of the promoted governance narrative. Empowerment is in this case understood as the enhanced capacity of a target group but also as the strengthening of the actor's role in the governance landscape. Through the manner in which the initiatives engage and the promoted governance narrative, a certain knowledge type could also be privileged.

2.4 Conclusion

This section introduced the conceptual framework which first outlines the anticipatory governance challenge of emerging technologies. Subsequently, the de facto governance lens is described, a simple but useful concept which emerged in the interdisciplinary STS field to capture less acknowledged sources of steering. To operationalise this concept, an analytical lens was developed which differentiates between the interventions and potential governance effect by these novel sources of steering. It is argued that the initiatives intervene through the advancement of a certain governance narrative including respective governance object(s) and through broadened engagement. The interventions then potentially add up to a governance effect which, in turn, has implications, also for how future de jure governance options are envisioned. Figure 2 depicts all the elements of the conceptual framework.

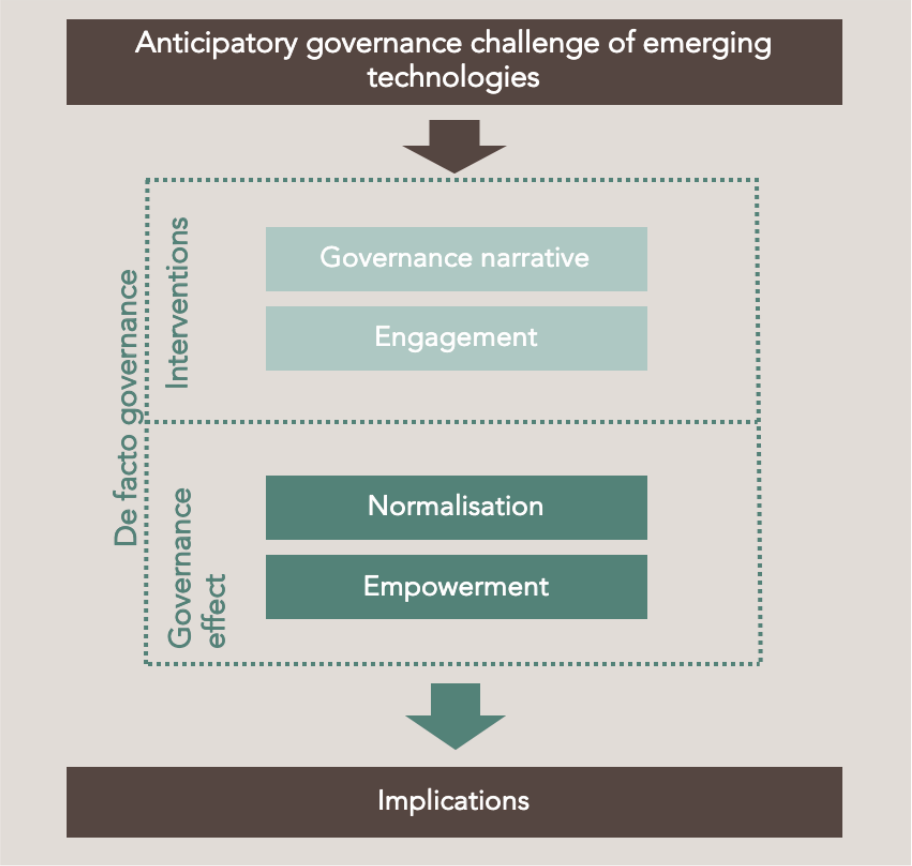

Figure 2: Overview of the Conceptual Framework

The next chapter will introduce the research design and the different methods used to gather the data for the analysis before the fourth chapter will introduce the SRM governance landscape, the research object.

3 Research design and methodology

The research findings' significance depends upon the research design and its methodology. Therefore, this section introduces the general study design, followed by a section on the methods used and an explanation of how the data was analysed. In addition to that, the study's scope and limitations is elaborated upon.

3.1 Comparative case study design

The approach to this empirical research is of explorative and qualitative nature. The research makes use of a comparative case study design. A case study observes a "case or phenomenon in its real-life context" by making use of multiple types of subjective and objective data (Cohen, Manion, & Morrison, 2007, p. 253-254). Case studies are, therefore, an in-depth examination of certain aspects the author wants to get more information about (Kumar, 2014). Strengths of case studies include their ability to catch unique features which would otherwise get lost, thus paying attention to cases' complexities (Cohen et al., 2007, p. 256). The boundaries around the case(s) are generally drawn according to the temporal, geographical, organisational or institutional characteristics (Cohen et al., 2007, p. 253).

There exist different types of case studies (Kaarbo & Beasley, 1999). One possible classification differentiates between exploratory, descriptive or explanatory case studies (Cohen et al., 2007, p. 254-255). In this case, the comparative case study is of more exploratory - or as others put it - intrinsic nature (Cohen et al., 2007, p. 254-255). Both cases chosen for this study, the two governance initiatives operating in the SRM space, are quite unique. Therefore, the aim of this research is more to understand the particular case in question, a sort of pilot study. This does, however, not imply that a (comparative) case study cannot contribute somehow to theory development to counter a widespread critique of case studies (Steinberg, 2015). Kaarbo & Beasley (1999) define the descriptive case study, also referred to as disciplined-configurative or interpretive, as follows: "The interest remains on the case (or the actor or actors of the given case), but the theoretical interpretation of the case may provide some prescriptive leverage".

According to (Kaarbo & Beasley, 1999), a comparative case study "is the systematic comparison of two or more data points ("cases") obtained through the use of the case study method". Regarding the selection of comparable cases it is important that researchers choose "in an effort to control for known or suspected alternative causes of the relationship under investigation" as the context can make a well-known difference (Kaarbo & Beasley, 1999). The case selection for this research is further explained in the subsequent section.

3.2 Case selection

In the following, the two empirical cases, SRMGI and C2G, are introduced in more detail. Since the two NGOs are the only two initiatives of that kind in this field of emerging technologies, an actual case selection process has not taken place. The two initiatives were chosen on the basis of their prominence and the fact that they have not been studied yet.

3.2.1 SRMGI

In March 2010, subsequent to the publication of the Royal Society report, SRMGI was founded in partnership by the Royal Society (British national academy of science), the Environmental Defense Fund (EDF) and the World Academy of Sciences. SRMGI therefore constitutes an "international NGO-driven initiative" and is co-chaired by the three organisations (AAS & SRMGI, 2013). In addition to that, SRMGI does not have a formal mandate and should be considered as a voluntary, not

democratically representative and self-organised initiative (SRMGI, 2011, p. 13). On the one hand, SRMGI aims at "expanding an informed international conversation about SRM research and its governance" and on the other hand it wants to build the capacity of developing countries to assess SRM techniques (SRMGI, 2019). Andy Parker, SRMGI's project director, worked as a policy advisor in the working group of the 2009 Royal Society report. Next to the project director, four additional staff members work part-time for SRMGI. The initiative also provides over a steering group which consists of a member from each convening partner, so three in total.

Originally launched with the goal to explore the need for special SRM governance mechanisms, the initiative convened a first conference of its working group in March 2011 out of which a comprehensive report resulted. The 2011 report did not only serve as a compilation of the meeting's results but was also supposed to form the basis for further efforts by the initiative to broaden the conversation about SRM research governance (SRMGI, 2011, p. 11-12). Message 8 of that report (2011, p. 10) states that SRM research governance arrangements would only be perceived as legitimate and equitable on the basis of broad debate and deliberation. This recognition has motivated SRMGI to build developing country stakeholders' capacity regarding SRM and SRM research governance in so-called outreach meetings which became the initiative's main activity throughout the years after the 2011 conference failed to reach a consensus on some governance recommendations. Apparently, opinions diverged on a moratorium on SRM deployment (Hamilton, 2011; Stilgoe, 2016). In the aftermath of this conference, SRMGI has become more "process- than results-oriented", thus not prescribing certain governance arrangements for SRM research.

In 2018, the initiative launched a USD 400,000 Developing Country Impacts Modelling Analysis for SRM (DECIMALS) fund to support developing country scientists who plan to model the impacts of SRM in their countries, thereby focusing on the most important regional climate variables respectively (SRMGI, 2018). The fund was designed by the project director with some input from Global South climate experts and leading SRM scientists (SRMGI, 2018a). The fund is managed by the World Academy of Sciences and the grants of up to US$ 70,000 for each of the eight project teams can be used for the attendance of conferences, the collaboration between the teams and with SRM modelling experts and for discussing their research findings with other local stakeholders (SRMGI, 2018a). Supported by eight so-called collaborators, experienced SRM modellers, the DECIMALS project participants are introduced in SRM geoengineering modelling and the interpretation of the data (SRMGI, 2018c). But not only the fund's design was chosen carefully, a lot of attention seems to have been paid to have most developing country regions of the world represented as well as to cover different country groupings such as BRICS, SIDS and LDCs (SRMGI, 2018b).

The initiative transparently provides its current funding sources. In July 2015, the Open Philanthropy Project provided a two-year grant to SRMGI which amounts to US$ 500,000 (Open Philanthrophy Project, 2016b). Another grant was provided from 2018 through 2020 for the DECIMALS fund and additional workshops. Behind the Open Philanthropy Project is a joint venture of GiveWell and Good Ventures, a private foundation launched by a co-founder of Facebook and Asana. Earlier funding sources comprise the InterAcademcy Panel, UNESCO, Zennström Philanthropies, the Carbon War Room and the Fund for Innovative Climate and Energy Research (SRMGI, 2017b).

3.2.2 C2G

C2G was launched in February 2017 and is led by Janos Pasztor, a former UN climate change diplomat. C2G's aim is it to facilitate the creation of effective CE governance at a global level by "encouraging a broader, society-wide discussion about the risks, potential benefits, ethical and governance challenges raised by climate geoengineering" (C2G2, 2018a). The end goal is to "enable intergovernmental decision making on whether or not to make use of these technologies, and if so, how", thus putting SRM deployment on hold until a better understanding regarding some of the technology's features has been gained and an agreement on the necessary governance framework has been adopted (Harvard Project on Climate Agreements, 2018, p. 59). This shall be reached by expanding the scientific and research-focused discussion to more political arenas, predominantly targeting UN organisations (C2G2, 2018a).

C2G does also not take a position regarding whether and what type of research should be conducted (C2G2, 2018b, p. 14). In general, the initiative seems to see a need for well-governed research (not necessarily research on technology development) for informed decision-making on the governance of solar geoengineering (C2G2, 2018b, p. 14). Therefore, the executive director argued in 2018 that research on risks, potential benefits and governance requirements of solar geoengineering needs to be incentivised (Harvard Project on Climate Agreements, 2018, p. 59).

The initiative's motivation to become active in this space is based on the decision-makers' reluctance to engage with the topic (C2G2, 2018, p. 12). To overcome this reluctance, efforts from informal actors would be required to share knowledge and mobilise stakeholders (C2G2, 2018b, p. 12). The initiative considers itself an impartial platform for all voices and opinions regarding the governance of geoengineering or "a convener, a catalyst, and an ideas incubator" (C2G2, 2018b, p. 2). The result of its work should manifest itself in a global network of leaders who work in multilateral or national institutions or engage with the civil society who have an advanced understanding of the topic and its geopolitical, scientific and ethical dimensions (C2G2, 2018b, p. 9). C2G's three governance priorities are to catalyse international agreements for the prevention of solar geoengineering deployment, to encourage the development of CE research governance, particularly solar geoengineering research and to support discussions on governing CDR technologies (C2G2, 2018b, p. 10).

C2G can best be described as a global virtual team with staff members spread worldwide (C2G2, 2017b). The number of staff members has constantly been increasing since its launch and currently amounts to 14. The initiative has an advisory group which is formed by scientists, academics and government representatives but also NGO representatives. The non-profit organisation behind C2G is the Carnegie Council for Ethics in International Affairs which was founded by Andrew Carnegie in 1914 and is based in New York. C2G sources its funding mainly from the Danish family foundation, Kann Rasmussen Foundation (2017-2020) and smaller amounts have also been provided by the OAK Foundation (2018-2020) and the IKEA foundation (2019).

3.3 Research methods

As this research seeks to analyse the initiatives' role in the SRM governance landscape, qualitive research methods are of great importance to answer the respective research questions. To understand the importance relevant actors assign to these initiatives, the reasoning behind certain activities and to understand how the broader governance landscape is shaped, interviews have been conducted. Next to semi-structured interviews, an extensive literature review, document analysis and participant observation constitute other methods this research has made use of. The research

thus applies a multiple methods approach which allows for improved accuracy and depth of research findings. In the following, the different research methods will be introduced briefly.

3.3.1 Literature review

Scientific and grey literature as well as white papers were used throughout the research process. At the beginning of this research, scientific literature was relied upon to get a better understanding of the relevant theoretical perspectives and concepts. Literature review also played an important role in the development of the interview guide during the data gathering process. For the data analysis phase, relevant academic literature was used to triangulate data from interview transcripts and results of the document analysis.

Relevant academic literature was identified with the help of scientific search engines such as Scopus and Google Scholar. Also, new publications were often shared on Twitter by people who form part of the CE research community which simplified the identification of significant research and helped to stay up to date in terms of issue-specific academic research. White papers and grey literature were retrieved directly from government websites, international treaties and websites of actors with a position in the SRM conversation.

3.3.2 Document analysis

According to Bowen (2009), a document analysis can be described as a systematic approach to the review and evaluation of documents. The document analysis process can be considered as an iterative process which "combines elements of content analysis and thematic analysis" (Bowen, 2009). Document analysis forms an integral part of this study's research methods as the statements made by representatives of the two governance initiatives in different documents are scrutinised to help identifying the nature of their intervention in the SRM governance landscape. Documents by the two initiatives were investigated to reach a better understanding of their positions in different debates revolving around SRM but also to analyse the initiatives' activities and their impact. The initiatives' knowledge claims in their publications solidify as discourses, revealing certain problem understandings and values (Keller, 2011).

The documents to be included in such an analysis can take a variety of forms (Bowen, 2009). For this document analysis, multiple kinds of documents have been considered, ranging from blog posts over agendas, minutes of meetings, manuals, background papers, emails to press releases, program transcripts, presentations and newspaper articles. All these documents were saved in the data analysis program *NVivo* which allowed for a well-structured approach to the subsequent data analysis process considering the large number of documents. The deadline for including documents was beginning of June 2019. The materials for both initiatives were divided in documents which were issued directly by the initiatives themselves and documents published by other actors that include statements made by representatives of the initiatives.

Whereas official reports released by the two initiatives were easily accessible, some documents addressing the initiatives' positions had to be tracked down. The geoengineering Google group which is moderated by Andrew Lockley has been of great help in that. Barred pieces which were not tracible with search engines anymore were still saved as raw text in the Google group as well as interview and conference transcripts as well as original emails. With the help of the search function in the geoengineering Google group relevant documents were identified. Due to the rise of an active CE research community on Twitter, the geoengineering Google group seems not to be used as frequent as before. For C2G, some of the tweets from the initiative's Twitter account were

also taken into consideration for the data analysis as long as they provided new information next to the initiative's publications on its website.

3.3.3 Semi-structured interviews

Another method upon which this research is based are in-depth interviews which best allow for a depiction of complex systems (Ritchie, Lewis, McNaughton Nicholls, & Ormston, 2013). One of the most important aspects when conducting interviews is to determine the size and nature of the sample of interviewees. Despite the fact that the number of people who are knowledgeable about CE is still manageable, the whole population could not be considered for data collection. Instead, interviewees were selected on the basis of their potential knowledge about the two governance initiatives and the SRM debate. This is also referred to as purposive sampling as the selection process was driven by an interest in specific in-depth knowledge (Cohen et al., 2007, p. 114-115). The research's purposive sample includes international diplomates, NGO representatives and researchers who have been involved in some way with one or both of the initiatives. Next to these in-depth interviews, some interviewees have been selected on the basis of their expertise of the broader CE governance debate to get an idea of the prominence of the two governance initiatives which are embedded into the CE governance landscape. Purposive sampling requires advanced issue-specific knowledge and the identification of important actors. This was achieved through extensive literature research and the following of CE researchers' Twitter accounts prior to the contacting of potential interviewees.

For this research, a total number of 18 interviews was conducted. Due to the nature of the current conversation around SRM, the majority of interviewees are academics from various backgrounds, followed by NGO representatives. As decision-makers and state officials at all levels have not publicly addressed this topic, it was challenging to identify available decision-makers. As government positions are just enfolding, there is a certain reluctance discernible to publicly talk about the topic. All interviews were conducted via Skype (16) or phone (2) as interviewees were based in different parts of the world. The interviews followed a semi-structured approach which meant that some questions were formulated prior to the interview in the form of an interview guide. An interview guide provides more structure than a topic list which is often referred to in qualitative methods books when talking about semi-structured interviews (D. W. Turner, 2010). This does, however, not mean that the questions of the interview guide are exhaustive, new ones can always be asked during the course of the interview and existing ones altered if appropriate. Questions were formulated in an open-ended manner as this allows interviewees to respond in their own words (Cohen et al., 2007, p. 119). As CE is often considered a sensitive topic due to its underlying ethical choices and socio-political implications, it made more sense to ask open and long questions to overcome interviewee's initial unease (Cohen et al., 2007, p. 130). The course of the interview was left open and followed the direction of interviewees' answers through follow-up questions. New input from interviews was used to adjust the interview guide for subsequent conversations. However, it was ensured that every interview covered the same areas of interest and was steered in the same main directions (D. W. Turner, 2010).

At the beginning of the fieldwork, the interview guides included some specific questions about the two governance initiatives, but I realised that this approach is not necessarily expedient. Therefore, the interview guide got adjusted by adding more general questions which asked for the same knowledge but in a more indirect manner (see Annex IV). Thanks to this adjustment, the quality of the interviews changed as respondents felt safer and started to talk more which made following up on mentioned aspects easier and more fruitful. The structure of the revised interview guide

followed a strategic approach by asking content mapping questions at the beginning which was then followed by content mining questions (Ritchie et al., 2013). Whereas content mapping questions aim at opening up a conversation, content mining questions seek to understand certain developments, thus narrowing down the area of interest (Ritchie et al., 2013).

Every interview was conducted in a confidential manner. This implies that any harm of research subjects is avoided by ensuring respondents' privacy by for instance anonymising their data (Cohen et al., 2007, p. 129). Whereas some interviews mainly focused on querying insights from one initiative, others comprised the activities of both. All interviews were recorded in accordance with interviewees. Three interviews were (partly) conducted in German. As recommended by Cohen et al. (2007, p. 261), key respondents were interviewed at a later stage of my research to ensure that I had been put into the picture fully thanks to preceding interviews and document analysis. An anonymised overview of the interviewees is provided in Annex I. Four different codes are used comprising the following groups of actors: Researchers from the Social Sciences & Humanities (ReSo), Researchers from the Natural Sciences & Physics (ReNa), NGO representatives (NGO) and diplomates (Dip). Throughout the thesis, these codes will be used in combination with a number to indicate the group the respective respondent belongs to.

3.3.4 Participant Observation

On 19 September 2018, I attended a discussion meeting of a report on the *International Governance of Solar Radiation Management* written by a group of global governance experts in Reading (UK). The meeting was convened by the Forum for Climate Engineering Assessment which is a US-based initiative at American University in Washington. Constituted in 2013, the forum's work comprises multiple projects: a scenario/modelling development project which aims at integrating social and environmental aspects of geoengineering in these; the creation of a SRM governance report by 14 global governance experts which got published in October 2018 (see Chhetri et al., 2018); the development of a global clearinghouse of CE research and the production of policy-relevant research also on CDR (FCEA, 2019b). The initiative wants to ensure that social sciences concepts such as justice, equity, agency and inclusion are considered in CE conversations (FCEA, 2019b).

In the course of the meeting, academics - predominantly from a global governance or ethics background - engaged in a vivid discussion on the recommendations developed by an expert group. The discussion took place according to Chatham House Rule which means that information shared during the meeting can be reported by meeting participants, but the source of that information may not be disclosed explicitly or implicitly. The notes taken during the meeting are also a source of data which was fed into the qualitative analysis software and which will be referred to as *Conference Reading* henceforth. The content of the meeting was relevant for this specific research as staff members of C2G were present at the meeting. Therefore, first impressions and contacts could be made. Also, it provided the author with a better understanding of the different controversies revolving around SRM.

3.4 Data analysis

As outlined above, all data gathered was fed into the qualitative analysis software NVivo. For this purpose, the recorded interview materials were transcribed. NVivo software was originally chosen as its NCapture plugin for the Chrome browser allows for the collection and subsequent analysis of Twitter feeds and other online sources. Due to the specific nature of this research, the

presumption that the document analysis would comprise a large number of materials, a qualitative analysis software was considered more manageable for the coding and analysis process.

After feeding all the data sources for the analysis in the program, the materials were coded using a specific coding scheme. The categories of the coding scheme coincide with the main themes of this research. Every code represents a certain key word and got assigned a colour code for better visualisation. For both governance initiatives the same coding scheme was applied. However, different colour tones were used to differentiate between the two initiatives. The coding of the data was facilitated by the software as it easily assigned the main themes to certain text passages and visualised the used codes afterwards. The data analysis process can best be described as an iterative process of reading transcripts and documents, coding them, visualizing results and establishing links to relevant concepts. Iterative also because sometimes new themes appeared within the materials which resulted in the adding of additional codes to the coding scheme during the coding process. The labelled interview transcripts and documents provide the basis for the analysis and discussion chapters of this research, next to secondary data from academic publications.

3.5 Limitations

Obviously, the results of this study have to be seen in the context of its limitations. This section covers the following limitations: research scope, selection of interviewees, the manner in which interviews were conducted and the theoretical approach.

Regarding the scope of this research, the analysis focused solely on one of the two CE categories. In the case of SRMGI that does not really play a role as it only operates in the SRM field and specifically on the two techniques with deployment in the global commons, SAI and marine cloud brightening. C2G, in turn, addresses both categories and its work is therefore not comprehensively reflected. This research's emphasis on SRM should not be understood as an endorsement of the sharp distinction of SRM and CDR. However, a choice had to be taken considering the available time for this research. Some references to CDR will be made but it needs to be mentioned that these brief insights do not give a full overview of the CDR governance discussion.

What concerns the selection of interviewees, the approach was chosen to contact knowledgeable people about the two governance initiatives but also about the broader CE debate. As has been mentioned in the research methods section already, the two biggest interview groups are academics from various backgrounds and NGO representatives. The number of interviewed government officials is, however, rather small. This limitation is a result of the current degree of involvement of political decision-makers in CE debates. Even though the best has been done to counteract this limitation, it was to a certain extent an unavoidable one.

Considering the interview process, in a small number of interviews language barriers constituted a limitation. As interview respondents come from different countries worldwide, not every interview could be conducted in the interviewee's native language. Apart from two interviews which were conducted in German, all interviews were conducted in English. This made it more difficult for some respondents to express themselves or to correctly understand the question. To counteract this issue, additional explanations were given to decrease the likelihood of misunderstanding the interview question. Another limitation regarding the interview process, was the fact that all interviews were conducted over Skype due to the geographical spread of interviewees. Whether a Skype interview would take place with camera or not was sometimes not really influenceable. Therefore, facial expressions of interviewees could not be taken into account in the majority of

interviews. This might have had an impact on the direction of the interview of some follow-up questions regarding a specific issue.

Another limitation of this study is that this topic is politically sensitive and many of the interviewees indirectly showed a certain reluctance to share their opinion about specific events and actors despite the reassurance that they would stay anonymous. It seemed that some of the interviewees were also restrained by their organisation's mandate. To account for this, a lot of emphasis was put on the triangulation of different data and the above described adjusted interview approach.

Regarding the theoretical approach, it has to be said that the analytical lens was self-developed based on different literature. To analyse the initiatives' activities through the de facto governance lens by differentiating between interventions and the governance effect is thus a novel idea. Therefore, it might well be that other scholars would choose a different lens to study the initiatives' activities. In addition to that, it has to be mentioned that an analysis of their governance effects might come early, at least for C2G as the initiative was only launched at the beginning of 2017. According to the author, it is, however, important to have a closer look as de facto sources of steering while they are still evolving. So, the full extent of the initiatives' governance effects is at this point in time not assessable.

After introducing the design and methodology of this research including its limitations, the three empirical chapters will follow. Each chapter answers one of the sub-questions by drawing from the different data sources outlined in this chapter. The next chapter addresses the SRM governance landscape and provides the basis for the subsequent analysis of the two empirical cases. Chapter 5 and 6 build on chapter 4 as the manner in which they are embedded in the governance discussions is shown. As described in this research's conceptual framework, the initiatives intervene with a certain governance narrative comprising frames which are also built on taken-for-granted assumptions. Chapter 4 therefore also provides an overview of the different controversies which are relevant for the governance discussion to see in which case both initiatives take a stance on them.

4 Mapping the SRM governance landscape

This chapter provides a comprehensive overview of the current sites and sources of SRM governance, thus introducing the SRM governance landscape. First, formal SRM governance at the international and at the national level is analysed before current research programs and funding are outlined. This is followed by a detailed analysis of the ongoing SRM governance discussions. The purpose of this first part of the chapter is to outline the elements of the governance landscape before the second part embeds the governance initiatives in it. This chapter as a whole answers research question 1.1.

4.1 Formal governance

This section comprises two sub-sections which outline the formal SRM governance arrangements at the intergovernmental level and also provide some insights into how national governments have so far engaged with SRM and whether concrete measures have been decided upon.

4.1.1 Intergovernmental governance

There exists only a limited amount of agreements at the international level which directly address CE techniques. The first one was the adoption of a de facto moratorium on ocean fertilisation by the Conference of the Parties to the CBD in May 2008 (Oldham et al., 2014). Decision IX/16C (CBD, 2008) establishes that ocean fertilisation activities should be banned until an adequate scientific basis for such activities is put forward with the exception of small-scale scientific research studies in coastal waters. Whereas this decision does not concern SRM as ocean CE forms part of CDR, COP10 of the CBD (2010) expanded its original statement to include the broader category of CE in its decision X/33. It allows for small-scale research "in a controlled setting" after conducting an environmental impact assessment (CBD, 2010). In 2016, the COP to the CBD adopted decision XIII/14 on climate-related geoengineering to reinforce the two preceding statements and to emphasise the need for more transdisciplinary research and knowledge sharing. The decision from 2010 provides the first holistic approach to CE but it is not legally binding (Owen, 2014; Proelß & Güssow, 2011). Therefore, the legally binding provisions of the international law of the sea prevail for example in the case of ocean fertilisation, also marine geoengineering. In 2008, an agreement had been reached by the Parties to the London Convention and London Protocol (LC-LP.1) that ocean fertilisation is only allowed as part of legitimate scientific research projects (IMO, 2008). To identify legitimate scientific research projects, scientific guidelines were adopted in 2010 with which project proposals have to comply with (IMO, 2010). The broader question of what exactly constitutes legitimate scientific research remains, however, unclear. The CBD explicitly endorses the LC/LP's strict regulations (CBD, 2012). In addition to that, Parties to the London Protocol adopted an amendment in 2013 to include all forms of marine geoengineering (IMO, 2013). In general, the CBD is often not recognised as the appropriate international forum to address the topic as it would be too normative in terms of its technology scepticism (Möller, 2018a).

Legal scholars emphasise that the international law does not yet comprise any legal norms that address CE research and deployment in a holistic manner. However, the framework approach to international (environmental) law makes it possible that specific CE activities are covered by existing framework conventions despite the fact that the phenomenon was still unknown at the time of their original adoption (Proelß & Güssow, 2011). The absence of an overarching international CE framework explains the lack of a binding authoritative definition of CE (Proelß & Güssow, 2011). At the international level, the CBD was the first one to include a definition which is not legally binding (CBD, 2010; Proelß & Güssow, 2011). The CBD made thereby use of the Royal Society's definition

which categorises CE into two technology groups, CDR and SRM, which has been widely adopted by actors ever since (Gupta & Möller, 2018).

Potential overarching legal CE instruments

A series of other treaties adopted by international legal institutions might theoretically be applicable to certain aspects of CE technologies. First, some treaties with potential overarching applicability for CE are introduced.

The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD – Environmental Modification Convention), a legally binding treaty, might for example be applicable to CE technologies (UNGA, 1976). The applicability of the treaty to CE is however challenged by the fact that it actually aims at regulating hostile intentions regarding the use of environmental modification techniques. Adopted in the aftermath of the Vietnam War, the treaty mentions that the use for peaceful purposes should not be restricted by the convention (UNGA, 1976). Therefore, the norm cannot establish CE's lawfulness and goes only as far as declaring research into environmental modification techniques as compatible with principles and rules of international law (Proelß & Güssow, 2011). Only if a certain CE technique is understood as a military or hostile activity, the Environmental Modification Convention would apply.

The Paris Agreement which builds upon the United Nations Framework Convention on Climate Change (UNFCCC) puts its overall focus on the acceleration of Parties' mitigation and adaptation efforts. Many negotiators take a rejective stance towards the consideration of CE technologies in the global climate change negotiation agenda as they fear moral hazard issues. Especially solar geoengineering is met with hostility by the UNFCCC establishment and many parties (Baskin, 2019, p. 258). However, some publications also argue that the Paris Agreement's extremely ambitious climate targets to stay below 2 °C warming, pursuing efforts to even limit warming to 1.5 °C resulted in increasing research efforts into CDR but also SRM (Horton et al., 2016; MacMartin et al., 2018). Regarding solar geoengineering, Baskin (2019, p. 256) is, therefore, talking about a shadow presence in the Paris Agreement. Craik and Burns (2016) also argue that "the potential role of climate engineering under the Paris Agreement arises most directly from the agreement's objectives themselves". CDR technologies are in line with the Paris Agreement's language, particularly Article 4 which refers to carbon removals as a form of mitigation (UNFCCC, 2015). Zelli et al. (2017) argue that "the UNFCCC plays a key role in justifying development and use of land-based CDR". Since SRM technologies do not address GHG sources or sinks, the incorporation of an SRM regulation framework into the Paris framework is questionable; they are not really in line with the Paris Agreement's objective but might indirectly contribute to its achievement. Some articles in the Convention (1992) clearly emphasise the need for research into and development of new technologies. Apart from this, Craik and Burns (2016) argue that the "building blocks for an internationally integrated approach to climate engineering law and policy are faintly present in the Paris Agreement's procedural and institutional capacities". In the Convention-related bodies, CE has not yet been addressed. Even though CE is not addressed during the actual climate negotiations, a rise of CE-related side-events during Conferences of the Parties (COP) is observable. At COP 21, a first talk during a side-event referred to NETs, at COP22 one side-event covered NETs and another one geoengineering in general. At COP 23 two events were about NETs and at COP 24 four CE-related side-events took place including three referring to geoengineering in general and for the first time one directly addressing SRM and its governance (UNFCCC, 2019). An international diplomat interviewed for this research also noted the increased presence of geoengineering scientists and

experts at COP 24 in Katowice as they see new opportunities to introduce the topic into the UNFCCC also due to the IPCC's special report on the impacts of global warming of 1.5 °C (SR15) (Dip1).

In 1980, the United Nations Environment Programme (UN Environment) adopted non-binding provisions for the cooperation between states in weather modification which might be applicable to CE technologies with atmospheric impacts (UNEP, 1980). Proelß and Güssow (2011) argue, however, that conclusions by analogy should be avoided and that the distinction between weather and climate should be emphasised, thus excluding the provisions' applicability to CE. Next to binding rules, international institutions can play a pivotal role in the development of norms. The United Nations Environment Assembly (UNEA) is a multilateral forum with a broad environmental view. Therefore, some academics have stressed that it would be the most appropriate one to address CE (FCEA, 2019a). In March 2019 at UNEA-4 the first step into that direction was taken as the Swiss government brought a draft resolution on CE forward. The draft resolution asked for an independent assessment of CE including the potential governance mechanisms available. However, the resolution got rejected. As C2G was a driving force behind this resolution, the events at UNEA-4 will be examined in more detail in chapter 6.

CE activities must also be assessed against customary international law. Especially one of its principles is applicable to CE, the prohibition of significant transboundary pollution (Proelß & Güssow, 2011). However, the mere possibility of harming the environment which is inherent in so many CE techniques is not sufficient to call for a ban of planned activities. Also, the principle of prevention is not to be equated with the no harm rule as this would undermine national sovereignty and is therefore rather to be seen as due diligence, an "obligation of conduct". The principle of prevention with the ban of significant transboundary pollution is only applicable to CE if it can be proven with a sufficient degree of probability that a state caused damage and that it did not live up to its due diligence obligations, thus revealing its limited suitability for activities with global impact.

Conventions encompassing potential SRM activities

There are some legal instruments in place with potential relevance for SRM activities which are introduced in the following table.

Table 1: SRM-related conventions (compiled by author from Proeßl & Güssow, 2011)

SRM technique	Legal instrument(s)	Relevance for respective SRM activities (Proelß & Güssow, 2011)
Space sunshades	Outer Space Treaty (UNOOSA, 1966)	• Sunshades do not fall under space research but use of space • A state can only deploy reflective material in space in case no reasonable doubts exist about potential damages for other contracting states • Article IX of the Outer Space Treaty acts as a precautionary principle in case of substantial uncertainties regarding the harmfulness of a contamination, unfavourable changes of the Earth's environment in light of CE deployment → There exist **serious concerns** regarding the compatibility of SRM activities in space with the provisions of the Outer Space Treaty
Reflective particles in the Stratosphere	Convention on Long-Range Transboundary Air Pollution	• Actual purpose of the Convention is to curb air pollution and acid rain, its open character provides, however, leeway for its use in the case of the deployment of chemical aerosols or other reflective particles in the stratosphere → **Adverse environmental effects** would need to be proven before a ban for the deployment of reflective particles can come into effect according to the Convention

	(UNECE, 1979) Montreal Protocol of the Vienna Convention for the Protection of the Ozone Layer (1987)	• The Protocol obligates signatories to achieve their respective mitigation targets → The Protocol **could gain in importance** for SAI research/deployment in the future as sulphur can be added through a two-thirds vote to the Protocol's scope according to Article 2 of the Montreal Protocol
Marine Cloud Brightening	Vienna Convention for the Protection of the Ozone Layer (1985)	• Signatories are obliged to take protective measures for human health and for the environment in case the respective activities have (potential) detrimental impacts on the ozone layer • The introduction of steam in the troposphere through CE activities with the aim of cloud formation and cloud-whitening has potential impacts on the ozone layer • Here the question arises how CE's climate protection benefits are to be assessed against the probability of the activities' harmfulness for the local or regional environment

Other SRM techniques such as surface albedo modifications would fall under national sovereignty and are therefore not included in this table.

Summarizing the results of this analysis of legal instruments at the international level, one can conclude that there are no binding legal instruments for large-scale outdoor research activities and deployment of SRM in place. However, there are some binding international rules and conventions with a sectoral focus in place which might be applicable to SRM activities. An amendment to the London Protocol regulates for example marine geoengineering but has so far not been ratified by a sufficient number of states. The non-binding CBD decisions remain contested in the CE field. Next to binding international rules, norms play an important role in such contested spaces. International institutions play an important role in norm development. UNEA has already addressed geoengineering in its fourth session in March 2019 and there are many other international institutions which could play a role in SRM governance (see section 4.3). After introducing international governance, the following section will dive deeper into governance at the national level.

4.1.2 National governance

This section provides a short introduction on what has been undertaken by national governments so far in relation to SRM. This includes national legislation which might be relevant for outdoor SRM research activities but also white papers or decisions which allow for the identification of a governance direction.

Regarding national legislation, this section will not provide an overview of all the national legal instruments which might be relevant for outdoor SRM research activities as this might go beyond the scope of this chapter. However, it is important to mention that countries usually have environmental laws that determine how many particles may be emitted into the atmosphere without the need to conduct an environmental impact assessment of specific research projects. The emission of particles into the atmosphere over land as part of outdoor research is thus covered by local pollution regulations that does not account for the release of particles over the ocean (ReNa2).

In the following, white papers, governmental decisions and statements are summarised to provide a first indication of the direction in which certain governments tend to go.

In 2009, the UK House of Commons Science and Technology Committee (HOC-STC) and the US House of Representatives Committee on Science and Technology, launched a joint inquiry of geoengineering (House of Commons, 2010). The inquiry included hearings on the implications of geoengineering in Washington at which mainly natural scientists testified (House of Representatives, 2010). The hearings are referred to in a technical assessment by the US Government Accountability Office, a government agency, in 2011 (US Government Accountability Office, 2011).

The UK House of Commons Science and Technology Committee (HOC-STC) issued its report *The Regulation of Geoengineering* already in 2010 whose conclusions were also presented at the last hearing with the US committee. In this report, the committee adopted the terminology and definitions from the Royal Society report (House of Commons, 2010). Among the report's recommendations was the support of investigative research and the implementation of some regulatory frameworks. The committee endorsed the so-called Oxford principles developed by five UK-based scientists which they consider a good basis for discussions. Regarding SRM specifically, the committee concluded that development and small tests of SRM should be allowed if they comply with a set of internationally agreed principles, entail "negligible or predictable environmental impact" and "have no trans-boundary effects".

The US National Academy of Sciences (NAS) report on climate interventions issued in 2015 had been commissioned by multiple US government agencies. In November 2017, the US House of Representatives held a hearing on "Geoengineering: Innovation, Research, and Technology" which was more focused on solar geoengineering and might result in more interest by the government in these technologies (House Science, Space, and Technology Committee, 2017). Witnesses which were invited to the hearing were as follows: climate scientist Dr Phil Rasch, Dr Joseph Majkut, Dr Douglas MacMartin and Kelly Wanser (House Science, Space, and Technology Committee, 2017).

In 2011, the Swiss Agency for the Environment published a fact sheet on geoengineering which emphasises the support for geoengineering research on the basis of the precautionary principle as this would call for a wide range of climate policy tools next to mitigation to adaptation (BAFU, 2011, p. 8). Geoengineering research should, however, comply with international regulations and ethical principles such as inter- and intra-generational equity. In addition to that, the Swiss government endorses the CBD decision on small-scale research and calls for international governance which comprises the regulation of geoengineering research and development.

In 2008, it was the German government which brokered the CBD decision on ocean fertilisation. Apart from this, the Federal Ministry for Education and Research commissioned an interdisciplinary assessment which got published in 2011 (Rickels et al., 2011). The report does not constitute a technical assessment and is rather a critical analysis of the CE debate. Upon a parliamentary request, the at the time acting federal government emphasised that the role of geoengineering in meeting the temperature target has not been defined yet and that this assessment would not be necessary (Deutscher Bundestag, 2012, p. 4). By referring to the mentioned report, the government further argued that substantial research deficits were identified with regards to the effects, risks and potential implications of geoengineering deployment as well as economic, political and legal aspects (Deutscher Bundestag, 2012, p. 5). In addition to that, only basic scientific research which

aims at a better understanding of the interaction of the earth system shall be supported, research for technology development is not supported (Deutscher Bundestag, 2012, p. 3). Compared to the HOC-STC, the German government did not evaluate the Oxford principles (Deutscher Bundestag, 2012, p. 6). Unlike the Swiss government, the German government did also not compare the risks of climate change against the ones of geoengineering due to insufficient scientific insights (Deutscher Bundestag, 2012, p. 6). Not only the Ministry for Education and Research but also the German Environment Agency which provides policy advice for the Ministry of the Environment issued a report on geoengineering in 2011 (Ginzky et al., 2011). The report is also very critical in its nature. In 2012, a special committee of the German parliament commissioned a biennial investigation of geoengineering. This investigation came to the conclusion that decades of experimental research would still be required to scientifically evaluate the technologies (TAB, 2014). Regarding SRM, it was warned that its deployment will entail severe ecological side-effects and impacts on human living conditions (TAB, 2014). Therefore, the establishment of a macrosocial discussion and communication process on how geoengineering should be handled is recommended (TAB, 2014).

Considering the provided overview, it is obvious that national governments have not taken a political position on SRM yet. There are some tendencies recognisable in line with known differences in risk cultures, but this cannot be compared to a clear political positioning.

4.2 Current SRM research programs and funding

In the following, ongoing (national) research programs including university-based ones are introduced. In case a source does not clearly indicate which amount of funding is allocated to CDR or SRM in a research program comprising both technology groups, the total sum is listed subsequently.

The UK was the leading country with regard to SRM research around 2010. The government-funded, university-led *Stratospheric Particle Injection for Climate Engineering* program which ran from 2010 to 2014 received a lot of international attention. The project aimed at assessing the potential benefits and costs of solar geoengineering and included a balloon project which had to be cancelled in the end. In 2017, the UK's Natural Environment Research Council launched a US$11,2 million (£8.6m) research program on greenhouse gas removal (NERC, 2019). The government-funded research project is the first one worldwide focusing on negative emissions and looks at its feasibility and implications. After the *Stratospheric Particle Injection for Climate Engineering* project had to be wrapped up earlier than planned due to public outcry, the research council thus clearly moved away from solar geoengineering research (ReSo2).

Recently, the US National Academies of Sciences, Engineering and Medicine announced that it is forming a committee to develop an SRM[6] research agenda and governance approaches which will be published by 2020 (National Academies of Sciences, Engineering and Medicine, 2018). The federal government thus aims at developing its own research agenda regardless of ongoing programs at US universities. The committee's work builds upon the 2015 National Academies report and focuses on the analysis of potential impacts and risks, SRM's technological feasibility and research governance mechanisms at the international, national and subnational level. The study is funded by private funds and one belonging to the National Academy itself (National Academies of Sciences, Engineering and Medicine, 2018). However, it is still unclear whether some money will be available to actually carry out the developed research agenda (ReNa2).

[6] In this case: SAI, marine cloud brightening and cirrus cloud modification

As mentioned above, there is quite some SRM-related research being conducted in the US. First, the projects which comprise both research of natural and social science nature are introduced. Hereafter, the ones with an emphasis on the natural sciences are presented, followed by the social science initiatives.

Harvard's Solar Geoengineering Research Program is funded by private philanthropies (Harvard University, 2019a). The program has a budget of US$ 12 million and comprises eight projects: solar geoengineering and global climate governance under the Paris Agreement, interdisciplinary solar geoengineering research, SCoPEx, a chemistry project on aerosol particles, a project focusing on ethical and political dimensions, again governance, public attitudes and finally a project on moral hazard (Harvard University, 2019b). Despite the project's limited scale, SCoPEx attracted the most attention, as it would be the first SAI outdoor experiment. Others argue that due to its limited scale, the project will not provide any new answers regarding SAI's feasibility (ReNa1; ReSo3). As a lesson learned from the British *Stratospheric Particle Injection for Climate Engineering* project, a lot of effort was spent on developing appropriate governance mechanisms. Among other things they involve the establishment of an external advisory board before getting approved (NGO4; ReNa2). A transdisciplinary project running from 2012 to 2019, led by Penn State University and funded by the National Science Foundation on sustainable climate risk management also includes work on SRM (Pennsylvania State University, 2019). Estimates for the percentage of the budget flowing into SRM research amount to US$ 2.261 million (Necheles et al., 2018).

In 2008, two US climate scientists co-founded the so-called Geoengineering Model Intercomparison Project which analyses the expected climate effects of geoengineering (Kravitz, 2019a). The project, which solely focuses on SRM, aims at aligning ongoing climate model simulations of geoengineering, allowing for the comparability of results. The simulations are carried out across the globe and are jointly coordinated at the Pacific Northwest National Laboratory in Washington and Rutgers University. The National Science Foundation, a US government agency, has provided US$ 2.5 million for the modelling project since 2008 (Necheles et al., 2018). This year the project's ninth annual workshop will take place in Beijing. Another university-based research project takes place at Cornell University until 2020. The natural science project is focusing on the design of SAI experiments, effects of deployment choices and entailed uncertainty (Cornell University, 2019). Its funding of US$ 650,000 stems from different private sources but part of it also comes from the National Science Foundation and the Pacific Northwest National Laboratory (Necheles et al., 2018). Since 2013, the Fund for Innovative Climate and Energy Research has provided US$ 7.765 million to Harvard University to conduct additional natural science SRM research next to the already introduced program above (Necheles et al., 2018).

At the University of California, a privately funded social science project is conducted at the Emmett Institute on Climate Change and the Environment from 2017 until 2020 with a total budget of approximately US$ 1.08 million (Necheles et al., 2018). Another social science project is run from 2017 until 2019 at Arizona State University which aims at exploring the democratic governance of solar geoengineering research with a budget of US$ 299,574 (Alfred P. Sloan Foundation, 2019). The Forum for Climate Engineering Assessment constitutes another US-based initiative which is led by the American University since 2013 (FCEA, 2019b). The forum's work comprises multiple projects: a scenario/modelling development project which aims at integrating social and environmental aspects of geoengineering and the creation of a SRM governance report by 14 global governance experts which got published in October 2018 (see Chhetri et al., 2018). Another one is the

development of a global clearinghouse of CE research and the production of policy-relevant research also on CDR (FCEA, 2019b). The project budget of US$ 210,000 was provided by philanthropies.

In China, a US$ 3 million, government-funded research program on risks and potential impacts of geoengineering was launched in 2015 (Pike, 2018). The project comprises basic theory, earth system modelling and a social science component led by the Chinese Academy of Social Sciences (SRMGI, 2017a). The earth system modelling exercises are focusing on the effects of SRM deployment on the climate system including precipitation and the monsoon as its results are supposed to feed into the international Geoengineering Model Intercomparison Project. This focus on impact analysis resulted from prior consultation with stakeholders (Sugiyama et al., 2017). The program is led by the British researcher John Moore and involves more than 30 scientists.

In India, a government-funded research program of US$ 200,000 has been launched in 2017 which aims at identifying the implications of solar geoengineering for developing countries (Bala & Gupta, 2018).

Japan also provides over a government-funded modelling research project which includes the evaluation of "the effectiveness of artificial control of the climate such as scattering sunlight by distributing fine particles throughout the atmosphere" (Ministry of Education, Culture, Sports, Science and Technology, 2019). The budget for the entire project is around US$ 800,000 (Necheles et al., 2018).

Germany's research program *SPP 1689* focuses on the critical assessment of all geoengineering technologies. The project does not include any engineers and is thus not contributing to the development of the technology. The research is funded by the German Research Foundation which, in turn, gets its funding from the government. The project runs from 2013 to 2019 and is of interdisciplinary nature. It includes multiple universities across Germany, one Swiss and two Austrian universities (DFG, 2019a). Around US$ 3 million of the project's total budget have been spent on SRM work only (Necheles et al., 2018). Next to the SP 1689, the Institute for Advanced Sustainability Sciences (IASS) in Potsdam runs an interdisciplinary project on *Climate Engineering in Science, Society and Politics* from 2017 to 2020 (IASS, 2019). The project's focus lies on SRM research governance, especially field tests as well as on public perception of CE and its political and ethical aspects (IASS, 2019). The project's budget amounts to US$ 48,760 (Necheles et al., 2018). The institute receives its funding from the Federal Ministry for Education and Research and the federal government (Brandenburg), the project is thus publicly funded.

Excluding the activities of SRMGI and C2G, one can say that many of the introduced research projects (5) often contain both natural and social science components. Four of the ongoing research projects focus entirely on the natural science aspects of SRM and three on the social science aspects. Also, many of the research projects have a global focus and do not solely focus on the regional effects of potential SRM deployment with the exemption of DECIMALS. The majority of the SRM research projects are based in the US and tend to be financed by private philanthropies as only limited public funds are available. The positioning of SRM research advocates that they would not accept money stemming from private sources as public goods should be publicly funded and overseen, has changed over the years (ReSo6). This brings up new questions about the motivation of private philanthropies. It has for example to be ensured that these private funding sources are compatible with existing norms in the climate realm such as the priority of funding for mitigation and adaptation. It was argued that current private funding is very thoughtful and progressive but

that risks would remain, especially in jurisdictions that do not possess strong research governance standards (NGO6). Due to the absence of internationally agreed standards, loopholes in other jurisdictions could be taken advantage of (NGO6).

4.3 SRM governance discussions

In this section the essential points of ongoing governance discussions which are predominantly taking place among academics are outlined. As mentioned in the introduction, SRM research is very supply-driven, also concerning proposed governance options. The subsequent analysis of common ground and persisting controversies is based on interview responses and drawing on the multitude of CE/SRM governance publications.

As outlined above, formal governance arrangements are largely absent in the SRM field. Most academics seem to agree that some type of governance is required to ensure or to enable responsible research, to establish a set of norms and to prevent mitigation deterrence. Some academics have come forward and proposed expert-developed principles which are widely recognised in the CE research field. The *Oxford Principles* are the most referred to principles, developed right after the publication of the Royal Society Report by a handful of UK-based academics they were even endorsed by the UK House of Commons 2010 report (S. Rayner, Redgwell, Savulesco, Pidgeon, & Kruger, 2009). The principles have played a "pioneering role in the geoengineering debate" (Gardiner & Fragnière, 2018). According to the authors, CE research and possible deployment can only be legitimate when fulfilling the five principles, including its regulation as a public good, public participation in CE decision-making, transparency, independent impact assessments and the existence of governance mechanisms before the consideration of any deployment (Steve Rayner et al., 2013). Despite their prominence, the principles attracted some criticism due to the fact that they are too universalizing (ReSo6). In order to steer the discussion in more ethical directions, two critics of the Oxford principles recently proposed ten principles, the so-called Tollgate Principles, covering topics such as the framing of CE, authorisation of CE decision-making, consultation regarding CE research activities, trust, ethical accountability, technical availability, predictability, protection and respect for general ethical norms as well as ecological norms (Gardiner & Fragnière, 2018). Next to the Oxford principles, the principles resulting out of the Asilomar Conference in March 2010 are relatively well-known. Developed by 165 natural and social scientists the Asilomar principles highlighted research's promotion of the collective benefit of humankind and the environment, the need for governments to create mechanisms of the governance and oversight of large-scale CE research activities, the need for open, cooperative and preferably on an international framework-based CE research and the necessity of public participation throughout the entire research process (Asilomar International Conference, 2010). According to Schäfer and Low (2014), the Asilomar Conference decisively contributed to the broadening of discussions on relevant issues and challenges.

In addition to principles, a code of conduct has also been developed as part of the 'Geoengineering Research Governance Project', a joint initiative of the University of Calgary, the Institute for Advanced Sustainability Studies and the University of Oxford. A code of conduct is usually more specific than proposed principles, comprising non-binding rules. One of the leading researchers on this code argues that due to the fact that international law on CE is "largely silent", "a code of conduct could serve as an umbrella instrument to provide a gap-filling and harmonisation function for this emerging field" (Hubert, 2017). The approach to the code's development has been based on expert review, an open consultation, interviews with expert stakeholders and stakeholder workshops (Hubert & Reichwein, 2015). Also, the design of the voluntary mechanism is based on general

principles (e.g. precautionary principle), existing legal instruments, customary international law provisions, international decisions, rules and regulations (Hubert, 2017). The code of conduct is comprehensive and could be applied on different governance levels.

Next to a multitude of governance publications, academics are thus also proposing expert-developed principles and organising engagement exercises with the larger public. Public engagement exercises often focus on the general view of people regarding the emerging technologies and not so much on concrete governance options. Some NGOs take a position on CE governance but only slowly and hesitantly get involved into governance discussions such as the Canadian-based Action Group on Erosion, Technology and Concentration (ETC Group), the Union of Concerned Scientists and the WWF International (HBF & ETC Group, 2019). However, a multitude of environmental NGOs do not want to get involved in the CE governance debate as they entirely reject any engagement with the topic. Environmental NGOs have thus not really played a role in the development of expert-developed principles. Some common ground is recognisable among the research community and some NGOs regarding research governance. General norms such as transparency, public engagement and (international) cooperation are often referred to when talking about research governance. However, many things and governance options remain strongly contested among actors operating in the SRM governance landscape. The nature of potential governance including its purpose and scope is intensively discussed. The remainder of this section is therefore introducing the relevant controversial issues of the governance discussions. This will then feed into the following two empirical chapters as the initiatives might take a position on certain controversies.

The first controversy revolves around the meaning of uncertainty in this field of emerging technologies. Many authoritative reports refer to the high level of **uncertainty** associated with solar geoengineering. Advocates of solar geoengineering research often put uncertainty as a state which can be overcome with the help of more research or a practical trial and error approach (Baskin, 2019, p. 173; Rayner, 2014), thus "turning them [uncertainties] into a research agenda" (Stilgoe, 2015). Thereby, uncertainty is recasted as risk, thus avoiding "the implications, epistemologically, of acknowledging radical uncertainty" (Baskin, 2019, p. 171). The fact that uncertainty regarding some of the effects of solar geoengineering in a complex climate system might be unknowable is often not addressed (Baskin, 2019, p. 171). The deep uncertainty which might persist poses huge challenges to governance (ReSo3). More research could in fact also expand uncertainties about SRM (Hamilton, 2013; Stilgoe, 2015). Therefore, the nature of post-normal science which comprises societal challenges such as climate change and CE would need to be better embraced which comes with uncertain facts, disputed values, high stakes and the need to take urgent decisions (Flegal, 2018, p. 14). Post-normal science phenomena require that uncertainty is managed well, that public decisions are taken despite radical uncertainties and that underlying values are disclosed (Flegal, 2018, p. 14, 41). This obviously challenges "the prevailing assumptions and claims about how truth claims are made and knowledge and 'consensus' arrived at" (Baskin, 2019, p. 173). Often, the uncertainty reduction argument advanced by many SRM research advocates is coupled with better decision-making promises. But even if uncertainty is reduced this will most likely not result in more rational and better decision-making (ReSo6).

Strongly linked to this first controversy is then the question whether SRM **research should move forward**, another controversy circulating in this field. The concern regarding research moving forward is that this will put the technology on a slippery slope towards deployment, thus fearing lock-ins, entrenchments and path dependencies (NGO1; NGO2; Bellamy & Healey, 2018). However, an

STS researcher argues that the lacking research might prevent the technology from reaching its so-called sociotechnical maturity (ReSo2). Therefore, more research would be needed (ReSo2; ReNa2) as CE research's reality would rather resemble an "uphill struggle" (Bellamy & Healey, 2018). Baskin (2019, p. 154-155) argues that it has to be considered that only because the taboo has been broken in the climate science community, the same does not necessarily account for the broader academic community and the public. In general, the question is who should decide upon research moving forward (ReSo6). The term sociotechnical maturity implies that broad participation needs to be ensured to decide upon the question whether and what kind of research should be incentivised (Bellamy & Healey, 2018). One respondent noticed that the current state of things is very unhealthy and imbalanced as there is a lot of excitement regarding a potential SAI deployment, but necessary research would be lacking (ReSo6). Also, research into these technologies might not lead inevitably to deployment as other cases of emerging technologies have shown in practice (Bellamy & Healey, 2018). Therefore, serious research on solar geoengineering regarding its feasibility and desirability should be advanced to move from the "obsessing of an imaginary thing" stage (ReSo6). But not only whether or not SRM research should take place but also what kind is contested. Experts are not on the same page regarding the need for further modelling research to tell us something about the consequences of theoretical SRM. Some argue that these models are not suitable for the reliable identification of CE effects (ReNa1; ReSo6) and that no new insights will be gained through additional modelling work (Levitan, 2019b). Others, however, argue that modelling has still a lot to offer (ReSo5). And a third group claims that the knowledge about which model runs to do does not exist at the moment (Levitan, 2019b). Models are an oversimplification of reality and decisions should therefore not solely be based on these as they are misleading (ReSo6). Modelling work often comes along with many promises to reduce the inherent uncertainty to overcome policy disputes which hints at an over-reliance and even misuse of models (ReSo6). The question of feasibility shall be solved by relying on modelling exercises which does ignore the fact that SAI would also pose an engineering challenge (ReSo6). Equally contentious is the need to move from indoor to outdoor research and the utility of such a decision (NGO4; ReSo3). One respondent argued that there is a need for increased investments in modelling but also outdoor research as this would be the only way international governmental deliberations would have a chance as a reaction "to concrete things that are perceived to be challenges or crisis" (ReSo5).

SRM **research governance** questions are highly controversial. The predominant discourses have successfully legitimised SRM research as an object of governance over the last years (Owen, 2014). There is, however, a divide between people who argue that research should not advance towards outdoor research without international governance and others who do not see anything wrong in small-scale research moving ahead (NGO6). The research governance approaches already in place such as environmental impact assessments as part of the respective national legislation, transparency mechanisms and stage-gate review processes as during the *Stratospheric Particle Injection for Climate Engineering* project would be absolutely sufficient for research to move ahead (NGO6; ReNa2). Owen (2014) on the other hand argues that research of any kind "will require international agreement, strong institutions, and (fundamentally) a distinct culture change when this comes to science, innovation and its governance more generally" to be practically, feasibly governable. To make it even more complicated another respondent noted why this "governance before research" approach should hold true for developing countries (ReSo6). Others argue that governance needs would depend on the scale of the proposed research project (Asilomar International Conference, 2010; Chhetri et al., 2018; National Academy of Sciences, 2015). In this context, the argument is

also advanced that it should be differentiated between research and deployment. The opposite position is that a comprehensive research program including field tests would blur the lines between research and deployment (Robock, Bunzl, Kravitz, & Stenchikov, 2010). Therefore, some argue that there should not be a differentiation between research and deployment (see Jacobson, 2018). According to Owen (2014), this creation of "governance thresholds for research and deployment has neglected a fundamental issue: that research and projection through to application operate as simultaneous and (socially, politically, ethically) entangled frames". Therefore, any research efforts might "be symbolic, a signifier of intent" (Owen, 2014).

Another highly controversial issue are regional heterogeneities of theoretical SRM and especially SAI effects. Model runs suggest that SAI "would result in many gains, but also a new pattern of winners and losers" (McLaren, 2018b). However, it is very challenging to pin the losing or gaining areas down due to the "interplay of changes in temperatures, precipitation and other climate extremes" (McLaren, 2018b). Some people argue that developing countries will be disproportionately put at risk by solar geoengineering (ReNa2). In fact, modelling studies show that especially in the equatorial regions where the world's least developed countries are situated reduced precipitation patterns can be observed (Tilmes et al., 2013). According to observations of volcanic eruptions, SAI will result in reduced summer monsoon precipitation over Africa and Asia (ReNa2). According to model results, SAI deployment in the northern hemisphere would reduce precipitation patterns in the Sahel and some Indian regions (Jones et al., 2017). SAI deployment in the "southern hemisphere would enhance TC[7] frequency relative to a global SAI application, and vice versa for SAI in the northern hemisphere" (Jones et al., 2017). Others argue that the evidence for undesirable solar geoengineering effects at lower latitudes is not given (ReSo3; Rahman et al., 2018). Determining who would suffer from a certain SAI deployment is not a straightforward process (ReNa2). McLaren (2018) disclosed for example that the varying distributional SAI effects which result out of different model runs can be reduced to the assumptions and presumptions of the modellers. Climate engineers propose ever more complicated deployment designs to minimise or avoid undesirable effects (see Kravitz, 2019b). Against this backdrop, some respondents argue that it might be possible to deploy SAI without additional harms (NGO6; ReSo5). According to an interviewed climatologist, so far there does, however, not exist any knowledge on how to control local regional climates without screwing it up somewhere else (ReNa2). When reading Kravitz' (2019) blog post, it becomes, however, obvious that the proposed design approach to unequal effects would imply the tailoring of climates in line with regional needs. This might be feasible in exploratory modelling research but would not be able to provide the information needed to answer questions on heterogenous effects of an engineering system in a way that matters in reality (McLaren, 2018b). It is thus a difficult design question of an engineering system that will be impacted by many uncontrollable variables. Therefore, the regional distributional effects of a SAI deployment would not be predictable with confidence (ReSo6). This also implies that "geopolitical, perceptions will matter much more than scientific accuracy" (Geden & Dröge, 2019). McLaren (2018) even adds that it would be "profoundly dangerous to imply that such geoengineering could be delicately controlled and modulated so as to minimise negative impacts". One respondent also adds that this whole conversation about regional heterogeneity reveals an emphasis on deployment scenarios in terms of what would happen to the Asian monsoon, thus signalling that we would already know enough to deploy it (ReSo6).

[7] Tropical cyclone

The preceding paragraph about regional heterogeneities is essential as it raises many challenges regarding SRM governance. The argument that **developing countries will be the ones gaining or losing the most** from solar geoengineering due to their vulnerability to climate change impacts is popular in SAI discourses (ReSo2; ReSo3). If SAI works well then developing countries would gain the most from it as climate change impacts would be reduced thanks to the technology (ReSo3; ReSo4). This argument has turned out to be very effective in arguing for SAI since SRM modellers say that deployment without additional harm is possible and, in this case, vulnerable people have to fear less climate change impacts, thus making it a moral duty to geoengineer (McLaren, 2018b). According to an interviewed STS researcher, the argument that solar geoengineering will make things better or worse for specific groups of people in certain places around the world would need to be revisited as this is based on the visions of a narrow group of actors and a very thin evidence base (ReSo6). Also, McLaren (2018b) notes that this is "a very paternalist interpretation of the climate problem and possible responses". The fear that solar geoengineering could with the help of such discourses be imposed on developing countries without their consent is present in governance discussions (NGO3).

Another controversy revolves around the **probability of unilateral deployment** of SRM. The threat of unilateral deployment is based on the argument that irrational actions form part of the real world (NGO3). Jacobson (2018), however, argues that due to this highlighting of a potential unilateral deployment, the inherent risks of SRM are reframed toward the threat of likely unilateral actions. This would, in turn, support the argument that SRM research "by legitimate actors must be supported lest we risk illegitimate actors unilaterally pursuing AM [albedo modification] with the mainstream political and scientific community powerless to stop it" (Jacobson, 2018). Consequently, the primary risk becomes unilateral deployment instead of the known and unknown deployment effects, thus reorienting the risk from the actual activity (what) to the subject (who) (Jacobson, 2018). In addition to that, many claims hint at the potential threat of unilateral deployment most likely to be expected from a vulnerable state in a "desperate" situation (Goering, 2018; Techonomy, 2012). But is this really realistic considering the stage of development of these technologies and the limited financial resources for CE research in those countries? According to Baskin (2016, p. 10), only a major global power could dare to deploy solar geoengineering. In addition to that, McLaren (2018) argues that "the possibility (perhaps likelihood) of geoengineering designed to directly serve the climatic and financial interests of the rich and powerful is largely overlooked, even though this seems perhaps the most likely route through which SAI might come to be practiced". Therefore, it would be very unrealistic to think that a small island state would deploy SAI especially without the consent of a major global power (Baskin, 2016, p. 10). Hamilton (2013) argues that the evidence points in another direction, namely that it is actually developing nations which fear unilateral deployment by industrial countries which has led to rising calls for a moratorium on certain activities. Another controversial argument which is often brought forward in combination with the threat of unilateral deployment is SRM's **alleged cheapness**. Especially in the case of SAI, the direct costs of deployment are considered to be relatively cheap as compared to mitigation efforts (The Royal Society, 2009). However, a fact which is often neglected in this argumentation is that research of these technologies is far from cheap (ReSo6). Regarding deployment costs, one should not forget that continuous deployment might also turn out to be quite costly (Parson, 2014). Moriyama et al. (2017) find that "the preparation horizon of SAI would be longer than previously thought, i.e., it would require more intensive planning and greater allocation of resources to deploy SAI effectively". The authors further argue that there exist only a few countries which "could afford all the necessary steps from research to development, demonstration, and deployment" (Moriyama et al.,

2017). The acknowledgement that SRM's direct deployment costs might be larger than expected also lessens the concern of a potential unilateral deployment.

As just mentioned, calls for **moratoria** - meaning the temporary prohibition of certain activities until circumstances change - have been on the rise. Conditions which are usually advanced for the moratorium to get lifted are decreased uncertainty regarding entailed risks and benefits or the establishment of concrete governance mechanisms (Chhetri et al., 2018). However, calls for moratoria take different forms. Some actors call for governance before deployment (Chhetri et al., 2018; Hubert & Reichwein, 2015) whereas others call for it before outdoor research activities take place (Gardiner & Fragnière, 2018; Heinrich Böll Foundation & ETC Group, 2017). Often a certain scale is mentioned when asking for a moratorium on outdoor research questions which raises difficult definition questions. The discussion regarding the management of the moratorium raises another controversially discussed issue, the one of the involvement of governments.

The discussions about the questions if and when **(inter)national policy makers** should get involved and the need for **(inter)national governance** in this space has been heavily contested. Especially natural science researchers but also other researchers take the view that more open questions should be resolved before international governance discussions get started and policy makers involved or that little is to be gained by involving policy makers as divisive opinions would be the consequence thereof (NGO6; ReNa1; ReNa2; ReSo3; ReSo6). Some civil society organisations advance the argument that even the enforcement of an SRM moratorium on research or deployment would require some form of international governance (NGO1; NGO2). However, the need for international governance is also discussed in terms of broader governance meaning decision-making whether and how solar geoengineering could become a legitimate climate policy option among other climate responses. Many proposals circulate with regard to the appropriate intergovernmental institution for such a decision-making. The UNFCCC is often suggested as the appropriate intergovernmental institution for such a decision (M. Honegger, Sugathapala, & Michaelowa, 2013; Rickels et al., 2011; Zürn & Schäfer, 2013). Bodle et al. (2013, p. 164), however, argue that UNFCCC's institutional economy might not be appropriate and therefore argue for the CBD. UN Environment is also mentioned as a possible option (ReSo5). Other scholars argue for international institutions with a broader risk management approach such as UN Environment (ReSo5; ReSo7). Also, the establishment of a new international institution in this regard is proposed such as a World Commission on SRM (Chhetri et al., 2018). In general, the calls for broader governance presents geoengineering as another potential climate policy option which is a contested position as others argue it should just be considered a research question (ReSo6). Obviously, these proposals are in conflict with claims that SRM might actually not be democratically governable due to their effects, the inherent deep uncertainty, their ability to trigger conflicts in existing institutions and the improbability that a global agreement could be reached to deploy them (Hulme, 2014, p. 56; Szerszynski, Kearnes, Macnaghten, Owen, & Stilgoe, 2013). Therefore, it could only be governed through the imposition on others which is not compatible with democracy (Szerszynski et al., 2013). A recent publication (Horton et al., 2018), however, refutes the incompatibility argument by stating that SRM would be able to develop along different political trajectories. The authors reject the four arguments upon which they see the incompatibility argument based with the counterarguments that SRM would not bring democratic institutions to their limits, that SRM "might not require undue technocracy, and its implementation might not promote authoritarianism" (Horton et al., 2018).

This section makes clear that there are many different opinions circulating on what SRM governance should look like. The supply of governance research is immense and steadily increasing with

many different research groups (section 1.2) and individual researchers engaging with the topic. Identified controversies reach from the understanding of uncertainty over the nature of research governance, the impacts of SRM research and deployment on climate justice, the probability of unilateral/minilateral deployment to the question whether there is a need for moratoria and international governance in that space. In the following section, the governance initiatives position in the introduced SRM governance landscape is depicted.

4.4 Embedding the non-state initiatives in the SRM governance landscape

After introducing the SRM governance landscape, this section serves the purpose to embed the two initiatives, SRMGI and C2G, in it. In order to do so, it is differentiated between two areas, the research governance and broader SRM governance landscape (SRM as another climate response), as both issue areas attract different type of actors. This is done to keep the graphs clearer. Also, other non-state actors such as NGOs, think tanks and advocacy organisations, sources of governance which have not been addressed yet in this chapter, are also included in the graphs. However, funding providers have not been considered in the graphs. The graphs depict how the governance initiatives relate to different sources of governance and what role the initiatives currently play in the respective governance landscapes including where they have forged more links. The visualisations are based on information provided in the preceding parts of this chapter and information about the initiatives' activities (see Annex II).

4.4.1 The SRM research governance landscape

In the following a visualisation is provided to show which organisations are currently playing a role in the SRM research governance landscape.

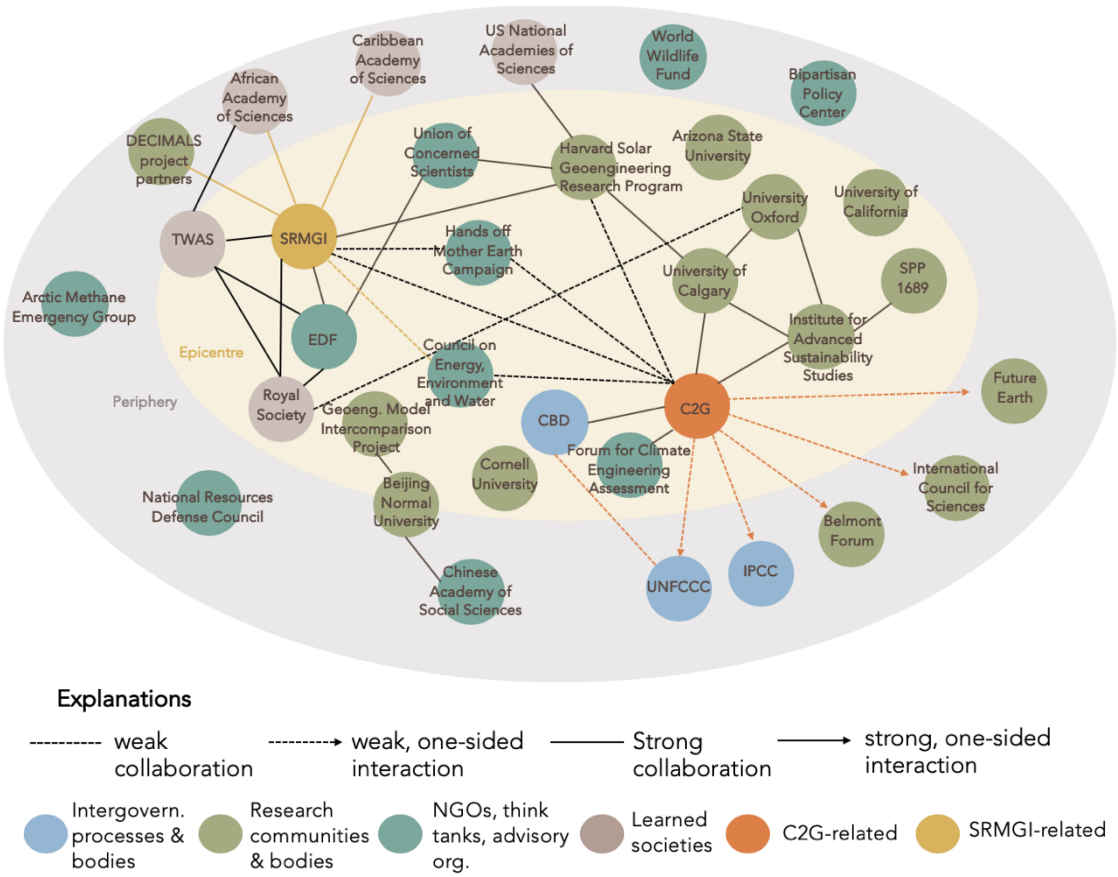

Figure 3: Embedding the initiatives in the SRM research governance landscape

Their influence is also indicated in terms of whether they form part of the epicentre of the landscape (beige) or the periphery (grey). Both governance initiatives can be situated in the epicentre of the SRM research governance landscape. As described in the preceding sections, the SRM research governance landscape is dominated by research communities, NGOs and think tanks. The *Hands off Mother Earth* campaign comprises 180 civil society organisations and movements and lobbies against CE and outdoor experiments arguing that humans are not supposed to intervene in such a manner in nature (HOME, 2018). The Canadian-based Action Group on Erosion, Technology and Concentration (ETC Group) has been the major driving force behind the campaign. In general, some organisations have been involved from an early stage onwards (e.g. EDF, ETC Group) whereas the Union of Concerned Scientists entered this space for example rather recently.

Regarding the research communities active in this space, some projects form part of the epicentre due to their publications' influence. In some cases, the researchers have not published any results yet and therefore it is argued that they form part of the periphery (e.g. DECIMALS projects). There are also some individual researchers who could not be considered. But in general, some of the universities have sought issue-specific cooperation. What concerns international institutions, only the CBD forms part of the epicentre of the research governance landscape. Other international institutions were considered but have not really shown any interest in taking a stronger role.

There are some strong collaborations between actors operating in this space observable. Both governance initiatives have included new actors in the research governance landscape or forged new links between actors which is indicated by the coloured arrows. When comparing C2G and SRMGI it seems that the latter has been more successful in establishing strong links. This is not surprising as SRMGI is operating in this landscape for a much longer period already. C2G also tries to strengthen interinstitutional cooperation on the issue. During a joint workshop, C2G pushed for example for a regular exchange regarding research governance between the focal points of the UNFCCC and CBD Conventions (C2G2, 2017c). The graphs are, however, not showing the full extent of the initiatives' networking activities as only the actors, which are currently playing a role in the respective governance landscapes are included. Chapter 5 and 6 will go more into depth about the initiatives' interventions.

4.4.2 The broader SRM governance landscape

After providing a visualisation of the actors which are active in the SRM research governance landscape, this section dives deeper into the broader SRM governance landscape. As mentioned above, broader governance is understood as decision-making regarding whether and how solar geoengineering could become a legitimate climate policy option among other climate responses.

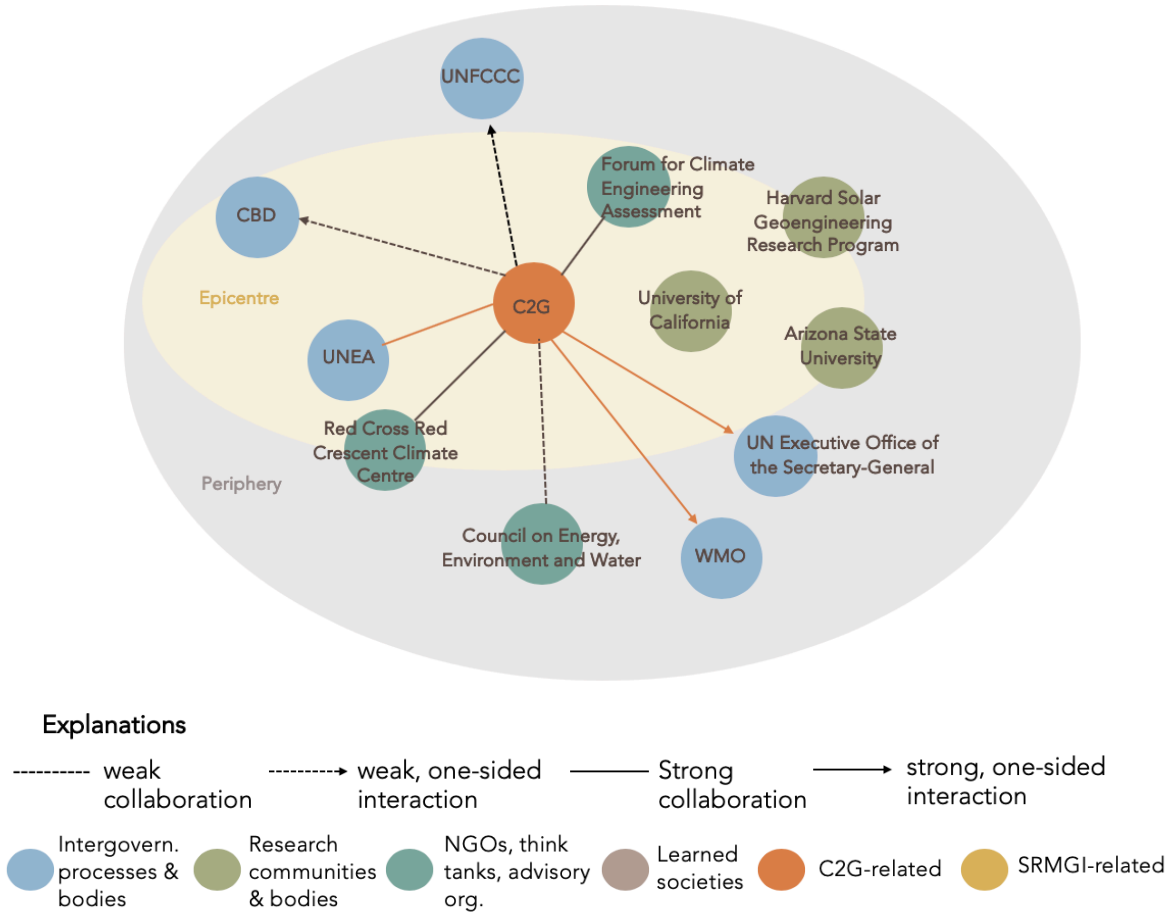

Figure 4: Embedding the initiatives in the broader SRM governance landscape

The number of actors operating in the broader SRM governance landscape is considerably smaller than in the SRM research governance landscape. As this graph shows, C2G is forming part of the epicentre of the SRM deployment governance landscape and can even be considered an important coordinator between the different actors. Whether an actor forms part of the epicentre of the landscape depends on its activeness in this space. SRMGI's work does not go beyond research governance and is therefore not included in the broader SRM governance landscape, are. The two international institutions which play an important role in the broader governance landscape, are the CBD with its decisions and UNEA that recently entered the field. It also clearly shows that some international bodies have somehow been involved but cannot be considered active participants in the deployment governance landscape such as the UN Executive Office of the Secretary-General. Some think tanks and policy advisory organisations are also very active in this space such as the Red Cross Red Crescent Climate Centre and the Forum for Climate Engineering Assessment. In this landscape, the role of research communities is more limited. Next to the research communities in the graph, some individual researchers also working on the issue have not been considered.

4.5 Conclusion

This chapter answers the research question how the two governance initiatives are embedded in the SRM governance landscape and what controversies they are engaging with. In order to answer this question, the governance landscape was introduced in the first part of this chapter. The introduction comprised the analysis of formal governance at the international and national level, current SRM research and funding and the state of SRM governance discussions. Summarising the results of the analysis of the SRM governance landscape, one can say that formal SRM governance at the international level is almost non-existent as of right now as there are no binding legal instruments in place and only some non-binding CBD decisions. However, there are some potential instruments such as sectoral conventions in place and norm development could also be driven forward by different international institutions. Regarding national governance, a limited number of states have published some first white papers on the issue but the fear to become a first mover on the issue is prevalent. There are some tendencies recognisable in line with known differences in risk cultures, but this cannot be compared to a clear political positioning. Regarding current research programs and funding, the majority of research projects are based in the US. Also, a lack of public funding for SRM research is apparent. The majority of research projects which are currently in place are financed by private philanthropies which, in turn, raises research governance calls.

What concerns research governance discussions, some expert-developed principles and more specific codes of conduct circulate in the space. The governance conversations are, however, characterised by many controversies. Controversies revolve around the understanding of uncertainty in terms of whether research will help to reduce persisting uncertainties in this pace and around the nature of research governance regarding whether research and what kind of research should move forward. Also, the climate justice arguments which are advanced in the SRM governance discussion have provoked controversy. In addition to that, the probability of unilateral/minilateral deployment is widely contested as well as the question whether there is a need for moratoria and international governance in that space and what this should look like. The controversies will partly come back in the other two empirical chapters, chapter 5 and 6, when it is shown what positions the governance initiatives take on certain controversies according to their interventions.

The provided visualisations in the last part of this chapter show how the governance initiatives are embedded in the introduced SRM governance landscape. Through the analysis of the governance discussions it has become clear that one should differentiate between issue areas, the SRM research governance landscape and the broader SRM governance landscape. The visualisations reveal that C2G is operating in both landscapes whereas SRMGI's work focuses entirely on the SRM research governance landscape. Compared to the SRM research governance landscape, a lot less actors are active in the broader SRM governance landscape which refers to governance in terms of whether and how SRM could become a legitimate climate response. In both cases, the governance initiatives form part of the epicentre of the respective governance landscape which reflect upon their influence in this space. The following empirical chapter 5 and 6 will provide more details about the manner in which the governance initiatives intervene and steer the governance landscape. Thus, more background information on the links in the graphs will be provided.

5 Promoting facilitative governance: The case of SRMGI

In this chapter, the manner in which SRMGI intervenes in and steers the SRM governance landscape is analysed to answer research question 1.2. The analysis is conducted according to the analytical lens developed in the second chapter. The lens differentiates between the activities through which the two interventions, the advancement of a certain governance narrative and the broadened engagement, are generated as well as the potentially resulting governance effect.

5.1 Activities

First, the activities through which the interventions are generated are briefly summarised. Since its launch in 2011 until 2018, the initiatives' main activity has been the organisation of so-called outreach meetings to build developing country stakeholders' capacity regarding SRM and SRM research governance. The global spread of the outreach meetings comprises countries such as China, Ethiopia, India, Pakistan, Senegal, South Africa, Jamaica, Brazil, Guadeloupe, Bangladesh, Thailand, the Philippines and Kenya (SRMGI, 2017b). According to the initiative itself, a typical meeting is convened in partnership with an NGO and attended by 30-50 academics, NGO representatives and policy makers (Open Philanthrophy Project, 2016b). The meetings are thus of small-scale nature and can be described as "ad hoc, one-off events" (Winickoff et al., 2015). The initiative claims that these outreach meetings would "not attempt to persuade people to think about SRM in a particular way, or even try to reach any consensus positions" but that they would serve as a platform for open discussions about the technologies (SRMGI, 2017b). It is mainly through the outreach meetings that the initiative shares information as it does not provide a lot of material on its website. Apart from one larger report, the initiative is sharing short summaries of the outreach meetings' format on its website.

In 2018, the initiative branched out to integrate research funding into its work with the DECIMALS fund. Unlike outreach meetings, the DECIMALS fund was launched in order to create "ingrained expertise" (NGO6). Eight international modelling projects in Argentina, Bangladesh, Benin, Indonesia, Iran, Ivory Coast, Jamaica and South Africa received a grant. Due to the planning around the DECIMALS fund, the number of outreach meetings stagnated in the last year. The initiative thus added a new dimension to its work during the period 2018 through 2020, that of research funding. The research projects shall serve as a basis for broader developing country engagement. Whether the project will receive some follow-up funding is not known yet. Therefore, the future of these research endeavours is still uncertain.

5.2 Interventions

The described activities result in two interventions, the advancement of a certain governance narrative and broadened engagement. In the following, the advancement of a certain governance narrative including the identification of (a) specific governance object(s) is focused upon.

5.2.1 Advancement of a certain governance narrative

SRMGI bases its efforts to expand the international conversation on SRM research and its governance on two recommendations of the Royal Society report from 2009 (Parker, 2016b). Recommendation 5 states that the Royal society should initiate a process of dialogue in collaboration with partners to explore public and civil society attitudes, concerns and uncertainties about SRM and recommendation 7.1 outlines the need for the development of a voluntary research governance framework (The Royal Society, 2009, p. 60, 61). SRMGI's research governance narrative makes use of the assumption of a possible near-term unilateral or minilateral SAI deployment (SRMGI, 2011,

p. 8; Techonomy, 2012). Therefore, wide participation in SRM research governance and collaboration on governance activities is recommended as this would reduce the risk of unilateral deployment (SRMGI, 2011, pp. 43, 54).

The initiative's capacity building activities are justified with the help of justice arguments. By invoking justice arguments, the initiative reinforces developing country actors to call for their nations to lead on solar geoengineering (in this case SAI and marine cloud brightening) research (Rahman, Artaxo, Asrat, & Parker, 2018). An article which appeared in the Nature magazine in April 2018 and has been co-signed by many co-organisers of the outreach meetings and SRMGI's project director leaves the impression that the climate regime moved into a post-equity era and that the only instrument left within the climate regime to address injustices would be the loss and damage provisions which would not leave a lot to hope for (Rahman et al., 2018). Another frame which tries to justify the initiative's capacity building work on SRM research is that SRM research by scientists from developed countries is inexorable and that developing countries should therefore step in and take the lead in this research project (NGO1). The Nature piece published for example conveys this outpaced frame: If developing country scientists do not take over, it will be scientists from the Global North (Rahman et al, 2018). No wonder then that developing country scientists feel the need to deal with this set of technologies and to start researching regional impacts.

This reveals that the initiative evokes certain urgency and justice arguments to justify the very idea of governance in this space in form of meetings to discuss SRM research and its governance and capacity building activities of developing country scientists in this regard. The promoted governance narrative is based on values, principles and taken-for-granted assumptions, thereby the initiative might also take a position on one of the controversies introduced in the preceding chapter.

Regarding research governance, the question does not seem to be whether more research is desirable but how it is governed (AAS & SRMGI, 2013, p. 7). The initiative's report from 2011 (p. 9) clearly indicates that it opines that uncertainty regarding the technologies' feasibility and effects will depend on the ability to "govern any future research effectively and responsibly". Research should thus move forward in a safe, transparent and responsible manner (SRMGI, 2013, p. 9). SRMGI endorses the opinion that more research will definitely lead to reduced uncertainties regarding the feasibility, advantages and disadvantages of SRM techniques and clarify whether SRM is harmful or helpful. That this uncertainty might not be resolvable and policy decisions might therefore need to be taken under radical uncertainty is not addressed and discussed during its outreach meetings (NGO5). The position that more research, especially natural science research, is needed to reduce uncertainties, seems to be echoed back in many outreach meetings at least what concerns the effects on the local climate (NGO5; NGO6; AAS & SRMGI, 2013, p. 8-12). This is not astonishing at all since the initiative enters the discussion with that position and this problem framing will most likely come through in the governance presentation or in the Q&A sessions. That this is how the efforts are perceived is revealed by one meeting participant who argues that "the idea [of the meeting] was to see if there would be some interest" in the country to develop the issue further in terms of research (ReNa1). Even though the initiative has tried to be careful when presenting information on SRM initially, the initiative's sympathy towards conducting more SRM research was already noticeable for meeting participants before the launch of the DECIMALS fund (ReNa1; ReSo3).

With the decision to branch out SRMGI's activities and to add the funding of modelling research to its work, the initiative has chosen its primary way of knowing the future, thus neglecting other ways of imagining the future. Also, the initiative entertains the illusion that scientific understanding

can be significantly advanced with these modelling exercises. The DECIMALS fund was launched in order to significantly improve the understanding of the potential regional impacts of SRM including droughts, extreme temperatures and precipitation changes (Parker, 2016a). As described in the fourth chapter, whether such an understanding about SRM effects can really be gained from modelling exercises, is highly contested. In addition to that, Foley et al. (2019) argue that the creation of ever more accurate predictive models might actually not be "helpful in resolving governance issues" and that this "knowledge first trap" has to be overcome to ensure that "knowledge creation is responsive to governing needs". Striving for a significant improvement of understanding by relying on data from inferior earlier climate model runs (ReSo5), the Geoengineering Model Intercomparison Project and the NCAR[8] Geoengineering Large Ensemble (GLENS), might create the wrong expectations. This means that the model is not run by the project teams but previous output for their region will be downloaded and potentially downscaled in order to use them for their regional studies (ReNa2). It should, therefore, not be understood as a separate study as time and resources would not be sufficient for this (ReNa2). It is rather an opportunity for experts from the Global South to re-analyse the archived data set of prior climate model runs in a manner which is important to their regional contexts (ReNa3; ReSo5). Therefore, it should be understood as a capacity and confidence building exercise but not as one which will advance scientific understanding (ReSo5). This contradicts the initiative's conception of the project to a certain extent with regard to significantly improving the understanding of regional impacts. However, the initiative also clarifies that not only the generation of research is the fund's aim but also capacity building, community building and the expansion of the SRM conversation (SRMGI, 2018a). In addition to that, a lot of emphasis is put on communicating the limitations of the modelling studies and the uncertainty of the models (NGO6). Despite these acknowledgements, the complete reliance on climate modelling for knowing the future which is very uncertain in the case of solar geoengineering, bears the risk that other ways of imagining the future are suppressed (ReSo6; Hulme, 2011). According to Hulme (2011), models possess almost automatically a "disproportionate discursive power", a process he refers to as "epistemological slippage". The climate reductionism through the sole reliance on climate models "renders the future free of visions, ideologies, and values" (Hulme, 2011). McLaren (2018) argues that climate modellers do not contrast "geoengineering with plausible mitigation scenarios (or models geoengineering as a supplement to such interventions)" but with the business as usual trends regarding GHG emissions. The modelling culture thus "ignores the risk of moral hazard" which is not done intentionally on the part of the modellers but is inherent to modelling work as it requires sharply defined scenarios to compare scenarios against each other (McLaren, 2018b). There is thus a risk that potential societal transformations in terms of mitigation and adaptation actions are not deliberated well within the scope of the initiative's capacity building activities due to the sole focus on modelling work. This concern has also been shared by one African diplomat who argues that "the perspective of Africa cannot be captured by those type of modelling" (Dip1). This would require an intensive discussion with the limitations of modelling work and the underlying assumptions which has so far not been part of the project.

When evoking justice arguments to justify its capacity building work, the initiative argues that equity would demand that the capacity of developing country scientists is built, thus equating justice with capacity building. Flegal and Gupta (2017) argue in a recent publication that "particular understandings of equity are constructed by, and embedded within, emerging expert visions as a way to legitimise further research in solar geoengineering". Whereas this publication focused on

[8] National Center for Atmospheric Research

the visions of Northern experts, mainly located in the US, the Nature article shows a similar equity framing but now advanced by developing country scientists themselves. However, when considering the writing process of the Nature piece, it was clearly initiated, coordinated and steered by the initiative's project director himself (ReNa1). This raises some important questions about the agency of developing country scientists when developing this frame. The prioritisation of capacity building is also justified with the argument that its need was widely supported by outreach meeting participants (AAS & SRMGI, 2013, p. 10; SRMGI, 2018a). In general, meeting participants confirmed that the majority was calling for more meetings and more research before decisions are taken on the issue (NGO5; SRMGI, 2016). The way equity-related issues are, however, framed in the initiative's discourses reveals that these issues are narrowed down. One interview respondent mentioned that equity-related issues were not really addressed at an attended outreach meeting (NGO5). The problem with this equity framing in conjunction with an overemphasis on modelling research is that it supports the "'clean sheet' framing that risks excluding corrective and reparative justice" (McLaren, 2018a). This is also mentioned in the article by Flegal and Gupta (2017) who argue that the danger with such a framing is that "equity debates become less about ambitious mitigation by those with the greatest historical responsibilities, and more about enhancing the capacities to take action of those with lower responsibilities". This framing is somehow reflected in the Nature piece as SRMGI's project director and eleven co-signing developing country scientists do not see any hope anymore that justice could be reached within the climate regime by referring to the vague provisions on loss and damage in the Paris Agreement (Rahman et al., 2018). This claim disregards all (ongoing) climate finance efforts and provided flexibilities for developing countries under the climate regime and clearly deflects the attention from ambitious mitigation actions. This, in turn, could divert attention from historical injustices and the moral responsibility of the Global North, a fear which has already been expressed by other developing country stakeholders in a different setting (Winickoff et al., 2015). This is exactly why it would be so important to address justice issues at the outreach meetings. The equity implications of using models would also need to be addressed within the scope of the initiative's capacity building activities which requires the involvement of social scientists. Capacity building "is a legitimate and desirable element of equity", however, "a shift in focus could also amount to a blunting of the politically contested edge of equity" (Flegal & Gupta, 2017). If this is not taken more seriously by the initiative, it risks doing exactly that.

Considering the preceding paragraphs, it becomes clear that the initiative tries to legitimise SRM research as an object of governance. Owen has argued already in 2014 that the initiative attempts to legitimise SRM research as an object of governance through its differentiated approach to research governance which it promotes in its 2011 report (Owen, 2014). SRMGI's steering group prescribed a differentiated research governance approach for the work of its in 2010 established working group (SRMGI, 2011, p. 12). This approach foresees the categorisation of different research activities according to their perceived physical risks reaching from non-hazardous studies over laboratory studies, small field trials, medium and large-scale field trials to deployment (SRMGI, 2011, p. 26). The critical line in terms of requiring binding international rules is established between category 3 (small field trials) and category 4 (medium and large-scale field trials) (SRMGI, 2011, p. 26). In general, the creation of governance thresholds for research and deployment remains contested as outlined in the fourth chapter. Owen (2014) even argues that a differentiated approach to governance would be "in danger of ignoring the core, ethical questions so central to SRM". During SRMGI's outreach meetings, the different categories are introduced as well despite its intent to not take a position on how SRM research should be governed (AAS & SRMGI, 2013, p. 8; SRMGI, 2017b). But the discussions often revolve around overarching issues not going as far as discussing

the establishment of specific thresholds or a concrete code of conduct (see SRMGI, 2016b). This is also not addressed within the scope of the DECIMALS projects. The design of the DECIMALS fund reveals that the differentiated governance approach is already put in practice as modelling research does not require any governance mechanisms apart from soft governance mechanisms such as international cooperation, transparency and public engagement (AAS & SRMGI, 2013; SRMGI, 2011). The initiative's implicit promotion of the differentiated approach through the design of the DECIMALS fund together with its tendency to scientise the issue favours scientific self-regulation, thus side-lining discussions on a potential research governance framework in form of (inter)nationally shared norms or a voluntary code of conduct. Matzner (forthcoming) distinguishes between two sub-patterns when analysing expert discourses regarding scientists' responsibility: "Scientists responsibly produce knowledge" and "scientists responsibly govern their research". The first pattern thus really focuses on the responsible production of scientific knowledge which is often equated with indoor research (Matzner, forthcoming). In practice, SRMGI's discourse is so far more in line with the first pattern and governance is more understood as the facilitation of capacity building to conduct research (SRMGI, 2018a).

To summarise, SRMGI nurtures justice and urgency arguments to justify its work on research governance and capacity building of developing country scientists to conduct SRM research. The initiative's governance narrative promotes governance of facilitative nature. When advancing its governance narrative, SRMGI takes positions on contested issues as outlined above. First, the initiative promotes the need for more SRM research to reduce uncertainties. By supporting only one type of research, namely that of modelling work, the initiative tends to narrow discussions down on socio-political and ethical issues. Also, the support of a differentiated approach to research by the initiative, might disregard core ethical questions. Finally, the framing around justice and the promoted need for SRM modelling research and capacity building in that respect contribute to the normalisation of SRM itself. The initiative narrows justice discussions down and the main focus of its capacity building work lies on the reduction of uncertainties, thus contributing to a shift away from other approaches to reach more climate justice.

5.2.2 Broadened engagement

In quantitative terms, the total number of outreach meetings and two larger conferences amounts to 21 events. SRMGI's intention has been to only involve a very limited number of Europeans and North Americans in these conversations with Global South scientists and interest groups (UCLA, 2017). With the exemption of the very first outreach meeting, the initiative adhered to this intent (see Annex II). Real effort was put in trying to engage different stakeholders ranging from academics over policy makers, NGO representatives, members of the public and the media. Sometimes advertisements were published in local newspapers to attract members of the public (AAS & SRMGI, 2013, p. 5). For some meeting participants, SRMGI is, however, suggestive of being only an initiative for scientists (ReNa1). The data analysed of the different outreach meetings discloses that academics have been the most represented group throughout its outreach meetings (see Annex II). In one of its reports, the initiative comes up with an explanation for the predominant representation of scientists at its workshops as they are often hold in conjunction with other scientific conferences (AAS & SRMGI, 2013, p. 5). In a later interview, the project director, Andy Parker, said that the main focus of the meetings would be on academics and NGO representatives not necessarily government representatives (Business Recorder, 2017). The lacking representation of decision-makers at some meetings was also addressed by some of the workshop participants (NGO5; ReSo3). Policy makers should only get involved when the expertise is already built by academics

and NGOs (NGO6). This is very much in line with the underlying position that more research will lead to decreased uncertainty and better decision-making. The involvement of policy makers would only contribute to the politicisation of an open process (SRMGI, 2013, p. 13).

Regarding the outreach meetings, it is important to have a closer look at the manner in which these are conducted. The introductory presentations last usually half a day before the more governance-focused part of the meeting begins. In general, it can be said that the introduction into SRM during these outreach meetings is kept open and gives a short introduction into the socio-political dimensions (Parker, 2016b). In the accessible presentation slides the ethical dimension was lacking but that might be because another Northern scientist covered this later on in the same meeting (SRMGI, 2016b). Usually, the moral hazard issue and the ethics of planetary interventions seem to be addressed in this introductory presentation as well (NGO5; NGO6). The second part of a typical outreach meeting begins with a research governance presentation held by the initiative's staff often in concert with an international governance expert (see Annex II). After the presentations, Q&A sessions, open participant discussions or World Café-style discussions in smaller groups follow during which stakeholders have the possibility to share their views on different governance issues (NGO5; AAS & SRMGI, 2013, p. 7). These are not always facilitated or moderated by SRMGI's staff but also by the workshop's co-hosts (see Annex II). During these outreach meetings, the different perspectives of Global South stakeholders are explored and recorded while no consensus is sought (NGO5; AAS & SRMGI, 2013, p. 5; Parker, 2016b). Line exercises are used to get a better picture of participants' opinions on whether certain scenarios should be facilitated, regulated or prohibited (see Annex II). This line exercise was criticised in a recent publication due to its, by Northern experts, pre-formulated nature (Biermann & Möller, 2019). Whereas the first part of the meetings indicates the direction of the discussions, the second half strives for enabling free engagement meaning that participants are able to steer the discussions in the direction they want to. Often, discussions revolve more around the bigger picture in terms of the need of SRM deployment and not about concrete regulative governance options.

Despite some diverging voices (Ogallah, 2017; NGO1; NGO2), other respondents said that outreach meeting participants were able to put their opinions and feelings across (NGO3; NGO5; ReSo3). Also, the initiative tries to get hold of national experts if available (NGO3; NGO6). Where data is available, the number of regional speakers is higher than the one of Northern speakers with two exemptions (Singapore, the Philippines) (see Annex II). Overall, the initiative has clearly been improving the format of the workshops throughout the years and has been open to suggestions from local co-organisers and participants (NGO3; NGO6). Another improvement has for example been to increasingly count on smaller table discussions instead of or before big plenary discussions to also counteract language barriers (see Annex II). Despite these efforts, it is clear that more creative approaches to engage with such a contested technology are lacking. One respondent said that the initiative could be more proactive about trying out creative ways of engagement (NGO3). Regarding the DECIMALS projects, a DECIMALS researcher explained that compared to traditional research funds, the DECIMALS fund grants them a lot of more freedom in terms of project management (ReNa3). Also, the SRM modellers who provide advice "have not dictated our agenda in terms of what we want to research" (ReNa3).

When the initiative invited 27 academics and NGO representatives in March 2011 to produce some SRM research governance recommendations, a lot of attention was paid on having experts with different backgrounds (SRMGI, 2011, p. 8). A closer look at the academic background of the speakers at SRMGI's outreach meetings discloses that the level of integration regarding diverse

knowledge types has varied from meeting to meeting, so no predominant pattern was recognisable (see Annex II). However, the number of STS researchers and risk community participants is quite low. Also, the integration of ethicists in SRMGI's outreach meetings is very limited (see Annex II). Only during the Jamaican workshop the need for ethical analysis to move forward together with the research process was addressed, so that ethics could "inform what SRM models investigate as well as how research questions are asked" (SRMGI, 2016a).

By setting up the DECIMALS fund, the integration of diverse knowledge types was entirely neglected. Apparently, reasons for this were lacking time and financial resources (NGO6; ReSo6). The research group members are solely coming from a natural science and physics background. As the DECIMALS fund aims at creating expertise, only modelling expertise is built, and other expertise should be gained in debates with "sceptical colleagues" (NGO6). Therefore, the fund "has really separated the social science questions from the natural and physical science questions" which should actually "move forward together" (ReSo6). Instead, the modelling research is presented as something feeding into social science discussions and informing policy makers (ReSo6). The attitude is to wait what the results say and then to think about how to move forward (ReNa3). Follow-up funding for some more social science research on the issue and public engagement processes is not confirmed yet (NGO6; ReSo3). This approach entirely resembles the outdated science communication process of scientists speaking truth to power without engaging with the diverse knowledge types and the broader public, thus entirely neglecting an integrated approach.

Despite all these engagement efforts and the attention payed to the format of its meetings, there is certainly some distrust by Global South decision-makers towards the initiative what concerns the question by whom its agenda is driven (Dip1). The fear is that the national development agenda is not paid enough attention to (Dip1). Sometimes invited government officials also seemed to have intentionally stayed away from the meetings (NGO1). Regarding the involvement of NGOs, it has to be said that only few critical voices have been included in the different outreach meetings (see Annex II). Some environmental NGOs have had a distrustful attitude towards the initiative since its launch and did also not endorse the project formally (SRMGI, 2011, p. 8). One of the reasons why some of the environmental NGOs participating in the SRM discussion are rather hostile towards the initiative's endeavours is that the "geoclique[9]" was involved in its initial working group and in some of its activities throughout the years and that the initiative would act in favour of CE and impose this on developing countries (Heinrich Böll Foundation & ETC Group, 2017). Two NGO respondents argued that SRMGI would promote the controversial technologies when reaching out to Global South stakeholders (NGO1; NGO2). This apparent distrust in the initiative's intentions seems thus to be related to its proximity to popular SRM proponents (ReSo5). In the Nature piece, the initiative accuses these Northern NGOs to paternalize developing countries by urging them to reject CE on the basis of risks thereby leaving aside potential benefits (Rahman et al., 2018). With US-based NGOs, on the other hand, the initiative developed close ties also due to the EDF, one of its funding partners (NGO4).

When having a closer look at the intervention in form of broadened engagement, it becomes clear that the initiative has been successful in reaching out to new actors and keeping the introduction into SRM open. The discussion of concrete governance options is not necessarily encouraged during outreach meetings. Despite its attempts to include diverse actors, it is also evident that SRMGI has so far been contributing to the scientisation of the issue due to its predominant focus on

[9] As this term which describes academics who are supportive of SRM (research) has a negative connotation (due to its prior use), the term which is used here to describe this group of people is epistemic SRM community.

scientists and the design of the DECIMALS fund. Emerging research communities in the Global South are thus steered into a specific direction due to the nature of the promoted research and the type of knowledge invited into these capacity building exercises. The initiative reinforces the obsolete science communication process of science talking truth to power instead of an integrated approach. As outlined in the preceding section, a predominant focus on modelling work tends to narrow discussions down on socio-political and ethical issues. This effect is reinforced by excluding social scientists or in general diverse knowledge types from the DECIMALS projects.

5.3 Steering the governance landscape

After introducing the interventions by SRMGI, it is analysed whether these have resulted in a governance effect in terms of strategically opening up the governance landscape which comprises SRM research trajectories and SRM governance discussions. It is analysed whether the initiative's efforts of pushing research trajectories and governance discussions in certain directions have been successful, thus de facto governing the landscape.

The potential governance effect resulting from interventions such as the advancement of a certain governance narrative including its governance objects and broadened engagement has been identified as strategically opening up the space. The strategic opening up of the space has in turn be determined as the normalisation of governance directions as well as the empowerment of a certain group of actors or knowledge types. Whether this effect materialises is analysed subsequently.

5.3.1 Normalisation of governance directions

As the thoroughly positive reactions to the launch of the DECIMALS fund have shown (ReNa1; ReNa2; ReSo2; ReSo3; NGO4), SRMGI has to a certain extent succeeded in normalising the need for capacity building of developing country scientists. The initiative has earned some credit for its capacity building efforts not only from academics but also from NGOs and some national decision-makers. The discussion is, however, also moralised due to a certain notion of equity used to legitimise the calls for more SRM research on the part of developing countries. Whereas many other academics evoked notions of equity to justify the need for more SRM research (see Flegal & Gupta, 2017), the initiative's governance narrative and the notions of equity advanced therein take a new dimension. In the initiative's narrative, capacity building on SRM research is framed as the only means left to realise climate justice as the provisions under the climate regime would have entirely failed to do so (see Rahman et al., 2018). As the framing has been taken up by some of the initiative's strongest supporters in the Global South (Lefale, 2018; Rahman et al., 2018), this notion of equity has thus been rendered less paternalistic. However, this notion does not arise from an open discussion on climate justice and alternative approaches in the Global South. Also, resistance to this perception of equity by Global South actors has risen (Dip1; NGO5; Elisara, 2018; HOME, 2018). However, the initiative succeeded to a certain extent in that its framing regarding equity has been taken up by some Global South stakeholders. Only the future will show whether a further normalisation of this notion of equity will take place or whether its opponents will manage to assert themselves. The developments after the DECIMALS projects' finalisation will be instructive in terms of whether the initiative will manage to normalise this notion, thus positioning itself as a "justice

broker[10]" in this space. The equity framing will most likely be one of the pivotal discursive battles on SRM in the (near) future.

Regarding the need for more SRM research, the initiative successfully normalised the assumption that more research, especially modelling research will reduce existing uncertainties. All interviewees who knew about the project considered it a great initiative. Many outreach meeting participants and DECIMALS participants share this view (ReNa1; ReNa2; NGO3; NGO5). The development country researchers see a lot of value in the DECIMALS projects as "the basic physics of the issues are not very clear yet" and the researchers will therefore "learn a lot on feedbacks in the climate system" (ReNa1). Whether one could argue that already the sole existence of the DECIMALS fund is a prove for the successful normalisation of the need for more research is a bold statement. There does not exist any prove that SRMGI pushed meeting participants into that direction but that the need for developing country research - both of natural and social science nature - was brought forward by them (AAS & SRMGI, 2013, p. 11). What can, however, be argued is that SRMGI influenced the question of what type of research would be needed as the design of the fund was in the hands of the project director. Also, the deliberation of different anticipation approaches did not really play a role during its outreach meetings as mentioned above.

But not only the conduct of more SRM research but also a certain approach to research has been normalised. With the design of the DECIMALS fund the initiative tries to normalise a pacing of research. This means that a purely scientific approach to research in the form of modelling work is supported which shall then feed into social science discussions and eventually inform policy makers. Once the DECIMALS fund's design got revealed this did not result in any contestation. On the contrary, most of the academics operating in the field have welcomed SRMGI's advance (ReSo2; ReSo3; ReSo4; ReSo5). Despite the widely accepted need for an integrated approach to knowledge production, the initiative succeeds in normalising a pacing of knowledge production in this case. Many voices warn against the dominant nature of CE modelling research and its inherent shortcomings (Flegal, 2018; Hulme, 2011; McLaren, 2018a) but the predominant perception seems to persist among scientists that modelling research alone can still provide useful insights at this stage. It is not only the pacing which gets normalised but also the differentiated approach to research governance. The call that all types of research governance would require binding international rules, is rejected by many scientists taking part in governance discussions (Matzner, forthcoming). SRMGI has also contributed to this.

As shown above, SRMGI's frame regarding capacity building and equity has already gotten normalised to some extent. This frame has clearly shaped research trajectories in terms of facilitating research which would be of interest to developing countries. Another consequence of the frame is that the governance discussions got further moralised as it narrows other approaches to achieve more climate justice down. With the help of the frame the need for SRM research in the developing country context got normalised. Also, the initiative has strategically opened up the space by promoting its scientisation by pushing for natural science research to be conducted first, neglecting an integrated approach to knowledge production and normalising a pacing regarding the conduct of research. SRMGI pushes into the direction of soft governance mechanisms and thus contributes to the normalisation of scientific self-regulation together with the epistemic SRM community.

[10] The term justice broker refers to "actors and institutions facilitating cross-scale communications amongst diverse actors on the identification, mobilisation and representation of justice-related norms" (Dawson et al., 2018).

5.3.2 Empowerment of actors and knowledge types

Different engagement efforts on CE with Global South stakeholders have been undertaken by academics or scientific organisations over the last years (Carr & Yung, 2018; IASS, 2014; Winickoff et al., 2015). However, none of these efforts has had such a long-lasting and wide-ranging effect as SRMGI's outreach meetings in the Global South. So far, the initiative's activities have not resulted in much sustained local engagement with the topic (Open Philanthrophy Project, 2016a). In 2014, the pan-African working group on SRM was established, a bottom-up initiative under the auspices of the African Academy of Sciences (Winickoff et al., 2015). The pan-African working group does not seem to be very active judging from an email exchange with involved people. However, after initial outreach meetings back in 2011, there have been other expert meetings involving policy makers in China and the launch of a research program in India as well as another open workshop with NGOs, academics and policy makers (NGO6). SRMGI might thus have triggered some national efforts and engagements; it is, however, difficult to entirely trace that back to the initiative. Thanks to informal connections formed during outreach meetings, the initiative has developed a "spiral-like network" (Open Philanthrophy Project, 2016a). Often these individuals continue to encourage national conversations but more at an academic level (NGO6).

SRMGI has included new Global South actors into the debate and has been quite successful in establishing a reliable network with some of these actors. In general, the initiative enjoys widespread trust among developing country academics but is not well known in policy making fields in the Global South. In general, the awareness about the initiative's activities is not very pronounced in the Global North and in non-scientific communities in the Global South (Dip1; ReSo2). Distrust towards the initiative comes especially from environmental NGOs in the Global North. By many interview respondents (NGO3; NGO4; ReSo3; ReSo4; ReSo5), SRMGI's efforts to engage Global South voices in the debate is considered valuable, even referring to it as "the first real effort" (ReSo3). The initiative's success would for example manifest itself in the increased number of Global South participants at the Climate Engineering Conference 2017 (CEC17) compared to the one in 2014 (ReSo4). Even though the initiative has made lots of efforts to ensure a broad engagement of different actors with diverse backgrounds in its outreach meetings, it has still pushed decisively into natural science directions through natural scientists' prioritisation at outreach meetings and their empowerment through the design of the DECIMALS fund. When it comes to other stakeholders than academics, it can be said that the participation of the public is usually neglected in outreach meetings.

Due to SRMGI's efforts, developing country actors got empowered to share their opinion and concerns during outreach meetings but also during international conferences and in publications. Even though the initiative promotes diversity in its discourse and strives for broad public engagement, the prioritisation of scientists is perceivable throughout its activities. Also, natural science knowledge production in form of modelling research is promoted despite doubts whether it might help to resolve governance questions. Therefore, the initiative has empowered especially one group of actors, developing country scientists.

5.4 Conclusion

This chapter answers research question 1.2. on how SRMGI intervenes and steers the SRM governance landscape. Figure 5 summarises the results of the analysis.

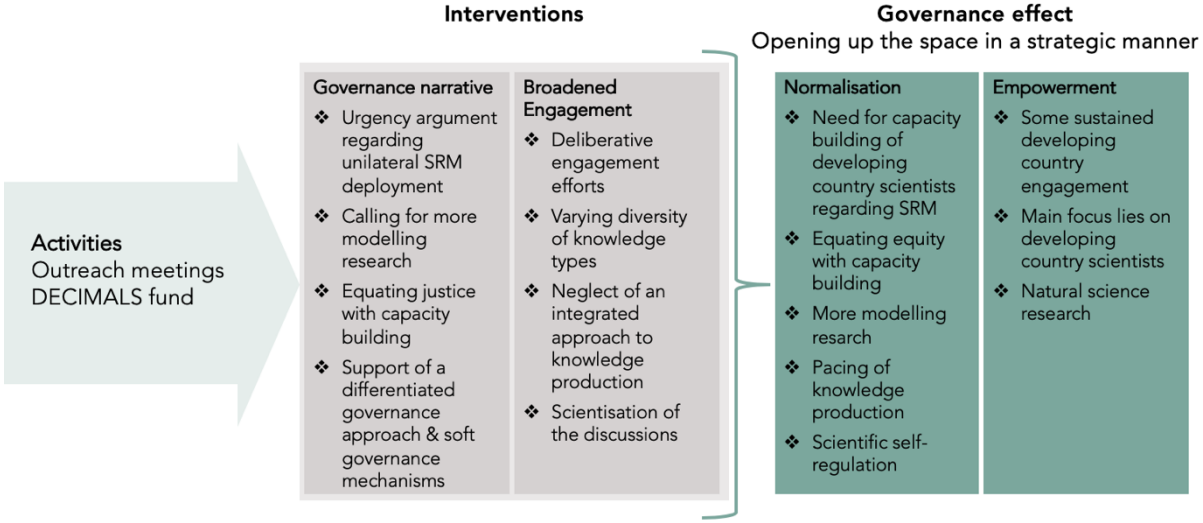

Figure 5: De facto governance by SRMGI

To summarise, SRMGI's interventions into the governance landscape resulted in the steering effect of opening up the space in a strategic manner. First, the initiative's equity framing got normalised to a certain extent. It equates equity with the need for capacity building of developing country scientists regarding SRM research. With the launch of the DECIMALS projects the need for more modelling research in this space has been normalised as well as a pacing of knowledge production. This implies that scientific knowledge should first be produced to then feed into social science discussions and inform policy makers. Its deliberation efforts are separated from the promoted research efforts. SRMGI's intentions regarding broadened engagement have been less successful in terms of the diversity of involved actors. In combination with the promoted governance narrative it is argued that a prioritisation of scientists and natural science research can be observed. Considering the initiative's background, one can thus argue that the initiative opens up the governance landscape in a strategic manner: proclaiming diversity, integration and deliberation in some respects but closing some issues down or excluding some actors, thereby side-lining socio-political and ethical questions.

The next chapter will analyse in what manner the other prominent governance initiative in this space, C2G, intervenes in and steers the SRM governance landscape.

6 Taking SRM governance to the next level: The case of C2G

After analysing how SRMGI is de facto governing the SRM governance landscape, C2G, the second case study, is examined through the same analytical lens in the following to answer research question 1.3. First, the activities by the initiative are introduced before analysing the two interventions and the actual effect on the governance landscape.

6.1 Activities

The initiative's activities comprise the organisation of educational briefings, webinars and all kind of meetings (see Annex III), the creation of information materials, the engagement with stakeholders and the encouragement and support of CE discussions in multilateral fora (C2G2, 2018a, p. 8). The initiative uses different communication channels including print and social media and has a website and a social media platform on Twitter which got launched in October 2017. C2G also publishes quarterly updates to inform about its activities. In its initial mission document the initiative outlines nine work streams: (1) work with intergovernmental organisations and non-state actors; (2) work with Convention/ treaty bodies; (3) building an informal network with government officials; (4) co-finance activities of intergovernmental organisations and NGOs; (5) establish a commission on research governance; (6) undertake preparations for an intergovernmental agreement of principles; (7) setting up a High-level Panel on CE governance; (8) communication and outreach activities and (9) program management (C2G2, 2017b). Not enough financial support was, however, available for work stream 4,5, and 6 (C2G2, 2017b, p. 2). Next to official events, the initiative relies heavily on informal talks with national government officials and delegates in line with its second work stream.

6.2 Interventions

Through the described activities two interventions are generated, the advancement of a certain governance narrative and broadened engagement which will be focused upon subsequently.

6.2.1 Advancement of a certain governance narrative

The initiative advances a certain governance narrative comprising values, principles and taken-for-granted assumptions which is shown in the following.

C2G's entire work revolves around the implementation of international CE governance. Thereby the initiative goes one step further than many other actors in this space and aims at catalysing international agreements to prevent premature deployment of SRM (C2G2, 2018b, p. 11). C2G thus strives for an implicit moratorium of SRM deployment which can only be lifted once risks and benefits of SRM are sufficiently understood and international governance frameworks adopted (C2G2, 2018b, p. 11). C2G's calls for such international SRM non-deployment governance are driven by the threat of a possible unilateral or minilateral SAI deployment in the near future. In many publications and during talks, the executive director expresses this likelihood (Brad, 2018; C2G2, 2018b, p. 4; CBC Radio, 2018; Dunne, 2017; Kahn, 2017; Levitan, 2019a; Pasztor, 2017b, 2019a; Pasztor, Nicholson, & Morrow, 2016). C2G's executive director holds a scenario of a billionaire providing funding for SRM deployment as plausible (Levitan, 2019a). The support of a billionaire or a larger state is seen as necessary in case desperate vulnerable states decide to get together and deploy SAI (CBC Radio, 2018; Levitan, 2019a). It is further argued that the global stocktake under the Paris Agreement in 2023 could trigger such a desperate move (Pasztor et al., 2016). In one publication, C2G's executive director even states that SRM deployment would not be that complicated at all (Levitan, 2019a), a taken-for-granted assumption which fuels further fears and governance calls.

In the case of SRM research, the slippery slope assumption is used to justify governance calls. SRM research is framed as being already on a slippery slope meaning that research will most likely lead to deployment, thus being able to "overtake society's capacity to respond prudently and effectively" (Novarina, 2018). By using the slippery slope argument in the case of CE research activities and the unilateral/minilateral deployment narrative the initiative evokes the urgency to act (C2G2, 2018b, p. 60; Pasztor, 2018b), thus justifying its call for international SRM governance and the engagement with multilateral bodies and processes. A justification for the evoked urgency in turn is that policy-making at the multilateral level would take much time. In addition to that, "the debate around and pressure to use these technologies may be moving faster than we thought" (Pasztor, 2018a). The urgency argumentation is also reinforced by referring to the low entry barriers of solar geoengineering in terms of "the relatively low costs, the availability of the required technologies, and a lack of legal barriers" (C2G2, 2018b, p. 11).

This urgency argumentation regarding fears of unilateral/minilateral deployment and slippery slope developments in the research space also supports a strong framing around top-down international governance. Despite the initiative's acknowledgement that the term governance includes multiple forms of steering (C2G2, 2019b), it becomes clear that the ultimate goal is the implementation of top-down regulations and rules at the international level, not only for SRM non-deployment governance but also for certain aspects of research governance (C2G2, 2018b, p. 12, 2019a). This top-down research governance narrative is justified with the argument that currently lacking public funds for research would only be provided if governance and oversight are in place (C2G2, 2018b, p. 14). Therefore, the initiative is aiming to set up an expert group or commission on research governance consisting of experts and intergovernmental processes (C2G2, 2018b, p. 7). The ultimate goal would be internationally-agreed principles for certain aspects of SRM research overseen by a respective governance body. The slippery slope argument leaves aside that there exist cases of research into technological development which did not lead to deployment (Bellamy & Healey, 2018). The strong framing around international research governance has met some resistance from the SRM research community as the international top-down approach would risk putting SRM research on a prohibition path (ReSo2; ReSo5; ReSo6). As a result of this slippery slope narrative, governance is framed of needing to be of prohibiting or at least constraining nature (ReSo2). One respondent argued that due to this top-down governance narrative, technologies especially the ones with less concerns such as surface albedo modification techniques might not reach the point of so-called sociotechnical maturity[11] (ReSo2). For this to occur discussions would first need "to be rolled back a little bit through a much broader conversation with different actors in societies around the world" to work towards sociotechnical maturity which then provides the basis for robust decision making (ReSo2). This, in turn, would not mean "that concerns about a slippery slope should be dismissed, however, but rather that flexibilities be built into the sociotechnical systems as they develop" (Bellamy & Healey, 2018). C2G supports mandatory approaches at the international level only for certain undefined aspects of CE research (C2G2, 2018b, p. 15) and the development and uptake of codes of conduct or the implementation of an advisory board for smaller scale research activities (UCLA, 2017).

In general, different multilateral institutions should be involved in international SRM governance as bodies could only address certain aspects (C2G2, 2018b, p. 7). Therefore, the initiative engages

[11] Sociotechnical maturity occurs when a broad understanding of possible governance arrangements as well as the core technical equipment and required processes for deployment is reached (ReSo2).

with different global bodies and processes regarding research and broader governance as has also been shown by the third and fourth figure in chapter 4. C2G's goal is the creation of multiple assessments by intergovernmental institutions on CE and its governance (C2G2, 2017b, p. 4). Regarding concrete outcomes, the initiative formulated certain interim targets such as the adoption of a transdisciplinary research framework for CE under the CBD in 2018, the adoption of a resolution on the research, testing, and hold on deployment of solar geoengineering at UNEA-4 and the discussion of CE governance at the UN Climate Change Summit in 2019 (C2G2, 2018b, p. 8).

On top of a strong international governance narrative, the initiative supports a broad risk management approach. This means that CE shall not only be considered in the context of other climate policy options but also within the broader sustainable development agenda (UCLA, 2017). The broader risk management frame thus also reveals that the initiative considers geoengineering as another potential climate policy option which is a contested position in this space. One of C2G's ambitions behind the catalysation of the UNEA draft resolution is the placement of CDR and SRM within the context of agenda 2030 and the Sustainable Development Goals (C2G2, 2018b, p. 12). C2G also commissioned a larger report on the potential implications of CE for the delivery of the Sustainable Development Goals which got published in May 2018 (see Honegger, Derwent, Harrison, Michaelowa, & Schäfer, 2018). There have been some publications which studied the implications of potential SRM deployment on sustainable development by referring to specific issues (see Buck, 2012; Morrow, 2014; Wong, 2014). But C2G's report is the first comprehensive one in the CE space clearly embedding the CE discussion in the development agenda, thus supporting a broader risk management approach. This view goes hand in hand with the general shift of mainstreaming climate action in the broader development agenda which is backed by the highest UN decision-making body. In many publications and during some meetings the initiative has spread this frame (C2G2, 2018b, p. 4; Harrison, 2017; M. Turner, 2018; UCLA, 2017). The initiative sets everything in the SD context, a tweet by the executive director reacting on SRMGI's Nature publication in April 2018 states for instance: "In spite [and perhaps because] of huge challenges in reaching their #SDGs developing countries must engage on solar geoengineering research on science and on governance" (Pasztor, 2018c). The statement also supports the initiative's focus on justice.

C2G's governance narrative is increasingly "de-geoengineering" the issue. The initiative changed its name recently due to the fact that after the publication of the IPCC SR15 the willingness to use the term geoengineering would have further decreased (Pasztor, 2019c). As a result, the initiative declared a name change in June 2019 and C2G2 thus became the Carnegie Climate Governance Initiative (C2G). The executive director gave the following explanation for the name change:

> "As an initiative with the term 'geoengineering' in its title, C2G2 was sometimes – mistakenly – viewed as promoting 'geoengineering'. This brought with it many negative connotations and misunderstandings, which hampered our ability to engage with society, and to catalyse the learning processes necessary to take informed decisions. If terminology stands in the way of understanding, then it should be changed." (Pasztor, 2019d)

The initiative thus contributes to the "de-geoengineering" of the debate. The executive director further explains that this would be necessary to enable constructive conversations and new learning about less controversial technologies as geoengineering would often be equated with SAI. With this decision the focus shall shift more to CDR technologies and surface albedo modification techniques in the case of SRM (Pasztor, 2019d). Even though this sounds as if C2G might shift its work priorities towards CDR as also argued by one respondent (NGO4), the initiative announces that its focus shall remain on those CDR and SRM approaches with governance gaps at the international

level (Pasztor, 2019d). However, another implication of the name change is that CE technologies are considered to be already part of the climate regime. As with the broad risk management frame, CE is thus put as another potential climate policy. Even though that might hold true for some CDR technologies, ocean iron fertilisation, marine cloud brightening and SAI (SRM in general) are far from that.

When having a closer look at C2G's governance narrative, it becomes clear that the initiative is very much focusing on pushing the need for top-down international governance, thus strongly framing the governance debate around international governance values. Next to research governance, the initiative is well known for its efforts regarding non-deployment governance which amount to an implicit deployment moratorium. Also, a broad risk management approach is supported which places CE within the sustainable development agenda. C2G's problem frame reveals a strong focus on the legitimisation of SRM as a prospective climate policy option. Eventually, C2G contributes to the "de-geoengineering" of the governance discussions.

6.2.2 Broadened engagement

C2G's governance narrative around international governance implies the shift of CE discussions from academics to the intergovernmental policy community. Therefore, the initiative is mainly seeking engagement with government officials, intergovernmental institutions and non-state actors. In the case of C2G, engagement is thus more aligned with its governance narrative and not really broadened in the spirit of deliberative engagement comprising diverse actors. The relation of the 'engagement' intervention with the 'governance narrative' intervention is more pronounced from the outset as in the case of SRMGI.

The initiative is very strategic about choosing their interaction partners. First, the initiative sought broad engagement with key influencers in the CE debate and with policy makers before zooming in on the active engagement with senior officials and opinion-leaders (C2G2, 2018b, p. 2). In addition to that, the initiative is forming a group of high-level individuals across the world which they refer to as "champions" due to their professional credibility, often former heads of state, in order to spread their message (C2G2, 2018b, p. 7). Due to many of the employees' former career paths, C2G is perfectly equipped to engage with these so-called agents of change. Regarding intergovernmental institutions, the initiative had multiple meetings with UN Environment senior staff members throughout 2017 (C2G2, 2017a). In 2018, the initiative declared that it would cooperate with UN Environment in preparing the Frontiers Report (Harvard Project on Climate Agreements, 2018, p. 61). The Frontiers report 2018/19 did, however, not include a chapter on solar geoengineering as announced by the initiative. It did not even mention the term geoengineering once in the entire report. There was only an implicit reference to CDR in its chapter on maladaptation to climate change (UN Environment, 2019, p. 72). This reveals that the topic must have been excluded post hoc from the Frontiers outline due to certain reasons. Interestingly, the Swiss Federal Office for the Environment shared the same information in its concept note of November 2018 which accompanied the resolution for UNEA-4 (FOEN, 2018). This, in turn, discloses the close ties between C2G and the Swiss Federal Office for the Environment but also that UN Environment did obviously not consider the topic ripe enough or appropriate to be included in the Frontiers report and raises some questions about C2G's cooperation with UN Environment under the new executive director. Next to UN Environment, other intergovernmental bodies the initiative has approached are UNESCO, WMO and IPCC. Also, access to UNFCCC processes has been sought in order to push CDR discussions on the international agenda. In addition to that, C2G collaborates with the CBD secretariat on CE research governance (C2G2, 2018c).

When it comes to the interaction with national officials, the intention is that a group of national governments also referred to as "friends of geoengineering governance" is formed which pushes the topic forward in diplomatic circles (C2G2, 2018b, p. 9). The initiative's statement that many doors at department-head or ministerial levels would have opened already to its plans is hard to prove (Harvard Project on Climate Agreements, 2018, p. 60). At the typical informal dinner events which C2G often organises around bigger conferences, the attendance of national officials seemed to be modest especially compared to present intergovernmental actors (NGO1). However, the initiative engages with national diplomats at a very informal level between negotiation sessions which is not officially documented (NGO1). Formally organised meetings with national officials were also organised as the initiative seeks active or passive support by around 25 countries with economic or political importance in the climate realm (C2G2, 2018b, p. 13). For this purpose, C2G talked twice to Chinese national officials including China's Special Envoy on Climate Change, to the Governor of California and to Brazilian government officials. Additional talks with government representatives have also taken place in India, Canada and France (C2G2, 2017a). Talks with the chair of the LDC group were arranged as the initiative recognises LDCs' moral authority (C2G2, 2017b; Pasztor, 2018e). National government officials were in one observed case not too keen to engage with the initiative and to support its mission as it was understood as supporting the technologies themselves (NGO1). In other cases, the initiative is, however, more successful. Some impacts of C2G's informal engagement with government officials are well-known. Its engagement with Swiss government officials resulted for example in the submission of the Swiss draft resolution at UNEA-4 (NGO4; ReSo3; ReSo4; ReSo5; Reading Conference).

Closer cooperation has taken place with the Forum on Climate Engineering Assessment and its Academic Working Group on International Governance of Climate Engineering (C2G2, 2017b; Reading Conference). A common briefing paper resulted for example out of the cooperation (see Pasztor, Nicholson, & Morrow, 2016). The initiative also publicly endorsed a report on short-term SRM governance recommendations which got published in October 2018 upon which the initiative builds its work (Pasztor, 2018d). Next to the Forum on Climate Engineering Assessment, C2G interacts with SRMGI to get in touch with developing country professionals (C2G2, 2017b, p. 9). Therefore, C2G's executive director has been present at some of SRMGI's outreach meetings over the last years (see Annex II). In addition to that, C2G cooperated with the University of Calgary which runs the Geoengineering Research Governance Project (C2G2, 2017b, p. 9). The project includes the development of a code of conduct for CE research which serves as a basis for C2G's work on research governance. The goal is to establish governance frameworks which both incentivise but also regulate research efforts. This is also why the initiative has been in touch with many academics working on the topic such as the epistemic SRM community (ReSo3).

In its initial mission document, the initiative also outlines its intention to cooperate with civil society organisations to engage with the broader public (C2G2, 2017b, p. 10). However, funding was first not available, and the list of events discloses that the events organised or hosted by the initiative have not really focused on public deliberation but instead invited some of these stakeholders to participate in a panel discussion or to share their perspective of the issue (see Annex III). The initiative has been clear about its primary focus on the intergovernmental policy community. The broader, society-wide discussion is therefore indirectly supported by interacting with civil society organisations, think tanks and faith communities (see Annex III). This is criticised by civil society organisations which do not consider this top-down approach to sensitise the broader public about such an issue appropriately (NGO1; NGO2). Despite this critique, one cannot argue that the

initiative does not actively and frequently seek the interaction with civil society organisations (NGO1; NGO2). The NGOs which the initiative invited to its events comprise the ETC Group, Greenpeace, the Climate Action Network and the Red Cross Red Crescent Climate Centre (see Annex III). In addition to this, the initiative engaged with the HBF and WWF. Think tanks which were involved in different events include the Climate Interactive, Chatham House, the Bipartisan Policy Center, the Mercator Research Institute for Global Commons and Climate Change and the Council on Energy, Environment and Water. Two events, a webinar and a seminar in the Vatican, focused on including the voices of faith leaders and communities (see Annex III).

When introducing new actors to the debate, the initiative pays a lot of attention to the manner in which this is done. When having a look at the list of events, it becomes clear that in cases where the initiative (co-)hosted or organised an event, ways were sought to ensure an open discussion (see Annex III). Many of the events would start with presentations and then be followed by breakout, World Café style or Q&A sessions. There are, however, also some workshops which are dominated by presentations and panel discussions. The informal evening receptions which have often taken place in conjunction with international conferences include usually a series of speeches from different stakeholders but no open discussions (see Annex III). Little can only be said about the deliberative quality of some events organised or co-hosted by the initiative. For the breakout sessions guiding topics and questions are usually given but all participants can express themselves freely (C2G2, 2017c; NGO3). C2G has shown much openness towards experimenting with creative tools by for example touching on the emotional dimension of risky decisions (see World Bank, 2018). Also, game sessions and the development of an animation to explore people's opinion have been endorsed, thus ensuring a fair and inclusive environment during engagements (NGO3). In addition to that, the initiative argues that in the case of briefings they would do their best "to invite a range of actors, from a variety of backgrounds, with different views" (C2G2, 2019a). In fact, when hosting or organizing events, the initiative paid attention to the speakers' backgrounds to ensure diverse views and insights (see Annex III). However, a tendency to invite high-level and senior speakers can be observed especially for panel discussions (see Annex III). This predominant focus on high-level and senior individuals invokes intergenerational justice issues. Even though C2G stresses the importance of including young people (C2G2, 2018b, p. 7), the initiative does not undertake a lot of actions to ensure that this is really happening. Also, an initiative with such an elite status risks excluding certain actors automatically due to its inherent top-down character. The strong media presence of C2G's executive director has also been criticised as this might undermine the diversity of voices in the debate (ReSo6). It is true that C2G's executive director has been heavily involved in different media publications and that these pieces did often only reflect the opinion and values of the initiative itself.

Despite its relatively recent launch, the initiative has engaged with a multitude of diverse actors. Due to the background of its staff members, the initiative is very successful in getting in touch with different intergovernmental institutions and convention bodies, especially UN Environment and CBD. Government actors are still reserved as some fear for their career when addressing the topic or some do not consider the topic ripe enough. Some government actors could, however, already be convinced to take first steps. Even though the initiative also aims for broader societal engagement, its activities clearly focus on intergovernmental processes and government actors with some limited involvement of non-state actors. Public engagement is not really striven for at least not at this point of time. When engaging with different actors, the initiative makes use of creative approaches and invites diverse voices, but it makes also sure that its own voice is heard.

6.3 Steering the governance landscape

In the following section, it is analysed whether the introduced interventions have resulted in an effect on the governance landscape in terms of strategically opening it up.

6.3.1 Normalisation of governance directions

The submission of the Swiss draft resolution on geoengineering for UNEA-4 was a big milestone for C2G to normalise international governance in the form of an assessment. The initial draft resolution asked for an assessment of CDR and SRM, comprising the current state of science and research gaps, research and deployment related actors and activities, state of knowledge regarding potential impacts for each technology (risks, benefits, uncertainties), current status of governance frameworks for research and potential deployment and conclusions on potential global governance frameworks for each CE technology (FOEN, 2019). Whereas C2G was first striving for a resolution to include the words "no solar geo deployment unless…" in April 2018 (C2G2, 2018b), it adjusted this interim target to an initial resolution to start UN Environment's work on CE in August 2018 (C2G2, 2018d). The adjusted interim target is thus reflected in the Swiss draft resolution. Not only did the initiative encourage the Swiss government, it was also involved in the crafting of the resolution and its promotion (ReSo3; ReSo5). To a certain extent the initiative encouraged countries such as Burkina Faso, the Federated States of Micronesia, Georgia, Liechtenstein, Mali, Mexico, Niger, the Republic of South Korea and Senegal to become co-sponsors of the resolution (Harvard Project on Climate Agreements, 2018, p. 61). Some countries supported the resolution at UNEA-4 including the EU despite not becoming a co-sponsor of the resolution (Reading Conference) and some other countries from Africa, South America, and Polynesia (Kahn, 2019; McLaren & Corry, 2019). In general, supporters considered UN Environment the appropriate intergovernmental body to tackle the issue due to its broader environmental view on the issue and the fact that IPCC's mandate does not include the generation of regulation (McLaren & Corry, 2019). The Swiss delegation showed patience and willingness to adapt to demands such as moving from an assessment to a global report, a simple compilation of existing knowledge about the technologies and governance frameworks (Dip2). Despite the draft resolution's modest nature, it faced firm opposition mainly from the US and Saudi Arabia (McLaren & Corry, 2019). The firm opposition from the US can be led back to a clash of risk cultures due to the EU's insistence on the inclusion of the precautionary principle in the preambular text of the resolution (Dip2). The main reason for conflict over the resolution were, however, vested interests as "the biggest fossil fuel producers around the table were also the most vociferous opponents of the resolution" (McLaren & Corry, 2019). Especially CDR governance would have been opposed by the US and Saudi Arabia as they have a huge interest in carbon capture technology (ReSo5). In the end, the resolution had to be withdrawn.

Despite the resolution's withdrawal, it is argued that the international governance direction has been normalised to a certain extent as it was taken up by several national governments also due to successful engagement efforts, was discussed at the international level and some countries are willing to introduce the issue again at UNEA-5. In the direct aftermath of UNEA-4, the initiative realised that "the current political climate may simply be too difficult for intergovernmental bodies to take well-informed decisions on these issues in the immediate future" (Pasztor, 2019c). C2G published a blog post on whether they should recalibrate their work due to the fact that the resolution which they decisively supported had to be withdrawn (see Pasztor, 2019e). However, C2G concludes that it does not see the need for a change, instead they want to redouble their "efforts working with and catalysing partners to increase learning, capacity building, and broadening the discussion about these issues to all sectors of society and in all parts of the world" (Pasztor, 2019c).

The initiative itself perceived the submission of the Swiss proposal for a resolution on CE as timely due to the messages of the IPCC SR15 (Pasztor, 2019b). For some interview respondents the initiative's reflectiveness does not go far enough as they argue that the time is not ripe for this conversation (ReSo3; ReSo6). The initiative would have wanted too much too soon (ReSo3). The informational deficits on this issue at the international level would be too big (ReSo6). However, the adjusted interim target also reveals that the initiative itself recognised these informational deficits and decided to first promote an assessment before catalysing discussions on a deployment moratorium.

C2G is not the first actor proposing a strong framing around international governance in this space (Bodansky, 2013; M. Honegger et al., 2013; Humphreys, 2011; Bodle, Oberthür, Donat, Homann, & Tedsen, 2013; Zürn & Schäfer, 2013). With its active engagement with national officials and political decision makers, the initiative partially normalised this framing at UNEA-4. In this context, the initiative achieved another important milestone which is that the involvement of government actors in CE discussions got normalised as the first national delegations openly and officially addressed the topic in an international setting. However, clear national political positions on CE have not been developed yet. The involvement of government actors is not necessarily well received by all members of the research community (Reading conference) and some key influencers in the CE debate. A governance expert (ReSo3) argues that C2G's approach to elevate the issue of governance to political decision-makers when too many questions are still unanswered could result in premature action. Another problem with addressing such a controversial issue at the international level would be that diverse national political cultures respond differently to technology and risk, thus adding another level of complexity to the governance discussions (ReSo6). The same ambiguity about C2G's plans is also perceived within the epistemic SRM community (ReSo3). There is some "healthy distance" between the initiative and the SRM research advocates also due to concerns that too restrictive research governance mechanisms such as a moratorium are supported due to its international governance narrative (ReSo3). This also reveals that C2G succeeds in shifting the governance focus back on political and ethical issues in a space which has been dominated by authoritative assessments doing exactly the opposite (see Gupta & Möller, 2018). The transdisciplinary research framework which has been developed together with the CBD secretariat, one of its reached interim targets, is another prove for that (see C2G2, 2018b).

In general, the initiative struggles with distrust from different actors which impedes the success of its engagement exercises. Pasztor argues that the initiative's credibility depends on whether people consider it an impartial actor (C2G2, 2019a). However, the claim to be impartial seems to have aroused suspicion than anything else (NGO1; NGO2; ReSo3; ReSo6; Dip1). The suspicion and scepticism also originate from the knowledge that the majority of C2G's staff members are former UN diplomats who usually "play their cards very close to the chest" (ReSo3) or are "chameleons" (NGO1). Especially the initiative's non-deployment governance narrative attracts a lot of scepticism. Some interview respondents expressed general incomprehension about the initiative's narrative regarding non-deployment governance (ReSo3; ReSo6) as it would treat "geoengineering as if it is an option to deal with climate when we really actually don't know if it is yet" (ReSo6). The broad risk management framing disseminated by C2G has also been taken up by the Swiss government as shown in the accompanying note to its draft resolution (FOEN, 2018). C2G's efforts regarding the establishment of a deployment moratorium and a broad risk management approach as well as its recent name change, tend towards the normalisation of CE technologies as an option to deal with climate change. STS researchers are trying to raise some awareness about this.

Whether the non-deployment governance narrative will get normalised will depend on how successful the initiative will be in the future to convince government actors to take up the issue. So far, the efforts to normalise the need for a deployment moratorium have been rather unsuccessful which is why the focus shifted to catalysing international assessments.

Regarding the term geoengineering, the initiative also holds it partially responsible for the withdrawal of the UNEA-4 resolution (Pasztor, 2019d). With its name change but also with the accompanying blog post (Pasztor, 2019f) C2G contributes to the normalisation of the distinction between CDR and SRM. Dropping the umbrella term has been a strategic decision to get rid of the negative connotations and to circumvent entrenched conflicts. Even though the initiative was already before UNEA-4 separating its work streams according to the CDR/SRM classification, it had still used the term geoengineering on a regular basis. With that decision C2G thus gave in to the demands of SRM research advocates who have always criticised the initiative for lumping CDR and SRM together as this would be misleading and that statements comprising both categories would be entirely trivial (see ReSo3). So far, these actors have jointly been relatively successful in normalising the dropping of the umbrella term.

In sum, C2G normalises certain governance directions such as the politicisation of CE discussions. In addition to that, the initiative has to a certain extent succeeded in normalising the need for international governance in the form of an assessment. The future will show whether the initiative is able to normalise its narrative regarding an international agreement to prevent premature SRM deployment as this is quite contested. The UNEA-4 resolution also normalised the broad risk management approach. Regarding research governance, the initiative's work has so far not resulted in any perceptible effects. The initiative's renaming contributes to the normalisation of the "de-geoengineering" of the debate which has been pursued by the epistemic SRM community already since longer. As its name change revealed the initiative is also struggling with a lot of criticism and distrust. Sometimes it looks as if C2G is torn between the different interest groups operating in the CE space, trying to please everybody. It is still too early to say whether the initiative will succeed in implementing its SRM governance priorities in the form of an international agreement on non-deployment governance (deployment moratorium) and internationally agreed mandatory approaches for certain aspects of SRM research.

6.3.2 Empowerment of actors and knowledge types

Even though the need for the involvement of policy makers has so far been normalised, the initiative's efforts have not yet resulted in the empowerment of policy makers with regard to taking policy decisions on the issue. The struggle C2G has been experiencing to overcome policy makers' reluctance to address SRM governance is evident in the fact that its initial aspiration to already adopt an agreement on a deployment moratorium at UNEA-4 was downscaled to a decision that would commission an international assessment. C2G's work in this regard is often hampered by the fact that senior officials do not dare to address the issue of CE openly as it would amount to career suicide (ReSo4; Harvard Project on Climate Agreements, 2018, p. 59). Political leaders, therefore, would only have limited incentives to take the topic on board in the short term (ReSo4). The governance initiative is struggling a lot with overcoming policy makers' reluctance to engage with the topic as the informational deficits could only be addressed then. With its rapid entry in the governance landscape and aggressive networking efforts, the initiative seems to have basically overrun some of the political actors, thus intervening decisively in the pace of this governance discussion.

In the case of non-state actors, the initiative supports some efforts to push SRM governance forward. As mentioned in the interventions part already, the promotion of public deliberation exercises together with civil society organisations does thereby not really play a role. All efforts are geared towards creating support for SRM governance. Its engagement with civil society or humanitarian organisations, think tanks and sub-national actors has not yet succeeded in terms of generating a bottom-up momentum for SRM governance. Distrust towards the initiative itself and diverging positions especially among NGOs impede this endeavour. Many think tanks are, however, closely cooperating with the initiative.

Through its governance narrative, the successful engagement with governance experts and think tanks, it becomes clear that the initiative primarily empowers research of social science nature and specifically governance research. However, the initiative also engages with CE researchers and supports a general need for more research. C2G's governance narratives reveals a focus on issues of justice and agency, thereby recognising the moral authority vulnerable nations hold in the climate or sustainable development realm. The initiative tries to strengthen the role of developing countries in CE governance discussions as for example shown during UNEA-4 as a CE assessment at the international level would also have benefitted those countries most that lack research capacities.

So far, the initiative's interventions have not resulted in the empowerment of policy makers to take policy decisions on CE. Whether the catalysation of partners to build a bottom-up momentum to put pressure on government officials and policy makers will become more successful in the near future needs to be seen.

6.4 Conclusion

This chapter answers research question 1.3. Figure 6 provides an overview of the results of the analysis of how C2G intervenes and actually steers the governance landscape.

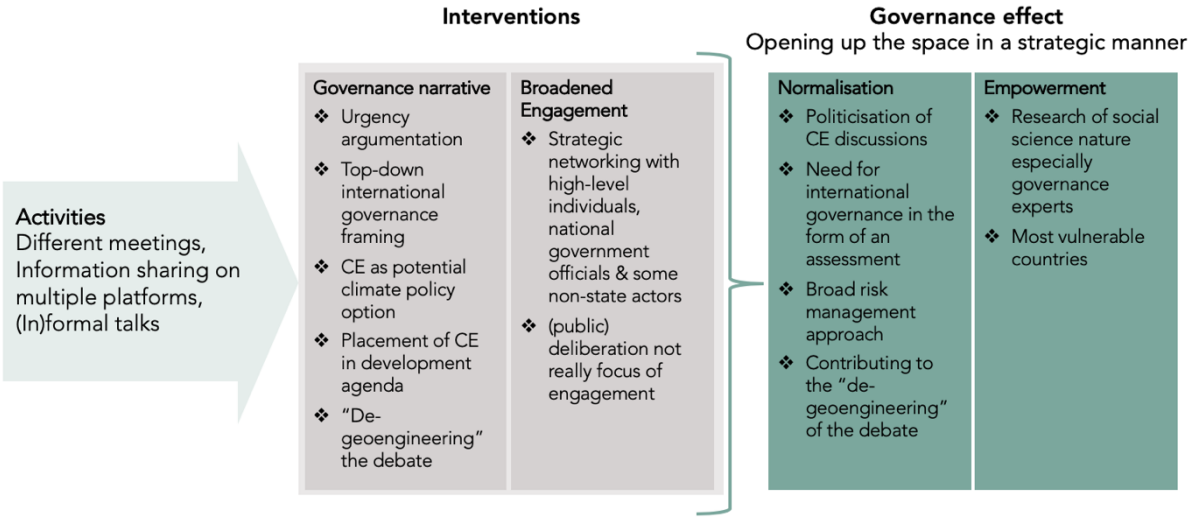

Figure 6: De facto governance by C2G

C2G's interventions into the governance landscape result in the steering effect of strategically opening up the space. First, certain governance directions got normalised as a consequence of the two interventions. A shift in CE discussions towards political and ethical questions is perceivable. In addition to that, the need for international governance in the form of an international assessment got to a certain extent normalised at UNEA-4 through the Swiss resolution on geoengineering. During the assembly the need for a broad risk management approach to CE governance got also normalised as the issue was taken out of the climate realm. C2G also contributes to the normalisation of the "de-geoengineering" of SRM (governance) discussions. Through the promoted governance narrative and the successful engagement with governance experts and think tanks, the initiative clearly empowers research of social science nature. So far, the initiative's interventions have not resulted in the empowerment of policy makers to take policy decisions on CE. Whether the catalysation of partners to build a bottom-up momentum to put pressure on government officials and policy makers will become more successful in the near future needs to be seen.

The following chapter will bring the results of this chapter and the other two empirical chapters together to answer the main research question and to reflect upon them.

7 Discussion and Conclusions

As final chapter, this part brings together all the results of the empirical analyses and reflects upon the broader theoretical context introduced in the conceptual framework. First, the overall research question is answered by also outlining communalities and differences in the steering effects of both governance initiatives. Second, it is reflected on the broader theoretical context by drawing lessons for anticipatory governance options. Subsequently, the research's theoretical framework is reflected upon before concluding this research with some final remarks.

7.1 SRMGI and C2G: Deadlock or communicative gains?

In this section the main research question "How are novel non-state initiatives steering the governance landscape and what are the implications thereof?" is answered. To answer the main research question, all the results from the three empirical chapters have to be brought together. The analyses in the fifth and sixth chapter have revealed that SRMGI and C2G have steering effects on the SRM governance landscape, they both open the space up in a strategic manner. In order to answer the main research question, it is analysed to which extent, the initiatives open the governance landscape up in common or different directions and what the implications are thereof. In addition to that, it is asked what effect their steering has on how future de jure governance options are imagined. The broader context introduced in the fourth chapter is also relied upon for answering the implications part. It has to be clarified that this research's goal is not to decry the initiative's efforts. On the contrary, the initiatives' efforts to strive for increased transparency, public participation and inclusiveness in the SRM governance landscape are highly valuable and a noble cause. This research only argues that one needs to be aware of the steering effects of the initiatives' activities and what implications that could entail. So, that countermeasures could be taken in case of unfavourable developments.

First, the few communalities regarding the initiatives' steering effects on the SRM governance landscape are outlined. As described in the fifth chapter, SRMGI empowers certain developing country actors. Even though C2G's activities have a global reach, the initiative still recognises the specific moral authority Global South stakeholders hold in the climate realm and tries to consider this in its interventions, thereby also relying on SRMGI's contacts. Therefore, it can in general be argued that both initiatives empower the position of developing country actors – though different actors - in the SRM governance landscape.

Another steering effect both initiatives have in common is the "de-geoengineering" of the SRM governance landscape. SRMGI has always been clear about the need to differentiate between CDR and SRM and is putting this into practice throughout its entire work (SRMGI, 2011, p. 14). C2G is also decisively contributing to the "de-geoengineering" of the discussions. Since its launch, the initiative has regularly been criticised by the epistemic SRM community for not differentiating clearly between the two CE categories. After the events at UNEA-4, C2G did then not only take the decision to separate SRM and CDR more thoroughly but also to change its name to "de-geoengineer" it. C2G indicates that its name change was motivated by the hope to dispel misunderstandings that the initiative would support CE and to put less controversial technologies more into the focus of the discussions. The need to drop the umbrella term is meanwhile widely recognised in the SRM governance landscape and both initiatives have been contributing to this situation by normalising the distinction between CDR and SRM. Due to these developments, it is also likely that at UNEA-5 two revised draft resolutions are submitted, one for CDR and one for SRM, according to two respondents (ReSo3; Dip2). At a recent conference it was, however, also argued that the

umbrella term would provide a common language and refence point to countries and other actors when addressing it in different environmental governance regimes and that it is therefore still a reasonable and valid term (DFG, 2019b). An implication of this shared steering effect could thus be that a common reference point is removed, and that entrenched conflicts are just circumvented instead of being addressed and resolved.

As both initiatives are seeking some governance change in this space, urgency arguments are brought forward to support this need. Both initiatives have in common that they hold a potential unilateral or minilateral SAI deployment scenario – also in the near future - as probable which forms the core of their urgency argumentation. Besides, C2G refers to the slippery slope development regarding SRM research to reinforce its urgency argumentation regarding research governance. An evident implication of this urgency narrative and their work's focus is the pushing of the governance landscape into the direction of SAI. Whereas SRMGI's work is officially only focusing on SAI and marine cloud brightening, C2G's work intends to address the entire range of SRM technologies. In both cases, however, the predominant focus lies on SAI as can for example be observed with the DECIMALS projects and C2G's events. It will need to be seen whether C2G's recognition that more emphasis should be put on less controversial technologies such as surface albedo modification will fall into place. The predominant emphasis on SAI is in line with the broader SRM governance landscape. The SAI imaginary holds a lot of power also due to this urgency argumentation and tends to overshadow broader CE governance discussions as seen during UNEA-4. Another implication of these speculations about potential SAI deployment is that these can for example distract from near-term concerns such as the current state of public engagement or private funding of SRM research. In fact, especially the issue of private spending on SRM research has often been mentioned by interviewees as a concern that has not yet been addressed adequately in governance discussions. The lack of public oversight of ongoing SRM research poses a challenge. It cannot be guaranteed that philanthropies' and other private funders' intentions are always well-meaning, especially in countries without good research governance standards. Both governance initiatives also mention it as an issue which needs to be addressed but do not take any concrete actions in this regard. As mentioned, the evoked urgency also risks undermining the need for public engagement or deliberation because it is a well-known fact that this requires time which contradicts the urgency argumentation. Moreover, the obsession about deployment scenarios is misleading as it gives the impression of ease of deployment. However, no SAI tests have been carried out to this day. Therefore, it is not even known whether these imagined technologies are actually deployable. Last but not least, in the urgency argumentation the planning for the future is framed "as a response to the implications of climate change, rather than about what we want the future to be and what options are open to complex societies navigating an uncertain future" (Foley et al., 2019). This implies a reactive approach to the climate risk instead of seeking a society-wide discussion on how the future should look like.

The preceding paragraph ended by emphasizing the importance of public deliberation which constitutes an anticipation process. SRMGI's interventions reveal internal inconsistencies when it comes to anticipation. On the one hand, the initiative promotes broad dialogic public engagement for exploratory foresight but on the other hand, SRMGI puts a predominant emphasis on modelling results and the importance of models in general, thus prioritizing predictive foresight. Despite the initiative's recognition that the governance landscape is narrow and that there is a need to broaden the discussions by including new types of actors, there is a lack of diversity in its engagement work. The analysis of SRMGI's steering effect reveals that certain kinds of publics are prioritised

throughout its activities, namely natural scientists. Lay publics and some environmental organisations are disadvantaged in this regard. C2G's engagement is different in a sense. C2G strives for a broader, society-wide CE discussion but organises only few (public) deliberation exercises as the majority of its activities take the form of advocacy for international governance in this space. This is the reason why C2G is mainly seeking engagement with state and intergovernmental actors as well as some non-state actors. The initiative takes more a meta-governance[12] role by for example aiming to catalyse public engagement exercises on SRM governance by civil society organisations which has not been put in practice so far. Therefore, the initiative also disadvantages certain actors. Despite the different nature of their engagement efforts, their steering effects have something in common: the sidelining of lay publics and some environmental organisations. There is thus a clear imbalance observable in the SRM governance landscape as the few engagement exercises conducted by academics cannot compare to the sustained engagement efforts by both governance initiatives that disadvantage lay publics. This might imply that lay publics do not have an equal voice in the development of SRM governance options.

In general, an important difference regarding the initiatives' interventions and steering effects is their understanding of governance. SRMGI does in general try to normalise governance of facilitative nature at this stage whereas C2G seeks top-down international governance of regulative nature. As shown in the fifth chapter, SRMGI is quite successful in normalising this facilitative understanding of governance in the form of capacity building of developing country scientists and cooperation on SRM modelling research also thanks to its justice argumentation which moralises the space effectively. C2G struggles with the normalisation of regulative governance as this requires overcoming policy makers' reluctance to address the topic. Another difference is that SRMGI restricts its interventions to research governance and does not go as far as to address broader SRM governance. C2G focuses on research governance but also broader governance of SRM as it is striving for an agreement on an SRM deployment moratorium. Regarding research governance, C2G is also clearly in favour of an international approach to research governance (for some aspects of it) which comprises principles and an oversight body but does not demand a moratorium on (outdoor) research activities until such governance is in place. However, such international research governance calls have not resulted in a steering effect yet in terms of getting normalised or empowering policy makers to work on the issue. Only the need for an international assessment to actually build states' capacity to perhaps take a decision on the issue of research and broader governance in the near future has been normalised to a certain extent. However, C2G's framing around top-down international governance has had implications on how policy makers start to think about governance as shown at UNEA-4. Getting to the heart of the distinction: Whereas SRMGI considers SRM solely as a research question, C2G tries to elevate the topic to policy makers to start a process by which SRM can be legitimately considered as one policy option to address climate change or better to ensure sustainable development (broad risk management approach) and be researched as such.

As mentioned in the preceding paragraph, SRMGI's justice frame got normalised to a certain extent as a handful of developing country scientists has taken it up. The initiative, therefore, successfully moralises the SRM governance landscape by giving a moral direction to the justice discussions. At the same time, SRMGI's work is solely focused on SRM by for example not juxtaposing it with other technological imaginaries in the climate realm such as an aggressive expansion of

[12] A meta-governance approach is "focused on framing the specific regulatory challenges, building governance capabilities, and creating policy networks." (Conca, 2018)

renewables, thus narrowing climate responses down. The upstaging of other climate responses in conjunction with the promoted justice frame normalises SRM itself. C2G, on the other hand, normalises the politicisation of governance discussions, thus trying to establish shared norms which recognise the moral authority of the most vulnerable countries in the climate and sustainable development realm but not narrowing discussions already down by spreading a certain frame and by focusing only on one climate response.

Another major difference which has already been briefly touched upon above are the knowledge types which get empowered by the initiatives. SRMGI empowers natural science research whereas C2G empowers social science research. In C2G's case the intended shift from scientists to policy makers and governance experts implies the sidelining of natural science research and for SRMGI the same applies to social science research. The design of the DECIMALS fund reveals that natural science research results shall then feed into social science discussions, thus supporting a pacing and not an integrated approach to knowledge production. Therefore, both initiatives are contributing to the separation of social from natural science questions in this space.

Considering the initiatives' governance effects and their implications, the initiatives are further contributing to the polarisation of the SRM governance landscape. Conca (2018) identifies the need for communicative gains in dialogues on CE (governance) due to a clash of epistemologies in terms of what is relevant knowledge to decide on CE development and governance and the tendency to talk past one another (Conca, 2018). Despite both governance initiatives' ambitious efforts to broaden informed discussions, there seems to be little progress made into the direction of communicative gains, especially regarding concrete governance options. Collective learning is impeded through the prioritisation of certain types of knowledge as well as types of actors by excluding others. The lack of communicative gains is contributing to the deadlock of the SRM governance debate. More communicative gains could perhaps be reached if the governance initiatives decide to join forces or to increasingly combine efforts as the polarisation is only leading to a situation in which people keep talking past each other.

These identified de facto governance effects also shape how future de jure governance options are imagined. The distraction from near-term governance concerns which is inherent to C2G's steering has for example implications for how formal, state-led anticipatory governance is imagined. Due to its deployment obsession, the sidelining of lay publics and the framing around top-down regulative governance, little imagination is left for an international deliberative body before taking any regulative decisions as revealed during UNEA-4. The role of national governments and intergovernmental actors is considered the one of regulators instead of members of a collective learning process which is essential to deliberative engagement. Therefore, many actors in the SRM governance landscape fear the involvement of (inter)national policy makers as that this might result in premature regulations. These reactions and the UNEA-4 resolution reveal that the establishment of an international deliberative body is currently not considered a de jure governance option. In the case of SRMGI, state actors are not really considered relevant participants of anticipation processes. If at all, state actors should get involved at a later stage. The moralising effect flowing from its equity frame might work against concrete (de jure) governance options as it carries the implicit message that developing countries should not care about the development of a(n) (inter)national research framework even when research is moving forward. This might also be one of the reasons why SRMGI's engagement work does not so much revolve around the discussion of concrete research governance options which got also revealed with the design of the DECIMALS fund. Therefore, it is argued that a certain disconnection of engagement from decision making is supported

by its work. Since C2G's interventions sideline deliberative engagement and seem to solely focus on catalysing decision making, the same disconnection is recognisable in its interventions and governance effects. All in all, it can thus be concluded that an overall steering effect flowing from both initiatives is the tendency to support a disconnection of anticipation from decision making in different contexts. This is not really in line with the rationale of anticipatory governance.

7.2 Constructing anticipatory SRM governance

The analysis of the initiatives' governance effects allows for the drawing of some lessons for the general construction of anticipatory governance of these emerging technologies. The initiatives' steering effects thus provide an insight into the realities and challenges of constructing anticipatory governance options which are outlined in the following. Unfavourable tendencies and developments should be counteracted because only if practiced well enough the ideals of deliberative democracy are met (Foley et al., 2019).

To put anticipatory governance in practice is clearly a difficult undertaking. As outlined in the conceptual framework, anticipatory governance involves an anticipation process which can take different forms (e.g. public deliberation/engagement, scenario development, foresight methods). SRMGI's steering effect reveals the challenge of implementing anticipation processes in terms of how fast issues can be narrowed down (e.g. justice argumentation, need for more modelling research) instead of opened up and how much it takes (e.g. time and financial resources) to design an integrated research project. Even though it is important to not let the perfect be the enemy of the good, non-state, state or intergovernmental actors carrying out deliberation/engagement processes should be reflective on these steering effects and whether they really reflect participants' opinions. Anticipation processes can have certain tendencies in terms of justifying specific paths or decisions. The establishment of a legitimate (international) oversight body which coordinates the different anticipation processes and follows up on their outcomes might be a sound solution. This is where governments could come in and take over a minimal governance role. Whether state actors will, however, overcome their reluctance to engage with the issue remains to be seen. In the meantime, non-state actors will go on playing an important role in the organisation of anticipation processes with or without the backing by state actors. Non-state actors operating in this space need to put a lot of emphasis on creating legitimacy for their activities as shown by the case studies. The above identified disconnection between engagement and decision making undermines the actors' legitimacy. Current anticipation processes predominantly engage with peoples' opinion on the controversial technologies and with the question whether there might be a need for their deployment one day. It would, therefore, be essential to engage more thoroughly with concrete governance options. Current anticipation efforts in the SRM governance space would have greater potential if more cooperation and coordination would take place between them, also in terms of experimentation with different forms of dialogue.

Even though the fact that a resolution on geoengineering has been brought forward at UNEA-4 shows some states are willing to slowly start an international process, an assessment is still far from an agreement on an SRM deployment moratorium. Therefore, it would perhaps be more fruitful if international governance would not immediately be equated with regulation(s) but take a more deliberative nature. The incomprehension which has been expressed by many natural scientists, by some social scientists and other non-state actors towards the need for international SRM governance or in general the involvement of (inter)national policy makers at this stage, reveals how differently the concept of anticipatory governance is understood in various research communities. Many STS researchers consider it a science project and do not really see a role for international

institutions or discussions in anticipatory SRM governance, also often referring to it as responsible research and innovation. It is feared that the sociotechnical maturity of a technology could be interfered with if restrictive (inter)national governance is implemented. First, more responsible research should be conducted to resolve some of the open scientific questions before (inter)national policy makers get involved. The fear that conversations in a multilateral context could lead to overly restrictive (inter)national research governance is obviously also shared by many SRM research advocates. There is thus little support from some powerful stakeholders in the SRM governance landscape in initiating a multilateral discussion at this stage. In general, this reveals that the role of international institutions in anticipatory governance is right away imagined to be of (restrictive) regulative nature. The point that (inter)national institutions could play an important role in the promotion and strengthening of anticipation processes before taking up discussions on regulative governance mechanisms is thereby not really considered. Therefore, some exchange between the different research communities might also be helpful in enhancing dialogues. Another argument which is brought forward against an international conversation is the fact that national political cultures respond differently to technologies and risk. Due to different civic epistemologies[13], international conversations about SRM would only further complicate the issue. However, especially then multi-stakeholder dialogues could help to advance social learning by embracing these conflictive viewpoints and placing them into a sustained and transformative communication (Conca, 2018). The challenge is that this social learning should have worked out the SRM governance needs before the culturally specific practices of science take hold in these discussions.

The preceding paragraph revealed that the striving for an SRM deployment moratorium, thus regulative governance at this stage is not backed by many actors in the SRM governance landscape. This does not mean that the same accounts for policy makers. However, the developments at UNEA-4 clearly showed that the time was not ripe for an agreement on an SRM deployment moratorium. Therefore, it might be more valuable for C2G to pursue the establishment of a global forum for stakeholder dialogue. This has also been proposed by governance experts together with an intergovernmental body whose task it would also be to manage the forum (see Chhetri et al., 2018). Even though C2G often talks about encouraging society-wide discussions in its publications and endorsed the recommendations of the cited governance report, its efforts so far do not really align with the near-term establishment of some sort of multi-stakeholder dialogue. The strengthening of capacities for such public engagement or in general of anticipation processes by national governments or appropriate UN bodies might be a good first starting point. Instead, all efforts are geared towards an agreement to implement an SRM deployment moratorium, thus kind of skipping the intermediary step of debating the purpose of SRM research and development and whether and how SRM could be included in the portfolio of climate responses. This is at least how its efforts are perceived by many stakeholders in the SRM governance landscape. Its work might be less criticised if the emphasis would be put on the catalysation of anticipation processes involving broad range of stakeholders which is essential for anticipatory governance.

Whether such a global-scale multi-stakeholder dialogue is really feasible remains contested though. The events at UNEA-4 revealed that it might be more fruitful to start discussions not in an already established international forum or institution. Whereas many governance experts consider UNEA the ideal forum for such a discussion due to its broad environmental focus, UN Environment's dedication to the environment and the interests of developing countries might obviously

[13] "Civic epistemologies are the stylized, culturally specific ways in which publics expect the state's expertise, knowledge, and reasoning to be produced, tested, and put to use in decisionmaking." (Jasanoff, 2019)

not necessarily be in the interest of some influential states such as the US. Conca (2018) provides two arguments why the time might not be ripe for a global-scale multi-stakeholder dialogue. Usually multi-stakeholder dialogues emerge in case transnational regulatory negotiations are deadlocked or in case that a promotional coalition with broad-based support and influence senses benefits in overcoming confrontation to move on to dialogue (Conca, 2018). The first is not really the case for SRM governance discussions and the latter is also not foreseeable considering for example C2G's success in convincing major environmental NGOs that the issue would be ripe enough for them to invest more of their resources. Ripeness can also be brought about by changing circumstances such as an unexpected shift in climate politics (Conca, 2018). However, the SR15 revealed that the issue is not considered ripe enough among the climate science community and the IPCC's Sixth Assessment will probably also not assess SRM more extensively. In addition to that, the fact that the UN Environment's Frontiers report 2018/2019 did in the end not include a chapter on solar geoengineering and that the topic was not mentioned at all at the UN Climate Change Summit in September 2019 can be considered a sign for the topic's perceived immatureness. Therefore, one interviewed governance expert (ReSo5) argued that deliberative international governance would probably only get initiated by an upsetting change in the SRM governance landscape such as for instance a radical increase in funding for indoor and outdoor research.

The construction of anticipatory governance will remain a challenging task but, ending on a positive note, it has also to be considered that "elements of anticipatory governance are in practice and that we may, in fact, be doing better than we have done recently with nanotechnology or with genomics" (Foley et al., 2019).

7.3 Theoretical reflections

In the following, a reflection on the theoretical concepts introduced in the second chapter and used in this research is presented. The case studies have provided some insights into the debate on anticipatory governance that can help to understand its realities and challenges with the help of the de facto governance lens whose operationalisation is reflected on subsequently.

As mentioned above, the two governance initiatives are very different organisations. Therefore, choosing a comparative case study research design has proven challenging in terms of developing an applicable analytical lens to assess the empirical findings. It hast to be mentioned that there are obviously also other theoretical approaches possible to look at the governance initiatives. One could for example also have worked with relevant literature on policy or norm entrepreneurs to distill typical qualities of these. The concept of de facto governance is still considered a suitable lens as it allows for the highlighting of the unique way in which the novel non-state initiatives intervene in and steer this governance landscape of emerging technologies. The de facto governance lens has also been helpful in understanding the influence that de facto governance can have on formal, de jure types of steering.

De facto steering can take implicit but according to Owen (2014) also more explicit forms. In the case of SRMGI, the steering is more implicit whereas in the case of C2G it is more explicit. Therefore, this research supports a broader understanding of de facto governance compared to the publication by Gupta and Möller (2018). So far, the de facto governance lens has mainly been used to investigate the steering by scientific assessments or experts. This research, however, argues that it is also applicable to the case of the two governance initiatives. A recent publication by Boettcher (2019) who analyses the discursive structure of the governance debate through interview with governance experts applies the de facto governance in a similar manner as the presented research.

Therefore, it is argued that the de facto governance lens provides valuable insights into the discursive but also non-discursive structures of ongoing governance debates around emerging technologies.

In the case of the governance initiatives it is not only the discursive but also non-discursive activities which result in interventions and realise a governance effect. Therefore, the de facto governance lens had to be operationalised to fit the purpose of the governance initiatives. As the lens introduced in the second chapter constitutes a self-constructed one, there might have been other ways to do so. The developed lens fulfilled its purpose though. The distinction between the advancement of a certain governance narrative and broadened engagement was in the case of C2G not straightforward as engagement is not solely understood as deliberation but also as creating legitimacy for the initiative's goals itself. The distinction between the two types of interventions is of analytical nature. Also, the lens was intentionally kept quite broad due to the assumed differences between both initiatives which turned out to be the right approach. In general, the constructed lens can provide valuable insights into the steering effects by similar non-state initiatives in other fields of emerging technologies. The steering by such initiatives is subtler than that of typical advocacy organisations.

A limitation of this research is the fact that the governance initiatives' work is going on. It is argued, however, that it is important to have a closer look at de facto sources of steering while they are still evolving. The steering by both initiatives might, however, change in the coming months/years. SRMGI's work was recently branched out with the launch of the DECIMALS fund and C2G's mission might also slightly change after the UNEA-4 events. Therefore, a follow-up research in two or three years with the same analytical lens might provide some new interesting insights obviously also because the SRM governance debate might have seen some new developments as well.

The discursive and non-discursive interventions in the governance landscape require continued consideration and scrutiny. However, it has also to be noted that the field of SRM research is currently a very supply-driven one. Therefore, this research will not end by stating many proposals for further research on the SRM governance landscape as long as there is not any new political, scientific or public input into the field observable. Considering the vast amount of available governance-related publications, I would argue that academics have exhausted the majority of topics right now. There is no forward-momentum in SRM (governance) discussions due to lacking demand. The only need for more research which is created by the current supply/demand mismatch of SRM research would be to look further into the responsibility of academic researchers in terms of contributing to this oversupply.

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Annex I: Overview of interview respondents

Due to the political sensitivity of the issues addressed during the interviews, none of the interviewees are named by name or organisation. The respondent type allows for some broader allocation to show the distribution across different groups of actors involved in the current SRM debate.

Code	Medium	Date	Respondent type
ReSo1	Skype	07/12/2018	Researcher from the Social Sciences & Humanities
NGO1	Skype	18/12/2018	NGO representative
ReSo2	Skype	20/12/2018	Researcher from the Social Sciences & Humanities
ReNa1	Skype	22/01/2019	Researcher from the Natural Sciences & Physics
NGO2	Phone	25/01/2019	NGO representative
NGO3	Skype	28/01/2019	NGO representative
NGO4	Skype	05/02/2019	NGO representative
ReSo3	Skype	21/03/2019	Researcher from the Social Sciences & Humanities
NGO5	Skype	22/03/2019	NGO representative
ReNa2	Skype	01/04/2019	Researcher from the Natural Sciences & Physics
ReSo4	Skype	09/04/2019	Researcher from the Social Sciences & Humanities
ReSo5	Skype	12/04/2019	Researcher from the Social Sciences & Humanities
Dip1	Skype	22/04/2019	Diplomat
ReNa3	Skype	23/04/2019	Researcher from the Natural Sciences & Physics
ReSo6	Phone	24/04/2019	Researcher from the Social Sciences & Humanities
NGO6	Skype	26/04/2019	NGO representative
ReSo7	Phone	09/05/2019	Researcher from the Social Sciences & Humanities
Dip2	Phone	15/05/2019	Diplomat

Annex II: SRMGI's outreach meetings – A summary

Setting	Organizers	Participants	Procedure	Integration
Governing Geoengineering in the 21st Century **18-19 July 2011** **Singapore**	RSIS Centre for non-traditional Security Studies, Oxford Geoengineering Programme, SRMGI	24 local participants from different backgrounds including representatives of the government, WWF, ETC Group, EDF	discussions on appropriate framing of CE, importance of public engagement, challenges of effective governance	**Regional speakers**: governance consultant, climate scientist, meteorologist, NGO representative **Northern speakers**: 3 STS researchers, SRMGI staff member, 5 Royal Society panel members
Geoengineering: Science, Ethics, Politics and Governance **20 September 2011** **Delhi, India**	Council on Energy, Environment and Water; Centre for Study of Science, Technology and Policy; SRMGI	Participants working on environment, climate and development issues including representatives of the government, Harvard University, UCL, World Bank, TERI, Indian Institute of Technology, Tata Institute of Social Sciences	introduction in SRM science, presentation on SRM research in India followed by a panel of social scientist discussing ethical and governance issues, scenario exercises	**Regional speakers**: climate scientist, a penal of Indian social scientists **Northern speakers**: climate engineer, STS researcher
Symposium on SRM research, governance and uncertainty **October 2011** **Tianjin, China**	China Association of Science and Technology, Geographical Society of China, SRMGI	Over 100 participants who were mainly academic from the physical sciences, social sciences and engineering from different Chinese universities, CEEW, The Royal Geographical Society	presentations on climate change and its effects, international governance of solar geoengineering, carbon balance and the effects of rising sea levels followed by discussions	-
Workshop on the research, governance and implications of SRM geoengineering	Sustainable Development Policy Institute, SRMGI	30-40 participants from academia, policy-making, civil society	-	-

November 2011 Islamabad, Pakistan				
Governance of SRM: African Perspectives 27 June 2012 Dakar, Senegal	African Academy of Sciences (AAS), National Academy of Science and Technology, UNESCO, SRMGI Funding by InterAcademy Partnership	45 participants including policymakers, academics, journalists and the members of the public On the picture: 31 participants, 8 women	Presentation on the climate threats faced across Africa and possible SRM implications, followed by a talk on the scientific and socio-political implications of SRM and its governance issues, lecture on Africa's involvement in SRM, group exercises and plenary discussion	**Regional speakers**: environmental scientist, geologist, physicist, environmental scientist, economist **Northern speakers**: 2 SRMGI staff members
Solar Geoengineering: Research, Governance, and African Involvement 28 November 2012 Boksburg, South Africa	African Academy of Sciences (AAS), SRMGI Funding by InterAcademy Partnership	On the picture: 13 participants, 4 women	presentation on climate change in Africa, followed by an interactive group exercise (line exercise) on SRM research and governance, followed by a discussion on the engagement with SRM research and governance by African stakeholders	**Regional speaker**: chemist **Northern speaker**: project director
African Involvement in Solar Geoengineering 14 January 2013 Addis Ababa, Ethiopia	African Academy of Sciences (AAS), SRMGI Funding by InterAcademy Partnership	On the picture: 26 participants, 4 women	Focused on participant dialogue, small group discussions and group exercises, open plenary discussion	**Regional speakers**: 2 chemists **Northern speaker**: project director
Climate engineering as a response to climate change? 21 July 2014 Berkeley, USA	Beahrs Environmental Leadership Program	45 participants from 33 different countries, mainly developing countries	-	-
International workshop on CE (focus on Asia-Pacific region) to discuss challenges of	-	Natural scientists, social scientists, humanities scholars from Japan, Asia and the Pacific	-	-

international collaboration on CE research; discussions focused primarily on SRM geoengineering options, particularly SAI 22-23 March 2016 Tokyo, Japan		islands as well from the USA and Europe		
Workshop on SRM 7 July 2016 Kingston, Jamaica	Caribbean Academy of Sciences Jamaica Chapter (CAS-J), University of West Indies (UWI), and Build Better Jamaica, SRMGI	50 people including local academics, policy makers (relatively many government officials) and NGO representatives	Stronger focus on the ethics of SRM than usual presentation of climate threats faced by SIDS, followed by an introduction to the scientific and socio-political dimensions by the project director, a presentation on the economics of SRM, a presentation on the ethical issues, followed by one on the religious perspectives, a panel Q&A session, a participant discussion with a facilitated plenary conversation	Regional speakers: Ministry representative, President of the Academy of Sciences, director and program officer of university, engineer, chemist, climate scientist Northern speakers: economist, STS researcher, project director
Workshop on SRM geoengineering research and governance 22 November 2016 São José dos Campos, Brasil	Brazil National Space Research Institute, SRMGI	40-50 people including local academics, policymakers, and NGO representatives	presentation on the climate context and science behind SRM techniques by a national scientist, introduction in the scientific and socio-political dimensions of SRM by the project director followed by one on the potential risks and benefits of SRM, open discussion, presentation on research governance (project director) and the international governance dimension, Q&A session, World Café-style exercise, participant discussion	Regional speakers: 2 climate scientists, economist, physicist, international governance expert Northern speaker: economist, project director

Workshop on SRM **25 November 2016** **Guadeloupe**	Jamaica Chapter of the Caribbean Academy of Sciences	25-30 people – mainly scientists from different disciplines	Presentation on climate context, scientific and socio-political implications followed by a group conversation	-
Workshop on the Science and Governance of SRM **29 November 2016** **Delhi, India**	Council on Energy Environment and Water, SRMGI	28 experts	First session: usual SRMGI program Second session: presentations on SRM research around Asia (Philippines, Japan, India)	**Regional speakers**: Geographer, 2 atmospheric scientists, 2 CEEW staff members, 2 environmental scientists **Northern speaker**: project director
Workshop on SRM **6 December 2016** **Islamabad, Pakistan**	Sustainable Development Institute (SDPI)	50 people	presentation into climate context followed by introduction into the sciences, socio-political issues and governance of SRM, participant discussions on the next steps for SRM research governance in Pakistan	**Regional speakers**: Ministry representative, geologist, political scientist **Northern speakers**: Germany-based climate consultant, project director
Workshop on SRM **27 February 2017** **Dhaka, Bangladesh**	Bangladesh Centre for Advanced Studies	46 people	-	**Regional speakers**: hydrologist, environmental policy expert, climate scientist **Northern speakers**: C2G director, project director, Germany-based environmental consultant
Workshop on SRM **1 March 2017** **Bangkok, Thailand**	National Science Museum, Stockholm Environment Institute, SRMGI	40 people	presentation on climate threats in Thailand, introduction to SRM, Q&A and plenary discussion, World Café exercise, panel discussion	**Regional speakers**: science communicator, Ministry representative, institute representative

				Northern speakers: project director, SRMGI staff person, C2G director
Workshop on SRM **8 March 2017** **Manila, Philippines**	The World Agroforestry Centre, SRMGI	45 people		**Regional speakers**: 2 environmental scientists **Northern speakers**: international governance expert, climate engineer, NGO representative, project director
Workshop on the Science and Governance of SRM **13 May 2017** **Bejing, China**	Beijing Normal University, SRMGI	56 climate experts from around Beijing, representatives of the China geoengineering research programme, former Minister of Science and Technology for the People's Republic of China	introduction into SRM science and governance, introduction into the Chinese SRM research programme, presentation on governing SRM research by project director, small group table exercises, plenary discussion	**Regional speakers**: environmental scientist, hydrologist, engineer, 2 physicists, climate scientist, STS researcher, former Minister of Science and Technology **Northern speakers**: physicist, project director
Introductory workshop on the science and governance of SRM **6 June 2017** **Nairobi, Kenya**	AAS, Stockholm Environment Institute Africa, African Technology Policy Studies Network, African Centre for Technology Studies	60 participants from varied backgrounds, including academia, government, NGOs, intergovernmental bodies and media	-	**Regional speakers:** environmental scientist, geologist, NGO representative, 2 meteorologists, chemist **Northern speakers:** project director
SRMGI Global Forum **October 2017** **Berlin, Germany**	Held in concert with the Climate Engineering Conference 2017	-	-	

	Goal: SRMGI participants can connect with geoengineering researchers from developed countries and discuss Funders: Open Philanthropy Project, IASS			
Introductory workshop on the science and governance of SRM **20 February 2018** **Wellington, NZ**	LEA International, SRMGI	-	-	**Regional Speakers**: international governance expert, environmental scientist **Northern speakers:** engineering, project director

Annex III: C2G's events

Location and Partners	When?	What?	Who? (only for (co)hosted/ organized events)
UN Environment Assembly (UNEA-4)	11-15 March 2019	- C2G2 was present at the conference as a driving force behind the Swiss resolution - on the 6 March (during OECPR 4), C2G2 convened a lunchtime discussion on "Learning to govern geoengineering: insights from different experiences on environmental governance" in the VIP Delegates Lounge	
Chatham House Panel discussion: "Rethinking the Governance of Solar Geoengineering" (co-hosted by C2G2)	21 February 2019	- Panel discussion with four speakers with different backgrounds	Speakers: Institute for Governance & Sustainable Development repr., Mechanical and aerospace engineer, Chatham House repr., C2G2's executive director
Evening reception at the Asia-Pacific ministerial meeting in Singapore (convened by C2G2)	23-25 January 2019	- Bilateral meeting with representatives of governments, IGOs and CSOs - Hosting an evening reception for delegates to inform about latest developments regarding the governance of geoengineering	
COP24: IETA side event on the governance of solar geoengineering deployment (attended by C2G2 repr.)	12 December 2018	- Four panellists (Janos Pasztor, David Keith, Daniel Bodansky, Susan Biniaz) discussed the potential role of SRM in addressing cc – relative to mitigation and adaptation	
COP24: Royal Society side event on CDR (attended by C2G2 repr.)	6 December 2018	- Pasztor presented C2G2's new CDR governance paper	
CBD COP14: side event on governing climate-related geoengineering in the context of CBD's 2050 vision and related strategies (attended by C2G2 repr.)	18 November 2018	- Format not specified	

Paris Peace Forum (attended by C2G2 repr.)	11 November 2018	- Pasztor participated in a panel discussion on the state of multilateralism	
5th Taihu World Cultural Forum in Beijing: panel discussion (attended by C2G2 repr.)	17-19 October 2018	- Pasztor was a panellist at a session on Ecological Civilization Governance - Pasztor also had a private audience with Minister XIE Zhenhua, China's Special Envoy on Climate Change with whom he mainly seems to have addressed CDR and the Swiss resolution at UNEA-4	
C2G2's Advisory Group meeting	28 October 2018	- Addressed the implications of IPCC SR15 for C2G2's work - Reflection on C2G2's progress achieved since its launch - Identification of opportunities, challenges and activities for C2G2's work in the following year	
Reading conference (attended by C2G2 repr.)	September 2018	- Discussion of an expert report on short-term recommendations for SRM governance	
CBD SBSTTA side event: "Climate related geoengineering: research, governance and the 2050 vision" in Montreal (co-hosted by C2G2)	6 July 2018	- Discussion among 43 international experts which was stimulated by presentations and commentary on substantial research and governance knowledge gaps	Presenters: Head Rio Conventions, Mercator Research Institute for Global Commons and Climate Change repr., C2G2's senior program manager, C2G2's senior director programme manager, ETC Group repr., indigenous repr., Egyptian Environmental Affairs Agency and National Focal point repr.
Vatican Seminar on the Governance of Geoengineering (organized by C2G2)	1 June 2018	- The seminar included presentations - Next to academics, several religious congregations and Catholic NGOs took part in the seminar	Speakers: scientists from IASS and Climate Interactive and humanitarian experts from the Red Cross Red Crescent Climate Centre
Briefing and workshop on geoengineering governance at UN Environment in Nairobi (organized by C2G2)	22-23 May 2018	- 22nd of May: Briefing of UNEA ambassadors and civil society organizations - 23rd of May: Workshop on geoengineering governance for advisors which was attended by over 20 government, civil society and academic participants; the workshop included an **interactive game** on that "explore the challenges of balancing	Discussions on 23rd of May were stimulated with short presentations from: Assistant Secretary General, World Meteorological Organisation; 2 natural scientists, ETC Group repr., Indian think

		development needs with managing climate risks"	tank repr., 2 C2G2 staff members
Geoengineering session at the "Understanding Risk Forum" in Mexico (co-organized and moderated by C2G2 repr.)	17 May 2018	- C2G2 and the Red Cross Red Crescent Climate Centre introduced risks (and potential benefits) caused by potential solar geoengineering deployment - **Framing techniques which were inspired by well-known art and board games** were used to express people's emotions regarding solar geoengineering and its humanitarian dimension - The event was attended by over 1000 stakeholders including governments, academia, civil society, donors, and private sector experts - After an initial presentation on basic concepts, two art-infused short videos were streamed both revolving around SRM, an introduction in compensation instruments in case of deployment followed, then parallel discussions with a different focus followed	Speakers and Moderators: C2G2 repr., 3 Red Cross Red Crescent Climate Centre repres., environmental governance expert
2018 Climate Engineering Governance Workshop): "Governance of Climate Interventions on a Warming Planet – the importance of stakeholder participation"	6 April 2018	- Presentation by Pasztor at Arizona State University	
Joint webinar with GreenFaith and C2G2 (co-organized by C2G2)	April 2018	- Goal: introduce geoengineering to interested faith leaders from a range of religious backgrounds - Panel of four speakers	Speakers: Climate Interactive repres., IASS repres., philosopher
Workshop on transdisciplinary research and governance on climate-related geoengineering in Montreal (convened by C2G2 in collaboration with the Secretariat of the CBD)	17 December 2017	- Workshop on the transdisciplinary research and governance on climate-related geoengineering in relation to the CBD which was attended by 47 international experts - Two breakout sessions followed	Short presentations and commentaries stimulated the discussions; speakers were: C2G2's executive director, Deputy Executive Secretary of the Secretariat of the Convention on Biological Diversity, solar geoengineering researcher, FCEA representative, UK research council member, STS

			researcher, ETC Group repr., indigenous people repr., international law expert
Panel session at the Planetary Security Initiative conference in The Hague (attended conference but hosted panel session)	12-13 December 2017	- The topic of the panel session was "Security Dimensions of Geoengineering"	
COP23: Panel discussion on the need for geoengineering governance (attended by C2G2)	13 November 2017	- Three speakers (Pasztor, Honegger & Hunt) discussed the topic: "Can we refreeze the Arctic? – Geoengineering governance"	
Webinar on the governance of geoengineering research under the Convention on Biological Diversity (co-convened by C2G2)	2 November 2017	- Aim: inform a broad range of participants about the state of play of geoengineering research and its governance - Structure: seven 10-minute presentations from speakers with different backgrounds followed by a Q&A session	Speakers: Environmental scientist, Mechanical and aerospace engineer, engineer & geochemist, Harvard Solar Geoengineering Research Program repr., STS researcher, Indigenous International Forum on Biodiversity repr., NGO repr.
Workshop session at the CEC17 in Berlin (organized by C2G2)	10 October 2017	- Convention of a 90 minutes World Café style workshop session with over 60 participants - Topic of the discussion: *Achieving the SDGs: Governing Geoengineering in a post-Paris world* stimulated by expert presentations	Moderation by executive director; presentations by Assistant Secretary General of the World Meteorological Organisation, Director of the UN Secretary General's Sustainable Development Unit, Deputy Executive Secretary of the Secretariat of the Convention on Biological Diversity, an adviser at the South Centre
Informal evening drink at the Asia-Pacific Ministerial Summit on the Environment in Bangkok (hosted by C2G2)	6 September 2017	- Drinks including short speeches	executive director, executive secretary of UN Economic and Social Commission for Asia and the Pacific (ESCAP), ETC Group repr., Chinese think tank repr.

Webinar – "A briefing and discussion on solar geoengineering: science, ethics and governance" (co-convened by C2G2 and FCEA)	16 May 2017	- the webinar sought increased stakeholder engagement on the question if, and how research should be conducted and considered the possible deployment of SRM	Speakers: Mechanical and aerospace engineering; humanitarian expert, Atmospheric Scientist, Indian think tank repr., environmental governance expert, STS researcher, ethicist
Forum on U.S. Solar Geoengineering Research (attended by C2G2 repr.)	24 March 2017	- Pasztor contributed to the panel discussion 'State of Play'	
Launch of the initiative at the Carnegie Council headquarters in New York City	16 February 2017	- Panel discussion on CE key issues	Panel participants: FCEA representative, computing scientist, Bipartisan Policy Center repr., humanitarian repr., Greenpeace repr., journalist, C2G2's executive director

Annex IV: A selection of interview questions

In the following, a selection of some interview questions is presented. It is to be noted that the interview guides varied decisively depending on the interviewee's background and that therefore only a small sample is provided.

General questions:

What do you think needs to happen next in the SRM space? What should we be looking for?

Do you see a need for more research? If so, of what kind?

What is your take on the events at the fourth session of the UN environment assembly this March?

Do you see the need for more scientific assessments of CE technologies by other intergovernmental bodies next to the IPCC?

Are there any aspects you think that do not receive enough attention in the current SRM governance debate?

How should anticipation/engagement processes be conducted on SRM (governance)?

How should private funding for SRM research be governed?

What should be the role of (inter)national policy makers in SRM governance at this stage?

What is the role of non-state initiatives in the current governance debate?

Questions relating to the governance initiatives:

How should the conversation on SRM (governance) be broadened?

Which actors do you consider as influential in the current SRM governance debate?

What role do the governance initiatives play in SRM (governance) discussions & research?

What is your take on the capacity building of developing country scientists to conduct SRM research?

What implications have SRMGI's developing country engagement efforts had on SRM (governance) discussions so far?

Do you see a need for an SRM deployment moratorium?

What do you think - what kind of implications will the events at the UNEA-4 have for C2G2's work?