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Scenarios
on stratospheric Albedo Modification Deployment in 2030

WORKSHOP REPORT

Priority Programme 1689 of the
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Content

Preface

This report, and the SPP 1689 scenario workshop informing it, had a short gestation. Stimulated by modeling efforts within the GeoMIP framework and constant encouragement from the SPP 1689 office in Kiel, we began to consider the social, economic and political patterns and determinants of future decision-making on climate engineering (CE) in mid 2014.

Because we cannot know or foresee the future of CE, we used scenarios to envision alternative plausible futures rather than to predict a probable policy trajectory. Scenarios provide an excellent tool for basic research on long-term policy problems with high conflict potential because they ideally identify plausible unintended consequences and pitfalls of decisions that may (or may not be) taken in the future.

The longer we thought about the scenario exercises already conducted on the topic of CE, the more we were convinced that we would like to take a slightly different route. First, we thought that we have to differentiate between several stages of CE deployment – technology development, testing, and intentional deployment – in order to get a more comprehensive picture of political decision-making on CE. Secondly, we found that a project with a shorter time frame (up to the year 2030), had so far not been carried out, although CE testing seems plausible within the next 15 years (this is not to suggest that we foresee that CE development, testing or deployment will or should have come to pass by 2030). Third, the composition of the scenario development group had to suit its purpose – to untangle existing narratives and long-held convictions and to explore new possibilities. We therefore deliberately involved junior researchers in the field who may (or may not) hold less set views on the politics and economics of potential pathways towards CE deployment, testing and deployment. Fourth, we applied a rather formalized and structured scenario construction method in order to create a more complete and evidence-based anticipation of future decision-making pathways.

We wrote the first proposal for the project in November 2014. Since then, we have received a lot of constructive advice from colleagues, workshop participants, and the SPP 1689 members. The Haus Rissen in Hamburg provided a splendid venue for the workshop and the hospitality of Rachel Folz has been instrumental in pushing this project forward and making it a truly rewarding experience. None of the above-mentioned institutions or individuals is responsible for any errors which may remain in this report.

We are grateful for the invitation and funding by the SPP 1689.

Sebastian Harnisch, Johannes Gabriel, Miranda Böttcher

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WORKSHOP REPORT

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1. Introduction

In today's world, policy makers face a host of long-term policy problems such as climate and demographic change, or technological revolution. These problems involve high levels of uncertainty and will have huge impacts on future generations (Sprinz 2013). Climate or geoengineering, the »deliberate, large-scale manipulation of the planetary climate system to counteract global warming« (Royal Society 2009: 1) represents precisely the kind of complex issue characterized by high levels of uncertainty and the potential to have huge impacts on future generations.[1] Whereas CDR technologies are projected to be more expensive and less effective, SRM technologies are often described as cost-efficient and are

1 There are two main categories geoengineering: Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM). CDR methods reduce the levels of carbon dioxide (CO_2) in the atmosphere, allowing outgoing long-wave heat radiation to escape more easily. SRM methods reduce the net incoming short-wave solar radiation and thus warmth reaching the Earth (Royal Society 2009).

expected to have an immediate effect, if ever deployed. In particular, stratospheric albedo modification (SAM) could potentially offer strong leverage.

In the face of deep uncertainty, the field of futurology is becoming increasingly relevant. Futurology is »the scientific study of possible, probable and desirable future developments, the options for shaping them, and their roots in past and present« (Kreibich 2007: 181). Among the multitude of futurology methods, scenario approaches are becoming increasingly popular (Kosow & Gaßner 2008: 6). A scenario is »a description of a future situation, including paths of development which may lead to that future situation« (Kosow & Gaßner 2008:11). Scenarios do not claim to predict the future, but rather provide a »hypothetical construct of possible futures on the basis of knowledge gained in the present and past« which can be used to reflect upon a set of numerous possible futures (Kosow & Gaßner 2008:12).

It may be impossible to foresee if and when SAM might be deployed in the future. However, it is possible to think about alternative deployment (or non-deployment) situations: Different scenarios based on alternative expectations and analytical thinking can be generated to contribute to anticipatory governance.

The goal of this SPP 1689 scenario project was to develop a first appraisal of what effects a high-risk climate intervention technology such as SAM could have on the dynamics of international relations. More concretely, it aimed to develop scenarios regarding »Political decision-making on stratospheric albedo modification deployment in 2030« to examine under which conditions states could opt for SAM deployment. In preparing for this project, we examined a variety of CE scenario exercises to identify potential gaps in the literature. The following section will position our scenario building exercise in the existing CE scenario landscape before the scenario building process we used is explained, the scenarios developed are outlined and the implications for further research are discussed.

2. The CE Scenario Landscape

While an unknown number of informal, unpublished scenario sessions have been conducted on the topic, there has so far been no comprehensive overview over the types of climate engineering scenarios developed and the methodologies they have utilized. The following represent the most well-documented scenario development exercises in the field of climate engineering.

The CGG Geoengineering Governance Scenarios Workshop which was held in October 2014 in London aimed to develop scenarios around the central question: How far may geoengineering technologies develop and under what institutional arrangements (ESRC 2014)?

The Scenario Planning for Solar Radiation Management (SRM) workshop was held in September 2011 in Yale, and the workshop

report and detailed scenarios were published in August 2013 (Banerjee, B. et al. 2013). The workshop was loosely based around the question: What key uncertainties need to be reduced before SRM research and deployment can be considered?

The Global Governance of Geoengineering: Using Red Teaming to explore future Agendas, Coalitions and International Institutions was based on an exercise carried out in Kingston, Ontario in 2011 (Milkoreit et al. 2011). It aimed answer the central question of how policy entrepreneurs can use the potential for strategic agenda-setting to shape the governance of geoengineering. The policy scenarios developed aimed to simulate and test the possible options for action and their consequences.

Several other authors have published articles which include the discussion of possible future »geoengineering scenarios« without using any explicit scenario techniques (see Baum, Maher & Haqq-Misra 2013; Bodansky 2013 & 2011; Planungsamt der Bundeswehr 2012; Schneider 2009). Numerous other scenario games and workshops have taken place at geoengineering conferences and academic gatherings without the proceedings having been published or otherwise made publicly available.[2]

An analysis of the most well-documented scenario-building exercises has shown that: The majority of scenarios developed were explorative policy scenarios based on qualitative data. They all sought to answer central questions on geoengineering governance. The chronological scope was generally medium- to long-term, and the geographical scope of all scenarios was international to global. The participants involved in the development of the scenarios were primarily academics or experts in the field, and the scenario techniques used were generally creative-narrative. State actors were privileged, and uncertainty and conflict potential were identified as central issues in all scenarios developed. All exercises included the eventual deployment of geoengineering technologies. Solar radiation management technologies were more commonly considered than carbon removal methods.

Our scenario project was far from the first conducted on the future of climate engineering. However, it had some features which make it unique in the CE scenario landscape.

First, our scenarios focused on a shorter time horizon than previous foresight projects (15 years) because we believe it is plausible to assume that deployment could happen within a short time frame if ongoing research shows that CE techniques currently under discussion can provide even limited leverage to lower global mean temperature. Secondly, our scenario development process did not, as former projects did, focus on governance

2 Examples include scenario activities at the Climate Engineering Summer Schools in Banff, Canada and Harvard, USA in 2011 and 2013, at an interdisciplinary workshop on geoengineering in Heidelberg, Germany in 2012, and at the CEC 2014 in Berlin in August 2014.

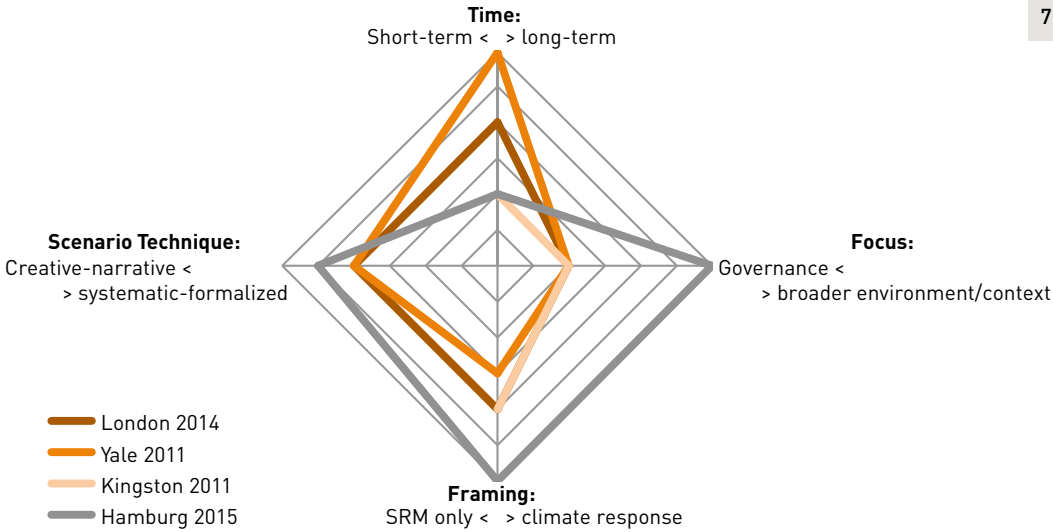

Figure 1: This project's scope vis-à-vis former foresight projects | *own illustration*

questions themselves. Rather, we wanted to focus on possible situations governance frameworks could face in the future, to address specific political, economic and social contexts and to trace the dynamics of deployment decisions. We therefore cracked open the black box concept of the state and integrated the impact of various non-state and societal actors into our analysis. Thirdly, while our scenarios focused on the question of SAM deployment, they specifically aimed to incorporate all climate response strategies, including mitigation and adaptation. Fourthly, we used a more structured scenario construction technique in order to increase the analytical depth of our scenarios. Figure 1 illustrates the similarities and differences of this project's scope vis-à-vis former foresight projects.[3]

3 For London 2014 see ESRC (2014): Economic & Social Research Council: CGG Geoengineering Governance Scenarios Workshop Outline, 13 October 2014: Royal Institution, London. For Yale 2011 see Banerjee, B. et al. (2013): Scenario Planning for Solar Radiation Management. Workshop Report and Scenarios, Scenario Planning for Solar Radiation Management (New Haven 2011), New Haven: Yale Climate and Energy Institute. For Kingston 2011 see Milkoreit, Manjana et al. (2011): The Global Governance of Geoengineering: Using Red Teaming to explore future Agendas, Coalitions and International Institutions, in: CEADS Papers Volume 1: Red Teaming.

3. The Process

This scenario project consisted of three phases: Preparation, implementation, and follow-up. In preparation for the scenario workshop, the program team defined the scope of the targeted scenarios:

1. The focus and the title of the scenario development was stated as »political decision-making on stratospheric albedo modification deployment in 2030«.
2. The context was set to include all climate response strategies, including CE, adaptation and mitigation.
3. The time frame was set to 2030.
4. Several basic assumptions were set. These included the assumptions that non-state actors are not capable of deploying any SAM effectively alone, that climate disruptions are increasingly perceived as a threat, and that there are several stages of deployment between the untested technological capability to deploy and intentional deployment in order to lower the Earth's average temperature.
5. The program formed an interdisciplinary team for the scenario workshop by selecting 9 PhD students and scientists from the SPP 1689[4] with various backgrounds in natural sciences, social sciences and law and disseminated the project's scope in a concept note.

Implementation occurred during a two-day workshop, held at Haus Rissen in Hamburg between March 22nd and March 24th, 2015. The participants were guided through a structured communication process that included several analytical steps:

1. The group analysed the broader environment of »political decision-making on stratospheric albedo modification deployment« in order to identify a range of political, social, technological, economical, and other descriptors that play a role in this issue. From these 50 descriptors, the group selected eight key uncertainties by first assessing the impact and uncertainty of every descriptor individually with the help of an online rating program and then discussing the individual assessments and deciding on the key uncertainties as a group (see α in figure 2).
2. Each of four breakout groups defined 2 key uncertainties and developed between 3 and 5 possible outcomes in 2030 for each factor. The results of the breakout groups were discussed by the whole group to create and ensure shared understanding (see β in figure 2).

4 Barbara Saxler (Trier University), Christian Baatz (Kiel University), Christine Merk (Kiel Institute for the World Economy), Christoph Kleinschmitt (Heidelberg University), Fabian Reith (GEOMAR), Martin Behrens (Kiel Earth Institute), Miriam Ferrer-Gonzales (Max Planck Institute for Meteorology), Nils Matzner (Alpen-Adria-Universität Klagenfurt), Tobias Pfrommer (Heidelberg University)

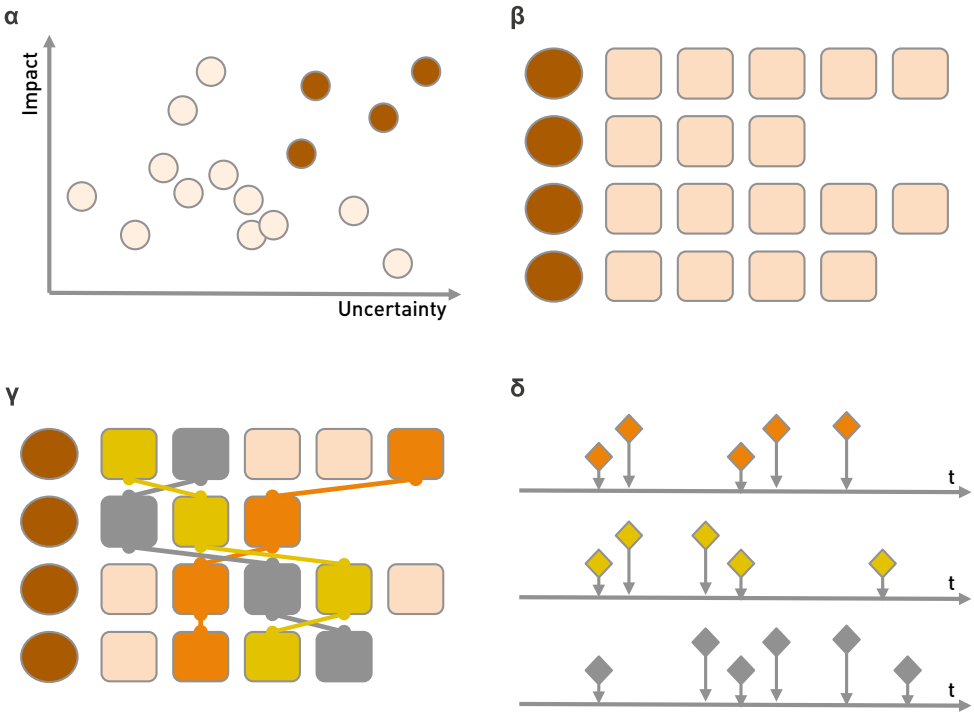

Figure 2: α: descriptors (light) and key uncertainties (dark), β: key uncertainties (dark) and respective projections for 2030 (light), γ: alternative scenario frameworks (gray, yellow, orange), δ: plausible pattern of events into alternative futures (gray, yellow, orange) | *own illustration*

3. The group created four very different yet plausible scenario frameworks. A scenario framework consists of a plausible combination of one projection from each key uncertainty. In order to ensure equal participation and to establish consistency within the frameworks, the group conducted a structured communication process which we called a reduced morphological analysis. A morphological analysis is a methodological approach used to explore solutions for multidimensional problems, like constructing consistent (multidimensional) scenario frameworks. The group deployed a reduced analysis because it did not test every possible combination (34,600) but developed highly consistent frameworks step by step, connecting a first key uncertainty's projection with the most plausible projection from the next key uncertainty and so on (see γ in figure 2)

4. Three breakout groups were created to build upon the three most interesting scenario frameworks. Each group was asked to first describe the state of their respective world in 2030 and then to define the events that led to this future situation. By constructing a plausible pathway leading to the consistent picture of the future, each group reviewed and reinforced the consistency of their respective scenario and created a storyline that was essential to communicate the still rather abstract scenarios to people who had not been part of the construction process (see δ in figure 2).

In the follow-up phase after the scenario workshop, the program team took over. Based on the work of the workshop participants, the program team created text versions of the scenarios in order to present the scenarios in a written report and allow the participants to review the scenarios they had created.

4. The scenarios

The following summaries provide an overview of the analytical building blocks of each scenario. The fully-fledged scenario descriptions, which provide an in-depth perspective to prove the logical consistency and thereby the plausibility of the scenarios constructed, can be found in the annex.

4.1 »CEmerging Countries«

The first scenario on SAM deployment in 2030 is entitled »CEmerging Countries«. It envisions a fluid and presumably growing coalition centred on China and India, who intend to deploy SAM after conducting more large-scale testing in the near future (2035?). Several underlying core dynamics drive this scenario:

First, natural disasters hit Asia and Africa more frequently and with an higher amplitude than the Americas and Europe, causing vast economic damages. People in the affected states are convinced (or have been convinced by others), that these floods, droughts, typhoons, and monsoon anomalies are a direct result of ongoing climate change. Second, China and India succeed in their joint push for the highly competitive development and production of renewable energy technologies and reduce the CO2-intensity of their economies by investing in non-carbon electricity, heating, and mobility systems. In combination, these dynamics entail an interest for the »young powers« to deploy climate engineering

technologies in order to buy time until economic transformations around the globe (with the help of their technologies) results in successful mitigation. A third dynamic forces China, India, and other countries with similar political non-carbon economies – such as Brazil and South Africa – to co-operate, not only in economic relations but also on climate engineering; namely the fact that SAM has been shown to be an inefficient and costly technology.

Similar core dynamics apply to a group of »old powers,« but they have the converse effect: The economies of the US and the EU are in a stalemate, financial resources to push economic transformation onto a more sustainable track do not exist, while consumption and production patterns are still based on fussil fuels. Unlike in Asia and Africa, people perceive the impacts of climate change to be acceptable, as natural disasters are less frequent or perceived to be not directly associated with climate change. Moreover, social rejection due to the fear of unintended consequences and the lack of public financial resources lead to SAM tests being banned in the US and the EU.

In this scenario, opposing interests, triggered by different socially constructed aims of SAM and diverging political economies, as well as an alienation of the old powers due to shifts in economic and innovation power, lead to a situation in which a loose coalition of young powers has the tested capability and the intention to deploy SAM, whereas the old powers are hesitant to follow the young power's invitation to jointly buy time for mitigation.

4.2 »Warming War«

The second scenario's title is »Warming War«. It illustrates a situation in which two opposing coalitions – the US, the EU, and Australia on the one hand, China and Russia on the other hand – are on the brink of military conflict over SAM deployment. The underlying core dynamics can be summarized as follows:

In addition to causing many deaths and direct economic damages, natural disasters in the US, the EU and Australia triggered social unrest arising from massive crop failures, water shortages and forced mass relocations. These regional disasters were perceived as the outcome of a global climate on the verge of a tipping point. As many European countries and the US are occupied with implementing adaptation measures, there is no room to consider further mitigation efforts or strategies on how to make the transition to a sustainable and CO2-independent lifestyle, they are trapped in transition. The result of these two driving forces is the shared understanding that a permanent cap on global warming is needed to maintain lifestyles and save lives. With a proven radiative forcing capacity of 6 W/m², SAM turned out to be not only effective but also highly efficient, giving single states the financial and technical means to intentionally deploy SAM unilaterally to cap warming.

There are almost diametrically opposing forces driving the other front of this »warming

war«, namely China and Russia. China is in the midst of a successful transition to decouple economic development from CO2 emissions by transforming its energy system to renewables and by exporting renewable energy technologies. In contrast, Russia is actually benefiting from global warming as it allows resource extraction in and inhabitation of the northern regions. Besides the economic factors opposing SAM deployment to cap global warming, Chinese and Russian societies fear (possibly with propaganda support) the intended and unintended detrimental effects of SAM on their environments. Some South American and Asian coastal states join the front against SAM due to similar fears. India is indecisive on SAM deployment because it is in a difficult situation: On the one hand, India's economic survival depends on CO2, on the other hand, research indicates that SAM deployment would have negative effects on India's own environment. Due to Cold War-like block-building and alienation between western and eastern powers, the front against SAM deployment solidifies the coalition for deployment.

4.3 »COAL-ition«

»COAL-ition« is the title of the third scenario for SAM deployment in 2030. This scenario is also about a two opposing coalitions. However, in this case China, the US and Australia are ready for SAM deployment, while European, African and some tropical island states are against deployment. The dynamics driving this trajectory look familiar:

While droughts in the US and China caused extremely high crop yield loss, China, Indonesia, and Australia started to cooperate to stem the wave of climate refugees from other Southeast Asian states. The growth model of China and Australia is based on industrial production fired by coal, supplemented with CCS technologies. A Republican political campaign in the US for cheap fossil fuel aims to revive the ailing US economy while pushing for climate engineering research to counterbalance additional CO2 emissions. In combination, these developments lead to a common interest in buying more time to transform national growth models and in implementing mitigation strategies in the medium-term (2040) with the help of SAM deployment. In addition, some technological breakthroughs in spraying technologies positively influenced the interest in SAM deployment as it appeared more efficient.

Unsurprisingly, the opponents of SAM deployment face different developments: Driven by Russian natural gas embargos, the EU finally implemented a common energy market and an emissions trading system, pushed for renewable energy technology innovations, and invested in photovoltaic projects in Africa. Russia, however, is profiting from global warming and therefore in line with European countries on opposing SAM deployment as both the EU and Russia fear the side effects of SAM: The halt of global warming, the

moral hazard that would eliminate mitigation efforts and the unintended consequences of a technology that has not yet been fully tested. As SAM deployment needs planes in the air, the opponents can threaten the doers with military intervention, which could easily escalate this tense situation.

4.4 Observations and Interpretation

Scenarios can be analysed through the three analytical layers that were used to construct the scenarios in a group process: Projections, key uncertainties, and scenarios.

A closer look at the analytical components of the three scenarios, the projections, can reveal some indications regarding the probability of the different scenarios. A word of caution is necessary here: probability is not a scientific criterion that has anything to do with the future, it just reflects current expectations in the light of past developments (Gabriel 2013: 117-118; Gabriel 2014). Nonetheless, it could be useful to think about the likelihood of a scenario in relation to other scenarios in order to draw implications not only for basic research, but also for policy planning. Three projections are worth highlighting here: One component of the scenario »Warming War« is the proven efficiency of SAM to reduce warming by 6 W/m^2. This projection certainly delineates the realm of possibility, which is a useful thing for scenario planning, because scenarios are first and foremost about possibility. However, if computer models were to prove this value impossible in the near future, the likelihood of this scenario would clearly decrease. Another interesting projection is part of the scenario »COAL-ition« and assumes negative CO_2 emissions due to major innovations in CDR technologies. If discussions on the general efficiency of CDR technologies in the near future conclude that CDR can never be more efficient than not emitting CO_2 in the first place (see Keller et.al. 2014; Mathesius et. al. 2015), the likelihood of the scenario would be reduced. Yet another projection assumes the ongoing power shift to China and other emerging economies, which from a current perspective indicates a higher likelihood of the scenario »CEmerging countries«.

Focusing the analysis on the level of key uncertainties leads to two interesting observations. First, there is an obvious correlation between the factor »Major Shift in Global Power Balance« and the countries which deploy SAM in the scenarios. If China and the US stay in a power balance for the next decade, it is plausible to assume that both states will be in favour of SAM deployment. If China and other emerging countries gain relative power vis-à-vis the old western powers, it is plausible to assume that the former will be working towards SAM deployment while the latter oppose it. If, on the contrary, the US and the EU regain momentum, it seems plausible that they would push for SAM deployment. Of course, further conditions apply, as illustrated in the scenarios.

This leads to another observation from a systemic perspective which is illustrated in the analytical scenario summaries above: SAM deployment is politically and socially constructed. One could argue that technology in general cannot be isolated from a social context because it is always a means to an end, and all social ends are constructed. Also, successful technology innovation – the process that leads from an idea to its lasting application – is a societal phenomenon as various groups like producers, consumers, regulators and others interact in markets. However, SAM is a special case because this technology deals with problems on the scale of societies and therefore also with global risks. The special character of SAM is reinforced by the fact that SAM is still nothing more than an idea at the very beginning of the innovation process. The scenarios reveal some constructed elements in the innovation process, namely the perception (by the public) and the securitization (by politicians) of the link between extreme weather events and climate change, as well as the political aim of SAM deployment itself. Moreover, it turns out that these elements are rather independent variables in these (incomplete) theories of the future, while technological influences such as the efficiency of SAM are rather intervening variables.

In all three scenarios, SAM has already been deployed either in the form of a technological component test or in the form of large-scale field tests. In two of the three scenarios, some governments have even made their intentions to deploy SAM as a means to alter the global temperature explicit. One has to wonder why there are no possible futures in the scenario tableau in which SAM deployment does not take place. The answer has a practical and theoretical component. First of all, during the workshop the participants actually framed a non-deployment scenario (see the grey-marked scenario in figure »Scenario Frameworks«). Since this grey scenario was composed of many »status quo« projections, it was not considered to be an interesting case about the future in the context of a scenario project because describing the status quo would have been very close to the situation today. In addition, a status quo scenario would not have been an interesting case for »SAM deployment in 2030« because there was no deployment at all. These practical reasons for rejecting a non-deployment scenario of course do not speak against the general development of non-deployment scenarios. It would, for instance, be very interesting to deliberately construct a set of non-deployment scenarios and analyse under which conditions these scenarios could be considered »best cases« or »worst cases«. The theoretical component of not choosing a grey status quo scenario concerns the likelihood: Is it likely that there is no political, social, technological or economical change over the next 15 years (remember, 15 years ago we did not have smartphones, no war on terrorism, and no IMF/ECB/EU Troika)? For these reasons, the group constructed the

»COAL-ition« scenario, altering the status quo only slightly by integrating the assumption that some states plan to deploy SAM while others oppose it (key uncertainty »Doers and Opposers«, projection C).

As one participant in the end of the scenario workshop indicated, all scenarios are based on two fragile assumptions: First, actors make rational choices and second, there is sufficient information available about actors' preferences and agendas. Both assumptions are questionable yet justifiable – in particular in a scenario project. A justification can be made using a pragmatic argument: In order to construct and analyse a system that is complex in its structure and in its dynamics, it is necessary to reduce the degrees of freedom of this system by making basic assumptions. Rational actors and sufficient information are useful assumptions that help to make the complex system of »SAM deployment in 2030« manageable for an interdisciplinary group. A more theoretical justification could point out that these assumptions only apply to the analytical process of scenario construction, but not to the scenario descriptions themselves. Irrational behaviour and deception could have played a role in some parts of the scenario trajectories. However, illustrative elements are not appropriate to alter the core development logic of scenarios. The scenarios developed here are not sufficient to provide insights on the role of deception and irrational behaviour in the field of SAM deployment.

5 Implications

Our scenario-building exercise and the subsequent analysis of the results revealed several interesting implications. The first two are insights into the scenario-building process, and the following four are substantial findings which provide suggestions for further research.

First of all, our scenario-development approach made it possible for the group to construct a range of plausible scenarios first and then to assign probabilities to these scenarios, as outlined above. It is important to note, however, that probabilities cannot tell us anything about the future. Probabilities are simply indicators for current expectations based on many status quo assumptions. The incorporation of experts from various fields and an expert in the field of scenario methodology in the scenario-building process allowed the team to not only span a broad range of plausible futures, but also to draw on expert knowledge to isolate probable futures within this span and to pinpoint indicators worth monitoring to identify the approximate direction of long-term change.

Secondly, the interdisciplinary nature of the scenario-building group enabled us to identify and delve into the complexity of actor constellations in a range of climatic, economic, social and political environments with regard to decision-making on a specific set of CE technologies (SAM). The workshop demonstrated that scenario

building is a useful method for facilitating interdisciplinary thinking and communication on SAM development and deployment. The group activity also helped to increase the participants' understanding of the complexity of the multi-faceted cause-effect relationships between extreme weather events and political decision-making. As the discussions during the workshop and the resulting scenarios have demonstrated, this type of interdisciplinary understanding is essential as political decision-making on SAM in the future will depend on both the physical characteristics of climate change AND the configuration of domestic and international political systems, political economies, cultural beliefs and societal perceptions.

Several substantial findings were revealed during the scenario-development process. The first is that the group implicitly held a central assumption throughout the scenario construction process: That we will be able to attribute SAM deployment to specific actors. But if we do NOT assume rational actors with access to full information, the assumption of attribution becomes perforated: SAM deployment might be attributed in the sense that it can be detected, but the attribution of intention would be almost impossible – are others put in jeopardy intentionally or not, and can those affected successfully attribute this intention to the actors responsible?
Secondly, it became clear during the workshop discussions that the perception of climate emergencies and extreme weather events as a causal result of climate change are essential to understanding decisions on SAM deployment: SAM deployment will not be a predominantly technological phenomenon, but first and foremost a political and social one. In connection with this, it was pointed out that it remains unclear exactly what kinds of extreme weather events could potentially be countered by SAM. It is necessary to establish if and how extreme weather patterns or climate emergencies can be addressed using SAM, as this will determine how calls for SAM may be connected to crisis perceptions in the future. Finally, a significant point which arose was that the group emphasized the key role of powerful, carbon-dependent economies in future decision-making on SAM, and the US and China in particular were considered to be central actors in all scenarios generated during the workshop.

6 Appendix

6.1 Scenario Description: »CEmerging Countries«

THE GLOBAL OBSERVER, MARCH 31st, 2030

Climate Emergency Matching Fund Created by Young Powers after SAM Test in China

After a decade of power shifts and constant flux, China, India and other young powers have taken over the vacant driver's seat in international climate politics. It remains to be seen if the Climate Emergency Matching Fund (CEMF) as proposed by the Coalition against Climate Emergencies (CCE) on Saturday evening will find supporters among the old powers, as the coalition's agreement regarding specific regional and global deployment parameters for future stratospheric albedo modification (SAM) is fragile. Regardless of its prospects of success, the announcement itself is remarkable and deserves a closer look, because just a couple of years ago no one would have expected these global shifts in economic power, the alienation between young and old powers, the estrangement of science, scientists and politics, and the changing perception of climate emergencies – all developments interwoven in an unsteady chain reaction, to take us step-by-step to where we are today.

It all started in 2017 when the EU unofficially split into the North and the Mediterranean due to internal conflicts over monetary policies and foreign policy towards Russia and the Eurasian Economic Union. As a result, the integration of the European electricity market ground to a halt, innovation capacity in renewable energies, especially in photovoltaic, stalled. In its economic and political downturn, the EU rushed to conclude the Transatlantic Trade and Investment Partnership (TTIP), ignoring warnings from the emerging economies, which increasingly feared not only exclusion from the emerging US-EU economic block, but also a political roll back to western-dominated international organizations. These fears were driven by the US intentions to revive the Bretton Woods institutions such as the World Bank and the International Monetary Fund vis-à-vis its emerging power counterparts.

Xi Jinping's response was logical yet unexpected: Chinese government officials from the National Development and Reform Commission (NDRC) had been in contact with their Indian counterparts and announced their plans to build a trade and investment regime. The »Innovation Partnership 2030« was sealed in December 2017. The heads of states involved declared their goal to become the world leaders in renewable energy production and non-carbon technologies by 2030. »We decided to join forces to develop the technological means and to design societal blueprints that will help us to develop and de-carbonize our economies«, explained President Modi, whereupon Xi added: »Other economic systems that cannot deal with these tremendous tasks today will profit from our experiences, products and services in the near

future.« In hindsight, Modi and Xi were only partly right: China and India did develop fast – but they are still carbon economies. The two countries are now technology leaders – but first and foremost in the field of climate engineering.

This was an unintended consequence rather than a deliberate choice by the young powers. In fall 2018, the Washington Post reported on a SAM field test being carried out in the US by a group of scientists from national research laboratories and universities. The test was designed to test a new hydrosol disperser and to gain insights into aerosol-dynamics in the lower stratosphere. Intransparent funding, a lack of scientific oversight, poor public relations, and unsatisfactory coordination with policy makers before and during this small-scale test led to large-scale resentment in the United States, culminating in a Congressional hearing in February 2019. Asked for a comment after the hearing, one of the principal investigators said: »I still don't understand why everyone is so upset. Our tests were less invasive than a transatlantic flight! Aside from that: When decision-makers complain about the weak economy and shrinking budgets for national laboratories, researchers of course welcome private investment from people who see the dire need to develop SAM capabilities. The government should at least support our efforts to combat climate emergencies by giving us administrative support. But this seems to be difficult in a democratic system.« His reference to democracy's inability to fight climate change was overshadowed by the testimony of a high-ranking official from the US Department of Health who stated »it cannot be ruled out that this SAM test is responsible for an unusually high rate of skin diseases in November and December 2018.«

The hearing deepened the polarization of the debate on climate engineering in general and SAM in particular. New NGOs, some in favour of and some in opposition to SAM, entered the opinion market, fuelled by money from various sources. In October 2019, one year after the first field test, events moved forward fast as a research group – which later became known as »the Safeguardians« – announced a bigger, large-scale, five-year field test to examine the reflective capacity of sulphur particles. The outcry in the media was enormous and thousands of ordinary people went onto the streets, venting fears associated with SAM. A small group of Chemtrailers also found its way to the lead scientist's house and set fire to his car.

If »the Safeguardians« were looking for even more reasons to leave, the US government delivered them in January 2020 by announcing a comprehensive SAM test ban on and over US soil. The European Commission had introduced an SAM test ban just one month earlier than the US. Although the Commissioner for Climate Action, Ikarus Elsol, officially justified the ban with the precautionary principle, the EU's major concern might have been the extraordinary expense of an SAM research and development program.

Subsequently, various media outlets reported that »the Safeguardians« had been offered senior positions at the Chinese Academy of Sciences and the India Institute of Technology in Delhi. Leaving the US behind, they took all their knowledge of how to develop SAM to an unknown location in central China where the Sino-Indian SAM joint venture was initiated in 2020. According to press releases by the Indian Ministry for Research, the SAM research project focused on positive influences on crop yields, the mitigation of typhoons and effects on the monsoon.

In the same year, societal changes impacted the climate situation. Driven by demographic changes in northern Europe and the US, the volatility of the economic development path increased. In spite of functioning innovation systems and stable growth, the perception among politicians and societies on both sides of the Atlantic prevailed that their economic systems were aging and crumbling. On the one hand, the remaining Northern EU was still stricken by the financial fallout of the Euro crisis, and the resulting in a brain-drain towards Asia since 2022. On the other hand, the perception of being a »hegemony in terminal decline« caused hasty actions in the US. For instance, during his re-election campaign, US President Ted Cruz proclaimed in a heated TV debate: »The US economy is not weak because we are not working hard enough. It is not weak because many of our citizens have worked hard and enjoy their deserved retirement. It is weak because so many people from other countries are unjustly enjoying pensions here which are paid for by our shrinking working population!« He later confirmed rumours that the Congressional Committee on Social Security was already working on bill to »provide incentives for elderly Chinese and Indians to move back home«.

Congress passed the bill after Cruz's re-election in May 2020 and many Chinese and Indians over the age of 67 were faced with a choice between receiving USD $15.000 to cover travel expenses and leave the country, or staying and suffering a cut in their pension. Roughly 1.3 million Chinese moved back to China between 2020 and 2024. It was (and still is) a tremendous challenge for the Chinese government to integrate the elderly Chinese Americans into the aging Chinese society. »We acknowledge the tight economic situation in the US and we are already engaged in a constructive dialogue with the Old Powers on how to revive the global economy«, a Chinese spokesperson said at a press conference and added: »Nonetheless, in our view – and this view might be shared by many people around the world – elderly persons deserve our greatest respect. How can we trust a government that treats its own people in such a disrespectful way?«

In the mid 2020s, alienation between the older and younger powers grew over these issues and was fuelled by a resource race in Africa. At that time floods and droughts also hit Asia and Africa more often than the

Americas and the European continent. »For unknown reasons«, the IPCC Report of 2025 stated, »the amplitude and frequency of extreme weather events is on the rise in Asia and Africa, while on there is no change on other continents.« Scouting satellites detected anomalies in monsoon patterns and typhoons and special reports on the massive impacts on coastal economies were released in Australia, many Southeast Asian states, India, and China.

In 2026, the »Innovation Partnership 2030« established a working group on climate emergency response strategies and invited Australia and other neighbouring states to participate. After the conclusion of the first five-year SAM field test in 2027, carried out by the joint venture with »the Safeguardians« from the US, the working group was renamed »Standing Group on SAM Measures«. The international community took this as an indication that the results had been promising. Neither the Chinese nor the Indian government or any scientific agency of either state officially commented on the field test's results. It is a topic of speculation why they waited until 2029 to publish the results. Maybe one reason was the sequence of massive eruptions of rigorous anti-SAM sentiment in India and pressure from Delhi's political elite not to touch this issue again before national elections. Maybe it was because of the protests in Xiamen calling for more effective (and costly) adaptation measures after the floods in 2026 that kept the Chinese government from advertising long-term and budget-intensive climate response strategies.

On April the 1st 2029, the Indian and Chinese Chairs of the Standing Group on SAM announced that the SAM field test had shown that: »SAM induced radiative forcing was proven to be effective. Our scientists found evidence that SAM is a promising instrument to mitigate regional climatic disasters such as floods, while the effect on the monsoon is still not entirely clear. However, SAM radiative forcing seems to be negatively correlated with cost. Although the test has proven the overall effectiveness of SAM, we will most probably have to invest more money than first thought to prevent climate emergencies.« Commentators saw that as a first invitation to the Old Powers to join forces on building SAM capacities.

Russia's President Putin told Gazprom Media in an interview the next day that he would never join »such endeavours that are more dangerous to global security than all the nuclear warheads of Russia and the US combined. The only thing I can read from this announcement is: April fools!« The interview was part of a media campaign to recruit gas field workers and foreign experts for the newly developed gas fields around the Kara Sea. Russia is one of the last countries on earth to profit from climate change and has tried to consolidate its low-grade innovation economy by focusing on carbon-based energy products.

Slowly but steadily a coalition for SAM formed under the umbrella of the Standing Group on SAM. Although NGOs lobbied for

closer cooperation on the topic under the UN umbrella, China and India as well as the countries that established SAM test bans refused to take up this idea. In its constituent meeting in Jakarta in January 2030, China, India, Brazil, Australia, South Africa, and Indonesia officially formed the Coalition against Climate Emergencies (CCE). The closing communiqué states that they want to focus on mitigating climate emergencies by implementing SAM in Asia first, but they are welcoming »partners from the Americas and Europe« to jointly invest in a »harmonic path to climatic sustainability«. The Australian Prime Minister said in a BBC interview: »The purpose here is to buy some time until the CO2 concentration can be reduced in the future. Right now, it's the Asian countries taking the lead here just because the EU and the US, due to their fragile economies, do not want to call Midwest droughts or the floods in the coastal areas of Europe climate emergencies. If they had to suffer from climate emergencies the same way we are suffering, they would be eager to invest more in mitigation – and in SAM to bridge the time lag between implementation and effect.«

Shortly after the CCE meeting in Jakarta, Indonesia changed its status from member to observer. When heavy rains hit Jakarta, as they do every other year, NGOs started a media campaign and cited scientists from the Bandung Institute of Technology, saying that SAM could alter precipitation patterns in Indonesia and therefore cause an increase in the frequency and magnitude of floods in Indonesia, especially in Jakarta's metropolitan area. It is rumoured that China is considering a compensation scheme for SAM side-effects. However, it remains unclear whether and how China (probably again in companionship with India) can calculate and then compensate for the side-effects of SAM.

There are more open questions: The US government and US citizens are keen to know more about the possible health side-effects of the 5-year SAM test in China. The US debate is stuck between a rock and a hard place: On the one hand, memories of the SAM test disaster of 2018 still play on people's minds, and joining an initiative led by China and India is not an attractive option for an old power. On the other hand, the carbon intensity of the economy is still high and transformation needs time, especially when you are a late-starter and the occurrence of regional climate emergencies is – because they are socially constructed as Australia's Prime Minister stated so openly – probably just a matter of time.

In contrast, Europe is in a more comfortable but equally troublesome position regarding carbon intensity: nation states alone are not able to deal with SAM questions because of its transboundary nature. It is thus inconceivable that Europe, although its debate is less polarized, can speak with one voice on SAM. As a consequence, the EU is likely to stay out of the discussion to prevent its member states from moving in opposing directions.

6.2 Scenario Description: »Warming War«

SAN FRANCISCO INTERNATIONAL TIMES, MARCH 31ST, 2030

Tensions rise between East and West as SAM deployment announced

Following yesterday's announcement that the joint US/EU Climate Protection Coalition intends to deploy their stratospheric albedo modification (SAM) fleet within six months, the Chinese and Russian governments have issued a warning that they are mobilizing their combined United Green Front anti-aircraft battalion and are prepared to use all force necessary to prevent the launch. While the US/EU Climate Protection Coalition has faced pressure from the RUS/CHN United Green Front in the form of economic and diplomatic sanctions, imposed in the wake of SAM testing last year, this escalating step adds a military dimension to the evolving conflict.

The Coalition denies claims made by the Front that it is acting against the interests of many states and a majority of the world's population, citing last year's Pew poll which showed an overwhelming support for »reasonable and sustainable use of SAM« in Europe, the United States and South America. The poll revealed that most people are in favour of the deployment of SAM measures to put an end to the increasingly dire effects of climate change that have been hitting Europe and the USA hard over the past 15 years. The southern United States is still struggling to recover from the 2028 hurricane season which brought the deaths of over 5000 people in Louisiana and Florida and left New Orleans and Tampa uninhabitable. The evacuation of the Gulf Coast cities has only added to the social and economic unrest caused by the ongoing mass relocation of the drought-stricken Californian population to north-Eastern states with enough water to support them.

Europe also continues to fight the effects of climate change on two fronts: As Italy, France and Spain battle wildfires and crop failures with the little water they have left, the United Kingdom Holland and Germany are struggling to stay afloat in the face of increasingly devastating annual floods. Last year alone the WHO reported over 1500 heat-related deaths in southern Europe, while northern floods have claimed the lives of more than 1000 and caused approximately USD $10 trillion in damages since 2025.

Faced with these devastating effects of climate emergencies, the members of the Climate Protection Coalition believe there is no choice but to deploy SAM to stabilize the global climate system at under 2°C of warming. The Front, on the other hand believes that the countries which make up the Coalition are simply taking the easy way out instead of following China's lead and delinking their economic growth from CO_2 emissions by committing fully to renewable energy sources. As Chinese President Wei so famously shouted at US President Bush and European Commission President Merkel when they

broached the topic of SAM deployment during the disastrous 2026 Global Climate Security Conference (GCSC): *»I am not convinced. By clinging to your decadent carbon economies, you are selfishly dooming us all!«*

President Wei's anger towards the West appears not only based on his belief that SAM will negatively affect China's rainfall patterns, but also on the fact the deployment of the technology has the potential to bankrupt China, as the country's planned economy now relies substantially on the production and export of renewable energy technologies. Following the success of the US/EU Transatlantic Trade and Investment Partnership (TTIP) which hit China's economy hard by negating its competitive advantage in most market sectors, China's Green Leap resulted in the country's planned transition to solar, wind and hydro electricity and cemented its position as the global frontrunner in renewable energy technologies. Following the release of the 2020 IPCC report outlining the dark climate future predicted if drastic reductions in greenhouse gas emissions were not implemented immediately, China started its green leap to become the leader of the green-energy world. Now that the West is seemly offering the international community an alternative – a way to keep relying on CO_2 rich fossil fuels while at the same time maintaining a stable global climate system – China faces a double hit: a negative impact on its green technology-based economic model and a detrimental effect on its own environment.

Thus, President Jeb Bush's impassioned speech at the GCSC about the need to »preserve our way of life« and Chairwoman Merkel's appeal to world leaders to »unite to protect our climate« with the help of SAM only had the effect of cementing the belief among the Chinese that the West is acting solely in their own climate and economic interests. As Russian President Putina stated to the media following the failed conference, her people and those of many other countries are also struggling to survive in a global economy dominated by the TTIP members, and they »will not tolerate another level of western domination.« She posed the angry question: *»They already control the global economy, now they want to control the climate too – what gives the West the right to decide which temperature is best for us all?«*

In contrast to the USA, Europe and large parts of South America, Russia stands to benefit from a significantly warmer climate, with melting tundra and ice sheets making the country's northern regions increasingly habitable and allowing access to a range of natural resources which would greatly help the stagnating Russian CO_2 based economic model. The reversal of the warming trend as a result of the Climate Protection Coalition's SAM deployment is expected to force the abandonment of Russia's extensive northern development projects. As this became clear in the wake of SAM testing last year, Russia joined forces with China to form the economic and military alliance that we now know as

the United Green Front. The failure of last year's summer monsoon in many equatorial countries, which is attributed by some to the Coalition's SAM tests, encouraged a number of South American and Asian nations to voice their support of the United Green Front.

Surprisingly, India has not made any public statements about its stance on SAM deployment thus far. However, according to media sources quoting several emails leaked from the Cabinet of India last month, the Indian government believes its economic survival depends on continued reliance on CO_2, but is hesitant to openly support the Climate Protection Coalition's plans because SAM deployment is expected to have a negative impact on India's own environment as well as those of its political and economic allies, including Bangladesh. Additionally, India relies heavily on coal imports from Indonesia, which pledged its allegiance to China at the beginning of the year after the monsoon failure.

Although some governments, like India, are continuing to avoid taking sides for various geopolitical and economic reasons, the bloc-building seems set to continue as more and more smaller countries today pledged their allegiance to either the Climate Protection Coalition or the United Green Front in the wake of this week's confrontational announcements. All signs seem to point towards a deterioration of diplomatic relations between the two opposing blocs, leading many political pundits to wonder if we are heading towards a repeat of the Cold War stand-off – only this time the war could get a lot warmer.

6.3 Scenario Description: »COAL-ition«

THE ENVIRONMENTALIST, MAY 10, 2030

The Declaration of Independence from whom?

Climate Politics have never been so polarized: how did it come to this and why it may leave us all worse of.

These are heady times in international climate politics. Seldom have international climate conflicts been in starker relief: On July 4th, 2030 the US, China, Australia and a gamut of allies declared their »independence from the sun«, offering a solution to the world's climate change induced natural disasters by tinkering with the atmosphere's albedo. Yet the technical solution is unlikely to solve many political problems. Rather, SAM (Solar Albedo Modification), as it is called, will most likely create new, maybe even bigger problems.

It is odd: For over 32 years, until 2026, the mitigation-based Kyoto process seemed to be doing the trick, offering hope and resilience to the most endangered regions of the world. Competition to mitigate grew fierce for the first time in 2018 when the EU-Russia conflict over Ukraine escalated and Moscow first throttled and then ended the gas supply to the West. This resulted in a strong push for renewable energy and network integration in the EU. The failing of TTIP then facilitated the drifting

apart of the US and the EU: the former turning towards the Pacific, the latter engaging African states in large-scale photovoltaic projects. When COP 25 failed in 2019, mitigation policy trajectories in Europe and Africa as well as the US, China and Australia diverged even further: As this magazine reported, the Old Continent's Emission trading system (ETS) and smart grid revolution resulted in »an ever Greener Europe« (Special Report, November 2019), while political dynamics tilted China and Australia towards a coal-fired, CCS-supplemented industrial production model.

Alas, in 2020, when Hillary Rodham Clinton lost to the Republican hot-head Rand Paul, the climatic push came to shove. What Ike (Dwight D. Eisenhower) may have termed a »military-fossil, industrial, agricultural complex« back in the 1960s came to promote a »fast and cheap fossil fuel campaign« to jump-start the ailing U.S. economy. Then, to counterbalance the CO2 emission surge, Western Powers (US, Canada and Australia) launched the first major Transnational Solar Albedo Modification Research and Development scheme (TRANSAM-REDE). As a consequence, the German Defence Minister (ex- and newly appointed) K.T. zu Guttenberg announced a third phase of the German National Priority Programme on Climate Engineering, focussing on potential counter-SAM techniques to prevent negative climatic side-effects for Germany, Europe and its African climate allies due to SAM deployment. Poisonous distrust started to spread among the erstwhile allies as the gap between high-minded mitigation proposals and the nasty potential implications of SAM research and testing grew larger.

Until then, a common understanding of the problem had driven a climate policy trajectory of super-emitting powers. It included a major mitigation effort, a minor but cooperative adaptation scheme for nations in need and a lingering debate on the pros and cons of altering the planet's albedo. EU Council President Angela Merkel welcomed the US-China proposal on emission caps in 2040. Chinese President Li Keqiang praised the EU for the major contributions to the Climate Emergency and Extraction Fund (CLIMAX).

But such comity collapsed in 2022 and 2024. When the catastrophic typhoon »Votan« hit Indonesia hard – also resulting in biblical floods in Bangladesh – China and Australia started to cooperate militarily to stem the tide of climate refugees in Southeast Asia. In the »annus horibilis« 2024, Australia and Canada experienced the largest ever forest fires, while droughts in the US and China triggered a crop yield loss of 60% in major plantation regions.

What was going on? U.S. President Paul had an explanation: »Mitigation is too slow for the needs of the Planet's most productive industrial powers.« The whole planet had become polarized because while only a few were benefitting from global warming, such as Russian shipping and fossil recovery industries, many nations were suffering. What is more – as US policy makers suggested –

is that recent advances in modern spraying technologies had solidified the options on cloud brightening as well as sulphur injection. Your journal, the Environmentalist, has a different explanation, offered with regret. Perhaps climate politics is infested with countervailing claims of dubious scientific validity? Some of those vowing to »give mitigation a fair chance« or to «save the world from the climate« are sincere: Their conclusions from the existing climate science knowledge are modest, as they try to construct a spectrum of options which policy makers and the public on either side of the aisle may constructively debate. Other climate policy makers and scientists are partisans in disguise, engaging in a discursive arms race with their foes: they sow doubt about climate change impact or CE techniques' ability to counter it, and present the »scientific proof« to show it. While one party claims to be able to show how recent Sulphur Injection Tests will end life in Africa as we know it, the other states that climate projections prove that life there will be better in the future than it was 1000 years ago. In 2026, the COP process collapsed. The »COAL-ition« (led by carbon-dependent states as US, China, and Australia) proposed a CE governance scheme under which a substantial SAM deployment to counter 2.5 Watts per square meter would be complemented by minor mitigation efforts on the part of those nations who were willing to commit to it. In a COAL-ition of sorts, farmers in the US Midwest and Chinese citizens on Tian'men square celebrated the fact that their governments planned to field-test existing and deploy effective SAM technologies by 2030. As both countries were lagging in the development of affordable renewable energy alternatives, the populations of both the US and China were pleased to hear that their lifestyles, so dependent as they were on cheaper fossil fuels, would not be endangered. The whole logic of the approach was wrong, complained the Chairperson of the alliance of Tropical (including India), European and African states, Angela Merkel, the former EU Council President, German chancellor and environmental minister: It assumes that SAM, once deployed, will improve the situation and not worsen it for most global citizens. As a consequence, the Pacific Union, facing the imminent threat of inundation due to sea level rise, started talks with the COAL-ition on pre-positioning a Theatre-Missile and Drone Defence Shield (THMDDS) to protect potential future SAM airborne deployments in their region from counterattacks.

Each blow in the fight became a way of waging war against the other's economic production model. 2028 saw BOEING and COMAC, the Commercial Aircraft Cooperation of China, a joint venture established in the early 2020s, producing the first 50 Stratospheric Airplanes (STRAPS) for the COAL-ition's »Solar Remediation Strategy« (SRS). The French Justice Minister told of grim outcomes in international politics after studying the SRS, claiming that existing international law would

be undermined by it. Critics, including the Chinese and Canadian governments, retorted that the French Justice Minister's 's claims stemmed from an »arrogant, colonialist and old European view of international norms which needed to be interpreted in the new light of the »anthroprocenic age«. In turn, when newly elected U.S. President Ted Cruz vowed to stop talking about climate change and start acting, Russia's (eternal) President Putin threatened to take those SAM airplanes down. Even in Old Europe, where the growing solar industry was already worried about how SAM may reduce its revenues, militant voices gained the upper-hand: An unlikely alliance was formed between Vladimir Putin, Greenpeace Europe and the »Atmospheric Shepherds« (AS), a new semi-militant environmental transnational coalition, seconded Putin and asked for »military action by the European Union« without specifying what they meant. Now, in light of last week's »declaration of independence from the sun« by the COAL-ition states, readers of this journal and sanguine citizens of the globe may be forgiven for tuning out. But instead, they may also look at each camp in this evolving »Climate Cold War« and ask themselves if they trust each party's respective motives and measures. Our gut feeling may suggest we take sides without weighing the facts and interests carefully. But this may leave all parties worse off. Should we consciously choose to deprive ourselves the chance to shape a better future?

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Priority Programme 1689

In the priority programme »Climate Engineering: Risks, Challenges, Opportunities?« (SPP 1689) we want to evaluate climate engineering and assess consequences of climate engineering methods.

Sixteen universities and research institutes collaborated in nine sub-projects of the priority programme 1689 in the first phase (2013 – 2016). The second phase, starting in 2016, will run for additional three years. The SPP 1689 is funded by the German Research Foundation (DFG) and coordinated by Prof. Dr. Andreas Oschlies at the GEOMAR Helmholtz Centre for Ocean Research Kiel and the KIEL EARTH INSTITUTE.

MAIN OBJECTIVES OF THE SPP 1689:

- Investigation of the climatic, ecological and social risks and potential effectiveness of different climate engineering methods
- Evaluation of the scientific and public perception of climate engineering
- Assessment – not development! – of climate engineering, including scientific, social, political, legal and ethical aspects

More information about the priority programme 1689 and the individual projects is available at: www.spp-climate-engineering.de

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Scenarios on stratospheric Albedo Modification Deployment in 2030

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