CEC '14 Critical Global Discussions

Climate Engineering Conference 2014
Critical Global Discussions
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IASS POTSDAM

Climate Engineering Conference 2014

CRITICAL GLOBAL DISCUSSIONS

Conference Report

Contents

Conference Report

Climate Engineering Conference 2014

CRITICAL
GLOBAL
DISCUSSIONS

Hosted by

Institute for Advanced Sustainability Studies Potsdam (IASS)
Founded in 2009, the IASS is an international, interdisciplinary hybrid between a research institute and a think tank, located in Potsdam, Germany. The publicly funded institute promotes research and dialogue between science, politics and society on developing pathways to global sustainability. The IASS focuses on topics such as sustainability governance and economics, new technologies for energy production and resource utilisation, and Earth system challenges like climate change, air pollution, and soil management.

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http://www.naturkundemuseum-berlin.de/en/

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http://www.hkw.de/en/

The **Earth System Governance Project** is the largest social science research network in the area of governance and global environmental change. Our international research programme takes up the challenge of exploring political solutions and novel, more effective governance systems to cope with the current transitions in the biogeochemical systems of our planet.

http://www.earthsystemgovernance.org/

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http://www.futureearth.info/

The **International Global Atmospheric Chemistry (IGAC)** Project, a core project of the International Geosphere-Biosphere Programme (IGBP) and co-sponsored by the international Commission on Atmospheric Chemistry and Global Pollution (iCACGP), coordinates and fosters atmospheric chemistry research towards a sustainable world.

http://igacproject.org/

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http://www.clubofrome.de/

The **Solar Radiation Management Research Governance Initiative (SRMGI)** is an international NGO-driven project launched in 2010 and co-convened by Environmental Defense Fund, the Royal Society, and TWAS, the world academy of sciences. It aims to foster an inclusive, interdisciplinary and international discussion on how research into SRM technologies could be governed, and seeks to bring in new voices and perspectives, particularly from the developing world.

http://www.srmgi.org/

Polity is a leading international publisher in the social sciences and humanities, with a particular focus in the areas of sociology, politics and social and political theory.

http://www.polity.co.uk/

Routledge is the leading global publisher in the inter-disciplinary field of Environment and Sustainability studies, offering a broad array of titles from accessible introductions to supplementary readings to cutting-edge research for a range of academics, professionals and general readers.

http://www.routledge.com/sustainability/

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The IASS is funded by

The Federal Ministry for Education and Research (BMBF, Bildungsministerium für Bildung und Forschung).

http://www.bmbf.de/en/index.php

Research for Sustainable Development (FONA, Forschung für nachhaltige Entwicklung).

http://www.fona.de/en/index.php

The **Ministry for Science, Research and Culture of Brandenburg** (Ministerium für Wissenschaft, Forschung und Kultur des Landes Brandenburg).

http://www.mwfk.brandenburg.de/

1. Introduction

The "Climate Engineering Conference 2014: Critical Global Discussions" (CEC14) was the first large international conference of its kind on climate engineering. Held over a period of 4 days in Berlin, the CEC14 brought together over 350 participants from more than 40 countries. As representatives of academia, the policymaking community, non-governmental organisations (NGOs) and the wider society, they came to discuss the many complex and interlinked issues that arise when considering the possibility of deliberate, large-scale interventions in the climate.

The idea to host a large international conference on climate engineering emerged against the background of several important developments in discussions on climate engineering. 2014 marked the five-year anniversary of the Royal Society's 2009 assessment, which focused on the science, governance, and uncertainty of climate engineering and took the first major step towards broadening the conversation beyond the generally isolated, individual publications that had preceded the report. The 2010 Asilomar International Conference on Climate Intervention Technologies represented the first attempt by the academic community to generate research guidelines, and new governance proposals and initiatives have since proliferated. International governance for climate engineering is advancing rapidly in the case of marine activities; however, there has not been any significant advance in international governance regarding atmospheric activities beyond what is accepted as customary international law. Climate engineering has been addressed by all three working groups of the Intergovernmental Panel on Climate Change (IPCC) in their contributions to the Fifth Assessment Report, and at the time of the CEC14 many ongoing projects were coming close to conclusion or reaching important milestones. In particular, three large U.K. research programmes – the Oxford Climate Geoengineering Governance (CGG) project, the Integrated Assessment of Geoengineering Proposals (IAGP), and the Stratospheric Particle Injections for Climate Engineering (SPICE) project – held their joint final symposium just a few months after the CEC14.

At this important moment in the global discussions on climate engineering, we aimed to provide a forum for vigorous exchange and creative dialogue, for new voices to join the discussions, and for examining how climate engineering intersects with other topics both within and outside of the discourse around climate change. Thus, the overarching objectives of CEC14 were:

- to address comprehensively and in a balanced manner the technical, geophysical/geochemical, ethical, legal, and societal contexts in which the various ideas for engineering the climate are being discussed;
- to bring together the diverse stakeholders involved in climate engineering discussions – including academic researchers and representatives from the policy and civil society communities with geographically and culturally diverse backgrounds – in order to promote transparency and dialogue;
- to provide a forum to review the current state of climate engineering discussions, present and discuss recent research results, and scope key research questions and challenges for academia and society;
- to provide a forum for enhanced exchange through innovative session formats aimed at addressing the disciplinary, interdisciplinary and transdisciplinary complexity of the issue;
- to provide a platform for exchange, networking, and collaboration across disciplines, sectors (particularly academia, policy and civil society), geographical regions, cultures, and generations;

↗ to explore the value of a large-scale conference as an appropriate forum for the emerging field of climate engineering, with the potential future aim of holding such a conference on a semi-regular basis.

This report is a reflection on the conference, its overall themes, individual sessions, plenary events, format, and spontaneous developments that occurred over its course. It is not intended, however, to produce a definitive statement or set of recommendations. It serves to make many aspects of the discussions at the conference available to as broad an audience as possible. Thus, the report provides a concise, yet descriptive summary of the main outcomes of the various sessions at CEC14, including a summary of the controversy that surrounded the proposal for two "Declarations" regarding the governance of field experimentation. Where appropriate, the text provides hyperlinks to online resources such as video recordings from the conference or the websites of individual sessions. All online resources linked to in this report can be accessed on the website www.ce-conference.org.

We also aim to make transparent the considerations that went into designing the conference, how we feel the conference design shaped discussions at the conference and how we evaluate this, as well as the feedback we received and how we intend to incorporate it when designing the next CEC. At this point, we are also happy to announce that the success of CEC14 and the very positive feedback we received have convinced us that CECs can provide an ongoing and important contribution to the critical global discussions about climate engineering, and we therefore intend to hold one or more future CECs, depending on how the discussions around climate engineering evolve. We hope that many of you will join us for the next round of critical global discussions.

Mark G. Lawrence, Scientific Director
Institute for Advanced Sustainability Studies

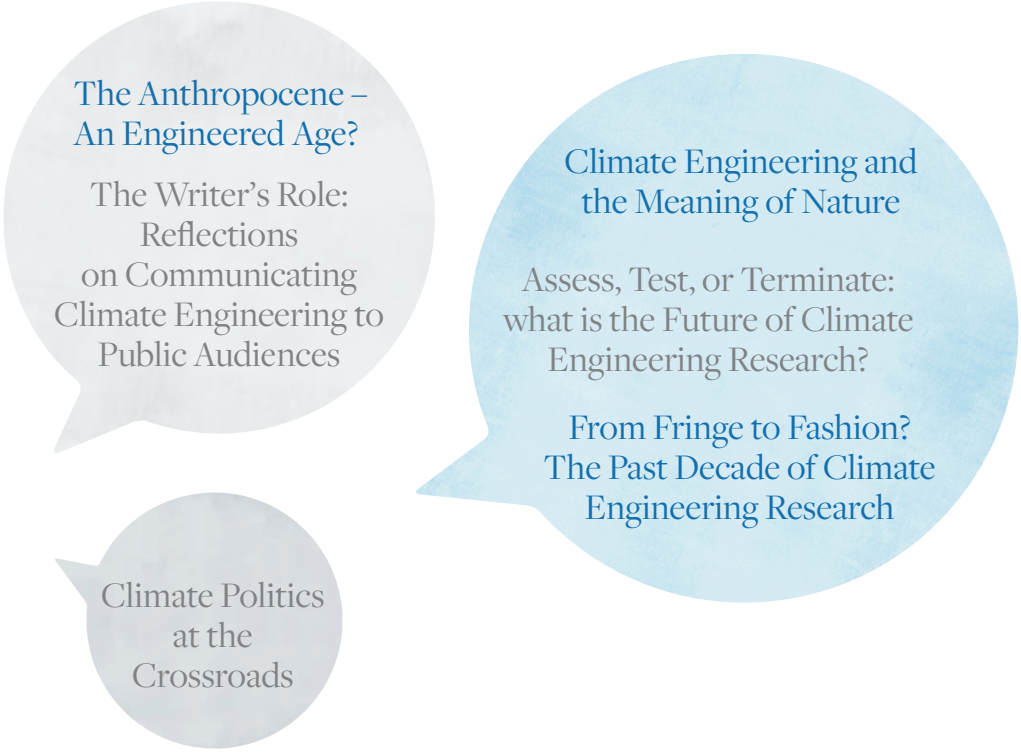
Stefan Schäfer, Academic Officer
Institute for Advanced Sustainability Studies

2. CEC14 Plenaries

A total of six plenary sessions took place at CEC14, distributed over the four conference days. The following subsections give an overview of these panel discussions, their composition, the panellists' opening statements, and the main points raised in the discussion.

Prior to the plenary sessions, three introductory speeches were given by Mark Lawrence (IASS Potsdam), Klaus Töpfer (IASS Potsdam) and Georg Schütte (German Federal Ministry of Education and Research); the texts of these speeches are available here.

All plenary sessions have been documented by video. They are available here.



2.1 From Fringe to Fashion? The Past Decade of Climate Engineering Research

Jason Blackstock and Ken Caldeira recount the evolution of the climate engineering debate.
©IASS/Piero Chiussi (Agentur StandArt)

Moderator:
Mark Lawrence (IASS Potsdam)
Panellists:
Ken Caldeira (Stanford University)
Alan Robock (Rutgers University)
Steve Rayner (University of Oxford)
Jason Blackstock (University College London)

The opening plenary featured some of the most active and influential researchers in the field and discussed major scientific findings and other milestones of the past decade in order to tell the story of the ongoing emergence of climate engineering research.

Ken Caldeira opened with an impulse presentation, arguing that the novelty of climate engineering approaches should be weighed against that of other large-scale environment-modifying infrastructure, such as dikes. He also argued that past usage of the umbrella term "climate engineering" has led to vague collective characterisations of very dissimilar technologies, and that future research and governance would be better served if discussions disaggregated individual technologies within the Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM) suites.

Alan Robock recounted the intents behind and the accomplishments of the Geoengineering Model Intercomparison Project (GeoMIP) and discussed how efforts to standardise model assessments of SRM, while useful for gauging physical processes and impacts, cannot answer social and ethical questions.

Steve Rayner noted his engagement with the production of the seminal 2009 Royal Society report *Geoengineering the Climate*, the generation of the Oxford Principles and its role in the governance processes of the SPICE Project, and requested consideration of "stage gates" and similar review processes to ensure that outdoors research has a social license to operate. He also proposed at this time the "Berlin Declaration", which is discussed in Section 4 of this report.

Jason Blackstock argued that the past decade's discussion has been reflexive and reflective, and driven by social and ethical questions as much as, if not more than, technical ones. Going forward, outdoors research may begin to drive discussions; "climate engineering" as a term should be parsed into constituent technologies, and intersections with mitigation and adaptation strategies as well as other global issues might receive greater attention.

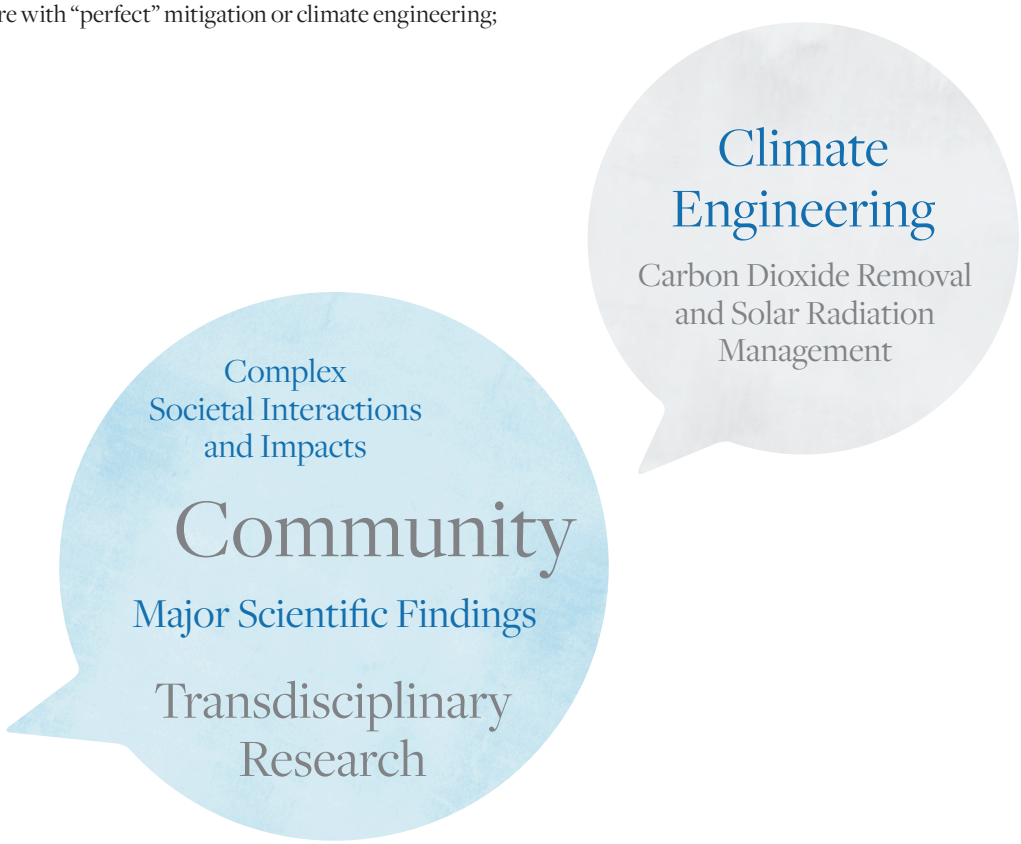
Points raised in the discussion included:

↗ The dangers of discussing the "community" of researchers engaged in climate engineering, or the term "climate engineering" itself, as collective nouns that encompass a spectrum of different positions or technologies;

↗ The need to acknowledge that scenarios in which climate engineering technologies are or are not deployed both present risks (although these are not necessarily comparable or exchangable) – there is no future with "perfect" mitigation or climate engineering;

↗ Whether an international governing mechanism is necessary – given the capacities of national governments or research bodies and consortiums to exercise regulatory authority – or even achievable given the technological immaturity of and social imaginaries associated with most climate engineering approaches; whether the international regulatory system for nuclear weapons provides proof of concept that seemingly ungovernable issues can successfully be "muddled through";

↗ The value of transdisciplinary research in investigating technologies with complex societal interactions and impacts.



2.2 Climate Politics at the Crossroads

Hans Joachim Schellnhuber tells the story of the rise of industrial civilization and global carbon emissions.
©IASS/Piero Chiussi (Agentur StandArt)

Moderator
Oliver Morton (Journalist)
Panellists:
Hans Joachim Schellnhuber (Potsdam Institute for Climate Impact Research)
Frank E. Loy (Environmental Defense Fund)
Harry Lehmann (German Federal Environmental Agency)
Jane C.S. Long (Earth scientist)

A panel of eminent and experienced scientists and policymakers provided their perspectives on the potential risks and opportunities for global climate policy posed by the emergence of climate engineering research, and its rapidly increasing prominence in the IPCC and various national and international research programmes.

Hans Joachim Schellnhuber opened with an impulse presentation that began with a historic overview of the acceleration of human civilisation's "industrial metabolism" – measured in cumulative carbon emissions – as it enters the Anthropocene, and concluded with an examination of the effects of CDR on ocean acidification.

Frank E. Loy led with an overview of international legal frameworks and principles relevant to the governance of climate engineering research and field tests, then argued that upstream governance of research should for now be treated as a scientific rather than a foreign policy issue, that science academies rather than governments or a universal treaty should be the first governance landing site, and drew a distinction between "sins of omission" and "sins of commission" in investigating climate engineering.

Harry Lehmann argued that the current state of knowledge in climate engineering – for example, through models – cannot and should not serve as the basis for active and sustained policy on developing climate engineering, and called for humility when translating early and imperfect conclusions gleaned from research into policy advice.

Jane C.S. Long noted that there is value in learning-by-doing, and that small experiments should serve as a test ground for revealing issues and developing ideas and mechanisms for governance, before scaling up to international coordination and structures; moreover, research should focus on regional and local impacts to better cater to political and policy concerns.

Points raised in the discussion included:

↗ Whether Germany's renewable energy transition (Energiewende) is a template relevant only to major (post-)industrial economies, or if it can be applied to economies with tremendous energy poverty; correspondingly, the need for a spectrum of decarbonisation strategies tailored to specific regional contexts and traditions;

↗ Whether the emission of carbon dioxide constitutes a form of climate engineering;

↗ The potential for the uptake of climate engineering research by defence departments, militaries, and associated complexes of actors, and for a corresponding shift in research and rhetoric towards more nationalist or securitised modes; or if uptake by military planners would presage a more rational, strategic and long-term outlook towards climate engineering research and climate change more generally;

↗ Whether discussing or developing climate engineering methods creates disincentives to reduce carbon emissions (the so-called "moral hazard"), or if the development of such methods and enthusiasm for their deployment could become inertial due to perverse incentives and vested or institutional interests on the part of researchers and technology developers;

↗ The value of the climate engineering discussion as a catalyst for discussion on how humans are culpable for the health and stability of natural systems, and how humans should assume a commensurate responsibility.

Learning by Doing ?

Germany's Renewable Energy Transition

The Need for a Spectrum of Decarbonisation Strategies

Perspectives

Moral Hazard

Global Climate Policy

2.3 Climate Engineering and the Meaning of Nature

From left: Jamais Cascio, Rafe Pomerance, René Röspel and Katrin Vohland discuss the interdependence between humanity and the natural world. ©IASS/Piero Chiussi (Agentur StandArt)

Moderator:
Katrin Vohland (Natural History Museum of Berlin)
Panellists:
Rafe Pomerance (Consultant in climate strategies)
Jamais Cascio (Open the Future)
René Röspel (Social Democratic Party of Germany)

Held at the Natural History Museum of Berlin, a panel of experts from the policy, civil society, and futurist research communities presented ideas about the meaning of nature in the age of human dominion over the earth, how climate engineering may challenge the notion of conservationism, and whether it might be seen as an enabler or impediment to harmonious human coexistence with what is commonly called the natural world.

Rafe Pomerance reflected upon his advocacy efforts for a stronger research programme for climate engineering in the US, the driving forces behind American opinions and choices on addressing climate change, and the need for governmental sponsorship and funding of 'high-risk, high-reward' research into low- or zero-carbon technologies.

Jamais Cascio noted that a futurist must consider the big picture: that in planetary terms the earth system will evolve and adapt to climate change, but human civilisation's dependence on the very specific climatic conditions of the past few millennia makes us far more susceptible to its changes. Therefore, the health of the planet today is inextricably bound to that of humanity 'over the long tomorrow'.

René Röspel expressed appreciation for the complex interdependence within all natural systems from human biochemistry to the climate, and acknowledged that while humans have always altered their environments, we might seek to reduce or reverse our footprint where possible. He also noted that the moral hazard is a concern, and that research into climate engineering methods might help us learn about its possible positive and negative consequences.

Points raised in the discussion included:

↗ Whether the increasing awareness that humanity is already modifying the planet in a collective – albeit uncorodinated – way suggests that ideas and aproaches should be developed to continue to do so, but with increased self-awareness of our own power and responsibility for the stability and health of the natural world;

↗ Questions of transparency and public access to research processes sponsored by the military or civilian agencies, exemplified by the approach of government-sponsored accelerated research advocated earlier by Rafe Pomerance;

↗ The need to forgive a certain degree of experimenting with modes of discussion, technology development, and governance going forward; as well as the need to be able to reverse our courses of action should they turn out to be undesirable.

2.4 The Writer's Role: Reflections on Communicating Climate Engineering to Public Audiences

From left: Oliver Morton, Dagmar Dehmer, Gwynne Dyer and Jamais Cascio discuss the power of the written word in communicating complex scientific and political issues. ©IASS/Piero Chiussi (Agentur StandArt)

Moderator:
Jamais Cascio (Open the Future)
Panellists:
Oliver Morton (Journalist)
Dagmar Dehmer (Der Tagesspiegel)
Gwynne Dyer (Independent journalist)

This panel featured a conversation among experienced journalists engaged with the topic of climate engineering on the communicative role of the writer in complex science-policy discussions, as it is often those who translate "hard science" into accessible language and give it common meaning that are particularly influential in shaping perceptions. Panellists were first invited to read excerpts from their own writings on the topic.

Oliver Morton read from the first chapter of his upcoming book *The Deliberate Planet*, whose language evocatively transported the audience into the stratosphere, and called upon them to imagine and describe it as a playground for human endeavours.

Dagmar Dehmer read from an opinion editorial penned for the German daily *Der Tagesspiegel*, describing the context and challenges of global climate governance following the UNFCCC Conference of Parties in Durban, 2011.

Gwynne Dyer read from his book *Climate Wars* (2008), an effort to highlight the politics of an engineered climate in the form of imaginative, narrative, and often-dystopian scenarios reported as "future history".

Points raised in the discussion included:

↗ Whether the progress and growth of the discussions have caused these writers to alter their original perspectives on climate engineering; or whether the discussion had changed significantly enough over the past few years to merit such a re-evaluation;

↗ If sceptical attitudes in Germany towards climate engineering might be an outgrowth of past civic and policy engagements with nuclear energy; correspondingly, whether societies without a history of nuanced and conflicted engagement with technologies such as nuclear will have a similar attitude towards climate engineering development and deployment;

↗ Whether climate change – and by extension, climate engineering as a particular proposed response – reflects not only a technical or political dilemma, but also an emotional one;

↗ The role and value of narratives, as well as catering to one's audience, in crafting impactful writing;

↗ Self-awareness of the power of journalists to shape discussions.

2.5 Assess, Test, or Terminate: What is the Future of Climate Engineering Research?

From left: Hauke Schmidt, Mark Lawrence, Victoria Wibeck, Simon Nicholson and Andy Parker explore possibilities for how research and public engagement may evolve in the next decade. ©IASS/Piero Chiussi (Agentur StandArt)

Moderator:
Andy Parker (IASS Potsdam)
Panellists:
Victoria Wibeck (Linköping University)
Hauke Schmidt (Max Planck Institute for Meteorology)
Simon Nicholson (Forum for Climate Engineering Assessment)
Mark Lawrence (IASS Potsdam)

In this panel, leading researchers supplemented the discussions of an earlier panel on the past decade of climate engineering research by sharing their visions and predictions of the next decade of activity. These included the possible roles and priorities of various stakeholder communities, and key scientific and social uncertainties that must be explored in order to support decision-making.

Victoria Wibeck extrapolated a number of trends from her bibliometric and public engagement research, noting that research on governance, social issues, and the methodology of investigating public perceptions, as well the geographic extent and diversity of participation in such engagement exercises, will increase; the natural and social sciences will increasingly disaggregate climate engineering into individual technologies; and the number of technologies discussed will diversify.

Hauke Schmidt noted that further climate engineering research would depend on perceptions of climatic conditions – for example, the recent warming hiatus, if sustained, might dampen enthusiasm for research. Regardless of that, modelling – as the only tool that can project climatic conditions – will intensify. Intercomparison projects like GeoMIP might be applied to CDR approaches, and model studies that focus more on climatic impacts of climate engineering deployment will become more prevalent.

Simon Nicholson called for further investigation of the political contexts surrounding climate engineering research. He rejected the idea that scientific research can be apolitical, as technological development is influenced by political pressures and in turn has political effects. Hence, there is a need to advance safeguards against rash or simplistic conceptions of CE's potential through careful conversation between policy and research communities.

Mark Lawrence predicted that the efforts to date by the research community to be critically self-reflective, looking carefully at the way that the broader community goes about studying and discussing climate engineering, and thinking about how this can be done more effectively, will continue and intensify.

Points raised in the discussion included:

↗ The capacity for perceived climate emergencies to catalyse public opinion in favour of climate engineering, with an attendant responsibilty for researchers to ensure that no hasty actions are taken on climate engineering in the event of a perceived emergency;

↗ Whether SRM via sulphate aerosol injections will ever be a politically feasible option, and whether or not it is comparatively technically or economically viable;

↗ Whether, in discussing the likelihood of CDR technologies to be deployed at large scale, these should be disaggregated between transboundary approaches such as ocean fertilisation and localised schemes such as biochar or BECCS with co-benefits for carbon capture and for local agriculture and livelihoods;

↗ The relative roles of the natural and social sciences in experimental design; as well as caution regarding any notion that the input of social scientists into technological research or development can act as a surrogate for the overall input from the public;

↗ Perspectives provided by "futurism": that predictions of the future are almost always wrong, especially when attempting to be specific. Rather, the goal of thinking ahead is not to predict what will happen, but to aid planning processes by making us sensitive to early indications that changes are underway, and to consider and prepare for a variety of plausible contingencies.

2.6 The Anthropocene – an Engineered Age?

From left: Klaus Töpfer, Armin Grunwald, Thomas Ackerman, Clive Hamilton, and Oliver Morton investigate the evolving relationships between science and technology, nature, and human societies. ©IASS/Piero Chiussi (Agentur StandArt)

Moderator:
Oliver Morton (Journalist)
Panellists:
Armin Grunwald (Office of Technology Assessment of the German Parliament)
Thomas Ackerman (University of Washington)
Clive Hamilton (Charles Sturt University)
Klaus Töpfer (IASS Potsdam)

In this public panel discussion held at the House of World Cultures, a group of eminent individuals with high-level scientific and policy experience explored our capacity to engineer or at least intervene substantially in systems from the genetic code to the climate, and discussed the promise and pitfalls of relying on ingenuity to guide us through a geological epoch profoundly defined by the power of human choice.

Armin Grunwald expressed, from his background in technology assessment, a twinned fascination and anger with climate engineering with regard to the global potential of its intents and impacts. He also questioned whether deployment of climate engineering approaches would over time become inevitable once enough efforts had been put into their development. However, he also noted that the climate engineering discussion is at a sufficiently early stage that we can still question what ethics and philosophies can or should guide our efforts, and closed with the thought that climate engineering is perhaps, like human enhancement technology, a symptom of a growing attitude that nature should not only be studied, but intervened in and improved.

Thomas Ackerman wondered if the realisation that humans can and are comprehensively altering the global environment may represent a paradigm shift in how environmental scientists engage with their work – a movement from a more passive "observational science" to active creating and tinkering in "laboratory science". Moreover, the boundary between research and deployment, or between simulation and reality, can be blurry in these imagination-fraught, future-oriented discussions. Scientists should therefore consider, beyond intellectual curiosity, the moral imperatives of their research.

Clive Hamilton described what he sees as the Baconian roots behind CE – the idea that science represents a transformative power over nature – and linked this tradition to "Prometheans" of today, who view the Anthropocene as a celebration of human ingenuity, agency and control over the natural world. He argued that the opposite is true: rather than effecting control over nature, humanity is jolting the climate out of a 10,000 year period of stability that cradled and still sustains civilisation. The question now is whether to continue activities that perpetuate the logic of Baconian control – such as climate engineering – or to consider efforts that reflect more humility towards our dependence on a stable climate.

Klaus Töpfer reflected upon how previous discussions on climate engineering had reinforced the need for institutes like the IASS to act as focal points between science and society, stressing that in such emerging technological discussions 'knowledge must be equivalent in extent to the consequences of our actions', and that such knowledge must be co-produced with society rather than simply communicated.

Points raised in the discussion included:

↗ As climate engineering enters mainstream societal and policy discussion, there is a need for discussions to revolve around concepts of care, responsibility, caution, respect towards natural systems, and human interdependence with them;

↗ Whether, following historic analogies such as nuclear technology, "big" technology is susceptible to centralised or even dictatorial control, and whether authoritarianism is a prerequisite for the deployment of technologies such as SRM via sulphate aerosol injection;

↗ Whether scientific inquiry is or should be free from moral constraints, and how attempts to answer this affect individual researchers or the scientific enterprise as a whole;

↗ Whether there are more benign, localised climate engineering approaches such as biochar and afforestation that should receive more attention than the transboundary, system-modifying approaches; in addition, whether the tendency to focus on transboundary methods stems from their perceived capacity to address climate emergencies;

↗ How the language used to describe climate engineering in engagements with the public and policymakers contains narratives that reflect values and agendas, and will strongly influence the evolution of the discussion and the development of climate engineering approaches;

↗ The Anthropocene as an epoch should be marked not only by renewed responsibility and justice in the relationship between humans and nature, but also between and within human societies.

3. Outcomes of CEC14 Sessions

The following sections summarise and synthesise key insights from the CEC14 sessions, organised according to five broad groupings:

↗ 3.1 Mechanics and impacts of approaches within Solar Radiation Management

↗ 3.2 Mechanics and impacts of approaches within Carbon Dioxide Removal

↗ 3.3 Models and assessments that gauge climatic and societal impacts

↗ 3.4 Political issues, actors and agendas

Session formats ranged from academic presentations to more interactive, participatory approaches. Linkages and overlaps between sessions can be seen across the conference, demonstrating and mirroring the complex interplay of issues involved in the climate engineering discussion.

3.1 SRM Mechanics and Impacts

A number of sessions highlighted engineering aspects of SRM techniques, focusing on the mechanics and feasibilities of their delivery systems, as well as their interactions with the physical environment and potential impacts on the climatic system. In addition, innovative new techniques and improvements to established approaches were discussed. It was noted that these CEC14 sessions represented one of very few efforts to date in interdisciplinary conference settings to host substantial discussion of engineering detail, allowing for a more comprehensive comparison of technical feasibilities and providing a valuable background for sessions on modelling, assessment, and governance.

Design of Practical Hardware for Climate Engineering explored engineering developments in – and improvements to the viability of – a number of approaches that have existed for a significant period (in some cases decades), but have received less attention than sulphate aerosol injection. Among these were improvements to the longevity of foams on seawater to reduce the energy demand of sea-going hardware, methods for delivering materials to the stratosphere via pipeline or artillery technology, spray ship design, and the production of salt nuclei in marine cloud brightening. Exploring the Intersections between Climate Engineering and Systems Engineering focused on the chemical, radiative, and microphysical effects of using alumina particles as opposed to sulphate aerosols, as well as a method of reducing atmospheric methane concentrations via the activation of chloride that simultaneously addresses multiple sources of climate change. Novel SRM Techniques explored the practicalities and climatic effects of cirrus cloud thinning, marine sky brightening, and microbubbles that increase ocean surface albedo. Exploring the Intersections and Novel SRM Techniques also contained presentations that broadened explorations of engineering aspects to intersections with climate and other systems: on the improvement of detection and attribution, climate feedback loops, the design of a particular field experiment to assess the effects of stratospheric water vapour on ozone, and the viability of earth radiation management strategies as alternatives to SRM.

The Potential Role of Space in Climate Engineering Concepts investigated space-based SRM methods and uncertainties in the form of space-mirror configurations and laser filamentation. However, the application of space-based assets for mitigation activities was also explored, including the harvesting of solar energy from space instead of at the planetary surface, reductions in the carbon footprint of infrastructure

in space as compared to on the earth's surface, and the effects of cloud coverage. A crucial linkage was made to the climate modelling community on the need for space-based hardware to contribute to monitoring and verification of atmospheric and surface carbon concentrations as a first application.

3.2 CDR Mechanics and Impacts

CDR is an explicit component of the vast majority of mitigation scenarios that could achieve concentration pathways as represented in RCPs 2.6 and 4.5, the IPCC Fifth Assessment Report's two most optimistic scenarios for global temperature rise. Carbon Air Capture Efficiency Prospects: Current Research and Future Directions investigated the capacity of both technological and naturally occurring (biological) methods to directly capture and store carbon from ambient air. Enhanced Mineral Weathering: Potential and Consequences examined the processes and potential impacts of accelerating or artificially stimulating weathering – a breakdown of mineral rocks that sequesters CO_2 in terrestrial, coastal and oceanic environments. Attention was also paid to the effects of enhanced weathering on reducing ocean acidification and restoring ecosystems, and its combination with carbon air capture technologies to enable long-term sequestration.

Biogenic Carbon Sequestration: Multifunctionality for Global Resilience connected CDR to land-use and agricultural issues, examining afforestation for its effects on irrigation and desalination of soils, and biochar for its effects on crop yields. It became clear that the viability of these methods rested not only on their capacity for carbon sequestration, but also on the desirability of such methods from the point of view of local communities, who are more concerned with the co-benefits generated by managing local CDR and enhancing resources, such as wood and crops, from the land.

Understanding Carbon-Cycle and Climate Feedbacks of Carbon Dioxide Removal Methods highlighted recent work exploring the capacity of CDR to create feedback processes in the climate system. These can be direct (on the carbon-cycle response) and indirect (physical or biogeochemical climate processes), and influence the viability of techniques as diverse as ocean iron fertilisation, terrestrial CO_2 removal strategies, desert greening strategies, and SRM methods. Further discussion revealed a need to improve the comparability of the different Earth System Models used by the session's presenters to scope various techniques, in order to draw more systematic conclusions. To that end, a working group was formed by the session's participants to design a CDR model intercomparison project to address both general questions about the efficacy of CDR – how "reversible" is the climate system by applying a CDR strategy and what components of the climate system exhibit hysteresis – and the climatic feedbacks associated with specific techniques such as afforestation or enhanced weathering.

3.3 Models and Assessments

How can the processes and impacts of climate engineering be modelled and assessed, and what is their value as tools to facilitate decision-making under conditions of uncertainty? Deploying – perhaps even researching – these technologies will have complex repercussions for the climate system, politics, economy, and society that can only be observed in hindsight. For example, the climate impacts of SRM would not be easily separable from the impacts of GHG-driven climate change for several years following deployment. Hence, we must rely in part on projections and simulations of climate and society in a climate engineered future to provide such information and strive to make their parameters, data, and comparability more robust, while remaining conscious of their limitations, and understand how models influence and are influenced by political concerns and contexts.

The Geoengineering Modelling Intercomparison Project (GeoMIP) has since 2010 sought to improve the comparability and credibility of SRM simulation results across a range of climate and Earth system models. In a dedicated session, the project presented results from a wide variety of fields, including climate variability, the cryosphere, ocean circulation, the carbon cycle, and extreme events. There were also presentations that discussed attempts to translate the climate modelling results of GeoMIP into impacts and regional inequalities, representing the project's first steps toward interdisciplinary and transdisciplinary efforts to understand SRM. The session concluded with a presentation of the newly-designed GeoMIP simulations that will contribute to major worldwide climate modelling efforts. Comments on the design of these experiments was opened to the audience and the broader community, and continues to be open to all interested parties regardless of discipline, in an at-

tempt to make the output of GeoMIP more relevant to decision-makers.

Building on this modelling basis, Modelling Extreme Risk: Assessing High Impact, Low Probability Events discussed frameworks for how extreme events might be modelled. Beginning with statistical fundamentals and differences between near-term and long-term modelling of extreme events, discussions then delved into how an extreme event might be conceptualised in the first place, as climatological impacts exacerbate or intersect with a wide range of global issues. The effects climate engineering may have on the "trajectory" of society, and the implications of Collingridge's "control dilemma" – that the risks of emerging technologies are best understood at the stage of deployment, when they are also least controllable – were also explored.

From Projections to Control: The Role of Climate Modelling in SRM deepened the discussion on the capacity of Global Circulation Models (GCMs) as tools in decision-making on SRM. The decadal timescales necessary to produce reliable, empirical knowledge about the climate effects of SRM may not be relevant to the socio-political concerns of governments and societies, who would desire more immediate information. Models cannot provide fine-grained data over shorter timelines and below continental scales; moreover, they not only incorporate physical data, but also the conceptual theories and emphases of the scientists who build them. This can create multiple idealised realities – that amplify certain factors and simplify others – on which to base decision-making prior to making a decision on SRM deployment and after deployment in attributing observed changes and events. What are the implications for scientific research, political engagement and governance if models, and the augmented realities they contain, are to serve as the main source of information, and a key spur to or even precondition for policy in climate engineering? Further research is required with regard to the climatic changes projected in models and the uncertainties of such projections; the relationship of models to observation and the challenges of detection and attribution; how models intersect with policy and the confidence different groupings of scientists and societal stakeholders have in them; and, on a more overarching level, the value and necessity of evidence in simulations that are part projection and part thought experiment.

While not modelling per se, foresight exercises as described in Climate Engineering in Popular Culture can supplement the modelling of physical impacts by focusing on wider sociopolitical challenges, stakeholders, and agendas. Foresight is widely applied in military, corporate and governmental settings as an anticipatory measure; it assumes that while the future cannot be predicted, expansive and innovative scenarios of the future can generate an informative range of contingencies that cannot be extrapolated from current knowledge. These can be used to strengthen the resilience of decisions made today, as well as reveal and map the agendas of relevant stakeholders. To that end, foresight is designed to bring together participants from multiple disciplines and worldviews in forecasting contingencies. This is in turn connects to discussions on the wider landscape of issues, actors and agendas in global governance, and on whether further research and engagement in these areas narrow or widen uncertainty.

3.4 Political Issues, Actors and Agendas

Climate engineering cannot be narrowed down to its technical or scientific aspects – costs, feasibilities, and interactions with and impacts upon the environment. Climate engineering must also be recognised as a political and ethical discussion, in which the complex landscape of issues, actors and agendas in global governance provides the contexts – and shapes the consequences – of decisions made on research, deployment, and governance.

How can socioeconomic and geopolitical risks be scoped? Who are the relevant stakeholders in the discussion and in decision-making, and how can they be engaged? What are the values and interests that undergird their platforms? How does climate engineering intersect with long-standing global environmental and security issues and politicised communities in all geographic regions and at all levels of governance? How can these explorations be conducted in a forward-looking and adaptive manner? CEC14 sessions sought to investigate these questions in a comprehensive and crosscutting way.

3.4.1 Framings, Risks and Ethics

Stakeholders bring various perspectives to their engagement with climate engineering and sometimes seek to define the technologies and risks in very different ways. The construction and contestation of

initial framings can create boundaries around discussions that emphasise certain factors over others, with consequences for the scope and intent of research and governance. A number of popular framings were explored. In the session Exploring the Politics of Climate Engineering, it was suggested that SRM, by shortening the causal chain of harm and introducing intentionality, may make it easier to introduce friend-enemy logics and shift climate out of the normal sphere of politics into the security category where extreme measures appear legitimate – a so-called "security hazard". The Plan B or "emergency" framing was criticised for separating SRM measures from a more holistic mitigation portfolio, and framings that appeal to political failure or realism – that climate engineering research is necessary because mitigation cannot be expected to succeed – were seen to forestall critical discussion. In a similar vein, the session Climate Emergency: Science, Framing and Politics noted the potentially undemocratic nature of emergency declarations and the political risks inherent in a "state of exception", with a panel of experts pointing out that a climate emergency is a value judgment that is declared – not the subject of an objective evaluation – and generally favouring the abandonment of the emergency framing.

Will Climate Engineering Unduly Hinder Emissions Reductions? explored the idea that CDR and SRM might prove a distraction from mitigation or adaptation – a so-called "moral hazard". It was generally agreed that the term itself was unhelpful, and that "risk compensation" might provide a framework that is more conceptually accurate and empirically based. There were, however, questions as to how accurately such risk could be calculated. Assuming rational actors have accurate knowledge of climatic and economic impacts, redeploying some resources away from mitigation and adaptation towards climate engineering efforts might be both expected and prudent. However, it is also possible that that people might overestimate the potential of climate engineering and invest in it disproportionately. There might also be an "inverse moral hazard" effect, where concerns about climate engineering act as a spur to emissions reductions. Under such conditions, participants also examined the suitability of the incentive structures of politicians or scientists from the North and South to make choices between mitigation and climate engineering within an integrated and intergenerational climate strategy.

Intentional and Unintentional Interferences in the Climate System investigated the ethics of causing and addressing intended and unintended effects in deploying climate engineering. Much discussion circulated around the "doctrine of double effect", which investigates the permissibility of an action with good intentions but harmful side effects, with arguments ranging from whether the doctrine makes unintentional harms from climate engineering appear no worse than unintentional harms from carbon emissions, to whether other ethical principles, as well as the role of agency and uncertainty regarding potential harms of deployment, counteract this argument. The session also considered the permissibility of intentionally "diverting" climate-change related impacts by using climate engineering techniques to change the distribution of climate impacts.

Ethics of Carbon Dioxide Removal raised a number of normative and ethical challenges more particular to CDR. Issues ranged from the conceptual to the scientifically and politically practicable: the appropriate conceptualisation of the concept of CDR in the context of mitigation, the balance between the effects of climate change without any use of CDR and the side effects of CDR on the environment, and the scientific uncertainties linked to different approaches. Presentations also highlighted theories of justice, the normative and instrumental benefits of improving public engagement strategies for local support as well as insights into local conditions for success, accountability and responsibility for undesired consequences, and the capacity for the carbon price of CDR methods to influence the ethics of their deployment.

3.4.2 Intersecting Global Governance Issues

Climate engineering evolves within a spectrum of interlinked issues in global governance. Stakeholders from discussions as disparate as international security, humanitarian concerns, air and ocean pollution, agriculture and land use, and energy transitions were able to generate and explore linkages among these issues, creating a more holistic picture of the global governance landscape in an engineered climate.

International and human security issues, and the "securitisation" of the climate engineering discussion, were also raised in the Risks and Conflict Potential of Climate Engineering and in Climate Geoengineering and the Potential Roles of Human Rights Re-

gimes sessions. The former argued that while SRM and climate change both alter the environmental parameters affecting availability and access to resources, SRM creates an additional layer of complexity and associated challenges. The potential for weaponisation of these techniques and the multiplication and exacerbation of existing conflicts was discussed, as well as the possibility that militaries could become the dominant actors in any SRM deployment. Accordingly, the governing mechanisms discussed clustered around arms-regulating regimes rather than environmental governance institutions. Similarly, the language and legal conventions of human rights were examined for their capacity to address humanitarian crises in the political context of an engineered climate.

Linkages between Climate Engineering and Short-Lived Climate Forcing Pollutants (SLCPs) examined the potentials and trade-offs of managing emissions of black carbon (soot), methane, and sulphates, to reduce their impacts on both climate and human health. Although efforts have focused on SLCPs with warming effects, there is greater confusion surrounding industrial and shipping emissions of sulphates, an air pollutant that also cools the climate. Attendees discussed the dangers of establishing a conceptual linkage between SRM and the intentional management of sulphate emissions as a climate measure, and questioned the value of moving from a framework emphasising reductions in greenhouse gases to one that emphasises management of radiative forcing. In Biogenic Carbon Sequestration: Multifunctionality for Global Resilience, linkages were established to agriculture and land-use issues. Asian field cases emphasised that successful local stewardship of carbon sequestering options depended on their supplementary effects on crop yields. In addition, concerns were expressed about monocultures and biodiversity loss.

Climate Engineering and Human Engineering: Social and Technical Challenges in the Anthropocene examined these two discussions as anchoring cases of emerging technologies with transformative potential in society, in the context of the contemporary argument that the influence of human initiative and civilisation on the planet has become equal to geological forces. Questions were raised about the historical context and the normative good of using technology to alter or enhance the natural, be it climate systems or human genetics. Presentations also recognised that prior reflection on the ethics of new technologies like climate or human engineering can be curtailed or trumped by political contexts, and examined the power of individuals who catalyse new systems of technology, thought, and support during foundational periods of development.

3.4.3 Exploring Perspectives

The research or deployment of climate engineering may require engagement with affected communities. However, for techniques with transboundary or systemic impacts, the question of who to include in the discussions widens to encompass a potentially global system of stakeholders. It can also be argued, as in the Responsible Innovation session, that especially in the foundational stages of an emerging issue, a varied and open-ended range of participants and framings is needed to avoid overly hasty problem definitions and programmes of action – a component of anticipatory governance. Who, however, are the relevant stakeholders, how can they be fruitfully engaged, and what are their underlying values?

A number of sessions tackled these questions. What do People Think and Feel about Climate Engineering critically examined social science methods of soliciting and investigating public perceptions. Difficulties were revealed regarding how laypeople enter into expert-driven discussions; how studies are designed, as framing questions can influence respondents' answers; and models of scientific and political representation. For example, how does one garner an accurate sample of the public; are these comprised of individual "everymen" or of distinct communities and NGOs that form around political discussions? Can these opinions be taken as representative of wider demographics? Rationales for engaging the public were also discussed, such as the right to know, or the provision of perspectives for forward-thinking governance.

Climate Engineering in Popular Culture supplemented this by investigating art, film, literature, games and foresight methods as media that can investigate perspectives and expand discussion in a manner that expert-based research might not – by being open-ended and participatory in design, and innovative and expansive in conceptualising the (future) landscape of an engineered climate. Mapping the Landscape of Climate Engineering examined the ecology of perspectives from a bird's-eye view, with mappings of arguments and claims made about climate engineering, of topical constellations and

linkages within the scientific literature, and of framings and criteria of desirability that undergird a range of climate measures, including climate engineering, mitigation and adaptation options. A link can be seen between mapping and perspective-soliciting methods in revealing patterns for analysis and anticipatory thinking. To Gabon or Not to Gabon: A Game on Geoengineering Research engaged participants in an interactive exercise in which teams of players role-played countries with limited resources to combat the increasing effects of climate change on local livelihoods. More interestingly, teams were also given the option of investing resources in climate engineering, as well as cooperating in its research and deployment. The gameplay reflected, in a stylised way, the potential for geopolitical disagreements over the uneven effects of SRM deployments, competition based on different national capacities to weather climate change or develop climate engineering, and difficulties in communicating or interpreting complex scientific knowledge and developing new policy options under conditions of uncertainty and limited resources. The game exposed participants to a new method of exploring perspectives in two ways: by demonstrating the value of immersive and participative gameplay in generating new insights and perspectives, and as an accessible method to communicate scientific and political complexities to new audiences.

Perspectives on Climate Engineering From the Front Lines, Developing Countries and SRM, Civil Society and Geoengineering: Who's Engaging Whom?, and How can Civil Society and the Scientific Community Jointly Address Climate Engineering went beyond methods and mapping, targeting issues in two particular demographics: civil society as a broad category, and developing countries. It may be difficult to make general assumptions about the concerns of these demographics. The public engagements that informed these sessions are not comprehensive, echoing the concerns on methodology highlighted earlier; moreover, different countries and societal groupings may have varying attitudes towards certain climate engineering techniques due to their culture, socioeconomic factors, scientific and technological capacity, and historic relationships to other polities with regard to climate change and other geopolitical issues. Groups within the broadly defined "left" and "right" wings of North American society, for example, might be inclined towards certain viewpoints on climate engineering due to pre-existing sets of adopted values regarding the reality of anthropogenic climate change, social justice and environmental health, and the necessity of the carbon economy. It was, however, noted that wider publics might also broadly share concerns regarding secrecy and a challenge to democracy, vested interests, and profiteering based on financial or political motives rather than scientific ones in technological development and deployment.

Among some participants from developing countries, this concern, in a particular form, was especially acute: that many countries in the Global South share a history of decisions made by others that usually benefit actors in the Northern hemisphere, and that climate engineering might siphon off resources from mitigation and adaptation efforts and cooperation. In this context, humanitarian concerns and linkages to human security were again raised with regard to what resources would be available for the affected in the least developed countries should climate engineering (especially SRM) be deemed necessary. It was suggested that procedures be sought and capacities developed to include participants in research and decision-making, linking to a wider theme on the need for multilateral engagement and governance from the discussion's earliest stages to forestall future antagonism.

3.4.4 Legal Regimes and Governance Frameworks

Are climate engineering technologies governable, and if so, what mechanisms and forums are appropriate? A number of governance regimes and frameworks at international, national, and sub-national levels were explored, as well as broad drivers influencing the intent and scope of governance. These include: the particular technology or basket of technologies (SRM or CDR) to be governed; the state of technological development (research, field tests and deployment); and the indeterminate nature of risk and uncertainty that must encompass technical and societal concerns.

Responsible Innovation and Climate Engineering examined anticipatory modes of early governance for use within communities of researchers and technology developers. Discussions focused on "responsibility" as a concept and practice, on deliberately widening the scope of discussion, and on integrating scientific and societal actors and knowledge in assessing techniques and governing research through inclusive and reflexive methods. National Laws, Global Liability

compared national environmental and tort laws, assessed civil and criminal liability for transboundary effects, and discussed the capacity of existing or new international conventions to guide domestic applications. Climate engineering ultimately seeks to create transboundary effects, and if there is no international agreement in the near future, domestic national laws may provide the first effective basis to regulate climate engineering and impose liability for any damages or disruption that it might cause. Regional Paths to Global Change expanded these lines of discussion to sub-global regions, discussing how regions might use collective natural disaster management as a template for regional climate intervention, the differences in legal context between the governance of a deployment with global effects and one that is local or regionally based, as well as capacity building among regional coalitions.

The International Control of Climate Engineering and Research: Debating Why, How and Who, International Law for the Regulation of Climate Engineering and Climate Engineering Governance: Is the Climate Convention the Right Place for It? examined regulatory mechanisms at the international level. All noted that there is a rich but fragmented context of existing legislation that applies piecemeal to varying techniques, scales, and spatial environments (marine or atmospheric) impacted by climate engineering. Questions were raised on how to promote coherence across the relevant structures of these regimes, on the necessity of new statutes and structures specific to climate engineering, and on whether all climate engineering techniques or stages need be regulated internationally. Discussions tended to support the need for international control of experiments and deployments with transboundary risks, but there was less agreement on the appropriate level of regulation and how to achieve political buy-in.

An ascending scale on which research, field tests and deployment could be situated proved difficult to derive. There is largely no definition of "scientific research" in international environmental agreements, although one has been created recently in an amendment to the London Convention and Protocol with relevance to climate engineering in the marine environment. Although a distinction was made between indoors (modelling and laboratory work) and outdoors research (field tests), it was also acknowledged that the question of physical scale and impact creates an indistinct boundary between large-scale outdoors tests and deployment. However, can clear lines be drawn between small-scale, short-term SRM tests designed to examine atmospheric chemistry or aerosol delivery, and larger-scale, longer tests to determine physical impact? These distinctions proved more concrete in technical and physical definitions of risk. However, it was also noted that political agendas and societal anxieties surrounding the wider enterprise of climate engineering, and not the minutiae of individual tests or projects, shape calls for governance – a factor echoed in other sessions on modelling and public perceptions. In such an indeterminate climate, questions of the value of a moratorium on outdoor climate engineering activities prompted cautioning against the excessive restriction of scientific work.

The International Control of Climate Engineering and Research: Debating Why, How and Who provided the most in-depth treatment regarding the function, form, and design of governance structures, stressing that trade-offs are inevitable depending on the objectives and objects of regulation, and that there is no one obvious location or design. It was broadly noted that regulatory functions should provide internationally agreed standards for national oversight that remain light and flexible, monitor developments in climate engineering, create transparency in the face of potential commercial interests, engage the wider public, and exchange information between states and within the scientific community.

Regulatory form might need to account for differences in climate engineering methods, technological and political developments, and the current level of knowledge and uncertainty. There was some support for the idea of an international framework for both transboundary experiments and deployment, with a prohibition of deployment in combination with a requirement for permission in research experiments seen as a reasonable model. Such a forum might be multilateral, and the possible roles and the (dis)advantages of the CBD and the UNFCCC were discussed, although neither was clearly favoured. Climate Engineering Governance: Is the Climate Convention the Right Place for It? supplemented these discussions with presentations on the UNFCCC's potential to integrate climate engineering into the same science-policy interface as climate change, as well as the framework and negotiation agenda based on mitigation and adaptation.

On regulatory design, there was discussion on the level of government that should be responsible, the range of stakeholders, questions of gaining legitimacy, the substantial requirements experiments should meet, and the need for a *de minimis* clause. Regarding the level of government, participants took the view that there should be a differentiation of responsibility between the international and national level based on scale and transboundary effects, although the issue of the role of research institutions versus governments was raised for the latter. Participants argued for rules that take into account wide consultation and independent scientific and socioeconomic review, acknowledging that the participation of indigenous peoples would need different outreach methods. The question of legitimacy referred to the transparency of procedures and decision-making, the inclusion of expertise, peer review of research activities, third-party review of the decision-making process, and accountability for decisions made. For substantive requirements, impacts of experiments should be reversible or corrigible, with assessment against a baseline. However, participants saw it as very difficult to identify a *de minimis* threshold and expressed the opinion that it would have a negative effect on the creation of legitimacy.

4. Discussing the Draft Declarations on Research Governance

4.1 Background

CEC14 was conceived to promote transdisciplinary discussion of CDR and SRM, and to provide a platform that would allow a diverse array of participants to articulate a wide range of perspectives in a critical, yet constructive manner. The conference was not designed to, and did not, produce any kind of formalised group statement, though it also left open the door for all kinds of initiatives and proposals from the conference participants, which included windows for short-notice formation of sessions on ideas and topics that came up during the conference.

Since this degree of openness and flexibility at a conference is uncommon, it came as a surprise to many of the attendees when, without prior notification of the conference participants, a draft statement on research governance, titled the "Berlin Declaration", was presented at a plenary on the first day by members of the team behind the Oxford Principles. Some attendees strongly objected to having allowed the presentation of such a statement during the opening panel discussion. Later on, the statement was challenged by a second statement circulated by the participant Clive Hamilton. The initial draft statement was intended by the authors to be shaped over the course of the conference's four days and signed only by those participants that supported it at the week's end. Nevertheless, many felt that there would be a perceived association with the conference and its attendees, whether those agreed with the statement's content or not.

In retrospect it was a misjudgement to allow the introduction of a draft statement without prior notification of the participants, and without clear mechanisms for public debate and opposition. The organisers approved the request by Steve Rayner and Tim Kruger to introduce the Berlin Declaration to the conference, and announced this in plenary. However, it was not initially clear to many of the participants that the statement was not an officially endorsed conference output, but approved as an independent initiative within the framework of the conference. An important lesson for the future would be to circulate any proposed conference outputs – whether proposed by the conference organisers or by participants – well in advance, providing a meaningful opportunity for conference participants to provide feedback and input, including the possible recommendation to not introduce the document at all in plenary.

Nevertheless, by continuing to adhere to the conference principles of open and multi-faceted discourse, the introduction, discussion and eventual dismissal of the statement was, in the end, turned into a useful discourse. It gave participants an opportunity to express, share, and challenge their often divergent views on what may be one of the most pressing concerns in the climate engineering conversation today: the near-term governance of field experimentation. It also provided a fascinating inside view into the climate engineering research "community", and should be understood as a crash course in community politics, where concepts such as transparency, openness, reflexivity and inclusiveness were put into practice.

4.2 The "Berlin Declaration" and the "Scandic Principles"

The statement by the team behind the Oxford Principles (which can be read here) addressed the governance of SRM experimentation conducted outside the laboratory. It called for outdoors research not to be approved until transparent review processes had been established. They would mandate prior disclosure of research plans and independent evaluation of all existing evidence, plans and results, and would actively seek public participation. The process would give experiments a 'social licence to operate', the statement claimed.

The introduction of such a statement was generally not well received by the CEC14 participants. Many took exception at the process for revising the statement. No open discussion was planned, and the only way to provide input was to email edits to one of the statement's drafters, who would try to incorporate the different suggestions. Those who disagreed with the exercise were asked not to participate. Some participants were upset with the content of the statement itself, concerned in both directions: either it might prevent important climate engineering research, or provide a carte blanche for outdoors experimentation. Many worried about how those not attending the conference, especially those in the media, might spin the statement. From "climate engineers reject regulation" to "climate engineers write their own rules", a wide range of interpretations seemed possible.

On the day after the introduction of the Berlin Declaration, Clive Hamilton (Charles Sturt University) introduced another, alternative statement (titled the "Scandic Principles", which can be read here). It focused on longer-term governance challenges and on institutions rather than on near-term actions. Citing a range of potential risks, his statement called for the establishment of a multilaterally agreed international body to oversee SRM research.

In light of the widespread concerns about the Berlin Declaration, three participants[1] worked with the conference organisers and the team that had drafted the statement to develop a way forward. A town hall-style meeting was planned to allow the Berlin Declaration to receive a public hearing.

The video recording of the town hall meeting can be watched here. For further information, a detailed description of the meeting along with links to specific points in the video can be found in Annex I.

4.3 Discussion

Following the town hall meeting, the draft "Berlin Declaration" and "Scandic Principles" statements both went unsigned.

It was not clear whether disagreements over the statements' content were a result of entrenched opposition over small differences, or whether they showed that small details will matter for governance. For instance, many people agree that in the short term there should be standards for transparency in experimentation, and some degree of public engagement in the development of SRM. Similarly, it has frequently been noted that in the medium term an international process will be necessary if outdoors research approaches a scale where it might have transboundary impacts. The two statements showed that emphasis and prioritisation matter when formulating climate engineering policies. However, as Steve Rayner pointed out, the statements were not necessarily mutually exclusive, and focusing on the longer term design of institutions does not remove the need to design governance arrangements for projects in the near term.

[1] It is important to recognise the crucial role that Oliver Morton (science writer and journalist), Andy Parker (IASS Potsdam) and George Collins (Geoengineering Scenarios Working Group) played in organising the town hall meeting and thereby enabling this conversation to take place. Plans for this were discussed with and facilitated by the organisers, but the organisation of the town hall meeting was an independent effort provided as a service for the conference attendees.

One of the clearest conclusions from the town hall meeting was that the process by which group statements are drafted, introduced, discussed, finalised and signed is important. The most common complaints about the draft Berlin Declaration concerned the way it was introduced and the lack of opportunities for reshaping it or dissociating from the process. This is noted here so that it will be kept in consideration for future conferences on climate engineering and its various specific aspects.

Although as noted above it would be recommended to follow a different procedure in the future, the introduction of the draft "Berlin Declaration" did end up prompting several very useful discussions. Furthermore, there was clear support for a follow-up process to discuss and shape such statements, showing the desire for a focused discussion on practical steps forward for governance.

Perhaps the clearest message was about the climate engineering community itself. The short town hall meeting saw interventions from experts in international relations, anthropology, geography, ethics, engineering, humanitarian aid, climate modelling and environmental policy. Discussion of the draft Berlin Declaration, from its initial introduction in a plenary session to the occasionally tense exchanges in the town hall meeting, was all captured on camera and posted online for public review. The footage shows a diverse community that is at the same time thoughtful, conflicted and combative, with its members actively seeking constructive exchange and dialogue. Even though the Berlin Declaration did not proceed beyond the draft stage, it was encouraging that its deliberation took place in public view, and in the critical yet constructive manner that characterises the climate engineering discussion to date.


Can
Technology
control
the Climate?
Can we
control
Technology?

5. The Future of the Climate Engineering Conference

An objective of CEC14 was *to explore the value of a large-scale conference held on a semi-regular basis as an appropriate forum for the emerging field of climate engineering.* In this section we draw upon responses to a conference evaluation form completed by conference participants as well as the insights of the organisers in order to reflect on aspects of this question.

On the whole, reviews from conference participants were positive. The organisers are confident, given initial feedback, that a large conference of this type, which covers some combination of the technologies discussed at CEC14, is warranted on a roughly biennial basis. However, it is important to note that, while feedback was positive in general, individual conference participants' views as expressed in the conference evaluation forms, and subsequently in communications with the organisers, differed substantially on some of the aspects discussed below. Opinions vary especially widely with regard to the question of whether CDR and SRM should be discussed at the same event, as is depicted below in the section on the question of what range of technologies should be covered in future CECs.

5.1 What Range of Technologies Should be Covered in a Future CEC?

Objective: *To scope key research questions and challenges for academia and society, covering both solar radiation management (SRM) and carbon dioxide removal (CDR) technologies.*

Discussion: The degree to which it is useful to address both sets of approaches under the umbrella term "climate engineering" or "geoengineering" was a keenly debated subject at a number of sessions at CEC14. While there was no clear consensus about whether any future conference of the scale of CEC14 ought to, for example, limit its scope to either SRM or CDR, discussions during and after CEC14 indicate that it is not a question of whether discussions in this area should become more technology specific, but when, and in what contexts.

It was also pointed out that discussions on other technologies, for example nanotechnologies, have historically been initiated under an umbrella framing before narrowing down around the particulars of individual technologies and, perhaps more significantly, their various applications. Some participants expressed a concern that such a narrowing down might limit discussions to expert communities and exclude consideration of the broader context in which scientific and technological development take place.

Conclusion: A conference of the style and scope of CEC14 could serve the purpose of maintaining the existence of a regularly held open forum for discussion of the range of technologies contained within the umbrella of climate engineering, and the broader issues that come into view when discussing this highly complex and interlinked topic. Allowing for topical inclusivity at future CECs may help foster recognition of the societal contexts in which proposals for both SRM and CDR are situated, including questions of sustainability, development, human rights and many other topics, and has the potential to prevent discussions of climate engineering from proceeding in isolation of these important broader discussions. However, it should be recognised that, in order to meaningfully be subsumed under the umbrella term climate engineering, a proposal would need to envision some larger scale of activity that would have the potential to affect climate outcomes independently of managing greenhouse gas emissions. At the same time, other meetings organised independently of CECs could provide more in-depth treatment of technology-specific issues that require their own fora for scientific exchange, which could then be re-contextualised at future CECs.

Dissenting opinions: Several conference participants used the space in the evaluation form that asked for what might be improved in future CECs to express an opinion that future conferences should not focus on the collective suite of approaches that is currently subsumed under the umbrella term climate engineering. The reasons given for this were that the range of topics that such a conference would have to navigate would be too broad and too complex for a single event, and that the relevant issues attached to individual approaches are not sufficiently similar between the categories of CDR and SRM to warrant discussion at the same conference.

5.2 How Comprehensive and Inclusive Should a Future CEC Aim to Be?

Objectives: 'To provide a platform for exchange, networking, and collaboration across disciplines, sectors (particularly academia, policy and civil society), geographical regions, cultures, and generations', and 'to address comprehensively and in a balanced manner the technical, geophysical/geochemical, ethical, and social contexts in which the idea of engineering the climate is being contemplated.'

Discussion: Conference evaluations indicate strong support for two core aspects of the CEC14 concept – inclusivity and comprehensiveness. Many participants reported that their experience was enriched considerably by opportunities to engage with participants from a range of different disciplines, geographic and cultural backgrounds (with 41 nationalities represented), and political perspectives. Such diverse participation contributed to the comprehensiveness of topics covered, something that was also highlighted by many participants as a strength of the conference.

Figure 1: Participants' professional backgrounds

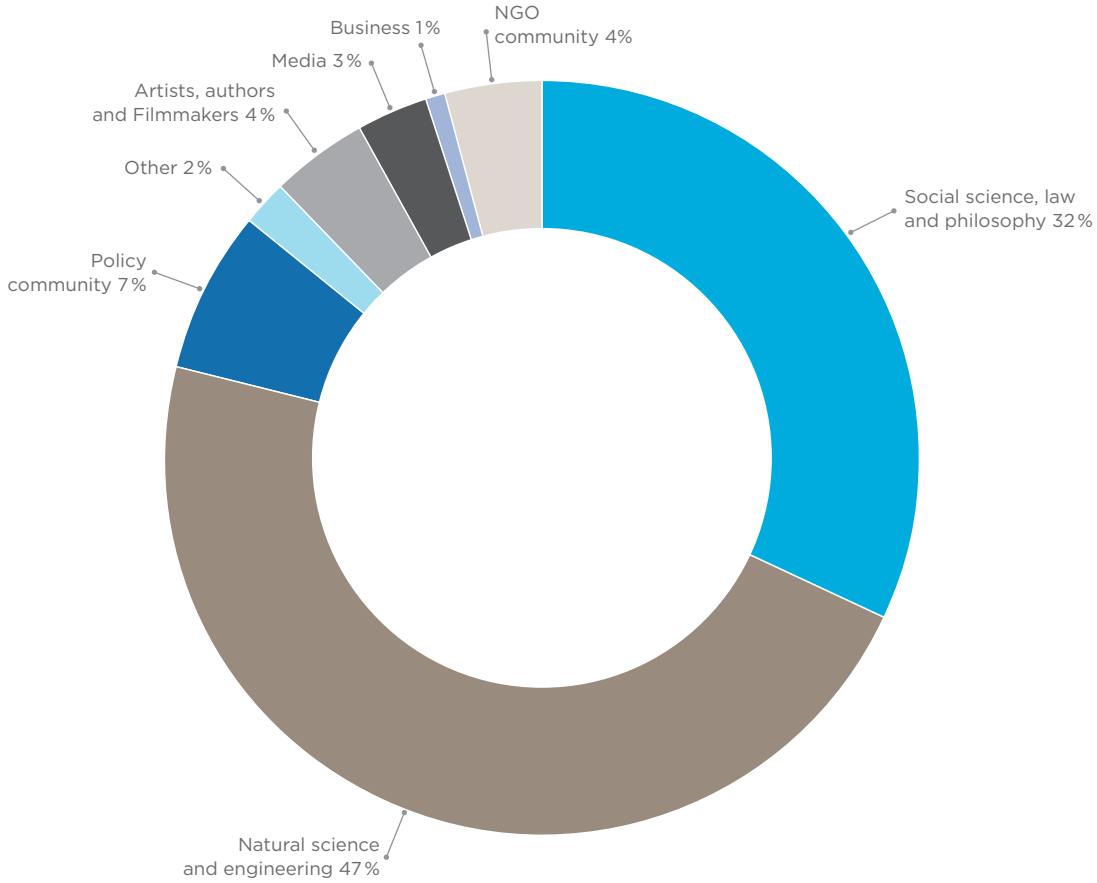
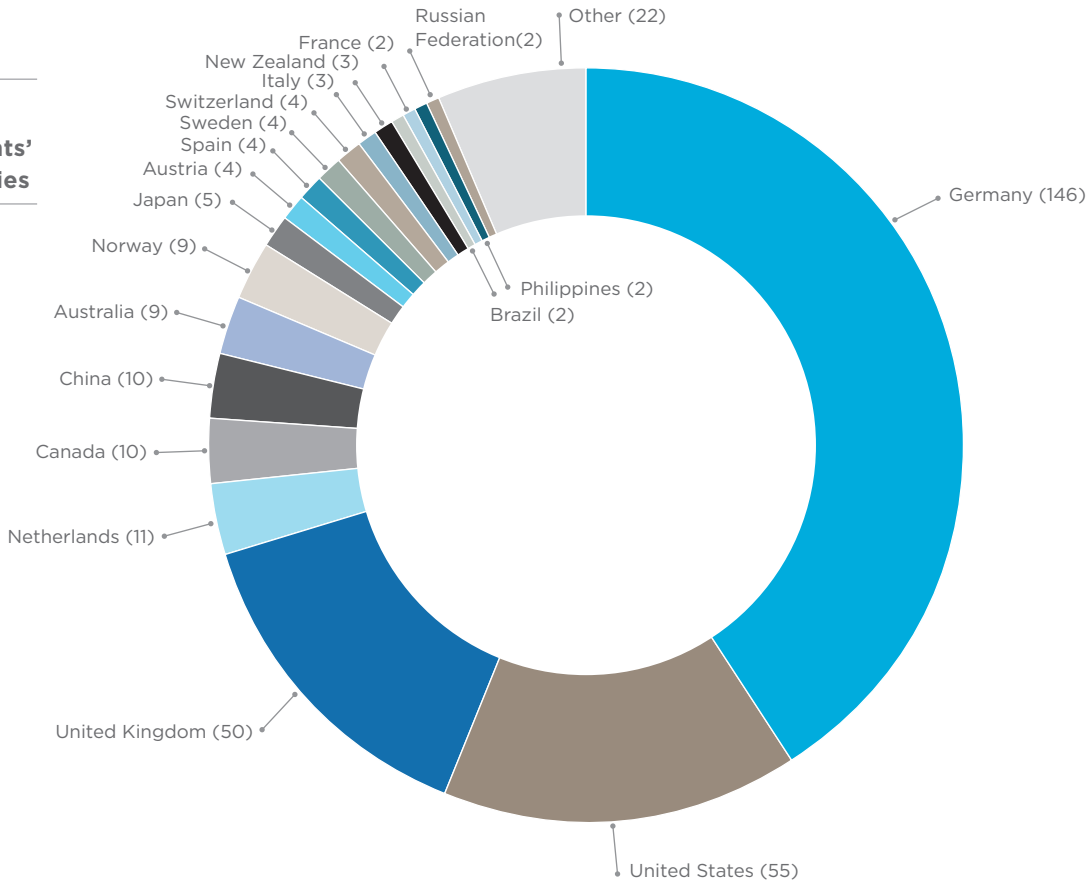
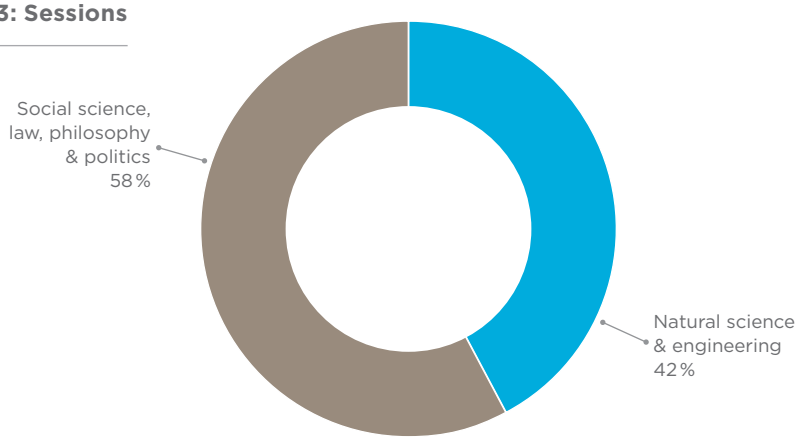


Figure 2: Participants' nationalities



A number of conference evaluations stressed that future meetings should, however, aim for better balance by increasing the proportion of NGO representatives, who only made up about 4% of total attendees. Many evaluations also suggested a need for a higher proportion of natural scientists and engineers. While this was already the most well represented group at the conference (47%), these comments may reflect the fact that there were fewer sessions focussed on the natural sciences (42%) than on the social sciences and related disciplines (58%).

Figure 3: Sessions



Another shortcoming highlighted in feedback reflected the fact that while 38% of conference participants were female, 90% of plenary speakers were male, and there was never more than one female on a panel.

Figure 4: Gender distribution in overall conference participation

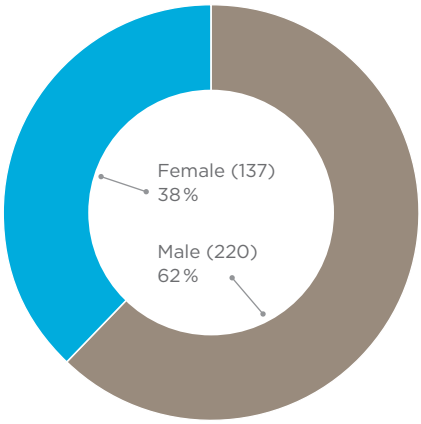
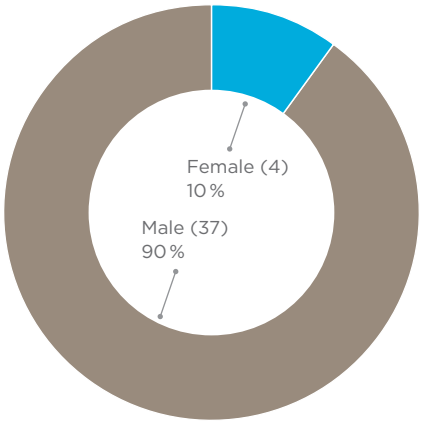


Figure 5: Gender distribution in panel discussions



Conclusions: A future CEC should continue to strive for inclusive participation and comprehensive coverage of the various technical and social contexts in which climate engineering is emerging. However, having such a diverse group of participants may favour broader political discussions over technocratic ones. A future CEC should aim to continue to attract wide participation, ranging from scientists to policymakers and NGO representatives, but in doing so it should maintain a commitment to providing a platform for disciplinary and technically-focussed discussions between experts. Balance in topical coverage should be achieved by allowing a large degree of freedom for conference participants to shape the conference content via open solicitation of session proposals, and through the conscious design by the organisers of plenary sessions that address a variety of key topics.

5.3 What Makes for an Engaging and Useful Session and How Should Different Formats be Balanced in the Schedule?

Objective: 'To provide a forum for innovative session formats aimed at addressing the interdisciplinary and transdisciplinary complexity of the issue.'

Discussion: While many efforts were made to encourage non-traditional session formats, most of the sessions convened by participants used a traditional conference format: a series of presentations by experts, followed by short discussion or question-and-answer periods. While this format clearly has a place at an academic conference, the organisers received particularly positive feedback on the few less traditional sessions that involved a lot of audience interaction. There was also a great deal of support for sessions that featured presentations on non-academic approaches to learning and deliberation, including through art, media and games.

Some participants found themselves frustrated by the large number of parallel sessions, which meant that no individual could feasibly attend more than ~25% of conference sessions. Reducing the number of parallel sessions presents other problems, however, including the need to have more participants at each session, thus potentially reducing the capacity for interaction. Spatial limitations at the conference venue also set scope conditions that could not be influenced.

Conclusions: One way to address the necessity of having parallel sessions is to encourage greater capture of session outputs, potentially through filming and other post-conference reporting. Any future CEC also ought to encourage sessions that feature a high degree of participant interaction. It is nevertheless important to achieve a balance between session formats depending on context, including allowing for more traditional modes of presentation where appropriate. Providing such a variety of sessions should also contribute to the ability of participants to tailor their conference experience to their own particular interests and therefore may help to maintain the attractiveness of the conference to a wide variety of constituencies. The inclusiveness of future conferences will greatly depend on their ability to garner widespread and diverse interest, which might be achieved in these ways.

Annex I: Town Hall Meeting

The town hall meeting took place on the third evening of the conference. Steve Rayner of Oxford University, who introduced the draft Berlin Declaration during the Monday plenary session, explained the statement's background, motivations and goals, before the floor was opened for discussion.

A number of speakers addressed the content of the statement. Some were concerned that without greater specificity over what activities were and were not covered by the proposed governance arrangements, it could inadvertently regulate innocuous activities. Alan Robock (Rutgers University) hoped that it would not prevent indoors research such as climate modelling and analysis of past volcanic eruptions from proceeding, while Tom Ackerman (University of Washington) wondered whether, without extra work on definitions, the statement could end up placing extra burdens on climate science that simply looked like SRM research. Andrew Lockley (independent researcher) worried that it could end up over-regulating small experiments that risked no physical harms. Duncan McLaren (Lancaster University) disagreed. He argued that due to the complex social context of all experiments, it would be important not to have 'allowed zones' that allowed small experiments to avoid important governance arrangements.

Engineer Hugh Hunt (Cambridge University) questioned the statement's negative tone, reflecting on the importance of encouraging young scientists and engineers to get involved in this new area of research. For Clive Hamilton (Charles Sturt University), the document was an "insiders' charter" that sought a licence to operate for the community that wrote it.

Content aside, some participants were dissatisfied with the process by which the statement had been introduced, and by which it was to be shaped and signed. Some questioned whether CEC14 had an appropriate mix of participants to seek to influence SRM policy with such a statement. Pablo Suarez (Red Cross/ Red Crescent Climate Centre) asked the conference participants to think harder about designing processes that are representative of the seven billion people on the planet, while Hugh Hunt noted the poor representation of the people who would be most affected by governance of small scale scientific experiments: the experimental scientists and especially engineers themselves. Eduardo Viola (Universidade de Brasília) countered that few people currently know about climate engineering and that CEC14 was sufficiently representative of those with expertise in the topic, and the different attitudes towards it.

Thilo Wiertz (IASS Potsdam) summarised concerns that many people had expressed when the statement was first introduced, about the process by which it was to be shaped and signed, and why it was being associated with the conference at all. He worried that the statement was co-opting the diversity and high profile of CEC14 – a conference designed to promote 'critical global discussions' – to promote a statement that had no process for a critical global discussion of its own. He pointed out that there was no way to engage with the drafting process beyond submitting comments, and argued that open discussion would be necessary to achieve the momentum needed to get sufficient support for the statement.

Jane Long and Rafe Pomerance (former US Deputy Assistant Secretary of State for Environment and Development) shared some of Mr Wiertz's concerns about process. Dr Long questioned the transparency of the statement's motivation, and Mr Pomerance argued that the conference was not set up to produce a policy statement, and that such a statement could end up having a divisive legacy if pursued.

Clive Hamilton agreed that some conference participants felt co-opted, and that if the statement was promulgated at the conference, shaped at the conference, and signed at the conference, unavoidably it would be seen as a product of the conference. He wondered how people who did not agree to the whole exercise could express this.

Steve Rayner, representing the group that drafted the statement, responded that the statement was very much an ad hoc process that was not meant to co-opt people or hijack the conference, which was why the Declaration was not proposed as a formal conference resolution. Eduardo Viola pointed out that the statement had very usefully provoked much discussion, and that was something to be grateful for.

Dr Rayner also pointed out that there was no direct conflict between the "Berlin Declaration" and Hamilton's statement, and that looking to the development of new international institutions in the medium term did not obviate the need for governance arrangements to guide research in the short term.

As the meeting drew to a close, the facilitators ran a straw poll to gauge participant attitudes to having a statement opened for signing at the conference. A majority opposed a statement of any kind, but many expressed interest in continuing the process of discussing the possible statements via other means.

Annex II: Conference Steering Committee and Advisory Group

The **Steering Committee** consists of eleven young researchers and practitioners from different disciplines and backgrounds that all have a strong knowledge of the issues associated with climate engineering. Its members were responsible for the structure and content of the conference, including the identification of key questions and themes that will be addressed at CEC14 as well as key stakeholders. Together with the Advisory Group, the members of the Steering Committee also reviewed session proposals following a process of double-blind peer review, and were responsible for producing this conference report. The Steering Committee is composed of the following members:

Schäfer, Stefan (Chair)
Stefan Schäfer is the Academic Officer of the Sustainable Interactions with the Atmosphere Research Cluster at the Institute for Advanced Sustainability Studies, Potsdam. He is also the co-leader of the research group on climate engineering at the IASS, together with IASS Scientific Director Mark Lawrence. A political scientist by training, his current research focuses on national and international governance of emerging technologies in general and of climate engineering technologies in particular.

Banerjee, Bidisha
Bidisha Banerjee is a junior research fellow at the Red Cross Climate Center and a 2013 Donella Meadows Fellow of the Balaton Group. She is the co-author, most recently, of a Yale Climate and Energy Institute report on scenario planning for solar radiation management. She is developing an ethical leadership curriculum for a global network of young social innovators.

Buck, Holly Jean
Holly Jean Buck is a PhD student in Development Sociology at Cornell University, where she looks at human-environment interactions. Her research interests include agroecology and climate-smart agriculture, energy landscapes, land use change, new media, and science and technology studies. With regards to climate engineering, she has written on humanitarian and development approaches to geoengineering, gender considerations, and media representations of geoengineering. As a geographer and creative writer, she approaches social science analysis with both spatial and narrative lenses: meaning that space and environmental geography matters, but so do storylines, imagery, and performance. Beyond academia, she has worked as a GPS technician for an international mapping company, a geospatial humanitarian analyst, and a writing teacher. She holds a MSc in Human Ecology from Lund University in Sweden and spends her time in Ithaca, New York and Washington, DC.

Collins, George

George Collins has worked on a variety of climate change topics, including common-law climate litigation, international treaty processes, a Bayesian framework for climate negotiations, and the embedding of agent-based political models inside global climate models. Within climate engineering, his current research interests include potential humanitarian consequences, interactive methods for exploring complexities and uncertainties, and communications heuristics for minimising the possibility that high-leverage climate engineering might interfere with efforts to effectively mitigate greenhouse gas emissions. He presently works with the Red Cross/Red Crescent Climate Centre on climate change and geoengineering games, and is a co-founder of the Geoengineering Scenarios Working Group (ge-scenarios.org). By day, he works at a law firm in San Francisco that represents corporate whistleblowers. George received his J.D. from the Yale Law School along with a Masters in Environmental Management from the Yale School of Forestry and Environmental Studies.

Heyen, Daniel

Daniel Heyen is a PhD student in environmental economics at the University of Heidelberg. His research focuses mainly on the role of uncertainty and learning in environmental decision-making. In a project funded by the German Research Foundation, he analyzes the impacts of regulatory mandates under uncertainty on the incentives to undertake information acquisition. Daniel was a member of the interdisciplinary Marsilius project "The Global Governance of Climate Engineering" (2009–12) which brought together young researchers from many different fields. During this time, Daniel began his research on the intergenerational and strategic challenges of climate engineering technologies.

Heyward, Clare

Clare Heyward is a Leverhulme Trust Early Career Researcher at the University of Warwick, where she is engaged in a three-year project on investigating and integrating various geoengineering responses into theories of climate justice. She was formerly James Martin Research Fellow for the Oxford Geoengineering Programme, University of Oxford. Clare is interested in issues of global justice and climate change, especially the cultural dimensions of climate justice (the subject of her D.Phil thesis), and justice towards future generations. During her time at the OGP, Clare had researched ethics and governance issues raised by the prospect of using geoengineering technologies as a response to climate change.

Kravitz, Ben

Ben Kravitz is currently a postdoctoral research associate in the Atmospheric Sciences and Global Change Division at the U.S. Department of Energy Pacific Northwest National Laboratory. His research primarily focuses on using climate models to answer fundamental physical science questions regarding the effects of climate engineering. Ben is the coordinator of the Geoengineering Model Intercomparison Project (GeoMIP), an effort in which climate modeling centers from around the world have conducted simulations of several core climate engineering scenarios. He is a contributing author to Working Group I of the upcoming Fifth Assessment Report of Intergovernmental Panel on Climate Change. His current research activities include coordination of and preparation of original research for a special issue of the Journal of Geophysical Research--Atmospheres, in which many of the results from GeoMIP will be showcased.

Steering Committee

Low, Sean

Sean Low is a Fellow at the Institute for Advanced Sustainability Studies in Potsdam, Germany. His research focuses on the uses and limits of scenario and gaming methods, as well as of analogies in previous debates on emerging technologies, to explore potential future contingencies in climate engineering. He also manages and edits a Working Paper Series on the ethical, political, and governance aspects of climate engineering. Sean has previously done research on the politics of climate engineering and global climate policy at the Centre for International Governance Innovation and the University of Waterloo (Canada).

Moore, Nigel

Nigel Moore is currently a Fellow at the Institute for Advanced Sustainability Studies studying the governance of climate engineering research. Since 2010 Nigel has been engaged in research on CE at the Centre for International Governance Innovation (Canada), The Oxford Martin School (UK), and the University of Waterloo (Canada). His work currently focuses on enabling transparency in CE research, particularly field-testing. In this vein, he co-leads a research project which is exploring the potential for a publically accessible registry of CE research projects and activities to enhance transparency. Previously he has created an online library of reference material on CE, and has been involved in the organisation of summer schools, workshops, and public seminars aimed at increasing the availability of reliable information about CE to the general public, and increasing the flow of information between research groups and individuals around the world.

Parker, Andy

Andy Parker is a Fellow at the Institute for Advanced Sustainability Studies, where his research focuses on the governance and politics of research into solar geoengineering. He was formerly a research fellow at the Belfer Center for Science and International Affairs in the Harvard Kennedy School. Before moving to Harvard he spent four years as a senior policy advisor at the Royal Society, leading the Society's work on geoengineering, including the production of the 2009 report *Geoengineering the Climate*, and the SRM Governance Initiative (SRMGI). As a central figure with SRMGI since its inception in 2010 he has planned and run geoengineering outreach meetings in India, China, Pakistan, Senegal, South Africa and Ethiopia. He was also a member of the UN Convention on Biological Diversity's expert working group on geoengineering and co-led the Royal Society's policy work on climate change, environment and energy. Previously, he researched and wrote on human security for the Canadian government and worked in home energy efficiency. Andy has an M.Sc. in international policy analysis from the University of Bath and a B.Sc. in psychology from the University of Warwick (both UK).

Vaughan, Naomi (Nem)

Naomi (Nem) Vaughan is a lecturer at the Tyndall Centre for Climate Change Research in the School of Environmental Sciences at the University of East Anglia. Her research interests focus on possible societal response options to climate change; mitigation, adaptation, carbon removal or 'negative emissions' and ideas of climate engineering. Her focus is on these issues at a global scale and over a long time (e.g. centuries), how they are constrained by the Earth system (including climate-carbon cycle feed-backs) and how they interact with one another. Nem is an interdisciplinary scientist working from a physical science background with colleagues across a range of disciplines. Nem is a lead investigator in the UK's Integrated Assessment of Geoengineering Proposals (IAGP) and a partner in the EU-FP7 project European Transdisciplinary Assessment of Climate Engineering (EuTRACE).

The **Advisory Group** consists of a diverse set of eminent researchers and practitioners in the science, policy, and civil society communities, who are engaged in discussions relevant to climate engineering. The members of the Advisory Group provided recommendations to the Steering Committee and contributed to the reviewing of session proposals following a process of double-blind peer review (together with the Steering Committee). The Advisory Group is composed of the following members:

Lawrence, Mark (Chair)

Mark Lawrence is the scientific director of the cluster "Sustainable Interactions With the Atmosphere" (SIWA) at the Institute for Advanced Sustainability Studies in Potsdam, Germany, and an Honorary Professor at the University of Potsdam. His primary interests lie in assessing the co-benefits of short-lived climate-forcing pollutants (SLCPs) like ozone, black carbon, methane and HFCs, numerical modeling and forecasting of the chemical weather and chemistry-climate interactions in the troposphere, and trans-disciplinary research into the impacts, uncertainties and risks of climate engineering. He has authored or co-authored over 100 publications on these and various other topics, including cumulus convection and its impact on atmospheric chemistry, lightning NOx production, and biosphere-atmosphere interactions. He received his PhD in Earth and Atmospheric Sciences from the Georgia Institute of Technology in 1996, followed by positions as a postdoc and research group leader at the Max Planck Institute for Chemistry. He taught regularly at the University of Mainz from 2002 to 2011, has supervised numerous PhD students, is coordinator of the EU Project EuTRACE and formerly co-coordinated the EU project MEGAPOLI, has been an associate editor of Atmospheric Chemistry and Physics (ACP) and on the editorial board of Atmospheric Environment, is a member of the UNEP/ABC-Asia science team and organiser of three ABC training schools in Bangkok (2006) and Kathmandu (2008, 2011), and was program Chair for the 2006 CACGP/IGAC/WMO symposium in Cape Town.

Abegaz, Berhanu

Berhanu Abegaz is currently the Executive Director of the African Academy of Science, a pan-African honorific organisation with headquarters in Nairobi, Kenya. Abegaz is a chemist by profession with a rich teaching and research experience in several universities in Africa, Europe and the United States. He has made outstanding contributions to the development of higher education in Africa. He is widely known for promoting South-South cooperation in research and postgraduate education. Abegaz has also served in many national, regional and global organisations such as the UNESCO Science Board (co-Vice Chair of IBSP), the Committee for Scientific Planning and Research of ICSU, as senior Advisor to IOCD, IFS, etc. He has also received a number of prizes and awards, the IFS-DANIDA award, the Pierre Crabbe Award, and the CNR Rao Award.

Artaxo, Paulo

Paulo Artaxo is Professor of Environmental Physics at the University of São Paulo (Brazil). He is a member of the IPCC Working group 1, and a lead author of AR4 (Chapter 2 - radiative forcing) and AR5 (chapter 7 - aerosols and clouds). He has participated in several major international research efforts, such as IGBP, IGAC, CACGP, IPCC, WMO and others. His scientific expertise is in radiative effects of aerosol particles, focusing on tropical aerosols, biogeochemical cycling in the Amazon basin, physical and chemical properties of biogenic and biomass burning aerosols. He published more than 320 scientific papers and has more than 8000 citations. He is a member of the Brazilian Academy of Sciences and TWAS, the Academy of Sciences of the Developing World. He is a fellow of the American Association for the Advancement of Science. He has received several awards, among them the title of Doctorate of Philosophy Honoris Causa of the University of Stockholm, Sweden.

Benedick, Richard

Richard Benedick is Senior Advisor to Battelle's Joint Global Change Research Institute at the University of Maryland. He has served as chief U.S. negotiator and a principal architect of the Montreal Protocol on protection of the ozone layer, as Special Advisor to Secretaries-General of both the United Nations Conference on Environment and Development (Rio de Janeiro, 1992) and the International Conference on Population and Development (Cairo, 1994), as Deputy Director in the Environmental and Health Sciences Division at their Washington D.C. office of Pacific Northwest National Laboratory, and since 1994 has been President of the National Council for Science and the Environment. He is author of the acclaimed book Ozone Diplomacy: New Directions in Safeguarding the Planet (Harvard University Press, 1991). Benedick was elected in 1991 to the World Academy of Art and Science, and in 2002, to the American Academy of Diplomacy. He has received the two highest Presidential career public service honors (the Distinguished, and two Meritorious, Service Awards), as well as the State Department's John Jacob Rogers medal and the United Nations Ozone Award.

Caldeira, Ken

Ken Caldeira is an atmospheric scientist in the Department of Global Ecology at the Carnegie Institution at Stanford University. He also serves as a professor in Stanford's Department of Environmental Earth System Science. Caldeira's research focuses on the long-term evolution of the climate and global carbon cycle; marine biogeochemistry and chemical oceanography, including ocean acidification; and energy technologies and geoengineering. Previously, Caldeira was with the Energy and Environment Directorate at the Lawrence Livermore National Laboratory. He received his B.A. from Rutgers College and both his M.S. (1988) and Ph.D. (1991) in atmospheric sciences from New York University. In 2000, he was a co-author of the first study to use a climate model to investigate solar climate engineering. In 2009, he served on the UK Royal Society panel that produced a report on geoengineering, and he is currently serving on a panel producing a report on climate engineering for the US National Academy of Sciences.

Childs, Mike

Mike Childs is Head of Policy, Research and Science at Friends of the Earth, where he has worked for more than 20 years. During this time he helped lead Friends of the Earth's Big Ask campaign for the Climate Change Act 2008, which was the first ever national law to commit a Government to making annual cuts in greenhouse gases. He has jointly authored and published "Reckless Gamblers", which identifies carbon budgets and reduction trajectories for countries based on a 70% probability of avoiding 2 degrees. In a lifetime of campaigning for environmental justice, Childs has written numerous policy briefings and articles, spoken at meetings, marched, and lobbied governmental figures.

Crutzen, Paul J.

Paul J. Crutzen is currently Emeritus Scholar at the Max Planck Institute for Chemistry in Mainz, Germany, where he had previously served as Scientific Director (1983–1985) and as Scholar (1980–2000). He has also been Professor at the University of Chicago (1987–91), the Scripps Research Institute (1992–2008), and the University of Utrecht (1997–2000). Crutzen won the Nobel Prize for Chemistry in 1995 (shared with M.J. Molina and F.S. Rowland) for his work demonstrating the effects of nitrous oxide on ozone layer depletion. He has been the recipient of numerous other awards and honors since 1985, including membership in the academies of sciences of the Netherlands, Germany, the UK, Sweden, and Russia. Crutzen earned his PhD (1968) and DSc (1973) in Meteorology from the University of Stockholm.

Ghosh, Arunabha

Arunabha Ghosh is CEO of the Council on Energy, Environment and Water (CEEW), an independent, policy research institution in India. He is also associated with Oxford's Global Economic Governance Programme and its Smith School of Enterprise and the Environment. He is involved with the UK Royal Society's Solar Radiation Management Governance Initiative and has co-chaired its international governance working group. He is a member of three track II initiatives: the India-US Dialogue on Climate Change and Energy, the India-Israel Forum, and the Islamabad Dialogue. He sits on the Governing Board of the International Centre for Trade and Sustainable Development, Geneva. Ghosh was previously Global Leaders Fellow at Princeton's Woodrow Wilson School of Public & International Affairs, and at Oxford's Department of Politics and International Relations. He was also Policy Specialist at the United Nations Development Programme in New York and has worked at the World Trade Organization in Geneva. He currently works on: climate governance; energy-trade-climate linkages; global energy governance; water governance and institutions; and international regime design. In 2011, the Asia Society named him an Asia 21 Young Leader. Arunabha holds a D. Phil. and M. Phil. in international relations from Oxford, where he was the Clarendon Scholar and Marvin Bower Scholar. He holds an M.A. (First Class) in Philosophy, Politics and Economics from Balliol College, Oxford, as Radhakrishnan-Chevening Scholar.

Gjerde, Kristina

Kristina M. Gjerde is Senior High Seas Advisor to IUCN's Global Marine and Polar Programme. A graduate of New York University School of Law, Gjerde is a recognised expert in the legal aspects of international marine conservation and management. She has published widely on fisheries, shipping, law of the sea and marine biodiversity conservation issues and serves as an advisor to governments, international organisations and non-governmental organisations. Recent publications include: "Ocean in Peril: reforming the management of global ocean living resources in areas beyond national jurisdiction" (Marine Pollution Bulletin) "Using the Public Trust Doctrine to Achieve Ocean Stewardship" (Cambridge University Press) and "Challenges to Protecting the Marine Environment beyond National Jurisdiction" (International Journal of Marine and Coastal Law). Gjerde has specialised in admiralty law at the New York City law firm of Lord, Day & Lord, served as a research fellow at the Marine Policy Center of WHOI and at the Law School of the University of Hull (UK), and represented WWF at the International Maritime Organization in London. In 2003, she was awarded a Pew Fellowship in Marine Conservation to support her work on high seas governance reform. Since then Gjerde has sparked a global movement for high seas conservation and has co-founded five thriving initiatives: the Deep Sea Conservation Coalition, the Global Ocean Biodiversity Initiative, the Sargasso Sea Alliance, the High Seas Alliance and the Deep Ocean Stewardship Initiative. The Sargasso Sea Alliance was awarded the International SeaKeepers Prize in September 2013.

Hamilton, Clive

Clive Hamilton is an Australian author and public intellectual. In June 2008 he was appointed Professor of Public Ethics at the Centre for Applied Philosophy and Public Ethics, a joint centre of Charles Sturt University and the University of Melbourne. For 14 years, until February 2008, he was the Executive Director of The Australia Institute, a progressive think tank he founded. He holds an arts degree from the Australian National University and an economics degree from the University of Sydney. He completed a doctorate at the Institute of Development Studies at the University of Sussex. Before establishing The Australia Institute he taught in the Graduate Program in the Economics of Development at the ANU then joined the Australian Public Service. In recent years he has held visiting academic positions at Yale University, the University of Cambridge and the University of Oxford. He has published on a wide range of subjects but is best known for his books, including *Requiem for a Species: Why We Resist the Truth about Climate Change (2010)* and *Earthmasters: The Dawn of the Age of Climate Engineering (2013)*. In 2009 he was made a Member of the Order of Australia (AM), and in 2012 he was appointed by the Federal Government to the Climate Change Authority.

Hulme, Mike

Mike Hulme is Professor of Climate and Culture in the Department of Geography at King's College London, where he is a member of the Environment, Politics and Development group. His work explores the idea of climate change using historical, cultural and scientific analyses, seeking to illuminate the numerous ways in which climate change is deployed in public and political discourse. Hulme was an employee of the University of East Anglia between 1988 and 2013, which included being a member of the Climatic Research Unit (1988–2000) and then the founding Director (2000–2007) of the Tyndall Centre for Climate Change Research. He is the author of Why We Disagree About Climate Change (CUP, 2009) and has just completed a book for Polity Press, 'Can Science Fix Climate Change?' – a critique of sunlight reflection methods. He is Editor-in-Chief of the journal Wiley's Interdisciplinary Reviews: Climate Change. From 2006–2009 he led the EU Integrated Project Adaptation and Mitigation Srategies (ADAM) and in his earlier career prepared climate scenarios and reports for the UK Government, the EU Commission, UNEP, UNDP, WWF-International, and the IPCC.

Keith, David

David Keith has worked near the interface between climate science, energy technology and public policy for twenty years. He took first prize in Canada's national physics prize exam, won MIT's prize for excellence in experimental physics, and was listed as one of TIME magazine's Heroes of the Environment 2009. David's academic appointments are at Harvard where he serves as the Gordon McKay Professor of Applied Physics in the School of Engineering and Applied Sciences (SEAS) and Professor of Public Policy at the Harvard Kennedy School. David divides his time between Boston and Calgary where he serves as President of Carbon Engineering, a start-up company developing industrial scale technologies for capture of CO_2 from ambient air.

Kriegler, Elmar

Elmar Kriegler is deputy chair of the Research Domain "Sustainable Solutions" at the Potsdam Institute for Climate Impact Research (PIK). He is coordinator of the EU funded projects AMPERE and ADVANCE, a scientific steering committee member of the Integrated Assessment Modeling Consortium (IAMC), and a lead author for the Fifth Assessment Report of the IPCC. His research focuses on the integrated assessment of climate change mitigation policies, scenario analysis and decision making under uncertainty. Kriegler earned a diploma in Physics at University of Freiburg, and a Ph.D. in Physics at the University of Potsdam, Germany. He was a Marie Curie Fellow at Carnegie Mellon University before returning to PIK as a senior scientist.

Kruger, Tim

Tim Kruger is James Martin Research Fellow and Programme Manager of the Oxford Geoengineering Programme at the Oxford Martin School. He has a broad interest in the area of geoengineering and the governance mechanisms required to ensure that any research in this field is undertaken in a responsible way. He has investigated in detail one potential geoengineering technique, that of adding alkalinity to the ocean as a way of enhancing its capacity to act as a carbon sink and to counteract the effects of ocean acidification.

Leinen, Margaret

Margaret Leinen is the Director of Scripps Oceanographic Institution and Vice Chancellor of the University of California at San Diego. She served at the Executive Director of Harbor Branch Oceanographic Institute and Associate Provost for Marine and Environmental Initiatives as Florida Atlantic University from 2011–2013. She was the Assistant Director for Geosciences of the US National Science Foundation from 2000–2007, and in that position chaired the US Global Change Research Program from 2000-2001 and was Vice-Chair of its successor, the US Climate Change Science Program from 2002–2007. During her research career, Leinen served as the Vice-Chair of the International Geosphere-Biosphere Program, and was a member of the US National Research Council Climate Research Committee, the Scientific Committee of the Ocean Drilling Program, and was President of the Oceanography Society. She was also Dean of the Graduate School of Oceanography, the Interim Dean of the College of Environment and Life Sciences, and the Vice-Provost for Marine and Environmental Programs of the University of Rhode Island. Dr. Leinen is President-Elect of the American Geophysical Union (AGU), Vice-Chair of the Gulf of Mexico Research Initiative and serves on the Board of the National Council for Science of the Environment (NCSE). She is a Fellow of the American Association for the Advancement of Science (AAAS) and the Geological Society of America (GSA). She is the past Chair of the Atmospheric and Hydrologic Sciences Section of the American Association for the Advancement of Science, and a former President of The Oceanography Society. She has also spent time in the private sector as the Chief Science Officer of Climos, Inc. and as President of the Climate Response Fund.

Long, Jane C.S.

Jane C.S. Long recently retired from Lawrence Livermore National Laboratory where she was the Principal Associate Director at Large, Fellow in the LLNL Center for Global Strategic Research and the Associate Director for Energy and Environment. She is currently a senior contributing scientist for the Environmental Defense Fund, Visiting Researcher at UC Berkeley, Co-chair of the Task Force on Geoengineering for the Bipartisan Policy Center and chairman of the California Council on Science and Technology's California's Energy Future committee. Her current work involves strategies for dealing with climate change including reinvention of the energy system, geoengineering and adaptation. Dr. Long was the Dean of the Mackay School of Mines, University of Nevada, Reno and Department Chair for the Energy Resources Technology and the Environmental Research Departments at Lawrence Berkeley National Lab. She holds a bachelor's degree in engineering from Brown University and Masters and PhD from U. C. Berkeley. Dr. Long is a fellow of the American Association for the Advancement of Science and was named Alum of the Year in 2012 by the Brown University School of Engineering. Dr. Long is an Associate of the National Academies of Science (NAS) and a Senior Fellow and council member of the California Council on Science and Technology (CCST) and the Breakthrough Institute. She serves on the board of directors for the Clean Air Task Force and the Center for Sustainable Shale Development.

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Oliver Morton is a science writer and editor who currently works as the briefings editor for The Economist, but participates in CEC14 in an independent capacity. He has also been energy and environment editor at The Economist and chief news and features editor of Nature, the international scientific journal. Morton specialises in the energy business, climate science and policy, and other environmental and planetary issues. He is the author of *Eating the Sun: How Plants Power the Planet*, a study of photosynthesis, its meanings and its implications, and *Mapping Mars: Science, Imagination and the Birth of a World*. He is currently writing a book on climate engineering, titled *The Deliberate Planet*.

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Andreas Oschlies is a Professor of Marine Biogeochemical Modelling at the University of Kiel and Head of the Biogeochemical Modelling Research Unit at the GEOMAR Helmholtz Centre for Ocean Research Kiel. Having studied Theoretical Physics at Heidelberg and Cambridge, he moved into Oceanography for a PhD in Kiel and worked as PostDoc in Toulouse, Assistant Professor in Kiel and Professor in Southampton. His research interests include the global carbon, nitrogen and oxygen cycles, their sensitivities to environmental change, and the development of numerical models appropriate to investigate these. He is PI of the Excellence Cluster "The Future Ocean", speaker of the Collaborative Research Centre "Climate-Biogeochemistry Interactions in the Tropical Ocean" (SFB754) and coordinator of the DFG Priority Program "Climate Engineering: Risks, Challenges, Opportunities?" (SPP1689). He was awarded the Georg-Wüst Prize in 2011.

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Konrad Ott is a Professor of Philosophy at the Christian-Albrecht University in Kiel. His research focuses on discourse ethics, environmental ethics, theories of justice, sustainability, ethical aspects of climate change, nature conservation justifications, and the normative basis for environmental policy. Prior to this, he taught Environmental Ethics at the University of Greifswald in the mathematic-scientific department of the interdisciplinary program "Landscape Ecology and Preservation of Nature". He has previously served on the German Advisory Council on the Environment (SRU) and is jointly responsible for developing the theoretical concept of "strong sustainability," which was later used as part of a research program focusing on the protection of nature and biodiversity, climate change, water resources, agriculture and remediation.

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Pan Jiahua is currently director-general of the Institute for Urban & Environmental Studies, Chinese Academy of Social Sciences (CASS), and professor of economics at CASS Graduate School. He received his PhD at Cambridge University in 1992. His areas of interest include economics of sustainable development, energy and climate policy, world economy and environmental and natural resource economics. His positions include: the UNDP Beijing Office as an advisor on environment and development, Lead author of the IPCC Working Group III 3rd, 4th and 5th Assessment Report on Mitigation; Member of China National Expert Panel on Climate Change; Member of National Foreign Policy Advisory Group; Advisor to the Ministry of Environment Protection; Vice president of the Chinese Society of Ecological Economists; and vice president of Chinese Energy Association. He was Co-Editor of Climate Change 2001: mitigation published by Cambridge University Press and is author of over 300 papers, articles and books in both English and Chinese.

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Alexander Proelss holds a chair for public law, in particular public international law and European law, at the University of Trier, Germany, and is the Director of the Institute of Environmental and Technology Law of that University. Proelss studied law in Bonn and Tübingen. In 2003, he obtained his doctoral degree with a thesis on "Protection of the Seas in Public International Law and European Law". Between 2007 and 2010, he was Professor for public law, in particular law of the sea, at the Walther-Schücking Institute for International Law, Christian Albrechts University at Kiel. In February 2010, he was awarded the postdoctoral lecture qualification (Habilitation) by the Faculty of Law at the University of Tübingen. The international law of the sea, along with other questions in the area of public international law, European law and constitutional law, constitute the focal points of his research. Proelss is a member of several national and international research consortia and has advised State authorities and other stakeholders at various occasions.

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Rosemary Rayfuse is Professor in the Faculty of Law at the University of New South Wales. Prior to that, she was a Research Fellow at the Lauterpacht Research Centre for International Law and taught international law at the University of Cambridge. She practiced law in Vancouver, Canada with McCarthy Tetrault and worked as a law clerk (judges associate) to the British Columbia Court of Appeal. From 1994 to 2006 Rayfuse was the Director of International Law Programs at UNSW, and was also co-founder and, until 2009, co-director of both the International Law and Policy Group and the Climate Change Law and Policy Initiative. She is a member of the editorial board of numerous international law journals including the Netherlands International Law Review, the International Journal of Marine and Coastal Law and the Aegean Review of the Law of the Sea and Maritime Law. She is a member of the IUCN Commission on Environmental Law, Co-Chair of its Working Group on High Seas Governance and a member of its Arctic Task Force.

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Catherine Redgwell is Chichele Professor of Public International Law at the University of Oxford and a Fellow of All Souls College, having previously she held the chair in Public International Law in the Faculty of Laws at University College London (2004–2013). Previously she was University Lecturer and then Reader in Public International Law at the University of Oxford and a Fellow of St. Peter's College (1999–2004), lecturer and then senior lecturer at the University of Nottingham (1990–99), and lecturer at the University of Manchester (1988–90). In 1992/93 she spent six months on secondment to the Legal Advisers, Foreign & Commonwealth Office. Catherine is a member of the Academic Advisory Group (AAG) of the Section on Energy, Environment, Natural Resources and Infrastructure Law of the International Bar Association, a member of the Council of the British Branch of the International Law Association, and of the Public International Law Advisory Board of the British Institute of International and Comparative Law. Previously joint general editor and chair of the editorial board of the *International and Comparative Law Quarterly* (2006–20012), she is currently joint editor of the *British Yearbook of International Law* and joint series editor of *Oxford Monographs in International Law*. Her research focuses on general public international law, with particular emphasis on international energy law and international environmental law issues.

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Alan Robock is a Distinguished Professor of climatology in the Department of Environmental Sciences at Rutgers University. He also directs the Rutgers Undergraduate Meteorology Program. He graduated from the University of Wisconsin, Madison, in 1970 with a B.A. in Meteorology, and from the Massachusetts Institute of Technology with an S.M. in 1974 and Ph.D. in 1977, both in Meteorology. Before graduate school, he served as a Peace Corps Volunteer in the Philippines. He was a professor at the University of Maryland, 1977–1997, and the State Climatologist of Maryland, 1991–1997, before coming to Rutgers. Prof. Robock has published more than 320 articles on his research in the area of climate change, including more than 180 peer-reviewed papers. His areas of expertise include geoengineering, climatic effects of nuclear war, effects of volcanic eruptions on climate, regional atmosphere-hydrology modeling, and soil moisture variations. He serves as Editor of Reviews of Geophysics, the most highly-cited journal in the Earth Sciences. His honors include being a Fellow of the American Meteorological Society, the American Association for the Advancement of Science, and the American Geophysical Union. Prof. Robock is a Lead Author of the upcoming Fifth Assessment Report of the Intergovernmental Panel on Climate Change, which was awarded the Nobel Peace Prize in 2007. He currently serves as a member of the Board of Trustees of the University Corporation for Atmospheric Research, which operates the National Center for Atmospheric Research.

Russell, Lynn M.

Lynn M. Russell is Professor of Atmospheric Chemistry at Scripps Institution of Oceanography on the faculty of University of California at San Diego. She completed her undergraduate work at Stanford University. She received a Ph.D. in Chemical Engineering from the California Institute of Technology for her studies of marine aerosols. She was a Professor at Princeton University before joining Scripps. Her research is in the area of aerosol particle chemistry, including the behavior of particles in marine and anthropogenically-influenced conditions. She received the Whitby Award of the American Association of Aerosol Research in 2003 for her contributions on atmospheric aerosol processes.

Santillo, David

David Santillo is Honorary Research Fellow (Greenpeace) at the University of Exeter. He obtained a degree in marine and freshwater biology in 1989, and a PhD in marine microbial ecology in 1993, both from the University of London, before continuing with postdoctoral research into nutrient pollution in the Adriatic Sea. A senior scientist, David joined the Greenpeace Research Laboratories in 1994, and now has almost 15 years experience in organic analytical chemistry and development of policies for environmental protection.

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Dane Scott is the Director of the Mansfield Ethics and Public Affairs Program at The University of Montana and Associate Professor of Ethics in the College of Forestry and Conservation. He holds a PhD in philosophy from Vanderbilt University and a BS in soil science from the University of California Riverside. He is currently Principle Investigator on a National Science Foundation project, "The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management." Scott's primary research interests are in ethics and philosophy of technology. He has published numerous articles and book chapters examining the ethical and philosophical implications of geoengineering and biotechnology.

Suarez, Pablo

Pablo Suarez is Associate Director for Research and Innovation at the Red Cross/Red Crescent Climate Centre, where he oversees work in Africa and the Americas, leads initiatives linking applied knowledge with humanitarian work, and explores new threats and opportunities on climate risk management (such as geoengineering, financial instruments, or participatory games for learning and dialogue). Pablo is also visiting fellow at Boston University and research scholar at the International Institute for Applied Systems Analysis (IIASA) in Austria. His work as researcher and practitioner focuses on the integration of climate information into decision-making, and on institutional integration across disciplines and geographic scales. He has consulted for the United Nations Development Programme, the World Food Programme, Oxfam America, and about twenty other international humanitarian and development organisations, working in more than 50 countries.

Tuana, Nancy

Nancy Tuana is the founding director of Penn State's Rock Ethics Institute and DuPont/Class of 1949 Professor of Philosophy and Women's Studies. Tuana is a philosopher of science who specialises in issues of ethics and science. She is a member of the NSF funded Network on Sustainable Risk Management (SCRiM) scrimhub.org which links a transdisciplinary team of scholars at 19 universities and 5 research institutions across 6 nations to answer the question, "What are sustainable, scientifically sound, technologically feasible, economically efficient, and ethically defensible climate risk management strategies?" She is project lead on the theme of coupled ethical-epistemic issues in climate science. This research includes an analysis of coupled ethical-epistemic issues raised by geoengineering approaches. She is also doing research on justice issues in the context of climate change.

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Mr. Matheus Zanella, Institute for Advanced Sustainability Studies, Germany
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Dr. Ying Zhang, Chinese Academy of Social Sciences, China
Ms. Zhihong Zhuo, Zhejiang University, China

18 Monday August 18th, 2014

12.00 – 14.00 Conference Registration

14.00 – 15.00 Welcome Speeches AB 2 and 3

» Prof. Dr. Mark Lawrence, Prof. Dr. Dr. h.c. Klaus Töpfer, Dr. Georg Schütte

15.30 – 17.30 Panel Discussion AB 2 and 3

» The Past Decade of Climate Engineering Research

18.30 – 20.30 Panel Discussion AB 2 and 3

» Climate Politics at the Crossroads: Is Climate Engineering a Wrench in the Works or a Tool in the Toolbox?

20.30 – 22.00 Reception Foyer AB

Friday August 22nd, 2014

9.00 – 17.00
Deepening the Debate: Conference rooms available for ad-hoc meetings and discussions.

Please contact the Conference Office for this.

Rooms:
Aurora Borealis 1, 2 and 3: AB 1, AB 2 and AB 3
Copenhagen: C
Pine: P
Stockholm: S
Birch and Yew: B and Y

19 Tuesday August 19th, 2014

9.00 – 10.30 Sessions

» Exploring the Politics of Climate Engineering **S**
» International Law for the Regulation of Climate Engineering (Part 1) **P**
» Perspectives on Climate Engineering from the Front Lines of Climate Change **AB 2**
» Progress in the Geoengineering Model Intercomparison Project (GeoMIP) **B and Y**
» Responsible Innovation and Climate Engineering **C**

11.00 – 12.30 Sessions

» Modeling Extreme Risk: Assessing High Impact, Low Probability Events **AB 2**
» What do People Think and Feel about Climate Engineering — and How do we Know? **C**
» International Law for the Regulation of Climate Engineering (Part 2) **P**
» Linkages between Climate Engineering and Short-Lived Climate-forcing Pollutants: Two "Quick Fixes" for the Climate? **B and Y**
» Understanding Carbon-cycle and Climate Feedbacks of Carbon Dioxide Removal Methods **S**

12.30 – 14.30 Lunch Break

13.15 – 14.15 Lunchtime Discussion

» Will Climate Engineering Unduly Hinder Emissions Reductions? Discussing the "Moral Hazard" **AB 3**

14.30 – 17.00 Sessions

» Risks and Conflict Potential of Climate Engineering **AB 3**
» Assessment Methodologies for Climate Engineering Technologies **P**
» To Gabon or Not To Gabon: A Game on — Geoengineering Research and Policy **AB 2**

17.30 – 19.00 Poster Session AB 1

» Lead-in Presentation: A Monument to the Anthropocene: The Solar Balloon and Tomas Saraceno's *Cloud City* **AB 3**

19.30 Shuttle from Scandic to the Museum für Naturkunde

20.30 – 22:00 Panel Discussion and Reception

» Climate Engineering and the Meaning of Nature

20 Wednesday August 20th, 2014

9.00 – 10.30 Sessions

» Civil Society and Geoengineering: Who's Engaging Whom? **S**
» Enhanced Mineral Weathering: Potential and Consequences (Part 1) **C**
» Exploring the Intersections between Climate Engineering and Systems Engineering **B and Y**
» From Geoengineering to Geo-weaponeering: The Security Dimensions of Climate Engineering **AB 3**
» Intentional and Unintentional Interferences in the Climate System **P**

11.00 – 12.30 Sessions

» Novel SRM Techniques: Cirrus Cloud Thinning and Marine Sky Brightening **AB 3**
» Climate Geoengineering and the Potential Role of Human Rights Regimes **S**
» Climate Engineering Governance — is the Climate Convention the Right Place for It? **B and Y**
» Regional Paths to Global Change: Approaches and Governance for Regional Climate Engineering Technologies and Strategies **P**
» Enhanced Mineral Weathering: Potential and Consequences (Part 2) **C**
» Climate Engineering and Human Engineering: Social and Technological Challenges in the Anthropocene **AB 2**

12.30 – 14.30 Lunch Break

13.15 – 14.15 Lunchtime Discussion

» The Politics of Climate Engineering **AB 3**

14.30 – 17.00 Sessions

» Climate Emergency: Science, Framing, and Politics (Part 1) **P**
» The International Control of Climate Engineering and Research: Debating Why, How and Who **AB 2**
» The Potential Role of Space in Climate Engineering Concepts **S**
» From Projections to Control: The Role of Climate Modeling in SRM **B and Y**
» Biogenic Carbon Sequestration: Multifunctionality for Global Resilience **C**

17.30 – 19.00 Poster Session AB 1

» Lead-in Presentation: Nephologies **AB 3**
» Fend for yourself dinner

Thursday August 21st, 2014

9.00 – 10.30 Sessions

» Strange Bedfellows — Political Contestation over SRM on the Left and Right **B and Y**
» Local Laws, Global Liability: Using National and Local Laws to Regulate Climate Engineering and Allocate Responsibility for Its Impacts **C**
» Carbon Air Capture Efficiency Prospects: Current Research and Future Directions **S**
» Climate Emergency: Science, Framing, and Politics (Part 2) **P**
» Mapping the Landscape of Climate Engineering **AB 2**

11.00 – 12.30 Sessions

» Design of Practical Hardware for Climate Engineering **S**
» The Ethics of Carbon Dioxide Removal **C**
» How can Civil Society and the Scientific Community Jointly Address Climate Engineering? **AB 3**
» Climate Engineering in Popular Culture: Art, Media, Games, and Fiction **B and Y**
» Developing Countries and SRM **AB 2**

12.30 – 14.00 Lunch Break

14.00 – 15.00 Panel Discussion

» The Writer's Role: Reflections on Communicating Climate Engineering to Public Audiences **AB 3 and AB 2**

15.30 – 17.00 Panel Discussion

» Assess, Test or Terminate: What Future for Climate Engineering Research? **AB 3 and AB 2**

17.30 Shuttle to Haus der Kulturen der Welt

18.30 – 20.30 Closing Panel

» The Anthropocene: An Engineered Age?

20.30 – 22.30 Conference Dinner

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March 2015

Institute for Advanced Sustainability Studies Potsdam (IASS) e. V.

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DOI: 10.2312/iass.2015.008

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