Information on Climate Engineering

With greenhouse gas emissions continuing to escalate, recent years have seen a growing discussion of climate engineering (CE) - an array of proposed techniques for manipulating the global climate in order to moderate or forestall some of the effects of climate change. Research has expanded rapidly and while it has become clear that climate engineering cannot serve as a direct substitute for emission reductions, the role of specific climate engineering techniques as responses to climate change within a portfolio of measures is being debated.

Potential climate engineering techniques

WHAT IS CLIMATE ENGINEERING?

Climate engineering (CE), also known as geoengineering, describes a diverse and largely hypothetical array of techniques for manipulating the global climate in order to moderate or forestall some of the effects of climate change. CE techniques aim either to remove carbon dioxide from the atmosphere and store it, or to reflect some of the incoming sunlight back into space. The former techniques are known as Carbon Dioxide Removal (CDR), and focus either on enhancing existing carbon dioxide removal processes in natural systems (e.g. soils, forest, and oceans), or on filtering carbon dioxide out of the atmosphere with technological means. The latter techniques, known as Solar Radiation Management (SRM), focus on increasing the reflectivity of existing surfaces (clouds, forests, deserts, oceans, urban areas), forming a reflective particle layer in the middle atmosphere, or deploying mirrors in space.

WHY IS CLIMATE ENGINEERING BEING DISCUSSED?

CE has been absent from serious discussion about climate change until the last decade largely due to concerns among scientists that the introduction of an "alternative" to mitigation and adaptation could reduce incentives and momentum to endure the transition to a low-carbon economy, or that the climate system is too complex to be altered by human activities in a predictable way. However, there are increasing concerns that existing efforts may be insufficient to prevent or withstand damaging climatic changes. This has been due to perceived stagnation in recent climate negotiations and, by association, only slow progress in reducing emissions, increasing doubt in scientific and political circles that warming can be limited to the internationally agreed target of 2°C, and the potential that the climate system may prove more sensitive than expected or reach "tipping points" (such as permafrost carbon loss).

Hence, there have been growing discussions about how the development of climate engineering technologies might complement or weaken efforts of mitigation – reducing greenhouse gas (GHG) emissions – and adaptation – buttressing societal capacities to endure climatic changes. Since CDR targets the reduction of GHG concentrations in the atmosphere, it is often seen as a supplement to conventional efforts of mitigation. Meanwhile, SRM is often framed as either an insurance policy against extreme climatic changes, or as a way to buy time for mitigation actions to take effect. The most prominent SRM techniques, such as the injection of sulphate aerosol particles into the stratosphere, have global impact, and are often hypothesized to be technically feasible, swift-acting in their effects on the global mean temperature, and cheaper to implement than comprehensive mitigation.

WHAT IS THE STATE OF RESEARCH?

The last half-decade has seen a proliferation of scientific studies, public commentaries, and limited governmental and private sector involvement. An expanding number of research programs – mostly based in the global North - are exploring CE's physical and social effects through computer simulations and assessments of potential risks and uncertainties. Much of the funded research goes beyond technical questions to focus on economics, ethics, governance, perception, and other aspects. Academic work has been accompanied by increased attention from the media, public intellectuals, and environmental and technology watchdog groups. The first government-commissioned reports have been released by the UK, USA, and Germany, and scientific researchers have begun to engage worldwide academic and policy-making communities. The Intergovernmental Panel on Climate Change has expanded its discussion of climate engineering in its upcoming 2014 Assessment Report compared to earlier reports. There has also been some commercial interest, with many patents being registered, and some companies having attempted to sell voluntary carbon credits based on CDR techniques.

Field-tests of prototype technologies are being discussed or have been done at small scales. Ocean iron fertilization experiments from 1990 to 2009 and a limited number of tests of small-scale prototypes for removing carbon dioxide from the atmosphere have already helped generate interest in (and criticism of) CDR techniques. Field-tests of globally impacting SRM technologies remain highly controversial – although none have taken place on a large scale, some small-scale tests are being planned. Due to concerns that efforts to scope CE might inadvertently generate momentum to develop – and perhaps later, to deploy – the technologies, there is a general climate of caution surrounding any actions that go beyond social science research, modeling, and laboratory work.

Many in the academic community have called for a global debate with scientists, policy-makers, and civil society on the state, risks, unknowns, and challenges of current research. Effective planning may need to take place decades in advance, and decisions made now – on switching to a low-carbon economy, developing particular CE techniques, or some mix thereof – may create pathways of development that could be difficult to re-orient later on.

There is a broad scientific consensus that no CE technique can be considered a solitary substitute for mitigation or adaptation. Many stress that the transition to a low-carbon economy is key to sustainably addressing climate change. CDR may complement the reduction of carbon emissions, but cannot viably replace it. SRM only masks the warming effect of GHGs, does not address non-warming effects of climate change such as ocean acidification, and abrupt termination may result in quick temperature rises with possibly dramatic impacts.

IS CLIMATE ENGINEERING FEASIBLE?

The feasibility of CE techniques is uncertain, and we may not be able to anticipate or address all risks beforehand. These range from technical questions on costs, mechanics, geophysical processes and environmental impacts, to wider societal repercussions. Modelling studies, small-scale field experiments, natural analogues, and political analysis may offer preliminary indications, but only multi-year experiments on regional-to-global scales would be able to shed light on the long-term impacts of various CE techniques. However, such experiments would in principle be indistinguishable from actual deployment.

There is no comprehensive economic assessment of CE techniques. The possible operational costs of CE techniques have been estimated with different methods. The costs of SRM have been estimated to be in the order of a few tens of billion US dollars per year or less, while CDR cost estimates range from tens to hundreds of billions of US dollars per year. These numbers strongly depend on the particular technology or technique involved, as well as the scale of deployment. Moreover, to date there has been no estimation of the costs that CE would impose upon society. Thus, the notion that CE may be cheaper than mitigation and adaptation rests on an incomplete assessment.

Current scientific knowledge infers that deployment will have unevenly distributed global effects. For example, increasing the earth's reflectivity on a global scale (SRM) is expected to lead to varying temperature reductions and precipitation changes in different regions. Similarly, particular CDR measures aiming at radically increasing biological processes taking up carbon dioxide, such as ocean fertilization, may impact regional ecosystems. Altered environments may have complex effects on human and state security, water availability and food production, biodiversity, and energy. The basic possibility of unilateral deployment of global SRM techniques, due to its comparatively low development, implementation and operation costs, exacerbates concerns about conflicts.

There are overarching concerns over how climate governance and human society may develop – and be changed by – CE. Developing CE technologies may create a "slippery slope" toward deployment, and siphon momentum away from already slow-moving efforts to reduce emissions. Moreover, should SRM ever be discontinued in the absence of comprehensive GHG reductions, a rapidly rising global mean temperature would create a "termination shock" to which ecosystems and societies would have severe difficulties adapting. Others criticize what they see as the postponing of transitioning away from fossil fuels to later generations, the unequal capacity between states to research and deploy the technologies, or shifting the effects of what would have been GHG-driven climate change to populations that will suffer from an engineered climate. Conceptually, there are questions of how CE alters (or confirms) humanity's relationship to nature, as well as the hubris (or ingenuity) of applying technological solutions to complex issues.

IS CLIMATE ENGINEERING LEGAL?

There is no international treaty that addresses CE as a whole, and existing rules may be general, vague, or contain gaps. However, some CE activities could violate specific rules in international agreements. Relevant treaties include:

- The United Nations Framework Convention on Climate Change (UNFCCC), which aims at the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. SRM techniques, which do not alter GHG emissions, are neither currently covered nor necessarily prohibited. CDR techniques may be implicitly covered by some articles. There have so far been no negotiations on CE within the UNFCCC.
- The Environmental Modification Convention (ENMOD), which outlaws the military or other hostile use of environmental modification techniques with widespread, long-lasting or severe effects. The treaty does not apply to activities carried out for peaceful purposes and its provisions have never been invoked in practice.
- The Convention on Biological Diversity (CBD), which addresses the conservation and sustainable use of biodiversity. The conference of parties of the CBD first discussed CE in 2008, and in 2010 adopted the only general measure to address all forms of CE taken to date. Although non-binding, CBD Decision X/33 establishes general criteria for CE governance and prohibits all CE activities except for scientific research that meets specified criteria.
- The London Convention and London Protocol (LC/LP), which govern the dumping of wastes and other matter at sea. In October 2013, parties will debate an amendment to the LP to create a legally binding regulation that would only allow ocean fertilization that is legitimate scientific research and that has been subjected to an environmental impact assessment (EIA).

Some rules of customary international law also have relevance to CE activities, including the duty of states to ensure that activities within their jurisdiction or control respect the environment of other states or of areas beyond national jurisdiction.

SUMMARY

1. CE is not capable of returning the climate to its preindustrial state, or even of keeping it at its current state.
2. No CE techniques can be considered a solitary substitute for mitigation or adaptation.
3. Individual CE techniques are expected to have different costs, feasibilities, timelines, risks, unknowns, and potential constellations of actors and agendas; and are not readily comparable.Any CE techniques will likely have technical risks, unequally-distributed environmental and societal impacts, and irreducible unknowns.
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5. Scientific research, public and policy engagement, and governance frameworks are growing, but field tests of certain techniques remain controversial, and the debate is still based largely in the global North.
6. Many researchers are calling for a timely and global debate to explore which CE techniques – if any – might be appropriate to combat climate change.
7. Many CE techniques are not strictly prohibited by international law, but there are treaties and strong principles urging caution with regard to research and development.

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SUSTAINABLE INTERACTIONS WITH THE ATMOSPHERE

The cluster Sustainable Interactions with the Atmosphere (SIWA) enquires into how humans, as the driving force of the Anthropocene, are modifying the composition of the atmosphere, how this in turn impacts humanity, and how this interaction can be made more sustainable. SIWA examines how unintended human perturbations to the atmosphere can be mitigated, particularly through rapid reductions of short-lived climate-forcing pollutants (SLCPs), and also addresses a major possible transition facing us: from unintentionally perturbing the global atmosphere, to large-scale intentional intervention in the climate system ("climate engineering").

INSTITUTE FOR ADVANCED SUSTAINABILITY STUDIES (IASS) E.V

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 utilization, and earth system challenges like climate change, air pollution and soil management.

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