

## **Geoengineering for Climate Remediation: Is this a Safe and Reasoned Response?**

The most challenging human impact on the global environment is climate change caused by human activity; the increase of carbon dioxide and other greenhouse gases in the atmosphere from burning fossil fuels, land clearing, agriculture and industrial activity. As noted recently by the Climate Commission “The global climate is changing and humanity is almost surely the dominant cause. We are already seeing the social, economic and environmental impacts of a changing climate.”

Discussion and debate at national and international levels on addressing the global problem of climate change has focussed on two different approaches, mitigation and adaptation.

Mitigation aims to address the causes of the problem, by reducing emissions of greenhouse gases associated with human activity. It involves the transition to low carbon energy sources, the reduction in energy use through efficiency measures, and reductions in emissions from industrial processes, as well as reducing land clearing and changes in agricultural practices.

Adaptation involves responding to the impacts of climate change, without directly reducing its causes. This can involve the development of systems and activities at local and regional scales that reduce the adverse impacts of climate change, as well as to take advantage of any beneficial impacts from climate change.

A third approach may exist for addressing climate change. Usually called geoengineering, it would involve deliberate manipulation of physical, chemical, or biological aspects of the Earth system to reduce human-caused climate change.

More than sixty scientists, engineers, social scientists and interested people gathered at the Shine Dome in Canberra from 26–27 September 2011 for the symposium *Geoengineering the Climate? A Southern Hemisphere perspective*, organised jointly by the Australian Academy of Science and the Academy of Technological Sciences and Engineering. This symposium addressed some of the implications of different approaches to geoengineering the climate, including their relative opportunities and risks, and the possible impacts in the Southern Hemisphere. Importantly, in addition to scientific and technological aspects of geoengineering, it also included consideration of ethical and governance aspects. It was the first major meeting in Australia to provide a forum for cross-disciplinary discussion on geoengineering the climate.

The symposium included presentations and responses from invited speakers on a wide range of topics, as well as plenty of time for discussion. The presentations and their summaries are available from

<http://www.science.org.au/natcoms/nc-ess/documents/GESymposium.pdf>  
and <http://www.science.org.au/natcoms/nc-ess/documents/symposium-ppt/>

One of the first conclusions from the symposium was that the meaning of the term ‘geoengineering’ is not clear. It is better to refer to ‘climate remediation’, as this more clearly identifies the purpose of the proposed actions. The second conclusion was that climate remediation cannot be seen as replacing the urgent need for substantial national and international efforts on climate change mitigation. In fact, the need for discussions of climate remediation highlights the inadequacy of action globally and in Australia to reduce emissions of greenhouse gases into the atmosphere from human activity.

There are two main types of climate remediation options that were discussed. One group involves enhanced removal of carbon dioxide from the atmosphere into vegetation and soils or into the oceans or injection underground. The other group involves reducing the amount of sunlight that warms up the Earth, through increasing the reflection of sunlight either from the surface or from clouds or particles in the atmosphere.

Examples of different approaches for enhanced carbon dioxide removal that were discussed include:

- Changes in land-cover management e.g. growing more trees or reducing land clearing
- Changes in agriculture to increase uptake of carbon in soils;
- Ocean fertilisation by adding iron or nitrogen to stimulate growth of marine plankton;
- Engineered capture of carbon dioxide directly from industrial emissions and then injection underground, often called carbon capture and storage (CCS).

Some of these options for enhanced carbon dioxide removal are already being seen as part of climate change mitigation actions, such as reforestation and increasing soil carbon, and as less risky in terms of adverse or unintended consequences. However, there was general agreement that there are large differences between the perceived potential for some of these approaches to lead to sizeable removal of carbon dioxide from the atmosphere and what is likely to be practical and achievable over the next forty years. Specific examples included the difficulties in achieving significant increases in carbon uptake in Australian soils, given the associated costly increases in nitrogen input that would be required and problems with measurement and validation of the amount of carbon actually sequestered. Substantial under-funding by industry and government of research and development on carbon capture and storage technologies is hindering progress; CCS can only be included as part of a package of climate change mitigation technologies if it can be demonstrated to be safe, effective, permanent and economically viable.

Examples of approaches that might be used to increase reflection of sunlight that were discussed include:

- Increasing reflection at the surface by growing crops or vegetation of high reflectance, or, for local urban effect, reflective painting of buildings;
- Enhancing cloud reflectivity or cloud brightening;
- Injection of aerosols or particles into the stratosphere.

These solar radiation management technologies were considered to be inherently more risky than carbon dioxide removal for a number of reasons. First, reducing sunlight absorbed in the climate system has quite different climatic responses than reducing greenhouse gas emissions, in terms of the spatial and temporal patterns of temperature changes and in terms of rainfall changes. Second, the responses to increased solar reflection are more localised, but are likely have uncertain remote responses. Third, there may be unintended consequences from these technologies, such as ozone depletion due to injection of particles into the stratosphere. Finally, these approaches do not address the biochemical problems associated with increasing carbon dioxide concentrations in the atmosphere and in the ocean, only seeking to offset the changes in physical climate.

Following the discussions on the science and technology aspects of climate remediation, a number of ethical and governance issues were discussed. A wide range of ethical perspectives were presented, including that any research on solar radiation management was just avoidance

of the urgent need for climate change mitigation. A different view was that research on solar radiation management was needed to underpin possible emergency measures to avoid rapid nonlinear climate change if some tipping point was passed, or that solar radiation management, combined with climate change mitigation, might minimise the level of global warming while slower reductions to greenhouse gas concentrations took effect. The inequities of the possible adverse or unforeseen impacts of climate remediation were also discussed, both the inequities between different countries or different peoples, as well as the inequities between current and future generations.

It was noted that effective global governance of climate remediation has been proving problematic. The world has been battling with governance and compliance issues of reducing carbon dioxide emissions for 20 years since the 1992 Framework Convention on Climate Change, without effecting any decline even in the rate of increase of atmospheric carbon dioxide concentration. That rate has in fact accelerated despite the international protocols.

A major problem with governance of some of the radiation management schemes is that it is conceivable that they might be put into place unilaterally either by a nation or a private entity. Some of the techniques discussed would cost only about a billion dollars a year which is not beyond some companies or even individuals. But the impacts, as intended, would be global, including any unintended or unanticipated repercussions. Hence the meeting recognised that ethical considerations are paramount and that well-informed, high-level international discussions are urgently needed to put in place procedures to avoid imprudent actions being taken unilaterally.

The symposium demonstrated the value of bringing together a broad spectrum of disciplinary interests to discuss climate remediation. It also demonstrated the limitations of available expertise in Australia in relevant areas of science, engineering and social science. No answers were provided to many difficult questions but a future joint meeting of all the Australian Academies, through the Australian Council of Learned Academies, was suggested. Such joint Academy meetings are one of the recommendations of the strategic research plan for Earth system science in Australia that was developed by the National Committee for Earth System Science of the Australian Academy of Science. The research plan, *To Live within Earth's Limits: An Australian Plan to Develop a Science of the Whole Earth System*, was developed over four years and can be found at <http://www.science.org.au/natcoms/nc-ess.html>.