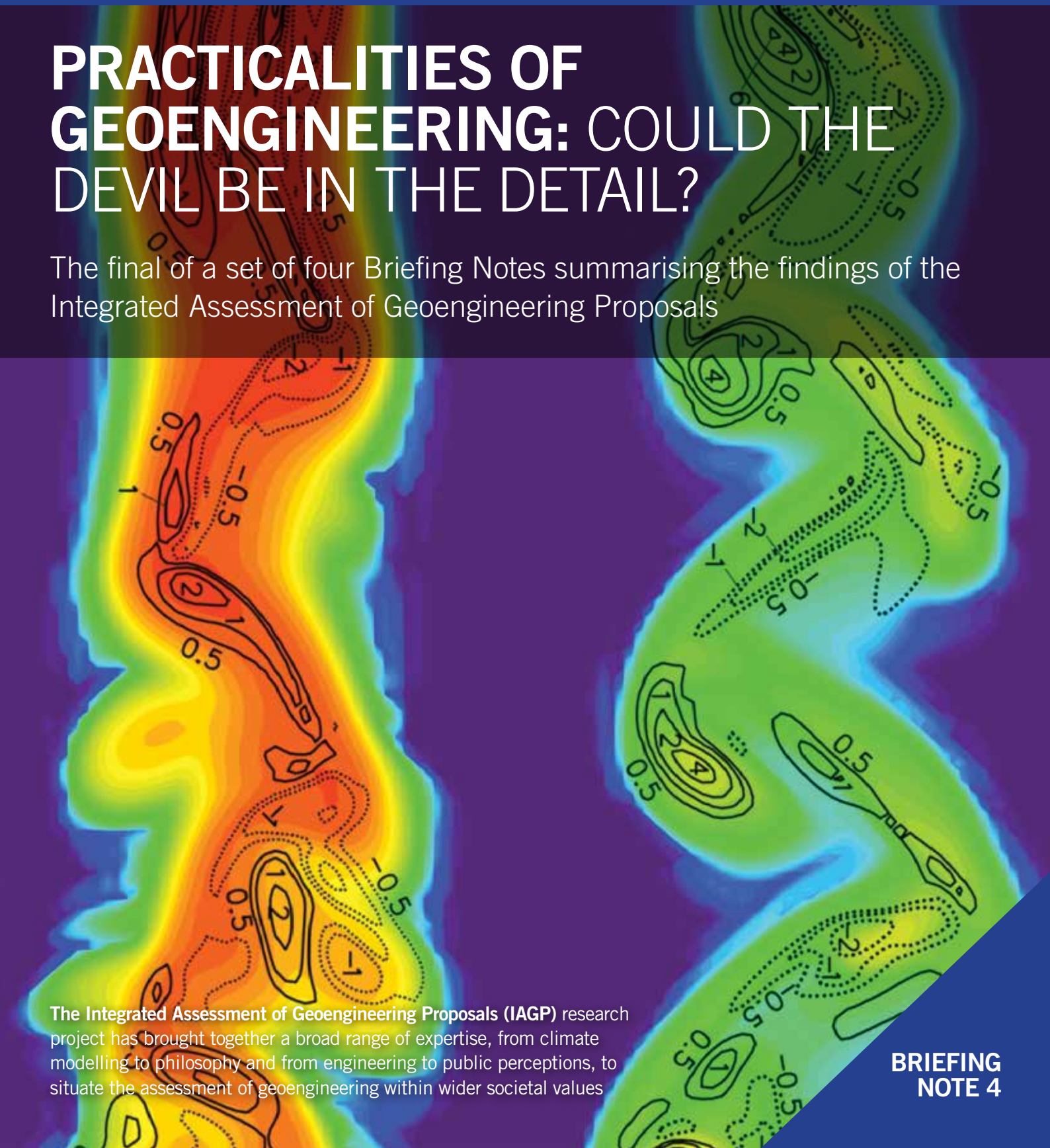
IAGP

Integrated Assessment of Geoengineering Proposals

# PRACTICALITIES OF GEOENGINEERING: COULD THE DEVIL BE IN THE DETAIL?

The final of a set of four Briefing Notes summarising the findings of the Integrated Assessment of Geoengineering Proposals



**The Integrated Assessment of Geoengineering Proposals (IAGP)** research project has brought together a broad range of expertise, from climate modelling to philosophy and from engineering to public perceptions, to situate the assessment of geoengineering within wider societal values

**BRIEFING NOTE 4**

**With geoengineering proposals currently being largely theoretical, it is easy to overlook the practicalities associated with implementing them in the real-world. These practicalities include the physical operation of the geoengineering proposal, whether the geoengineering proposal would alter the climate as projected, and how an altered climate may affect people and ecosystems.**

## What practicalities would be associated with geoengineering technologies?

Geoengineering would generally need some form of engineered technology.

Some geoengineering proposals – for example, solar geoengineering by forming particles in the stratosphere – are based on new and unproven technologies.

Other geoengineering proposals – often carbon dioxide removal – are based on well-known technologies. However, the massive scale of deployment that would be needed to alter the Earth's climate would be unprecedented, leading to various unknowns.

Aside from the design of the technology itself, other practicalities will also have to be managed. For example, locating and establishing new supporting industries and the consequences of increased competition for resources such as water, land, chemicals, and labour.

In spite of current unknowns, future scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) include carbon dioxide removal.

IAGP research shows that:

The early developmental stage of designs, along with instances of commercial confidentiality, currently limits the amount of technical information about potential geoengineering proposals in the public domain.

The current lack of information impairs evaluations of geoengineering proposals, which must instead rely on informed estimates and computer models.

In addition to the scientific and technological challenges, geoengineering raises many profound questions around social, moral, legal and economic issues. Any exploration or development of the engineering technologies will have to proceed responsibly and in parallel with these issues (see Briefing Notes 1 and 2).

## What do climate models tell us about the practicalities of a geoengineered climate?

IAGP researchers have undertaken a number of computer simulations of solar geoengineering (Box 1) using a global-scale climate model:

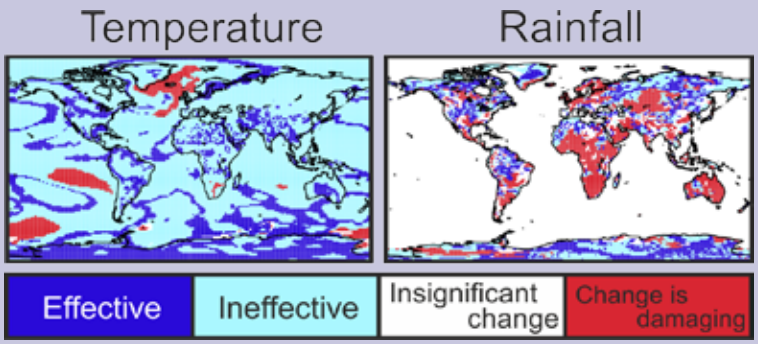
### Simulations of solar geoengineering Box1

| | |
|---|---|
| **Increasing the reflectivity of crops** | All grassland was made as reflective as possible in the model |
| **Increasing the reflectivity of deserts** | The model was altered to act as if all deserts were covered in highly reflective material |
| **Increasing the reflectivity of the seas** | The model was altered to act as if all open sea was covered in micro-bubbles |
| **Increasing the reflectivity of marine clouds** | Potentially cloud-altering particles were released over all tropical seas in the model |
| **Forming particles in the stratosphere** | Particles were formed in the stratosphere at the equator in the model |

These global-scale climate simulations showed that:

**1. Global average changes hide the regional variations that would be important in practice**
All of the modelled solar geoengineering proposals lowered the average global temperature, but the cooling was not uniform (e.g. Box 2). While there were reductions in rainfall, they were smaller over land than over the ocean. This initially appears to reduce the consequences for society, but there were still significant regional variations that would be challenging to adapt to.

**2. Geoengineering may not be able to keep up with increasing climate change**
In our simulations, none of the geoengineering proposals were able to keep the temperature at the 1986-2005 target for long, if at all. Keeping up with the increasing




## Solar geoengineering proposal: increasing reflectivity of the sea

Computer simulation of the global climate. How effective is this method at restoring temperature and rainfall?

Box 2

warming that would result from insufficient mitigation would instead need increasing amounts of geoengineering. While, in practice, some geoengineering proposals could be scaled-up, there would be physical and technical limits.

**3. Geoengineering would have lasting effects**
If solar geoengineering were started and then stopped, globally averaged temperatures and rainfall would quickly recover to close to what they would have been had the solar geoengineering never been used. However, in spite of global-scale recovery, solar geoengineering would leave significant lasting changes in regional patterns of temperature and rainfall. In practice, this would complicate issues of ethics and liability beyond any period of active geoengineering.

## How well are geoengineering technologies captured in global-scale climate models?

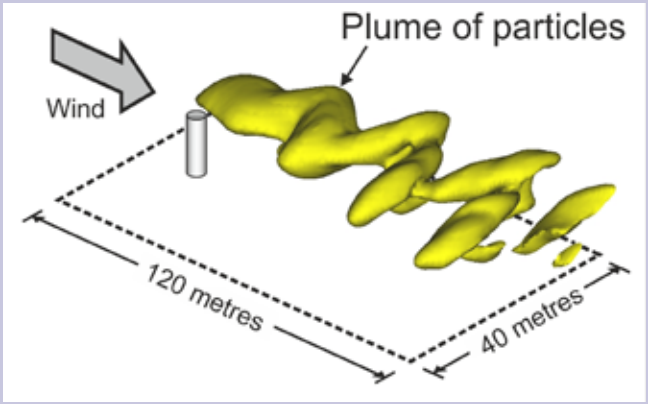
Geoengineering is typically simulated in global-scale computer models that can capture large-scale climate phenomena but cannot capture small details such as individual clouds or how geoengineering proposals would be implemented in the real-world.

For solar geoengineering by increasing the reflectivity of low-level marine clouds, cloud-altering particles would be emitted in dense plumes from sea-going vessels. These plumes would likely be only tens of metres across when emitted, and so cannot be captured in the global-scale models.

IAGP simulated these plumes of particles in a smaller, more detailed model (Box 3). The high numbers of closely packed particles in the plume meant that many joined together and so fewer particles were then available to alter the cloud. This meant that the geoengineering proposal was less effective than predicted by the global-scale models that did not account for this detail.

Improving how well global-scale models capture the practicalities of geoengineering will be important for improving the realism of future global-scale simulations.

## Solar geoengineering proposal: increasing reflectivity of clouds




Detailed computer simulation of a plume of particles

Box 3

## What does the IAGP project recommend?

The IAGP project recommends that:

- It is appreciated that with the current lack of technical information, evaluations of geoengineering proposals cannot be fully realistic.
- Future assessments of geoengineering should account for practicalities such as the need to locate and establish new supporting industries and the implications of changing demands on resources.
- Discussions of how geoengineering may alter the climate should move beyond global averages to incorporate the regional changes that will be more relevant to people and ecosystems.
- Climate modellers and engineers need to work together to improve computer simulations of geoengineering by better capturing practical details.

## Further resources


Crook, J. A., Jackson, L. S., Osprey, S. M., Forster, P. M. (2014) Effectiveness and side effects of geoengineering by different earth radiation management schemes. In preparation.

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Kravitz, B., Forster, P. M., Jones, A., Robock, A., Alterskjær, K., Boucher, O., Jenkins, A. K. L., Korhonen, H., Kristjánsson, J. E., Muri, H., Niemeier, U., Partanen, A.-I., Rasch, P. J., Wang, H., Watanabe, S. (2013) Sea spray geoengineering experiments in the geoengineering model intercomparison project (GeoMIP): Experimental design and preliminary results. Journal of Geophysical Research: Atmospheres 118(19):11,175–11,186.

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**http://www.iagp.ac.uk/publications/**

## About us

The IAGP project has been carried out by researchers at Cardiff University, Lancaster University, Met Office, Tyndall Centre for Climate Change Research, University of Bristol, University of East Anglia, University of Leeds and University of Oxford. The IAGP project has received funding from the Engineering and Physical Sciences Research Council (EPSRC) (EP/I014721/1) and the Natural Environment Research Council (NERC) and support from Living With Environmental Change (LWEC).

## Project Website

www.iagp.ac.uk

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