

The Earth's atmosphere is extraordinarily thin – and it is in serious danger. Consequently, researchers are working on methods to counteract anthropogenic climate change. At the same time, a legal framework for such large-scale experiments must be established.



Controlling the Climate

The global climate is changing – the world is facing global warming. Researchers are working on technologies to fight the causes and impacts of anthropogenic climate change. Yet, are such methods – if they even work – compatible with international law? Researchers such as **David Reichwein** at the **Max Planck Institute for Comparative Public Law and International Law** in Heidelberg are investigating just that.

TEXT **BIRGIT FENZEL**

Controlling the climate is one of mankind's age-old dreams. Many cultures had rainmakers, who used spiritual powers in an attempt to secure the goodwill of the weather gods. In the modern world, climate engineers have assumed this role. It has long since ceased to be merely about methods with which clouds can be "milked," heat waves cooled or storms tempered. Researchers are looking for new methods to counteract undesired effects of anthropogenic climate change.

Some consider this climate- or geo-engineering to be a silver bullet that, in addition to greenhouse gas reduction and adaptation strategies, could forge a third direction in the fight against the menacing rise in temperatures on Earth. Furthermore, many no longer believe that global warming can be halted solely by reducing carbon dioxide emissions.

In the quest for an air conditioner for the planet, there appear to be no limits to the geoengineers' ingenuity.

Time and again, their new recommendations have spawned headlines and controversial discussions. The measures essentially fall into one of two categories: those that aim to prevent further warming of the Earth by reducing solar radiation, and those that use artificial means to try to recapture the emitted carbon dioxide from the air. One example of the latter is the proposal to use iron fertilization to promote the growth of marine algae, which, in turn, consume large quantities of this greenhouse gas. When the algae die, the carbon dioxide sinks to the ocean floor with the remains of the plant.

With their Lohafex experiment, however, researchers from the Alfred Wegener Institute in Bremerhaven were able to witness first-hand how this plausible solution can yield unexpected results in practice. They had dumped iron sulfate over an area of about 300 square kilometers in the southern Atlantic east of the Falkland Islands, as fertilizer for the algae. Although the creatures flourished as

planned, swarms of small crustaceans suddenly appeared and torpedoed the climate experiment with their huge appetites. In the end, there were not, in fact, significantly more algae remains than without fertilizer. Therefore, it was also not possible to sink any more carbon dioxide into the ocean.

ARTIFICIAL CLOUDS ARE INTENDED TO KEEP THE EARTH COOL

The proposals for preventing a further rise in global temperatures by means other than solely reducing carbon dioxide emissions also include the one that is based on the idea that the Earth will heat up less if a larger share of the Sun's rays are reflected into space.

This effect could be achieved through large-scale installations on our planet – white roofs, for instance, or white clouds produced by spraying a fine mist of saltwater over the southern oceans from ships. The salt crystals would act as additional condensation nuclei and, upon evaporation, lead to a

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greater number of water drops in the clouds. This would make the clouds significantly brighter and they would thus reflect more sunlight.

One of the climate engineers' clear favorites, however, is Chemistry Nobel laureate Paul Crutzen's proposal that caused quite a stir some four years ago: bringing sulfur dioxide into the upper stratosphere, where it oxidizes to form sulfuric acid, which in turn condenses into small particles. The idea of forming a kind of sunshade over the Earth led to vigorous disputes among researchers and in the media.

Favoring this method, in the opinion of its proponents, is the fact that it is economical, it is technically feasible with a minimum of complications, and

above all, it will take effect quickly in an emergency. One argument often cited for the latter is the 1991 eruption of the Pinatubo volcano: it released around ten million tons of sulfur dioxide into the stratosphere, where chemical processes converted some of it into sulfate particles. The researcher believes that these tiny airborne particles resulted in an average drop of 0.5 degrees Celsius in temperatures on Earth the following year.

However, opponents of climate therapy through sulfur dioxide cite the imponderability of the risks of this model. "No one knows yet precisely what impact such an experiment might have on the global climate system and how differently individual regions would be affected," says legal scholar David Reichwein, who is exploring the legal boundaries and the regulation of geoengineering for his dissertation at the Max Planck Institute for Comparative Public Law and International Law.

After all, the failure of a geoengineering experiment need not always have as relatively harmless an outcome as that of the algae fertilization in the southern Atlantic, where, apart from a few overweight copepods, the environment is hardly likely to have sustained any major damage. "But even in the case of this attempt at removing carbon dioxide from the cycle, its use on a large scale threatens to severely upset the ecological balance," says Reichwein.

In his research, Reichwein uncovered, for example, a variety of significant studies that address the undesired side effects of climate therapy through aerosol screens in the stratosphere. As an example, he cites a study from November of last year: based on their models, Patricia Heckendorn from the Institute for Atmospheric and Climate Sciences at the ETH Zurich and her colleagues conclude that the use of stratospheric sulfur aerosols could result in a considerable breakdown of the ozone layer.

According to Reichwein, after the volcanic eruption in the Philippines in 1991, shifts in rainfall areas were also observed, which could certainly be among the undesired side effects of a large-scale climate experiment.

A CODE OF CONDUCT FOR RESEARCH

The consequences of such an event could be devastating – at least for the people who live in those regions, who suddenly find themselves high and dry, or whose fields are flooded after torrential rainfalls. "The problem here is that we can't simply test the results in experiments, as not all risks are detectable on a small scale or in simulations," says David Reichwein. "The consequences become apparent only with the first large-scale deployment." Moreover, the aerosol injection, in any case, would have to be done over an extend-

Historical atmosphere: The "House Buhl," built in 1722, is home to the Marsilius Kolleg.





At the Marsilius Kolleg, international law specialist David Reichwein (left) explores ideas for a rescue from the climate crisis. He appreciates the interdisciplinary approach of the young team (in the image at right, from left: Reichwein, Hannes Fernow, Wolfgang Dietz, Melanie Bräunche, Stephanie Uther, Daniel Heyen).

ed period in order to avoid potentially causing even faster warming after the injections are stopped.

This uncertainty regarding the risks and consequences of systematic technological interference in the planet's climate system applies to nearly all geoengineering proposals, says Reichwein. The 24-year-old international law specialist is part of the team of young researchers who are critically examining the various ideas for easing the climate crisis in the context of the project "The Global Governance of Climate Engineering" at the University of Heidelberg's Marsilius Kolleg. In this project, researchers work across disciplines and focus on the diverse relationships between technological, economic, cultural, political, social, psychological and legal aspects.

Their common goal is to consider, through dialogue and from a number of perspectives, the opportunities and risks of a controlled global climate, and to develop a code of conduct in research for incalculable side effects of the potential methods. "Among other things, we are concerned with the technical and economic feasibility of the proposals," says Reichwein. Furthermore, they want to examine how global climate models can be linked with geographic and socio-economic data.

To this end, the environmental physicists in the Kolleg are focusing on devising and comparing realistic sce-

narios for various methods, especially for artificial cloud formation. Philosophers and psychologists are shedding light on how geoengineering technologies are perceived by the public and how willing people are to invest in them. Economists are studying game theories on costs and benefits, as well as the economic feasibility of the technologies. Human geographers and political scientists are delving into public discourse, political strategies and the spatial distribution of the consequences of geoengineering measures.

Based on its experience in international environmental law and the law of the sea, the Max Planck Institute for Comparative Public Law and International Law is the only non-university research facility participating in the University of Heidelberg's Marsilius project. The project is supervised by Rüdiger Wolfrum, one of the Institute's two directors. This was prompted by a legal opinion on the admissibility of the iron fertilization research. Reichwein's role in the joint project is to model a possible international agreement from a political, economic and legal perspective.

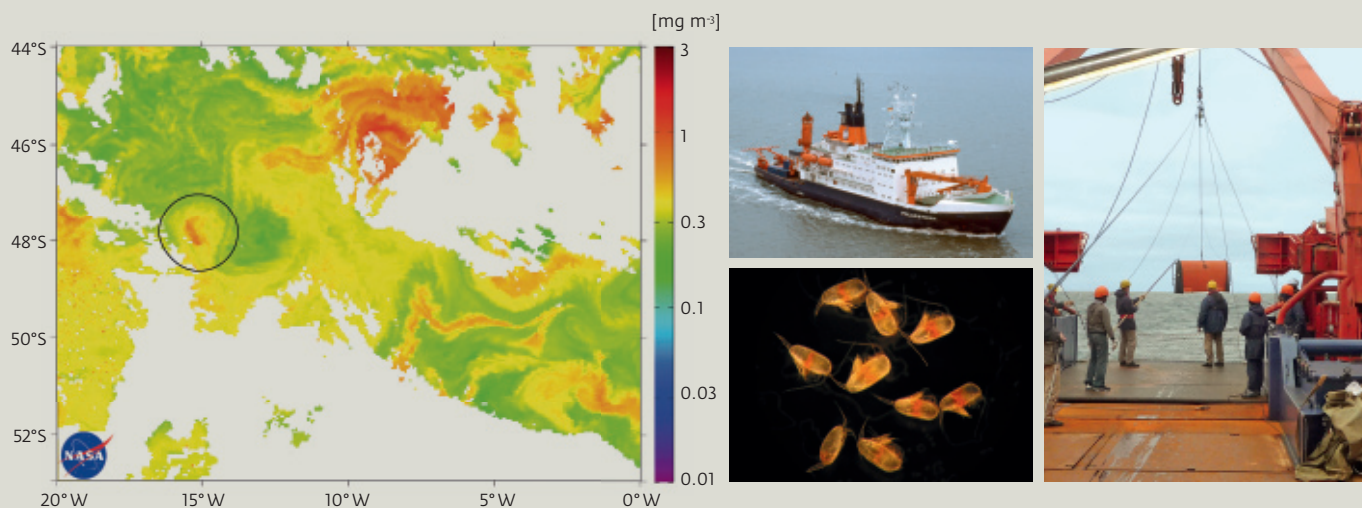
To what extent are the geoengineering research and models reconcilable with international law? That is one of the questions Reichwein will be addressing over the next three years. "I just find it interesting to think in broad categories," says the Max Planck re-

searcher, explaining his preference for global issues. He chose to focus on European and international law even while still studying at Bucerius Law School in Hamburg. He was aware right from the start that he was treading new legal territory with this project.

Half a year ago, however, Reichwein did not yet know just how far beyond the foundation of sure facts and laws this field lies. Describing the vague background of his research, he says, "The only thing that is certain here is that nothing is certain." This uncertainty is not limited to the technical feasibility and the side effects of targeted climate manipulation, but also extends to the legal level: "Geoengineering has not yet found its way into international treaties."

GAPS IN INTERNATIONAL LAW

In view of the global dimensions and the high risks of these climate manipulations, an entire array of fundamental questions on the legitimacy of relevant technologies need some deliberate answers. "For example, how can it be ensured that decisions to deploy any given method are made on a solid scientific basis?" says Reichwein. As yet, international law has no precept for this fundamental question. Furthermore, there is an urgent need to clarify who should have the right to implement such potentially conse-



The Lohafex experiment made the ocean bloom. Fertilized with iron sulfate, the algae flourished (circle on the satellite image, left), but they were devoured by small crustaceans. Conclusion: climate experiments definitely can have undesired side effects – and for this and other reasons, require a binding legal foundation.

quential interventions in the climate system. “Is only the community of states allowed to do that, or can one country act unilaterally?”

After all, there are, indeed, some proposals on the table now that – like the project to bring sulfur dioxide into the stratosphere – could certainly be managed, both financially and technically, by individual nations acting alone. This also constitutes a major legal difference from the strategies for carbon dioxide reduction that can be managed only by the community of states working together. But what happens if deploying such a method results in extreme weather changes in other regions of the world – such as cold snaps or heavy rains, and thus in crop failures, floods or other fatal consequences?

David Reichwein must explore these questions, too, because such cases also require legal bases on which claims for damages or compensation could be determined for those whose habitat was affected by climate manipulations. Even if the latter were regulated in an international agreement between the players involved, it would still need to be determined how such risks and uncertainties should generally be handled in legal terms.

The Ph.D. candidate hopes that his work will help establish clear and transparent terms, at least on the legal level. In addition to legal literature, he has been reading up on the scientific basis of geo-engineering since December 2009. Commenting on his efforts to bring his scientific and technological knowledge up to date, he remarks that it is sometimes some pretty heavy stuff. He says the talks and workshops with the other doctoral students in the Marsilius project, which are held every two weeks, are very enlightening. “A lot of my questions are answered there. The approach from various viewpoints is helpful and interesting,” says Reichwein.

But the open international law questions are something he has to address on his own. “In doing so, I have to differentiate between the various envisioned actions,” he says, describing his approach. It is about evaluating, from a legal perspective, whether existing international treaties or international customary law forbid targeted active influencing of the climate or make other legally binding statements about it. “For the use of sulfur sulfites in the stratosphere, some treaties that must be considered include the ENMOD convention, the Convention on Long-

range Transboundary Air Pollution, and the Vienna Convention for the Protection of the Ozone Layer,” says Reichwein, naming some examples from existing law that apply, at least in part, to geoengineering.

The London Convention – a Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter –, the UN Convention on the Law of the Sea and the Convention on Biological Diversity, among others, could pose an obstacle to the iron fertilization measures. According to David Reichwein, “The international legal custom of prohibiting cross-border environmental damage must likewise be considered. This prohibits every nation from developing or permitting activities in its territory that could lead to considerable cross-border environmental damage.”

REACHING A CONSENSUS AMONG STATES WILL BE DIFFICULT

In the second part of his dissertation, the young researcher first wants to find the various forms of legal and non-legal governance with global applicability in the context of environmental law. “The selection ranges from multilater-



Particle propeller: The Pinatubo volcano blew approximately ten million tons of sulfur dioxide into the stratosphere when it erupted in 1991. Some of the sulfur dioxide transformed into sulfate particles that evidently reduced temperatures on Earth by an average of 0.5 degrees Celsius the following year.

al international treaties to unilateral approaches to a complete ban on geo-engineering measures," he explains. "Then I'll look to see which could be fitting legal instruments for geoengineering, how they would have to be structured and what advantages and disadvantages they entail." In terms of international law, a binding agreement between countries, as well as a follow-up agreement to the Kyoto Protocol for joint efforts to reduce carbon dioxide would certainly be desirable.

However, the fact that this did not succeed during the climate negotiations in Copenhagen clearly shows how difficult it is to reach a consensus in the community of states. "In view of the potential risks and side effects of climate manipulation, and moreover, the fact that they can vary greatly from one region to the next, the process is not likely to be any easier for the geo-engineering methods," suspects Reichwein. However, the researcher does not consider it to be his job to determine

whether such climate manipulation should be permitted in the first place: "That is no more a matter for an international law assessment than is a moral evaluation of such interventions."

Rather, he and his colleagues want to help ensure that such discussions and decisions on potential measures can take place on legally firm ground. After all, it's possible that the carbon dioxide reduction measures will not be sufficient. "In that case, the climate activists will need a plan B. And maybe, through my work, I can do my little bit to halt climate change," says David Reichwein. ◀

GLOSSARY

Aerosols

Mixtures composed of airborne particles (aerosol particles) and a gas. The particles play an important role in the formation of cloud droplets and have a major impact on the climate.

Alfred Wegener Institute

Named after the eponymous polar researcher and geoscientist, the Alfred Wegener Institute (AWI) was founded in Bremerhaven on July 15, 1980. Its core subjects are marine biology, marine geology and climate research, and it is a member of the Helmholtz Association of German Research Centres.

Stratosphere

The atmospheric layer that lies above the troposphere and extends up to a height of about 50 kilometers. In comparison, the stratosphere contains a lot of ozone.

International law

A legal order that regulates the relationships between states on the basis of equality.