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Solar Radiation Management Technology (SRM): Stratospheric Controlled Perturbation Experiment (SCoPEx)

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This will be quite specific because it involves a very specific experiment on research on geoengineering, the Stratospheric Controlled Perturbation Experiment, and there are two components of that that I want to briefly present.

• The first is that the idea of SCoPEx, which Doug MacMartin had alluded to, is to perform a set of experiments that looks at a subset of risks and the efficacy of solar geoengineering, in this case the injection of aerosols into the stratosphere, and to hence be able to improve efficacy and perhaps reduce the risks or better quantify again some of the risks of solar geoengineering in the stratosphere.

• At the same time, due to the fact that in many ways it is a new type of experiment, we want to perform this experiment in a manner that shows good governance and that in a way also represents a test case of governance for solar geoengineering experiments.

[Slide] Doug already presented this. I just want to make clear that my perspective on solar geoengineering in the stratosphere is that clearly it cannot be a solution to the climate problem; at best, it is a supplement. However, due to the nature of climate change, I believe we need to consider and at least think about all options that may exist in the future — and "may" is an important word.

So this figure just reflects similarly what Doug showed, a lot of the risks of climate change – there are tipping points and thresholds – but also just the rate of change is a high risk. So one of the questions and one of the potential roles of SRM, if we understand the risks better at some point, is that it could perhaps reduce the rate of change due to climate change.

[Slide] The overall goal of this experiment, and the idea of the experiment, is to do an actual experiment, an outdoor experiment, where we inject aerosols into the stratosphere at about 20 kilometers. It should be clear that this is an outdoor experiment on a very small scale, which I will make clear soon, to get quantitative measurements of the details of what happens when you put that aerosol into an air mass in the stratosphere.

That means, how are the aerosols evolving over time, how is the chemistry in the stratosphere affected by putting something into the stratosphere, and having a better understanding of this so that one can put this new information that we gain from this into large-scale models that actually are the kind of models you use to model the climate impacts of geoengineering.

The first thing to make clear is that this experiment is not a climate-response test; it is a very small-scale test. There are a number of scientific hypotheses. A number of these are listed on the slide. I do not want to go through all of them.

If you start at the bottom of this hypothesis list, the first thing is that we actually just need to understand the ability of this experiment to try and perform these experiments. Can we really use this balloon that we want to put into the stratosphere to understand what is happening in the stratosphere? We want to better understand how the atmosphere in very small scales in the stratosphere mixes, how does the air mix around, how fast does this happen.

These are questions that are very important to understand, that if you put aerosol in the stratosphere how this actually evolves. We need to know how the aerosol size distribution evolves over time, how the chemistry of the stratosphere is impacted.

One example I take as a specific one — which is interesting as this was talked about in the previous talk — is this idea of using calcium carbonate aerosol in the stratosphere, which however does not exist there naturally. The aerosol that exists naturally consists of sulfuric acid. This is what you get from volcanic eruptions.

So there is this idea of trying to find different materials that have different properties which perhaps are better than the sulfate aerosol, as that is known to destroy ozone in the stratosphere, and the sulfuric acid is also known to heat up the stratosphere, which changes the way the stratosphere moves around, which of course is a big concern.

[Slide] The basic design of this experiment, to make this less abstract, is that we want to create a small volume of stratosphere at 20 kilometers that is a well-mixed volume where we have put in the aerosols that are being considered as potential candidates for solar radiation management and we want to observe how this air mass evolves over time: what is happening to the temperature, to the chemistry of the stratosphere up there?

The way we want to do this experiment, and how we are planning to do it, is to use a propelled balloon gondola. We have a balloon, there is a gondola suspended, and we have instruments on this and propellers that drive the balloon through with the stratosphere.

Usually aircraft are used for stratospheric chemistry experiments, but that is because you have to take advantage of the very natural variability of the stratosphere, which occurs on much larger-length scales. But we want to make a very small experiment, a small-scale experiment, and a balloon is a better platform for doing this.

[Slide] This is an image, to make this again less abstract, where you can see you have a stratospheric balloon. From that, suspended is an equipment gondola. In many ways that equipment gondola is what actually performs the experiments, which produces aerosol in the stratosphere, and which we then also use to measure the effect on the stratosphere.

The balloon itself is a very standard stratospheric balloon platform. These balloons are used on a very regular basis with a variety of platforms. The size of this balloon experiment itself is entirely within the normal science of stratospheric balloon launches.

[Slide] The reason we have planned this experiment the way we have is that the propellers actually serve two important functions on the balloon.

The first is that we want to make a volume. This now gives you an idea of the dimension of the experiment. The volume we want to make is about a kilometer long and about 200 meters in diameter. Initially that serves as our experimental beaker. This is where we have introduced aerosol in the stratosphere.

And then we want to use the propellers of the gondola, which you can see in the image down below — which is an actual simulation; it is not just an artist's rendition — where the balloon first makes the plume, which you can see going to the right, and then it sort of turns around and goes back and samples multiple times this plume that we have made, this perturbation.

The representative plume that you can see is the size of this. We want to use something like calcium carbonate in our initial experiments, and the total aerosol mass that we are going to introduce is well below a kilogram of material.

To give you an idea, this is truly a small-scale experiment. On the ground, there were will be no noticeable impacts from that aerosol being introduced into the stratosphere at 20 kilometers.

[Slide] What can't we just do lab experiments? This is a critical question for this endeavor. I have listed a number of bullet points you can look at in more detail. Fundamentally, this is also true for the regular research I do in tropospheric chemistry.

You always want to do laboratory experiments. For example, we are doing laboratory experiments at the moment trying to understand the impact of calcium carbonate, of limestone, better on the stratosphere.

But when you do laboratory experiments, you are never certain that it will reproduce the actual environmental system faithfully. For example, in the laboratory you have a lot of walls in your experimental setup — you can control temperature; you can control pressure; you can control ultraviolet (UV) radiation — but you cannot ever be sure whether there perhaps is a substance in the stratosphere that you thought is not important, or some condition, that actually does matter for the real system. The second one is you actually may not know about some of the things that may be important in the stratosphere and that can change the outcome of this.

So it is always critical for all the atmospheric research that my group has done on very different topics that you have a test in the real system, because otherwise the reliability of your results is not that high. In fact, the idea is to use the laboratory results, put them into a model and see whether the actual stratosphere, when you do the model of how this plume should evolve, reflects what we see in reality. That is why a laboratory experiment is not sufficient for knowing what really happens.

[Slide] I believe if we really want to understand some of the risks for the stratosphere — the physical risks, the changes in the stratosphere, we have to know — we have to do an experiment that actually measures these. At the same time, we also are trying to address governance requirements for this experiment.

There are some very obvious things that we do, and those have to do with the environmental health and safety aspects. We have to follow environmental health and safety requirements from Harvard University and from the balloon launch facility.

We are also having a scientific peer review of what we are doing, the actual experiment done, to see that other people agree that doing an outdoor experiment scientifically makes sense.

A very important aspect of the work we are doing is that this has to be entirely transparent with respect to presenting the results we find, making clear what the funding sources are, and the treatment of innovations. Everything will be treated transparently.

Lastly, this question of how you develop governance for field experiments is very important and something that I really look for feedback on from the community as I am not an expert in governance. We are talking to a lot of people. C2G2 is a very important source of information for us.

[Slide] I just want to make two things more specific. For environmental health and safety, one thing I want to make clear is that there are specific rules we have to adhere to from Harvard University. For the balloon launches, there are specific aspects that have to do with the Federal Aviation Administration (FAA) that governs stratospheric balloon flights.

One thing I want to make clear is that from the actual risks, the balloon flights themselves are standard stratospheric balloon flights. The amount of material that we inject into the stratosphere is less than what happens during regular airplane flights in the stratosphere. In fact, the balloons release ballast to keep the altitude of the balloons, and the amount of ballast is an order of magnitude more than the actual material we introduce.

I want to close by saying that I believe that with the SCoPEx experiment — and I am very interested in hearing feedback on this — the actual physical risks of the experiment — for example, on biodiversity, on anything on the surface — are really extremely small. We are addressing these, but they are really small. I think it is the implications of this experiment that go toward governance where the concerns and perhaps not direct physical risks that require discussion and that I am very happy to hear feedback on.