

Dr. Aarti Gupta (00:00):

It's a relatively small group that's calling for solar geoengineering research, and it is not the vulnerable calling for it. In fact, there are vital voices from the Global South speaking out, expressing deep concern about solar geoengineering, its development and potential deployment that includes small island developing states like Vanuatu or the African Group of Environmental Ministers. Mexico is one of the first countries to ban any experimentation of SRM. The SCoPEX [Stratospheric Controlled Perturbation] Experiment was cancelled because of Indigenous community opposition. And so, there are any number of examples I could continue to give as well as, of course, the 500+ signatories – academic signatories of non-use.

Dr. Pete Irvine (00:44):

Those of us who think we should take this seriously and study it, I think we're all very aware of the risks that we discuss, the geopolitical risks, the potential impact on emissions reduction. These are all things to be very concerned about. But so are the impacts of climate change. And these ideas have the potential to reduce some or many of the impacts of climate change.

Dr. Ryan Katz-Rosene (01:05):

Hello, everyone, and welcome to another episode of season 4 of the Ecopolitics Podcast. This is a podcast for students and researchers studying environmental politics. And I'm Ryan Katz-Rosene from the University of Ottawa, hosting this episode. And my co-host, Peter Andrée from Carlton University will be back in the host seat soon enough. For this episode, we are talking about an increasingly contentious area of environmental politics, and climate politics specifically, and that is geoengineering, and specifically solar geoengineering. This refers to intentional efforts to kind of modify the climate system to counteract global warming by reducing the amount of the sun's energy that enters or remains within the earth's system. And this idea is both increasingly being proposed, and it's increasingly controversial. Some argue it could really help to provide the necessary boost to climate mitigation efforts, and others warn about real potential unintended consequences and risks, governance challenges, and ethical concerns. So, we have two separate recorded interviews that we did with experts in this area to help us shed light on this topic. One with Dr. Pete Irvine, a research assistant professor at the University of Chicago and another with Dr. Aarti Gupta, a professor of global environmental governance in the Department of Social Sciences at Wageningen University in the Netherlands. Our first conversation was with Dr. Irvine, so we're going to go ahead and dive in and play that clip.

(02:56):

Pete, thanks for joining us. Can you start off by telling us briefly a little bit about your research background in this area and how you ended up co-founding this group, this organization, SRM360?

Dr. Pete Irvine (03:10):

Yeah, thanks for having me on. So yeah, I've been studying this topic for 16 years now. I started a PhD looking at the climate response to solar geoengineering back in 2009. I came out of a physics degree and I was really attracted to this idea because it was something which might

help the environment. It's something which leveraged my physics understanding. In a way, it boils down the climate problem to its most basic. It's a matter of energy in versus energy out. And most of our climate policies are targeted at that energy out – the heat-trapping effects of greenhouse gases and limiting that. But what if we could do something about the climate problem on that other side, on the energy that's coming in? But also, I was attracted to this as a problem because it's not just a technical problem, a scientific problem; it's an ethical and geopolitical problem. It's a really significant idea, a really significant challenge. And yeah, I've been studying it since then, as I said, focused on the climate response. But I've looked more broadly thinking about what the broader implications are of this on ethics law and other issues.

Dr. Ryan Katz-Rosene (04:22):

And tell us about this group, SRM360. What's it about? What does it even stand for? I know we're going to get a whole lot into that, but tell us.

Dr. Pete Irvine (04:30):

So yeah, I was using the term solar geoengineering. There's a number of different terms for the same idea. We use SRM, which we take to mean sunlight reflection methods, because that's a very straightforward way of describing it. There's also a more technical term that's more widely used in the field: solar radiation modification. So, SRM360 is a nonprofit organization that aims to support and inform discussion of these ideas. So, we publish explainer articles. We have a podcast, Climate Reflections, which I recommend you check out. A monthly newsletter and other types of content that track how the field is developing presents the diverse views of different experts on this issue, as well as, yeah, as I said, explaining the science of the topic and the issues that it raises.

Dr. Ryan Katz-Rosene (05:17):

Cool. Where's the funding come from for SRM360?

Dr. Pete Irvine (05:20):

Yeah, our funding comes from the LAD Climate Fund. It's three tech-rich people. I'm not quite sure how rich they are, but they made their money in the early rounds of Silicon Valley. So, they're from, I think, HP and other places. And yeah, they support our work as well as some other NGOs working in this space and, more broadly, in climate.

Dr. Ryan Katz-Rosene (05:40):

Interesting. Okay. So, let's dive into this substance here. There are many different types of proposals for geoengineering the climate. There's a category of proposals that focus on carbon dioxide removal, but your focus and the one that we're focusing on in this episode, is this category of solutions that aim to moderate the amount of solar radiation that arrives at Earth's surface; I think, is an accurate way of explaining it. And I think you're specifically focusing on a form of that, which is stratospheric aerosol injection or SAI. So, there's a lot of terms here, a lot of acronyms. We had SRM, we have SAI, and I'm wondering if you can just give us the 101.

What is SRM broadly, and what is SAI? And what's the sort of basic logic of how this works to moderate the Earth's temperature?

Dr. Pete Irvine (06:42):

Well, whichever term you use, the idea is that the earth is heated by the sun, but it's kept warm by the natural greenhouse effect of CO₂ and other gases in the atmosphere. By adding more greenhouse gases to the atmosphere, we're adding to that heat-trapping effect, and that's driving up the Earth's temperature. But we are also doing things that are increasing the amount of light or did increase the amount of light the earth reflected. Some types of aerosol pollution, the particulate pollution that we emit, reflects light, and it also makes clouds more reflective. That pollution is being cleaned up, and that cooling effect that we had that reflected more sunlight is being lost. We're now seeing a double whammy hitting the climate. The greenhouse gas emissions continue, and this pollution effect that we are cleaning up is removing a cooling that had been dampening that warming effect. So, ideas like stratospheric aerosol injection and the other SRM or solar geoengineering ideas they all involve increasing the amount of sunlight that the earth reflects.

(07:45):

Now I focus on, and I think most of the debate focuses on, stratospheric aerosol injection because it looks like it's the most feasible proposal. This is an idea which, in a way, draws its inspiration from major volcanic eruptions. You might have heard of Krakatoa in 1884, Tambora in 1815, and, less dramatically, Pinatubo in 1991. Each of these major volcanic eruptions added millions of tons of particular, compound sulfur dioxide into the upper atmosphere. And the key part being there, the upper atmosphere; many eruptions and much pollution goes into the lower atmosphere, and the sulfur dioxide forms tiny little particles that are very, very reflective, but in the lower atmosphere, they only last a few days before falling out. But with powerful eruptions and potentially by deliberately adding them to this upper atmosphere, the stratosphere, the particles would last many, many times longer. They'd last a year or two rather than just a few days. And so, you get substantially greater cooling effect. But from these volcanoes, these powerful ones, and from delivering it at that higher altitude. This isn't the only idea.

(08:55):

There are a number of other proposals, many of which aren't that feasible or wouldn't have that much of an effect. But it's worth mentioning the other one that's being discussed quite broadly and that's marine cloud brightening. This is an idea that the clouds, particularly of the ocean, could be brightened and have been brightened by our pollution, the little particles that are emitted by burning fossil fuels. These have made clouds more reflective; they've made them brighter, and we could deliberately induce that effect. We're cutting back on the pollution for health reasons, but if we were to spray up sea salt or some other aerosol particle, we might be able to stimulate the same kind of reflective properties, make the clouds more reflective, but without the health impacts the air pollution brings. So, these are the two biggest ideas. There's others out there, but these are the two biggest ones that are attracting the most attention in the field.

Dr. Ryan Katz-Rosene (09:53):

Well, thank you for that. Not an easy task to give the 101 on something so complicated such as this. So, the image that often comes to mind from stratospheric aerosol injection is of planes, kind of an image similar to airplane chemtrails, to be honest. Although I think we should be super clear with any listeners here that this idea of chemtrails is a conspiracy theory and very different from the kind of water vapor that you see coming out of an airplane. But what I want to ask you about is what kind of efforts are going on already to do this? Is there anything happening in any substantive level in terms of stratospheric aerosol injection? And I suppose I could ask the same question about marine cloud brightening. So, the image that comes to my mind for that is these sort of cannons, if you will, on the back of ships that are kind of taking up seawater and spraying these kinds of fake clouds over the surface of the ocean. And so, I'm wondering, is that something that's happening in any larger substantive sense or are these really kind of small research projects?

Dr. Pete Irvine (10:53):

Yeah, I mean, I've been working on this since 2009. I think there was a handful of people starting to work on it about then. There's now hundreds of researchers studying these topics, and almost all of what they're doing is studying it in climate models, writing about it in papers, doing kind of conventional academic stuff. There is a little bit of work inside, in labs, looking at particle properties that might be used. And there's also a small amount of work outside. So, for marine cloud brightening, there's actually been a couple of field experiments. There's one that's been ongoing a while in over the Great Barrier Reef. They don't have cannons exactly, but more snowblowers, I think, is the right analogy. So, they have a ship, they have this sprayer, and it has a fan, and it blows up this basically you aerosolize the seawater, and you get these tiny sea salt crystals, and you try and blow them up towards the clouds.

(11:48):

And so, there's work going on to see can we make sprayers that are efficient enough? What happens to the particles after they get sprayed out, and in time, they're looking to have larger experiments to see what impact that could have on clouds at the local scale to see if a change can be introduced. For stratospheric aerosol injection, there have been – I'm trying to think. There's been one hobbyist did an experiment that actually reached the stratosphere and recorded a few things. And there is a commercial effort called Make Sunsets, which is trying to sell cooling credits on the basis of they pop balloons in the stratosphere that have a small amount of sulfur in it. That is very far from where the bulk of the community is. They're not involved with the community. It's sort of a slightly cowboy operation that has basically nothing to do with the academic study of this topic. But on the academic side, yeah, there's a very small amount of work outside. Most of it's inside, and the vast bulk of it is climate modelling and conventional papers.

Dr. Ryan Katz-Rosene (12:59):

So, as far as no kind of big effort at the level of the state trying to do this and study this maybe in the military or something along those lines?

Dr. Pete Irvine (13:09):

Well, I mean, it would have to be pretty secret. I think people have pointed out to me that if someone was to develop an aircraft – I should maybe dwell a little on the aircraft. To get material up into the stratosphere you need to fly really high. So, most aircraft jetliners, when you're travelling across the Atlantic, fly about 10 kilometres – 30,000 feet. To reach the stratosphere, the tropical stratosphere, if you wanted to get the particles up there and produce this global haze that would cool the planet, you need to get to 60,000 foot, twice as high. An aircraft can get so high, but they aren't really designed for it at the moment. So, you need to design a new kind of aircraft. It seems pretty clear that that would be A) very expensive and B) quite obvious because there's all these military satellites everywhere, spying on everything. So, if someone was to start work on this, it would be spotted pretty soon. But yeah, there's none of that going on as far as I'm aware. And it would be a pretty big endeavour.

Dr. Ryan Katz-Rosene (13:50):

Yeah, I think I heard one kind of description of this as sort of a 10-year project that we would have to develop the specialized aircraft and the technology to get the sulfur in there or whatever it is that you do decide to use to inject. And that would take at least a few years to get off the ground.

Dr. Pete Irvine (14:08):

And that's the least of the challenges. I think it's worth stressing, building the aircraft, developing it, getting a fleet together, would take 10 years minimum. But why would we spend the tens of billions of dollars to do that unless we were pretty sure that it was a good idea and working out that it could be a good idea is going to take a long time. I'm not sure how much you know about the Intergovernmental Panel on Climate Change – the IPCC process – but the cycle there, it's an eight-year cycle, and then they take another three or four years to figure out what's going into the next one. So, the amount of time it will take to get together a very thorough scientific assessment of this could be 15 years minimum. So, if you add that 15 years to that 10, this would only be ready by 2050 if we really started working to study it now.

Dr. Ryan Katz-Rosene (14:56):

Well, that's a good segue to the next category of questions I wanted to ask you about, which were about risks as I think it's fairly clear that one of the clear benefits of doing something like this is that it would help to mitigate climate change or at least slow global warming. But as you know, there are this sort of litany or list of concerns about the risks of doing something like this. And I just want to get your sense on three big concerns that seem to emerge from the political discussion about SRM, and I want to hear what you and your colleagues are thinking about these concerns. So, the first is this idea of geopolitical risk, right? I've heard this expressed as this example of one superpower taking unilateral action to deploy something like SAI, or stratospheric aerosol injection. But then the following year, another neighbouring superpower

has poor agricultural yields and blames their crop failures on the country that took the unilateral action. So, it's this idea that it increases suspicion and increases risks, and it has this kind of unilateral dimension to it. This is not very particularly democratic in a global sense. So, does SAI increase geopolitical risk?

Dr. Pete Irvine (16:27):

Well, I think you laid out a scenario where it very well could increase geopolitical risk. And I should be clear: this is definitely one of the biggest concerns around this idea. I guess you skipped over quite quickly the potential for this to reduce climate risks, but there's some stuff to unpack there. But presuming it could and presuming it worked well, you're right. There are these big sociopolitical and geopolitical issues that could nevertheless arise even if it were to work well. And so, I think the scenario laid out where one country goes ahead alone in the face of global opposition, deploys it, and then bad weather happens or the ill consequences of the deployment materializes, it would be hard to tell the difference. Unfortunately, that could lead to trouble. And so, I think this is something even a selfish, unilateral deployer would be considering. If you were to deploy this, you know you're going to cause trouble. And so, I think there's good reasons for even a country that wanted to deploy this and didn't care too much about the rest of the world, there'd still be incentives for them to bring on a coalition of the willing at least to support this work. At least to sort of minimize the amount of pushback and trouble they get in. This is an area where there is a possibility for collaboration and for this to develop in a productive way. It's not guaranteed by any respect, but I think to make that more likely will require countries working together to share their intentions on research to be clear about what they're doing, to discuss things in international fora. It's not a foregone conclusion that this will be a unilateral thing, but if it's to minimize that risk, there's work to be done in these international fora and between countries.

Dr. Ryan Katz-Rosene (18:09):

Right. Well, that gets to the second concern that I think we often hear about, which is the long-term commitment required for this. So, my understanding is that once you start SRM, you basically have to do it in perpetuity until at least the warming effects of greenhouse gases are mitigated, which I think could take decades or even centuries. So, maybe you can contextualize that for our listeners a little bit. Like what's this idea of termination shock, and how are those risks interpreted by SRM researchers?

Dr. Pete Irvine (18:45):

I think it's worth first explaining the climate situation we're in. The planet is rapidly warming, and it will continue to warm until we eliminate CO2 emissions. Once we've eliminated CO2 emissions, the planet won't go back the way it was. It's going to stay warm, not indefinitely, but it's going to very, very slowly drop. Temperatures would very, very slowly drop over the course of many centuries. So, in the absence of SRM and in the absence of carbon dioxide removal, these ideas to suck CO2 out of the air, temperatures will remain above where they are today for a very, very long time. I'm not sure if it's as long as a millennia, but it's a hell of a long time. Carbon dioxide removal is kind of a key part of the world's plan for dealing with climate change,

at least on paper. It's that once we've eliminated CO2 emissions, we'll go further, we'll suck CO2 out of the air. And over the course of not just decades but it will be a few centuries, low centuries will drive temperatures back down from, let's say, 2.5C back down below 1.5C. But that's going to take a long time. So, that's the world without SRM. A world that is committed to substantial warming for centuries and for the sea level rise that would follow from that, for again, many, many centuries if not millennia.

(19:58):

So that's the world without SRM. You introduce SRM, and as I said, the world will be above 1.5C for, let's say two or three centuries. In some made-up scenario, that means you'd think that you need to deploy SRM for that same period, two to three centuries, to keep temperatures below. Now, every generation will have a choice whether to continue that effort. You wouldn't want to turn it off immediately because if you turned it off immediately, you would get a very rapid warming. And so, that's this termination shock that you mentioned. If you suddenly and permanently ended a deployment of a large-scale deployment of SRM, you would get a rapid warming. And that's a very good reason not to suddenly end a deployment. You might want to slowly and steadily end a deployment, but it would be very foolish to suddenly end it.

(20:40):

And yeah, the other thing, we've actually got some results that will be coming out looking at that commitment that two-three centuries I mentioned, we find that actually that time period that two-three centuries that you'd be committed to without SRM would be reduced if you were to deploy SRM. The finding was that basically because you've cooled the ocean or prevented it from warming, it's easier to drive temperatures back below that level than 1.5C by carbon acid removal. So yeah, there is an enormous commitment implied by climate change. And if SRM is used to manage climate change, it would also come with a big commitment, but a commitment that we could end if we chose to slowly and which would end a little earlier than otherwise.

Dr. Ryan Katz-Rosene (21:28):

Well, I wanted to ask about one more concern that I often hear about: the specific nature of the aerosols or the specific – this idea to use sulfur-based compounds. You were talking about you wouldn't want to suddenly shut off emissions of sulfur dioxide if you were doing this program like this, and that's sort of what we saw in the decision to cut out sulfur from shipping fuels. And so, I think we've seen arguments about this sort of natural experiment in termination shock, and that's, I think, something that we've discussed previously in this podcast. But, I guess I want to ask you, what are the risks of going ahead and using something like sulfur, which, as we noted above, and as the idea of taking out of shipping fuels, is that it creates air pollution, it's got all these other negative effects. So, isn't there a danger in going ahead and emitting these harmful compounds? And alternatively, if we use something other than sulfur-based compounds, what are some of the risks of those compounds? So, I think calcium carbonate is one that's often proposed as a safer alternative, but are there any kind of unknown effects that we might worry about for some of these compounds that are injected into the stratosphere?

Dr. Pete Irvine (22:52):

Yeah, so that's right. Sulfur dioxide, sulfates, are like the most discussed and most analyzed proposal for stratospheric aerosol injection. The reason being, we know that they produce this cooling, and our models are set up to simulate it because major volcanic eruptions add millions of tons and have added millions of tons of this stuff into the stratosphere. So, Pinatubo in 1991, it's around 14-15 million tons of sulfur was added to the stratosphere. That's on top of the around, at that time, 100-120 million tons that was added through burning fossil fuels. So, there's a huge background emission or pollution emission of sulfur oxide today, although it's smaller than it used to be, and we can look to volcanoes to see the effects of this huge addition of sulfur to the stratosphere. I should note Pinatubo put, let's say 14-15 million tons up and produced a cooling in the next year or two that was substantial. But if that had been put in every single year, you produced an enormous cooling effect. The potential cooling effect from stratospheric aerosol injection 's not unlimited, but it's more than enough to offset future global warming. And sulfur does come with side effects. This is something which, when free in the atmosphere for you to breathe in, damages your lungs. It is something which is acidic and so is one of the contributors to acid rain. It would be added to the stratosphere and it would interact with the ozone layer. So, these are all negative effects, or problems that we know sulfur has, but we've lived through them.

(24:29):

Sulfur dioxide, these sulfate particles, definitely have some side effects that we, as the scientists studying this, are concerned about. But I think it's worth putting those in perspective. The air pollution impact, as I said, you'd need much, much less than it already currently emitted to the lower atmosphere where people live. So, there'd be a much smaller amount of the stuff, and rather than being released where people are, it would be distributed much, much more broadly around the world. Sulfur dioxide would also add to acid rain, but whereas the previous or the familiar acid rain problem was concentrated near to polluting or downwind of polluting zones, so in Scandinavia, for example, next to Europe, there you had a much higher concentration, much greater emissions of sulfur than would be needed for SAI. And also it was falling in much more concentrated way. Whereas with SAI, we need relatively less, much less than is already being emitted by pollution, and it would be distributed much, much more broadly. And so, it would have a much smaller impact on the ecosystems around the world. So yes, it has these impacts: some impact on health, some impact on acid rain, and some impact on ozone. But all of these are relatively small compared to the existing problems that are reference points there.

Dr. Ryan Katz-Rosene (25:44):

I want to conclude with a bit of a discussion about SRM advocacy and research, and in our conversations arranging this interview, you said something along the lines of that you were an advocate for an informed discussion that draws on much more research, including field experiments, but you weren't an advocate for deployment. And I'm wondering if you can contextualize what that means and what the discussion is right now around researching SRM.

Dr. Pete Irvine (26:09):

Yeah, I think there's often these labels in the field, in the discussion, and in the media around this, that there are advocates for SRM, and there are opponents of SRM. And the advocates, it's presumed, are not just advocating for research but are advocating for doing this. And in my experience, that is not the case. There are many, many, many researchers studying this, and I don't know of any that would say we know enough to deploy this today. Let's get cracking. Those of us who think we should take this seriously and study it, I think we're all very aware of the risks that we discuss, the geopolitical risks, the potential impact on emissions reduction. These are all things to be very concerned about. But so are the impacts of climate change. And these ideas have the potential to reduce some or many of the impacts of climate change. And so, we shouldn't jump in with both feet, but we should seriously consider and seriously discuss this. Perhaps, I'm not sure if this is fully unfair, but I think some people on the other end of the spectrum who are against this are not against deploying this. They're also against deploying this, but they're also against studying it, against doing field experiments, against discussing it, at least having it discussed in international fora. So, there is a debate, but I think the center of mass of that debate isn't perhaps where people might assume.

Dr. Ryan Katz-Rosene (27:34):

Well, this is a super interesting discussion. I want to thank you, Pete, for sharing your expertise with, not just me, but our listeners. Are there any final thoughts that you'd like to share about the future of SRM?

Dr. Pete Irvine (27:47):

Well, I guess we didn't really talk about the climate consequences, and I think this is the whole reason we are thinking about these ideas. Climate change is happening. It's going to proceed very rapidly in the coming decades. And until we get emissions down substantially, that rate of warming is going to stay high. So, we are facing rapid warming and substantially growing impacts over the coming decades. And now we all hope that more can be done to draw down emissions, but emissions keep stubbornly rising much more slowly than before, but they keep stubbornly rising. These are ideas that could potentially substantially reduce the risk of climate change. I think something we should be clear about SAI cannot perfectly offset the effects of climate change. It doesn't do anything about ocean acidification. We've discussed some of the side effects that it has. And it would certainly not undo the effects of climate change on rainfall. One of the areas of concern about its potential side effects, the ways in which it's imperfect, are that it would rearrange rainfall patterns in some, so some regions might see greater changes in rain than they would've done under climate change, and that could be a big problem.

(29:03):

But many, if not most of the key risks or key hazards that climate change poses are closely tied to temperature. So, obviously, extreme heat is very tied to temperatures. A warmer world, you're going to see more extreme heat, but also you're going to see more extreme rain. Warmer air carries more moisture, and so it more dumps out when you have a storm. Furthermore, warmer air pulls more moisture out of dry soil, so you get more intense droughts. Warmer air melts, ice sheets adding to sea level rise. It also heats the ocean, expanding it. There's a whole host of

things that are closely tied to temperature. And the initial simulations we're doing of SAI suggest that it could reduce many of these risks, but not all. I mean, I'm quite concerned that there could be some regions that would be worse off. We've not confirmed that yet, but we are pretty sure that many of the hazards of climate change would be reduced by this, presuming we can do everything according to plan. Now, that's the hard part is that I think the geopolitics, geopolitics of this, is where it could all fall down. But there's something here, and it's something worth discussing, but we're not in a position to jump in and recommend going for it yet. We need to study this. We need to think about it. We need to work out if this is something that we can make work or whether it's something we should reject.

Dr. Ryan Katz-Rosene (30:17):

Well, I think we'll leave it there on those final thoughts, but thank you very much, Pete. Really appreciate it.

Dr. Ryan Katz-Rosene (30:26):

Our second conversation for this episode was with Dr. Aarti Gupta, professor of global Environmental Governance in the Department of Social Sciences at Vanhanen University in the Netherlands. Aarti, thanks for being here. I'm wondering if you can start off by just telling us how you ended up studying and researching the politics and ethics of solar geoengineering. How did you get into this?

Dr. Aarti Gupta (30:51):

Okay. Well, thank you very much, Ryan, and thank you for inviting me to be part of this podcast. So, how I got into this controversial, important topic, I'm a social scientist, and as you said, I'm a professor of global environmental governance. So, I look at how we can devise global governance systems, and by that, I mean globally agreed rules, principles, and institutional arrangements to help us address complex transboundary challenges like climate change when no one country acting alone is sufficient – we need international collaboration. So, that's my field of research. And one area where I've been particularly interested in is global governance of novel, speculative technologies, which don't yet exist, and where there might be a promise of future risks and benefits, but those haven't materialized yet. But these novel, speculative technologies, such as solar geoengineering technologies, for example, require present-day governance for steering to try to steer research, potential development, or the use or non-use of these still speculative technologies in order to mitigate future risk or to realize future benefits.

(32:05):

But that's a huge challenge because at this kind of governance, present-day governance, has to be developed under conditions of extreme uncertainty. And this raises a whole range of questions about who will decide what is to be governed, whether to govern speculative novel technologies to enable their future use or to restrict their future use. So, what's the fundamental purpose of global governance here? And what kind of political architectures do we even have for effective, stable, long-term, fair global governance? So, these are the kinds of questions I've been interested in. And specifically solar geoengineering, I came to this issue in 2016. It was an

initiative by American University to bring a group of global governance experts together and to look at governing solar geoengineering, specifically what could be the range of global governance options and challenges. And so, I started to look into it, and then I became more and more involved, but also concerned because it became clearer, and especially in the last few years, that this speculative technological option was becoming more and more normalized in terms of being discussed in the media, by elite institutions, mainly in the United States, and being contemplated as sort of a legitimate part of the climate policy portfolio. And I don't know if you are aware, but since January 2022, along with a group of other academics, I've been part of this initiative, an academic initiative calling for restrictive global governance of solar geoengineering. So, that's how I've come into this.

Dr. Ryan Katz-Rosene (33:55):

Yeah. Well, that's a great segue or introduction to my next question for you, which was about this open letter calling for an international non-use agreement on solar geoengineering, which you were one of the initiators of this open letter. So, my second question is kind of about that, and it was a little bit more specifically about the question of researching solar geoengineering. You mentioned that you were worried about the normalization, the legitimization of geoengineering, perhaps as a result of doing research on this. Can you tell us a little bit more about that initiative, that open letter, in relation to the researching of geoengineering technologies? And then we'll get later on into some of the other concerns that you have about this technology.

Dr. Aarti Gupta (34:41):

Yes, sure. So, this call for an international non-use agreement has now, I should just note, been signed by more than 500 scientists from more than 60 countries. And this is all disciplines, climate scientists, atmospheric physicists, social scientists, governance scholars, and also endorsed by more than 2000 civil society groups. This shows that there is a lot of concern about the many facets of this speculative option, solar geoengineering. But I think before – and I'll get to the research question you asked, but perhaps it's useful to specify that this non-use agreement call is specifically targeting stratospheric aerosol injection. One of the most widely discussed solar geoengineering options. The one that is most clearly intended to be a planetary-scale intervention.

(35:50):

And if we then are to think about, well, what does it mean to research SAI, I think it's also good to specify what this actually entails, research and potential future use of stratospheric aerosol injection. I think you might have covered this somewhat with Dr. Pete Irvine, but I think it's just to specify that, in fact, what the nature of this intervention is, even a temporary use of SAI means that this would require and you explained it a little bit, it's about injecting reflective particles into the stratosphere. But this would require hundreds to thousands of specially retrofitted aircraft flying 24/7, around the clock, injecting these substances into the stratosphere for decades, if not centuries. So, that's what even a temporary SAI deployment means. And I think when we think about what can research tell us? Should we be doing research? This needs to be kept in mind,

what does it actually mean? Because I think that's never really fully specified. So, this would be akin to one or two Mt. Pinatubo volcanic eruptions every year for decades.

(37:02):

So, then, the question of research, what would this kind of intervention due to a complex nonlinear climate system with its many feedback loops – even beyond temperature considering precipitation impacts, impacts on food systems, etc, it's in light of these questions that we need to think about, okay, what does it mean to do research into SAI? What does that actually entail? There, we need to think about, well, research can mean many different things. Are we talking about climate modelling? Are we talking about small-scale outdoor experimentation, large-scale outdoor experimentation? Even social science analysis are research. So here, what we say in the non-use call is we are talking about small or large-scale outdoor experiments, which would lead to technology development or the development of technological capabilities. And we are very concerned about that kind of research because the question for us is what would even small or large-scale experiments tell us about the question we actually want an answer to, which is, should one use SAI in the future? Should we deploy solar radiation modification? Would the benefits outweigh the risks? And if you want to answer that question, then nothing short of planetary scale experimentation is going to actually tell us what the regionally unequally distributed impacts will be of such a planetary scale experimentation.

Dr. Ryan Katz-Rosene (38:43):

Right. Well, I really appreciate that explanation and that kind of theoretical framing of risk vis-a-vis research and deployment. I want to kind of ground this a bit more for our listeners, what the actual risks of deployment might be, in your view. When you think about those risks, and they kind of range from geopolitical risks to, like you were mentioning, issues around rainfall patterns and things like that, what are the things that alarm you the most or what are the things that keep you up at night? What are the greatest risks in tangible, material terms of deploying SRM or, specifically, aerosol injections?

Dr. Aarti Gupta (39:31):

Yeah, well, I think we can look around at what's going on in the world as we speak, right? And I think one core concern that everyone should have is in whose hands we would be willing to place a planet-altering technology like solar geoengineering, with its unequal and unpredictable and unequally distributed planetary-scale impacts on the climate system, where there will be clear winners and losers. This is not a technology which will be deployed for the greater good of all. Where it'll be a win-win situation. It's like a global thermostat, which we're going to dial down to our desired temperature, and that will be good for all of us. That's not the way it's going to play out. So, if there will be unequal impacts, if there will be very different desired temperatures, for example, then the question is, who gets to decide all sorts of decisions about deployment of something like solar geoengineering? Would it be Musk? Would it be Trump? Would it be Putin? Who will decide? And who will ultimately have the opportunity to develop and deploy this technology? Will this be in some sort of considered global process? So, I think that those are the concerns, and that goes fundamentally to the nature of the global governance challenge.

There will need to be complex decisions about when to deploy. How much aerosol material to inject? How long to inject for? When to stop? What happens if there are harmful impacts? What about liability and compensation? These are extremely complicated decisions. And what the question we would have then is what kind of global governance architectures do we have to make these decisions? What we currently have are weak global governance institutions, and they are weak for very good reasons. Our UN system functions on a one country, one vote principle – a decision-making principle where every country has, in theory, one vote. That gives developing countries a majority in most fora, the UN General Assembly, and others. So, the question is that those countries or powerful actors or entities most able to develop and deploy a planet-altering technology like solar geoengineering will not be willing to place under the control of a UN system, where developing countries have a majority of these planet-altering technologies decisions about them. But if there are global impacts, one would consider that there should be some form of global control and global decision making. But that's highly implausible.

(42:04):

And even if we were to imagine that, okay, leave aside the UN system, whether it's one country, one vote decision making, what if we were to think of other alternatives? We would imagine some sort of global parliamentary assembly deciding this by population percentages. There too, for example, the United States would have in a one country, one vote system, one vote, or it would have in a population system, 4% or 5% of the world. This is highly implausible that a country like the US would place these planet-altering technologies under the control of our current global institutions. If you were to think outside the UN system and think about small alliances of small, powerful countries, we can just imagine that situation in today's context. What would these alliances look like? Would there be counter-alliances of powerful states? And would this exacerbate geopolitical tensions? And especially in a context where there are fundamentally divergent impacts on the climate system, the kinds of impacts one could see the unpredictable and largely unknowable planetary-scale impacts of a sustained intervention of the kind that we imagined with SEI. We can't know that. So therefore, it's hugely risky to think that we are going to be able to govern a multi-decade intervention like solar geoengineering in any kind of fair or even effective or stable manner using our existing global governance arrangements or even alternatives that we might imagine. Short of leaving it to a few powerful actors, and that seems hugely risky, undemocratic, and very, very dangerous with huge security implications. Because ultimately, as I said, this will not be used for the greater good of all. That is not the world we live in.

(44:05):

And that, in fact, is why key voices in the Global South are speaking out against this. Because it's clear, the question we need to ask ourselves is what kind of unequal world would solar geoengineering as a technology land in and be used for? It's a highly unequal and geopolitically tense world. It's not a neutral technology where there's a rational global decision-maker who's going to deploy this for the greater good of all, and especially for the benefit of the most vulnerable. These are arguments made that it's the most vulnerable countries and groups, those most highly impacted by climate change, that might require and might want this technology and

this option the most. I think that's a very disingenuous argument because these key voices in the Global South who are, in fact, calling for non-use and to take this option off the table. And I can elaborate on that as well.

Dr. Ryan Katz-Rosene (45:06):

Well, I think you did a good job of answering my next question, which was around why there's so much political polarization about it. And one of the things I'm hearing you say is this real governance challenge about who gets to decide. This is a global intervention. And I take that point. I guess I want to get to my last question for you, which is around this kind of counterargument that I have seen more and more, and I'll give you an example of it, but critics would say that this could very well be our last chance, so to speak. So, we are recording this episode in the middle of February 2025. Earlier this month, acclaimed climate scientist James Hanson published an update to his research team's work documenting the acceleration of global warming. And in that publication, he essentially says solar radiation modification could very well be the only way to avoid crossing the 2C warming threshold that the international community came up with at the Paris Agreement. And his argument is that SRM is not geoengineering, so much as undoing the geoengineering that humans have done to the planet through fossil fuel combustion and land use change. And so, I guess I'm wondering, when you meet up with Jim Hanson at a conference or others of that persuasion, what's your response to them? How do you respond to this kind of counterargument that this could well be our last shot at keeping the world to less than 2C of warming?

Dr. Aarti Gupta (46:49):

I think the biggest risk facing us right now is this idea that this could be very well our last chance becomes a self-fulfilling prophecy. Because we think that this might be an option and we take our eye off what we know we most urgently need to do and what we'll actually address the underlying causes of the climate crisis. We know what we need to do, and we are not doing that urgently, and we think that because we are not doing what we most need to do, we might well need solar geoengineering. But – I think the point is, this used to be talked about in terms of a Plan B, just in case we fail at ambitious mitigation, we have this fallback, last-ditch option. In case Plan A fails. But the point here is that having solar geoengineering as a potential option on the table where actually causes that Plan A to fail. So, it's not that in case we don't do what we should do here we have this fallback, it'll actually derail the original plan much more. It's not about buying time to do the right thing, it's about would it buy time or would it buy delay? Because if it's about buying time to do the right thing, we need to ask ourselves why we are not doing the right thing? And why we think that buying time through solar geoengineering will help us to come to the point where we do the right thing. I mean, this is a little bit also about the polarization question. I mean, there are entrenched interests in perpetuating the fossil fuel era, and for such interests, talking about solar geoengineering is very, very welcome. So, then I think the question here is that it's every ton of CO₂ that is emitted because we are talking about solar geoengineering, risks making these climate impacts that we are so worried about worse and risks pushing towards overshoot.

(48:44):

So, I think this idea that this would just be a way to combat pollution that we've already contributed to, it's not solar geoengineering, it's sort of some sort of reverse engineering, I find that also very unconvincing. Because – just because we have created a climate crisis through greenhouse gas emissions doesn't mean we should intervene with another set of substances into a very highly non-linear climate system and hope for good outcomes. That kind of intervention could also exacerbate climate impacts. We just simply don't know. I mean, I'm a social scientist, but there are enough climate scientists, natural scientists, atmospheric physicists, and others who are very worried about that kind of multi-decadal intervention, and what that would actually do to the climate system. So, the idea that that's the only way to stay below 2 degrees, there might be a potential to reduce temperature impacts, but what else? What other kinds of climate impacts would occur? Whether that's, in fact, an improvement is very much unknown.

(49:57):

So, we might be in a much worse, even in terms of climate impacts alone, let alone the geopolitical and the political risks of going down this path and locking in future generations into a solar geoengineered world, which is the other huge risk of thinking this might be our only way out. We risk going down that path where we lock ourselves into a solar geoengineered world because we think this is the only way, this is temporary. But there's nothing to suggest that once we go down that path, it'll be temporary. You're not drawing down greenhouse gas emissions sufficiently. Why would we suddenly accelerate that while deploying solar geoengineering and, in some sort of rational manner, draw down the solar geoengineering while accelerating the ambitious mitigation in some hypothetical future? That's, I think, very removed from the politics and the contested politics and the contested geopolitics of this. The contested security dimensions of how solar geoengineering will be deployed in the real world.

Dr. Ryan Katz-Rosene (51:15):

Well, thank you, Aarti. This has been a super interesting discussion. There are a whole bunch of additional things I would love to ask you about and maybe some counter-critiques that are swirling in my head from discussions I've seen both in favour and against solar radiation modification on social media, in particular. But we are unfortunately pretty pressed for time. So, thank you so much for sharing your perspective with us. Really interesting discussion that we've had with both of our guests. I want to thank both Dr. Pete Irvine and Dr. Aarti Gupta for joining us and sharing their expertise. I want to remind everyone that the full bios for our guests and a whole bunch of additional resources can be found for each episode of the Ecopolitics Podcast at our website, ecopoliticspodcast.ca. And that includes links to documents referenced in each episode. And, of course, a huge thank you to our production team, our producer, Kaleigh McIntosh, editor Nicole Bedford, and our technical and artistic design guru, Adam Gibbard. Take care, everyone, and stay tuned for our next episode.