Notes from call between GiveWell and Philip Rasch, 05/22/12

GiveWell was represented by Alexander Berger (Research Analyst).

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The following transcript is edited for length, flow, and content based on an audio recording of the call by GiveWell; it is not meant to be a word-for-word transcript of the entire conversation. Questions by GiveWell are in **bold**, answers by Dr. Rasch are in normal text.

GW: My impression is that a lot of the research on solar radiation management (SRM) right now consists of computational modeling, and things like studying records from volcanoes. Are there other major threads of research that are currently ongoing?

PR: Maybe. I think the volcanoes are a natural analog. Research on volcanoes has been ongoing for decades. Alan Robock is one of the leaders in that work. In the 1970s, people began talking about the prospect of introducing aerosols in the stratosphere. That research has been bubbling along at a low level since then.

Stratospheric aerosols have received the most research attention because that's the area where there was the most dramatic example in nature of a cooling event (i.e. volcanoes).

The other area that's being discussed is marine cloud brightening. I've also worked in marine cloud brightening. The effects of introducing aerosols into clouds are interesting not just because of geoengineering because we might be doing it inadvertently already.

SRM research has been explored using general circulation models (that Robock, I, and and others work with), and there are now also studies using a different kind of model "large eddy simulation" (LES) models, a.k.a. "cloud resolving" models, which try to do a high-res simulation of a small set of clouds. These models might divide a 100km square horizontal area into millions of columns. They do a much more careful job, but you can't do the whole atmosphere that way. These are all interesting both for climate engineering and basic climate science.

In addition to the research activities you mentioned, there are also people going out and attempting to make measurements related to these problems, e.g. by following ships and measuring the effects of their emissions on clouds.

GW: What the highest value research activity that's not being done right now? What's holding it back?

PR: I will respond to the second question first. I think there's just a tiny amount of research being done right now, especially that's listed as relevant to climate engineering. There's research ongoing about the effect of aerosols on clouds, but a lot of that isn't necessarily listed as climate engineering research.

Generally, climate engineering is so controversial that there's almost no funding for it. Scientists are encouraging policymakers to provide some low level funding for research relevant to geoengineering, but there's been no real success in the US so far. There is some funding for research in this area in Europe. I took a position at a new lab (for me) 3 years ago, before which I worked at the National Center for Atmospheric Research (NCAR), in Boulder. In that position, I had the freedom to allocate some fraction of my time to geoengineering research. I did it with the knowledge of my supervisors, but I had freedom within the lab. I also had some funding from Ken Caldeira and David Keith's foundation which provided me the opportunity to fund a support scientist and a post-doc. Subsequent to leaving NCAR, I now work at PNNL, a Department of Energy (DOE) lab. It's now more difficult to get funding, because there are no natural opportunities to get low-level funding to continue the research. My own time is also somewhat more restricted. My supervisors are comfortable with my work at a very low level on this stuff, but there's little in the way of funding. Right now I have support for a single post-doc to work on this, and my research has to be done on my own time, and only where it has a natural intersection with the rest of my research life.

In the U.S., this is the case for many physical scientists. Europe seems to have more funding for researchers. The only team I'm aware of getting money from a U.S. federal source is Robock's, which has a grant from the NSF. I think others are getting some money, but not much, from small foundations.

Now back to the first question --- In the physical sciences, researchers might look at the expected climatic impacts of a particular geoengineering strategy. But research outside of physical science is also important, ranging from economic assessments of the costs, to the ethical work on the issues associated with implementation, to governance issues as well. Each of these aspects of research are currently under-funded.

I can list off some research topics that are important in the physical sciences, if that would help.

GW: That would be great.

PR: There are a variety of different strategies that have been suggested for geoengineering, and each of them involve many steps in terms of trying to get the understanding we need. There are many steps in the puzzle. Here is one set of examples related to my own research. We've done a number of theoretical modeling studies that suggest that under some circumstances introducing sea salt aerosol particles under clouds might brighten them, but in other circumstances they might cause the clouds to dissipate. We don't know whether our models provide the right answers without being able to measure some basic cloud features after deliberately introducing extra sea salt particles below the clouds. We don't know how rapidly particles will mix between the surface where they are released, and the cloud base where they have a chance to influence the clouds. The particles might, just dissipate quickly. We also need to know how sensitive proposed strategies are to the kinds of cloud, time of day, and level of background pollution that clouds sometimes sit in. Each of these questions, and many more, require some research. We don't know whether attempts at cloud brightening might change precipitation, or soil moisture down wind (with subsequent impacts on for example agricultural productivity). Our models also suggest that under some circumstances, the clouds become brighter and thicker in the immediate vicinity of the aerosol release point, but the opposite effect occurs on the periphery of the seeded region. Those sorts of phenomena could be investigated. It may be possible to get a handle on questions like these with very small field tests, in

addition to detailed models. Similar questions arise for other geoengineering strategies.

Some questions require models, some need to be done in a laboratory setting, and some require small outdoor tests,. There are many scientific questions that would benefit from simple field experiments that can reveal important information that's central to understanding climate change, as well as important to geoengineering prospects. There's a whole spectrum of questions.

GW: What's the natural form of funding for more research on these questions? Do you basically pay for more grad students or post-docs?

PR: Well, David Keith and Ken Caldeira recently gave me money for a post-doc for two years, which I think is a pretty natural approach. It would be nice if there were sources that could help with funding my own research as well. This sorts of issues arise for any scientist interested in research on SRM.

GW: It seems like there's relatively few senior people working on these problems. How do you get more Principal Investigators (PIs)?

PR: There's a lot of interest in geoengineering, so if there were perceived funding, I think a lot more people would be interested in working in the field. I'm affiliated with the University of Washington, and through the College of the Environment, we established a small geoengineering program, and it was funded internally. There are perhaps a dozen professors located in different schools delighted to work on the issue, some of whom have gotten small amounts of funding to organize seminars and colloquia. One group has produced white papers outlining a systematic set of field experiments that could be done to improve our understanding of how clouds might be made brighter. If there were funding opportunities, I think a lot of people would be going after it. I think there are many research faculty and scientists in labs who would be interested in working on these issues if they thought they could get funding.

There is some concern both by research scientists and post-docs that they not to be labelled as "mad scientists", especially for very young scientists. They don't want to be identified as working in areas that aren't considered to be useful or important. I've had some very good young scientists and post-docs, but students and post-docs are careful about it. I have one post-doc position right now for geoengineering that I don't have filled, but of my 3-4 other post-docs, most of them didn't want to work on geoengineering because of these concerns.

GW: I've seen numbers like a $5 or 10 million annual research budget for geoengineering, scaling up over time as deployment becomes more likely. What would $5 or $10 million of research buy you?

PR: It would buy more time from researchers, especially post-docs and graduate students. A post-doc costs a researcher $100-150,000/year, so you can basically take your *n* million dollars and figure out how many post-docs that buys you. Scientists are a lot more expensive (2 to 3 times?) and they cost too, obviously.

There's also things like that white paper, which described a plan for a field experiment. I think they estimated a cost of $30M for their biggest experiment. That's sort of the most expensive test case I am aware of. That's the kind of thing you'd do once in a decade. Rather than trying to design a field

experiment around things that happen spontaneously, the idea would be to try to change clouds in a small region for a short period of time, and try to predict in advance the outcomes. It's much closer to the classical physics model of research, with designing an experiment to test a hypothesis.

David Keith is asking similar classes of question about releasing particles in the stratosphere, tracking them, how they grow, how they affect brightness, and some of the chemistry issues in a small-scale way. I believe he has some ideas for experiments that might be informative and relatively cheap, perhaps at around a few hundred thousand or a million dollars.

GW: It seems like a lot of philanthropic activity in this area has gone towards funding governance research. I'm interested both in what you think the historical returns to these kinds of activities have been and where more funding should go in the future, whether to more of this or more physical science research.

PR: It's important to consider governance issues. There are a variety of different sorts of governance. One level might require international treaties and approval by UN-like bodies. On the other hand, there might be something like institutional review boards (IRBs), the same kind of governance activities that take place in medical research or an experiment that involves humans or other animals. It makes sense to me that at a certain level, there's probably the need for transparency in research and some mechanism for reassuring society that individual researchers are not going to go do something crazy. I could see the need for a best-practices document for IRBs to ensure that all research being done is ethical.

I still occasionally participate in the discussions about governance and geoengineering, and I remain interested, but I'm not an expert on it. I certainly wouldn't say the money should just be spent on physical sciences.

There's another component related to the governance issues. There are communities of social scientists that have considered how society can be introduced to difficult and controversial subjects, like nuclear power. If you can get in front of the ball, you can begin dialogues with communities and reassure them that you're being thoughtful and careful, so that research can proceed. If you just go off, you have to worry about whether some crazy scientist is going to cross the line and do something that has clear unintended consequences and ruin the opportunities for the rest of the science community by prejudicing society.

GW: I heard last week that the SPICE field trials got canceled. Do you know of any other groups trying to do that?

PR: I think David Keith might be considering doing some very modest field experiment in the stratosphere.

There was one experiment that took place last summer off the coast of California, in which particles were released into the boundary layer in order to look at their effect on clouds. That field experiment was not identified as "geoengineering research," just looking at the effect of aerosol on clouds, but it was relevant to questions about geoengineering. It released a total amount of aerosols much smaller than a freighter crossing the Pacific. That experiment was E-PEACE; the PIs were Lynn Russell and John Seinfeld and Bruce Albrecht.

GW: Do you know why the NSF or DOE aren't already funding more climate engineering research? It seems like we've read a lot of reports recently advocating more research.

PR: I think the NSF is doing a bit and might be willing to do more. DOE should probably speak to that for itself, and I shouldn't speculate on DOE's motivation, but geoengineering and research about it is obviously sort of controversial. I believe it was 3 years ago, soon after Obama was elected, that John Holdren made an off-the-cuff remark about the need for some research on geoengineering, and there was a firestorm of attention following that remark. It took a while for it to die down.

I hope the reports advocating more funding should will make it easier, but I haven't seen any agency moving forward with funding.

GW: Who else should I talk to about climate engineering?

PR: It sounds like you've already talked to a number of the right people. I might add Armand Neukermans, who is doing research on nozzle design for marine cloud brightening, to your list, and Rob Wood at the University of Washington, who has been one of the people thinking carefully about how to design a field experiment that would provide useful information about cloud brightening.