In a paper published Friday as a Science Policy Forum in Science magazine, David Keith and I put forward some proposals to advance the debate over governance of climate engineering (aka geoengineering) research.

Climate engineering means actively intervening in the climate to offset some of the global heating and climate disruption caused by elevated $CO_2$ and other greenhouse gases. Many different methods have been proposed — some that alter the global carbon cycle to remove $CO_2$ from the atmosphere, and some that block a little sunlight from reaching the surface to offset the heating caused by elevated $CO_2$. From early study, it looks like the most promising approach is spraying a fine mist of light-colored material in the stratosphere to reflect a little incoming sunlight. Seen from Earth, this would make the direct beam of the sun a little dimmer (by a few tenths of 1%), and the rest of the sky a little brighter and whiter.

No one is doing this now, despite a few widespread conspiracy theories saying someone is. Let me say that louder: **NO ONE IS DOING THIS NOW.** Or to be more precise, no one is doing this now, ***intentionally***: lots of aerosol pollution being emitted inadvertently is having this effect already, so aerosols are masking quite a bit, maybe as much as half, of the heating and climate disruption we would otherwise already be experiencing from elevated $CO_2$.

But there are compelling reasons we might want to do this sometime in the future, because this would be a more powerful and faster way to cool the Earth – and so slow, stop, or reverse destructive climate changes even as they were underway – than anything that can be done by cutting emissions, or for that matter by removing $CO_2$ from the atmosphere once we have put it there.

To say this is not to disparage cutting emissions. Cutting emissions – by a lot – is the first, most essential task in limiting climate change and the only long-term solution. But cutting emissions, even with far more serious efforts than anything we've seen, is a many-decades-slow way to stop climate change – and it's possible we may face climate changes so severe that we need a response, even a partial and imperfect one, that can act fast.

Climate engineering approaches just re-appeared in climate policy debate a few years ago after a long absence. (They were first proposed in the 1960s, just a few years after the first expressions of scientific concern that human fuel use might disrupt the climate by increasing atmospheric $CO_2$.) They are intensely controversial, and for good reason. They offer the dual prospect of both greatly reducing climate risks, or of greatly increasing risks

— through their own environmental impacts, or even more seriously by worsening existing policy failures – e.g., further undermining the already woefully inadequate political resolve for serious emissions cuts, or providing potent new sources for international conflict.

If we want climate engineering to be available in those dire potential future situations where it would be needed, research is needed now into its efficacy and potential risks. But thus far, sharp controversy over these interventions has stalled attempts to research them. Opponents of research are concerned that even doing research might further obstruct attempts to cut emissions, or start us down a slippery slope to future deployment that would deprive future decision-makers of control over whether, when, and how to use these technologies. A few consultative bodies, in the US and internationally, have tried to develop proposals for governance and control of climate engineering research that would manage this tension, but have been unable to agree on key concrete points of how this would work. Meanwhile, a few research projects — all of them tiny and essentially riskless — have gone ahead by slipping between the cracks of current legal and regulatory attention.

This is where the contribution of our current paper comes in. David and I believe that research on the efficacy and risks of climate engineering technologies is urgently needed, but we are also acutely aware of the risks of thoughtless expansion, loss of legitimate public control, and provoking international conflict.

On this basis, we make three proposals for concrete, immediate steps that can let needed small-scale, tiny-risk research proceed, while allaying these concerns. Incidentally, our proposals would also help close a current void in international law, such that a government that wanted to conduct climate engineering interventions – small-scale research, or even full-scale deployment – could do it subject to no current international legal control, over its own territory or over the high seas. (See my post last October about the Haida ocean fertilization project for an explanation of this gap in current international law.)

Our first proposal, which is prior to the other two, is that governments interested in supporting or conducting climate engineering research begin international consultations on the design and oversight of research. These initial consultations would have to involve national research-funding agencies (e.g., in the United States, the National Science Foundation), and probably also other agencies with regulatory or coordinating responsibilities (e.g., in the United States, EPA and the White House Office of Science and Technology Policy). These initial consultations can be informal, aiming to exchange information and coordinate decisions within existing agency authorities. They need not, and arguably should not, involve the delay, formality, or rigidity of seeking new laws or treaties.

We further propose that these consultations should aim to agree on two widely separate thresholds of scale, and associated potential risk, of climate engineering interventions: a large-scale threshold to be subject to a moratorium, endorsed by both scientists and governments; and a much smaller threshold below which participants agree that research may proceed, subject to a few conditions: normal procedures and criteria to evaluate scientific merit; compliance with all existing environment, health, and safety regulations; AND some modest additional regulatory requirements to ensure transparency and discourage shopping for lax jurisdictions from which to operate.

Working out the precise definition and level of the thresholds would take some work and consultation, but we advance specific suggestions. For sunlight reduction methods, we propose the large-scale threshold for the moratorium as average change in radiative forcing of 0.01 Watts per square meter ($Wm^{-2}$). ("Average" means averaged over the whole Earth and over a year. This is about one hundred times smaller than the current anthropogenic increase in radiative forcing due to human activities, and is also about the smallest perturbation that could be detected by monitoring climate for a decade or so.) For the small-scale threshold, we propose a value, measured the same way, of $10^{-6}$ $Wm^{-2}$ — i.e., a factor of 10,000 smaller than the large-scale threshold.

That's it. It's a simple proposal for a first step of concrete action that would let needed research proceed, while addressing some of the most serious associated risks. We recognize that it is incomplete, and that it doesn't eliminate all risks — for example, there is nothing in it to compel a government to participate if it wanted to proceed on its own. Moreover, our proposals don't say anything about interventions that fall into the wide middle ground between the two thresholds, except to note that we judge it unlikely that anyone will want to try anything in that range anytime soon, even without an explicit moratorium prohibiting it. You can think of the proposals as mapping out a potential bargain between proponents and opponents of climate engineering research: proponents get to see small-scale, low-risk research go ahead, but subject to some modest additional regulatory controls and coupled with a moratorium on large-scale interventions.

In addition to the immediate benefits of such an agreement, we think the proposals also offer longer-term benefits, by simply getting governments to start talking about these interventions with cooperation and transparency about what they are doing. The scariest risks related to climate engineering concern what might happen in some future of severe climate change, if multiple rival nations start to research these technologies and are considering deploying them, without a shared knowledge base, in an environment of panic and mistrust. There are many plausible scenarios by which this could end very badly. Our proposals aim to let needed research proceed, allay well-founded concerns, and also start

nations down a path of dealing with these technologies cooperatively and transparently.