**A response to *Nature Climate Change Commentary: Climate emergencies do not justify engineering the climate***

This short [Commentary](https://www.nature.com/articles/nclimate2539) published by *Nature* in 2015 argued that climate engineering proposals do not address emergencies resulting from global warming. While now eight years old, it is well worth reading to see the cultural blockages that continue to prevent rational discussion of climate policy. My concern in reading it was how this critique relates to the broader discussion of the rationale for brightening the planet, enhancing albedo with solar radiation management (SRM). My impression was that the article was highly unbalanced, displaying credulity and rhetorical overreach about possible risks and difficulties, while simply ignoring the many likely benefits of a brighter world.

The authors of the paper were Jana Sillmann, Timothy M. Lenton, Anders Levermann, Konrad Ott, Mike Hulme, François Benduhn and Joshua B. Horton. My particular interest is the contribution of Tim Lenton. The implications of his world-leading work on the immediate risks of climate tipping points seem hard to reconcile with the views in this paper, as I explain at the end.

Engaging the scientific arguments in this article can open useful dialogue about the rationale for climate engineering. Unfortunately, their argument that solar geoengineering is not a response to specific emergencies misses the point of direct climate cooling, that it serves as an effective global insurance policy by mitigating the risk of extreme weather and other climate impacts.

The context is the prediction that business-as-usual will increase the likelihood of dangerous climate change. The predicted catastrophic consequences of the 5°C warmer world assessed by [Paul Crutzen in his 2006 call for albedo enhancement](https://link.springer.com/article/10.1007/s10584-006-9101-y) are seen by advocates to justify using stratospheric aerosol injection to prevent a future climate emergency, requiring immediate broadening of research on SRM.

Sillmann et al present a confusing response to Crutzen’s assessment. They deflect the main problem of how to prevent extreme warming by focusing on secondary questions and presenting dubious claims about emergency response.

They note that immediate potential climate tipping points include the Atlantic thermohaline circulation, the West Antarctic ice sheet, the Amazon rainforest and the West African monsoon, and usefully observe that “whether SRM intervention could actually prevent these elements from tipping, or counteract tipping that was underway, depends on: (1) their predictability, (2) their timescale of tipping and (3) their reversibility.”

These three criteria provide a good starting point, but leave out a crucial factor, the temperature at which these tipping points may be activated, which is closely linked to point 2 about timescale. If SRM could hold warming below 1.5°C, then it logically follows that all tipping points activated above that threshold would be prevented. The fact that scientists cannot predict exactly which tipping points would occur above or below this level indicates a high need to consider the precautionary principle. That means governments should assume that helping to prevent major effects by deliberate cooling with SRM serves as a form of insurance, given that earth system sensitivity and fragility cannot be predicted precisely.

The paper makes a number of assertions that look confused or false. They say “a proactive ‘emergency’ response is only conceivable if a tipping point can be convincingly forecast in advance.” That seems to conflict with the analogy of prudential actuarial practice in the insurance industry, where premiums are set on the basis of broad probabilities rather than specific forecasts. Once you have a flood forecast you can’t get insurance, and equally, once you are in an emergency it may be too late for SRM. This comparison helps to uncover the assumptions in play about the role of SRM.

Crutzen’s warning about a climate emergency was a generalised analysis about earth system stability, not a specific forecast about which tipping points might happen first. The proactive emergency response of SRM can be conceived in the absence of convincing forecasts, given the risk that once we know for certain it will be too late, and the danger that delay increases the risk of irreversible change.

Climate responses should be proportionate, based on detailed risk management assessment. This means the cost and safety and efficacy of SRM should be balanced against the predicted risks of unabated warming, notably the tipping points that SRM could mitigate.

The paper next makes the false claim that climate engineering can only be “a reactive response to tipping that is already underway.” That conflicts with the medical saying that an ounce of prevention is worth a pound of cure. If the world started now to deploy SRM in order to prevent tipping points, the speed of warming would be mitigated, and the tipping elements could be stabilised. That would be far better than the emergency scenario the authors paint of only applying SRM late as an attempted cure for accelerating feedback processes that are well under way. They rightly note that under the current scenario of continued political rejection of SRM, “excessive climate engineering — that is, over-cooling the planet — is likely to be required to recover their original state (and even then it may not work)”, but do not draw the logical inference that therefore we should start SRM in a small and controlled way now to prevent this emergency risk that would inevitably result from continued delay in the required response.

Placing the need for SRM in the context of an intergovernmental declaration of a climate emergency is the next scenario in the paper, based on the perceived crisis of measured ice loss in Antarctica. Of course, such a declaration is unlikely under current thinking, given the general unwillingness to take climate seriously. However, if it were recognised that SRM presented a safe and cheap response, perhaps that could change quickly.

The paper claims, without evidence, that “it is unlikely that SRM would be able to reverse the ice discharge from West Antarctica.” This fits with the agenda of negativity toward SRM, ignoring the need for major research to justify such large claims. I would welcome expert comment on this point. My own supposition is that Marine Cloud Brightening (MCB) in the Southern Ocean, possibly combined with a low level of Stratospheric Aerosol Injection, would have the major combined climate benefits of slowing loss of sea ice, increasing albedo, cooling the ocean currents, protecting biodiversity and reversing ice discharge. This is an area in need of significant research, considering that cooling of the Southern Ocean offers potential to mitigate extreme weather and sea level rise, with benefits that appear to far outweigh possible risks.

The paper discusses a possible abrupt shift in a monsoon, criticising Stratospheric Aerosol Injection as unable to prevent this, given that its much larger scale of effect is such a blunt cooling instrument. It would have been helpful here to recognise that SRM using Marine Cloud Brightening offers strong potential for localised weather management. For example MCB could target warm surface water that causes the Indian Ocean Dipole, the El Nino and La Nina effects, Atlantic and Pacific hurricanes and atmospheric rivers, offering potential to regulate planetary weather.

All this material does not justify their conclusion that “the potential for SRM to respond effectively to tipping-point ‘emergencies’ is very restricted.” They have ignored the possibility that a low quantity of Stratospheric Aerosol Injection would materially reduce the radiative forcing that produces tipping points, while also generating data to help assess the likelihood and scale of side effects. They have also completely ignored the potential for localised deployment of MCB to mitigate extreme weather.

They then assert that “decisions on how much SRM to implement would have to be based on experiments with the same global climate models that had failed to predict the occurrence of a tipping point in the first place.” This does not make sense. It would be possible to begin preventive SRM at small scale, with low quantities of aerosol, and use data from these field tests to assess the likely effects of gradually scaling up. That is a far better option than restricting all work to laboratories and computers before facing the political risk of public demand for implementation in response to worsening tipping points and weather. The best way to prevent what the paper rightly calls “the risk of recommending an excessive SRM intervention” is instead to start with small SRM activities and carefully measure what happens, to guide multilateral decision on whether, how and where to increase deployment.

They say “it remains unclear whether decreasing the global mean temperature by SRM can reduce the number and intensity of extreme events.” This is a surprising conclusion given that the increase of temperature has correlated with worsening extreme weather, such as hurricane intensity. Again, targeted deployment of MCB could combine with a low initial level of global SAI to clarify this question.

While it is true as they say that “the attribution of extreme weather events to specific physical causes is challenging”, the overall causal relationship between heat and instability is clear as a basic impact of climate change, for example with the [rising intensity of Atlantic hurricanes](https://climate.nasa.gov/news/3184/a-force-of-nature-hurricanes-in-a-changing-climate/). But this attribution point leads them to another dubious assertion, that “whether a particular extreme event is caused by human influence or natural variability is central to the public perception of SRM as potential emergency relief.” Assessing what may be ‘central to public perception’ is a matter of political judgement on which opinions are likely to shift. The public are intelligent enough to see that weather involves a combination of anthropogenic and natural factors, and can be convinced that it makes sense to address the anthropogenic causes. This assertion about extreme events misses the basic point that SRM is designed to mitigate broad trends, not individual events.

One way to better frame the benefit of SRM is to see its potential to deliver the real climate stability goal of Net Zero Heating, as a far better climate goal than net zero emissions. Equal and opposite cooling from SRM can balance the radiative forcing caused by emissions. That would then allow a slower transition toward net zero emissions, while tipping points and extreme weather are mitigated by SRM. Unfortunately, strong political opposition to this approach has influenced the scientific community, as reflected in this paper.

Their next assertion is that it might be “impossible to demonstrate beyond reasonable doubt that SRM prevented or reduced the occurrence and magnitude of extreme events.” This point is speculative and weak. SRM would brighten and cool the planet. It would naturally take some time for the effect of SRM to appear, and the destabilising effects of emissions will inevitably continue for some time, even with drawdown and SRM. Blaming SRM for events that are obviously caused by emissions might have some political traction, but is out of place in a scientific paper.

Next, the paper considers the global interaction of extreme climate events with socio-economic and political factors, recognising that “implementation of SRM can only be made within a much broader context than can be diagnosed by natural sciences alone.” This raises the challenging problem of economic fragility and sensitivity, recognising that climate change is likely to have steadily more severe political impacts. “Extreme local weather events might …have global impacts on critical socio-economic variables such as food prices, commodity prices, trade flows and migration” leading to “a fundamental scientific question …: can SRM counteract the climatic root of such a socio-economic emergency?”

The authors provide a highly dubious answer to this existential question, saying “the evidence suggests not, as it is difficult to envisage how SRM could be used effectively to address, for instance, interruptions in global supply chains or outbreaks of social unrest.” This claim continues a strategic failure to understand how SRM would relate to economy, society and environment. Rather than direct and immediate causal relations with events, the point of SRM is to reduce the radiative forcing that is the fundamental pressure pushing human systems into instability. It reflects poor logic to assert that inability to target social unrest directly means SRM cannot “counteract the climatic root of such a socio-economic emergency”, but that is exactly their claim. The climatic root is warming, and SRM counteracts warming. Strategic understanding is needed of what the purpose of SRM should be, but that is sadly absent in this analysis.

The paper arguably reflects the accepted [IPCC consensus](https://www.economist.com/science-and-technology/2021/08/14/geoengineering-is-conspicuously-absent-from-the-ipccs-report) that SRM should be ignored. It presents a series of false arguments to justify its position, which is based on politics rather than science. This illustrates that climate change is a social problem as much as a science problem, given that those who call us to follow the science hypocritically fail to follow their own advice. The need for political leadership to assess SRM is urgent, since influential scientific leaders like these authors present political views that are not in accord with evidence. Only when compelling scientific evidence is accepted by people with ability to communicate effectively to the general public will the need for SRM be understood. The situation now, as reflected in the ideological agenda of this paper, is that available scientific evidence is ignored because emotion-based arguments hold popular sway.

On ethical and political issues, after calling SRM “obviously ill-suited” as an emergency remedy, they turn to speculation about “shallow thinking and deliberation, and even militarization”, language that looks intended to sow groundless fear that a decision to deploy SRM would be undemocratic, a form of “pre-emptive warfare”.

The paper asks whether SRM could address jet-stream dynamics or monsoon systems. These are important questions that should be the subject of much more extensive research. It then presents another claim which seems to me to encapsulate the complacency and irrationality of mainstream climate policy. Noting correctly that the complexity of climate subsystems could not be repaired after tipping has occurred, they rightly infer that a climate emergency can only be prevented by SRM if the emergency is declared pre-emptively. The point of confusion and complacency is in the next claim, that this emergency declaration would involve “an unprecedented amount of risk”, in that the SRM response could actually provoke emergencies rather than avoid them due to the lack of knowledge.

The proper response to this observation is to do more on SRM, but instead they argue to do less. The paper concludes that “interlinking of scientific uncertainty and political opportunism should caution against implementing SRM as a climate emergency measure.” This should lead on to another point that contradicts the whole implication of the paper. This is that public attitudes on SRM have to be transformed from its current pariah status as a dubious emergency response. Instead SRM should be placed front and centre as the main global response to climate change, as the only action able to prevent tipping points. We need to reverse the order of climate responses, placing SRM first, while seeing carbon-based responses as slower actions that will eventually ramp up to stabilise the system.

The uncertainty of tipping points is high, making them a primary planetary security risk. Dr Tim Lenton has co-authored major papers that assess major tipping points. A 2022 summary, [World on brink of five ‘disastrous’ climate tipping points, study finds](https://www.theguardian.com/environment/2022/sep/08/world-on-brink-five-climate-tipping-points-study-finds), says “Giant ice sheets, ocean currents and permafrost regions may already have passed point of irreversible change.” Lenton says in this summary that “our work provides compelling evidence that the world must radically accelerate decarbonising the economy,” ignoring evidence that this strategy is unworkable.

Lenton asserts that SRM could not reverse or mitigate these massive planetary security concerns. He explained why at a [UN panel recorded on 15 December 2021](https://www.youtube.com/watch?v=dkDbCpn0_9I&t=3501s) (link is to his comments). He argues here that “solar radiation management could be at an equivalent level of riskiness to the risk you are trying to avoid.” That means humans lack the intelligence to test and deploy MCB and SAI in ways that have less risk than collapse of ocean currents, ice sheets and permafrost, massive risks that we know are likely without SRM.

He goes on to question the sanity of SRM, saying we could get it badly wrong. His examples of this risk are the [inadvertent geoengineering](https://phys.org/news/2013-03-stratospheric-aerosols-impact-sahelian-rainfall.html) of sulphate aerosols in the 1970s contributing to African famine, the fear that national deployment of SRM could lead to war, and uncertainty about climate sensitivity.  Criticising the “modernist mentality of a mechanistic universe”, Lenton posits the scary scenario of injecting too much aerosol to demonstrate an effect, overcooling the system.

This argument makes no sense to me, and seems full of untested and dubious assumptions and unstated agendas.  Dr Lenton seems to assume it might be possible to reverse tipping points with no action to increase planetary albedo. I find that highly questionable, given the powerful economic and political opposition to his preferred solution of emission reduction.  It seems a matter of simple logic that the risks of action to increase albedo are lower than the risks of inaction. This balance should consider the major benefit of reducing the risk of tipping points, with their cascading planetary dangers, and the political unlikelihood of emission reduction.

His argument about the sanity of risks is like classifying chemotherapy as an insane risk for a cancer patient. “Sane” is a loaded word for Lenton to use in this context. His example of how accidental aerosol release allegedly caused famine is an important caution, but such risks can be mitigated in a supervised and scientifically controlled and governed SRM program.

On the geopolitical risks, it seems that cooperation to refreeze the Arctic would offer considerable benefits for peace and security and cooperation, so the assertion that geoengineering is likely to create conflict is a straw man fallacy.  Geoengineering is actually more likely to reduce conflict than increase it, if communicators advocate international cooperation rather than competitive national deployment.  Lack of geoengineering will inevitably produce conflict from problems such as what to do about climate refugees caused by the resulting sea level rise.

On climate sensitivity, Lenton ignores the problem that inaction on SRM is really where we run the massive risk that sensitivity is higher than assumed, and could therefore bring tipping points faster than expected. Climate sensitivity is an argument for geoengineering, not against it. As noted above, SRM could be deployed gradually, enabling field assessment of risk, instead of the massive risk that Lenton’s approach would deliver, with delay potentially resulting in a public clamour for sudden large emergency deployment in response to extreme weather.

The irony of his comment about a modernist mentality is that it perfectly describes the current mainstream indifference to climate impacts and to factors that are poorly understood. SRM requires new thinking that is far from the degraded mechanistic worldview he caricatures.  A global approach to brightening the planet requires a paradigm shift to a wholistic and cyclic vision of the biosphere, embedded in a philosophical critique of the linear thinking of modernity.  My view is that the arrogance of science is a key problem in this debate.  The IPCC just ignores material that cannot be simply modelled, but which could rear up suddenly with major impacts.

Lenton’s claim that geoengineering would need strong demonstrated effects looks wrong.  A small initial effect could be enough. The predicted level of effect can be calculated based on current knowledge, and a precautionary level of intervention can be tested for years.  This scary idea that Lenton raises of the risk of doing too much SAI has somehow morphed into an irrational public mythology that totally bans any field research while wrongly claiming to follow the science.  That pervasive anti-science mentality with its slippery slope thinking should be a far greater concern.

Maybe Lenton is just expressing a tribal party line in response to fear of ostracism. Geoengineering has become a dirty word in much of academia, as certain scientists, interested in career advancement, deride the whole concept. It now takes courage to stand out against this trend, and if you are a University academic it is hard to summon up this courage.

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