

No quick fix

Re-engineering the atmosphere could be as dangerous as climate change

Challenging a Nobel laureate over a matter of science is not something you do lightly. I have hesitated and backed off, read and re-read his paper, but now I believe I can state with confidence that Paul Crutzen, winner of the 1995 prize for chemistry, has overlooked a critical scientific issue.

Crutzen is, as you would expect, a brilliant man. He was one of the atmospheric chemists who worked out how high-level ozone is formed and destroyed. He knows more than almost anyone about the impacts of pollutants in the atmosphere. This is what makes his omission so odd.

At the beginning of August, he published an essay in the journal *Climatic Change*. He argues that the world's response to climate change has so far been "grossly disappointing". Stabilising carbon dioxide concentrations in the atmosphere, he asserts, requires a global reduction in emissions of between 60 and 80 per cent. But at the moment "this looks like a pious wish". So, he proposes, we must start considering the alternatives, by which he means re-engineering the atmosphere in order to cool the earth.

He suggests we use either giant guns or balloons to inject sulphur into the stratosphere, 10 kilometres or more above the surface of the earth. Sulphur dioxide at that height turns into tiny particles – or aerosols – of sulphate. These reflect sunlight back into space, counteracting the warming caused by manmade climate change.

One of the crueller paradoxes of climate change is that it is being accelerated by reducing certain kinds of pollution. Filthy factories cause acid rain and ill health, but they also help to shield us from the sun, by filling the air with particles. As we have started to clean some of them up, we have exposed ourselves to more solar radiation.

One model suggests that a complete removal of these pollutants from the atmosphere could increase the world's temperature by 0.8 degrees. The virtue of Paul Crutzen's scheme is that sulphate particles released so far above the surface of the earth stay airborne for much longer than they do at lower altitudes. In order to compensate for a doubling of carbon dioxide concentrations (which could happen this century), he calculates that we would need to fire some 5 million tonnes of sulphur into the stratosphere every year. This corresponds to roughly 10% of the sulphate currently entering the atmosphere.

Crutzen recognises that there are problems. The sulphate particles would slightly reduce the thickness of the ozone layer. They would cause some whitening of the sky. Most dangerously, his scheme could be used by governments to help justify their failure to cut carbon emissions: if the atmosphere could one day be fixed by some heavy artillery and a few technicians, why bother to impose unpopular policies?

His paper has already caused plenty of controversy. Other scientists have pointed out that even if rising carbon dioxide levels did not cause global warming, they would still be an ecological disaster. For example, one study shows that as the gas dissolves in seawater, by 2050 the oceans could become too acid for shells to form, obliterating much of the plankton on which the marine ecosystem depends. In Crutzen's scheme, the carbon dioxide levels are not diminished. It would also be necessary to keep firing sulphur into the sky for hundreds of years. The scheme would be extremely expensive, so it is hard to imagine that governments would sustain it through all the economic and political crises likely to take place in that time. But what I find puzzling is this: that by far the most damaging impact of sulphate pollution hasn't even been mentioned – by him or, as far as I can discover, any of his critics.

In 2002, the *Journal of Climate* published an astonishing proposition: that the great droughts which had devastated the Sahel region of Africa had been caused in part by sulphate pollution in Europe and North America. Our smoke, the paper suggested, was partly responsible for the famines which killed hundreds of thousands of people in the 1970s and 1980s.

By reducing the size of the droplets in clouds, thereby making them more reflective, the sulphate particles lowered the temperature of the sea's surface in the northern hemisphere. The result was to shift the Intertropical Convergence Zone southwards. This zone is an area close to the equator in which moist air rises and condenses into rain. The Sahel, which covers countries such as Ethiopia, Sudan, Chad, Niger, Burkina Faso and Senegal, is at the northern limits of the zone. As the rain belt was pushed south, those countries dried up. As a result of the clean air acts, between 1970 and 1996 sulphur emissions in the US fell by 39%. This appears to have helped the North Atlantic

to warm, allowing the rains to return to the Sahel in the 1990s.

Since then, several studies – published in the Proceedings of the National Academy of Sciences, Geophysical Research Letters and the Journal of Geophysical Research – have confirmed these findings. They show that the 40% reduction in rainfall in the Sahel – which has “few if any parallels in the 20th century record anywhere on Earth” – is explicable only when natural variations are assisted by sulphate aerosols. We killed those people.

I cannot say whether or not Crutzen’s scheme would have a similar outcome. It is true that he proposes to use less sulphur than the industrialised nations pumped into the atmosphere, but does this matter if the reflective effect is just as great? Another paper I have read lists seven indirect impacts of aerosols on the climate system. Which, if any, will be dominant? What will their effects on rainfall be? Crutzen suggests that in order to keep the particles airborne for as long as possible they should be released “near the tropical upward branch of the stratospheric circulation system”. Does this mean that they will not be evenly distributed around the world? If so, will they shift weather systems around as our uneven patterns of pollution have done? I don’t know the answers, but I am staggered by the fact that the questions are not even being asked.

I am not suggesting that they have been deliberately overlooked. It seems more likely that they have been forgotten for a familiar reason: that this disaster took place in Africa. Would we have neglected them if the famines had happened in Europe? The story of industrialisation is like *The Picture of Dorian Gray*. While the rich nations have enjoyed perennial youth, the cost of their debaucheries – slavery, theft, colonialism, sulphur pollution, climate change – is visited on another continent, where the forgotten picture becomes ever uglier.

The only responsible way to tackle climate change is to reduce the amount of climate-changing gases we emit. To make this possible, we must suppress the political and economic costs of the necessary cut. I think I have shown how this can be done – you will have to judge for yourself when my book is published. But what is surely clear is that there is no uncomplicated short cut. By re-engineering the planet’s systems we could risk invoking as great a catastrophe as the one we are trying to prevent.

*George Monbiot’s book **Heat: how to stop the planet burning** is published by Penguin on September 28th.*