Climate Restoration using Natural Earth Systems

Iron Salt Aerosol

It looks very much as though Mother Nature may have provided an affordable scalable tool that in combination with other mitigation efforts would deplete most greenhouse gases, reducing warming. That tool also provides powerful, rapid cooling mechanisms. Until recently the only information on Iron Salt Aerosol was essentially invisible to all but the most determined academic researchers. Now an Australian website ironsaltaerosol.com provides a description of twelve natural cooling processes. Accessible technical material is also appearing on the ClimateGameChangers.org website. A growing international team of volunteers are promoting Iron Salt Aerosol as an immediate initiative for addressing climate change.

Iron Salt Aerosol (ISA) is $FeCl_3$ (ferric chloride) nebulized into the troposphere. It could be produced *in-situ* from chemical precursors combusted in hot flues designed to lift a plume 1km above sea level. Adding a total of 270,000 tons of iron annually to the iron-poor ocean regions could remove 40 billion tons of carbon dioxide and equivalents per year (more than quadrupling the abatement of the whole Paris Accord over the next decade). Iron Salt Aerosol could be implemented safely, quickly and at low cost. A first order estimate based on materials cost is 45 US cents per tonne of carbon-dioxide equivalent removed. Our official estimate is currently $1 per tonne of carbon-dioxide equivalent, which incorporates a 120% uncertainty.

The strongest Iron Salt Aerosol climate restoration mechanisms are:

- Depletion of powerful atmospheric warming agents: methane and tropospheric ozone. A sunshine-induced photo-catalytic reaction produces chlorine radicals – a powerful oxidising agent that is estimated to deplete methane at four times the natural rate, possibly much faster.
- A reaction that renders black/brown particulates more readily washable out by rain;
- Carbon-dioxide drawdown, from very low concentration but widely dispersed ocean fertilisation. We estimate 0.05mg per m^2 per day over 4% of the ocean may be sufficient;
- Rapid cooling by marine cloud brightening from ISA itself and the airborne excreta of phytoplankton;
- Ocean brightening, as growth of phytoplankton turns it from black-blue to turquoise.

The ocean has been a natural carbon sink for millions of years, as seen by the existence of the many millions of gigatons of continental carbonate rock. We argue it is capable of safely and permanently sequestering around 10 billion tons of carbon that needs to be removed yearly from the atmosphere from anthropogenic sources.

Iron Salt Aerosol already exists in the troposphere from steel manufacturing, coal fired power stations (along with the undesirable mercury compounds and particulates etc) and numerous other sources, including windblown dust.

An incremental scaling approach with testing at each stage is required to measure efficacy and safety. The ideal candidates for iron fertilisation are areas of open ocean that are 'High Nutrient, Low Chlorophyll'. One of our initial proposals is to carry out a field trial from a remote tropical island in such an area. This would deplete atmospheric methane and CO_2. The resulting cloud brightening would also have a cooling effect.

There is much more to it than that. Focused largely on chemistry, the ISA team have researched the way Iron Salt Aerosol encompasses both the global water cycle including ocean circulation, and large parts of the long-term geological carbon 'cycle', including sequestration into the ocean crust, sediments and continents. We do not accept the claim that the oceans can absorb only 1 billion tons of carbon each year owing to hypothetically large carbon-dioxide out-gassing from plankton litter oxidation. Most of the organic material produced by phytoplankton growth and its downstream food-web becomes oxidised back to bicarbonate and stays in the ocean for centuries. Eventually it becomes permanently sequestered either as carbonate or organic compounds in the ocean crust and sediments. In addition, contrary to claims that Iron Salt Aerosol damages the stratospheric ozone layer we argue that ISA depletion of methyl-halides is much more likely to strengthen the ozone layer.

The lead authors of the Iron Salt Aerosol paper (https://www.earth-syst-dynam.net/8/1/2017/) are chemical engineers Franz Oeste, and Renaud de Richter. Their proposal is being promoted in Australia by Robert Tulip and John Macdonald, and in the UK by Clive Elsworth. The Australians are in early discussions with Australian local government to plan an initial trial off the Bass Strait.

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