Global Cooling

Emergency Climate Protection through Maritime Cloud Brightening

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A fiscal project of Planetwork NGO, Inc.

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Program Description

Global Cooling is a geo-engineering research initiative led by Dr. John Latham designed to avert the immediate impacts of catastrophic climate change. This idea, called cloud-brightening, has become the focus of a growing network of world-renown researchers working to developed a safe and effective solution to what is rapidly becoming the issue of our time, global warming.

Mission

Global Cooling's mission is to research the potential for and create safe and controlled processes through which to effect global cooling in order to balance current and projected global warming resulting from CO2 emissions. The project involves seeding low-lying ocean clouds with seawater in order to increase their reflectivity and thereby protect and potentially restore the polar ice-caps. This process has the potential to delay or prevent the projected runaway feedback loops and catastrophic climate destabilization that the world's top climate scientists warn would result from inaction.

Funding Request

We propose research to prepare for the seeding of ocean clouds with seawater in order to produce a cooling effect that could hold back catastrophic climate change. The idea is to increase the reflectivity of the Earth to incoming sunlight. Computer modeling indicates that global temperatures could be stabilized for decades, and more importantly, sea-ice could be maintained at both poles, thereby preventing a catastrophic feedback loop that would result from the melting of highly reflective ice into highly absorptive water. This could, in turn, stop the runaway release of vast quantities of methane from thawing permafrost.

Context

As we have failed to reduce CO2 emissions rapidly enough to avert climate change, many leading climate scientists are urging an examination of 'geo-engineering' strategies in order to suppress these effects until renewable energy can be deployed on a global scale.

By employing wind-powered, satellite-controlled watercraft to “seed” low-lying clouds near the poles, we propose to increase the reflectivity in the cloud cover to protect the sea ice from further damage. Cloud-brightening effects already occur in shipping lanes and are observable from satellites, but to produce a global cooling effect, we would need to seed clouds deliberately, on a much larger scale. Our recent field tests have shown an increase in the reflectivity of existing clouds by up to 10%, which world-class global climate modeling suggests could balance global warming for perhaps 50 years. The technology involves spraying strategic areas of existing, low altitude ocean clouds with a fine, seawater mist. Professor Stephen Salter has developed engineering for the production and dissemination of seawater droplets at the rate and scale required.

Constituency

All of humanity and the biosphere - the melting of the polar ice caps and glaciers throughout the world all indicate that “global warming” already underway has the potential to create catastrophic runaway feedback loops.

Strategy

Cloud brightening has advantages over other geo-engineering proposals in that the raw materials are wind and seawater and the effect drops out and returns to previous weather patterns within a few days after deployment. This appears to be the most benign, reversible and low-cost option for achieving a cooling effect. Recent NCAR studies suggest that it may be possible to not only stabilize the Earth's temperature, but also replenish the Arctic ice that has melted. Further modeling and more extensive studies are needed to confirm this. Design work on the major technological aspects of our project has progressed well despite limited funding, but significant support will be required to produce and test prototypes, currently of the spray system, and advanced aspects of the global climate modeling. Two of the world’s best computational resources have assessed the idea separately; Hadley Center Meteorological Office, UK, and NCAR, US, resulting in two favourably published papers.

Goals & Accomplishments

The Global Cooling project has won critical acclaim around the world, receiving significant interest from the scientific community and media, including *Scientific American, The New York Times* and *Nature*, and has been the subject of documentaries by the *BBC* and *Discovery*, which manufactured a small "Flettner Vessel" for the show. It worked perfectly. For years John Latham and Stephen Salter worked alone, but in recent years have been joined by over 30 other scientists (many world-renown) working on a part-time and entirely voluntary basis (we have no money for salaries or consultancy fees).

Results so far have been very encouraging —- subject to the caveats below. Computations predict that marine cloud brightening could hold the Earth's average surface temperature and polar sea-ice coverage constant, even with up to double the current atmospheric CO2 concentration, which might be fifty years from now, buying the decades of time needed to deploy new energy sources to replace fossil fuels.

Caveats: that (1) all important technological issues are satisfactorily resolved, (2) the reflectivity increase of the oceanic clouds is as assumed (there exists supportive evidence from satellite studies, but more is required), (3) there are no unacceptable ramifications of the deployment that cannot be corrected. This last issue is currently under intensive examination.

We have published seven papers in peer-reviewed scientific journals; two appeared in the 2008 special geo-engineering issue of the *Philosophical Transactions of the Royal Society*, the most comprehensive and authoritative assessment of climate mitigation. The *UK Royal Society* conducted a survey of all geo-engineering, and ours was one of only two global cooling techniques recommended for support. A similar assessment by the *Copenhagen Consensus Center* concluded that cloud-brightening is the most attractive solution.

In November 2010 the Royal Society (the UK equivalent of the National Academy of Sciences) organized a 2-day conference on geoengineering in London; at which Dr. Latham was invited to present a comprehensive paper on Marine Cloud Brightening (MCB). We were also invited to submit a lengthy paper on our work for publication in the prestigious and venerable journal The Philosophical Transactions of the Royal Society, in which Isaac Newton published his papers. Our paper is now at the external review stage. A 15MB download is available here: http://www.planetwork.net/climate/cooling/Cloud_Brightening_private_DRAFT.pdf

Further Background (from the full RFP)

Increased awareness within the global scientific community indicates that climate change is in fact occurring, and that the manifestations (for example, polar ice melting, changes in weather patterns, ocean-level rise and ocean acidification) can be extremely severe. The prospect of additional warming as a result of even current CO2 levels has much greater credibility, as does growing concern over new feedback loops driving potentially even greater runaway heating as a result.

For those not familiar with geoengineering research, there are currently two major proposed methods of holding back the warming effect caused by excess greenhouse gases. Both involve increasing the net reflectivity of the Earth's atmosphere. Early thinking about this led to some ideas, such as mirrors in space, which are so expensive (and irreversible) that they are no longer under serious consideration, but evoked the term geoengineering, which unfortunately stuck. The two ideas that are now under serious investigation, injecting sulphuric aerosols into the stratosphere, or increasing the reflectivity of low ocean clouds, are both methods of increasing the reflection of incoming solar radiation, hence the rather arcane term Solar Radiation Management, or SRM.

Until this past year, many scientists and policy makers were using the term geoengineering almost interchangeably with the idea of injecting sulphuric aerosols into the stratosphere, as this was assumed to be the cheapest and easiest way of achieving a cooling effect. However, in the past year, as a result of the growing network of scientists who are investigating Maritime Cloud Brightening (MCB), this alternative is now being discussed equally in the scientific community.

Values

We regard the ethical questions associated with geoengineering as being of the utmost importance, and we explicitly and strongly oppose any use of our work as a rationale to justify not cutting carbon emissions as rapidly and drastically as possible. We believe that Marine Cloud Brightening should be fully researched as rapidly and fully as possible so that if and when the climate-change crisis reaches otherwise irrecoverable tipping points, we may have an established method of buying time to stave off ecological disaster long enough to make the transition to a zero-carbon energy infrastructure.

We acknowledge that none of the current Solar Radiation Management ideas, including our Marine Cloud Brightening idea, address the crucially important issue of ocean acidification. The severity of the effects of ocean acidity, even at CO2 levels currently being regarded as acceptable in climate negotiations, will force society to address CO2 much more rapidly than is currently expected.

It is, however, widely understood that glaciers, polar sea-ice, and permafrost are already rapidly melting now, as a result of CO2 emissions from decades ago. Even if we were able to instantly reduce CO2 emissions to zero today, we would still see additional increased warming for decades, in part due to the inertia associated with a century of unbridled emissions. Thus, even reducing CO2 emissions on a crash program would not prevent the loss of much of the world's fresh water supply currently fed by glaciers, or the irreversible loss of much of our biodiversity.

It is ironic that a small but vocal activist group was able to push forward a proposal in October of 2010 to insert language regarding the prohibition of geoengineering experiments under the UN biodiversity protocol, even though biodiversity is already under increasingly severe threat due to warming. Mass extinction will only increase under this inevitable additional warming unless we can hold back temperature increase, as well as cut CO2 emissions, and ultimately take steps to actually remove net CO2 from the atmosphere.

Most seriously, the risk of catastrophic methane release from the melting of permafrost is no longer a theoretical idea. Scientists are already seeing the early signs of this occurring. If a positive feedback loop were to takeoff whereby warming causes permafrost to melt and release methane, and that methane causes more warming, then the only defence for humanity, and biodiversity, would be emergency SRM, and the most effective approach would be MCB.

In our view, we are fooling ourselves if we imagine that research into emergency remedial actions are premature, or that we can responsibly continue to delay such research any longer. Computations made with world-class models suggest that (subject to the various caveats under current investigation) Marine Cloud Brightening could maintain polar ice cover and globally averaged temperature at roughly current values –– or even restore them to previous levels.

Leadership

Inspired by Dr. John Latham's original work on Maritime Cloud Brightening, first published in the prestigious science journal *Nature*, in 1990, we have assembled an international "team" of over 30 collaborating scientists (including several who are regarded as world ranking). Most work on a volunteer basis, none are paid from our funds, some are retired, and two are PhD students, but the majority are established scientists who have managed to devote a significant fraction of their time to MCB, and/or have asked their postdoctoral scientists to devote effort to this work. In the absence of significant funding our choice of strategy has been limited, but as it happens, has proved to be quite flexible and successful.

Collaboration

Our informal network of scientists and engineers share a common goal of subjecting MCB to objective, rigorous and comprehensive study, in order to establish whether it could safely produce a short-term global cooling to compensate for the warming resulting from the burning of fossil fuels. As part of this work it is our duty to identify and examine fully, any possible adverse consequences that might accompany the deployment of MCB. The detailed results of our studies should be made available to anyone. These common goals are what bind us into an effective international collaboration.

The paper recently submitted for publication in *The Philosophical Transactions of the Royal Society*, entitled Marine Cloud Brightening, has 25 co-authors, listed here, along with their affiliations: Authors:- John Latham1,4, Keith Bower4, Tom Choularton4, Hugh Coe4, Paul Connelly4, Gary Cooper7, Tim Craft4, Jack Foster7, Alan Gadian5, Lee Galbraith7, Hector Iacovides4, David Johnston7, Brian Launder4, Brian Leslie7, John Meyer7, Armand Neukermans7, Bob Ormond7, Ben Parkes5 , Phillip Rasch3, John Rush7, Stephen Salter6, Tom Stevenson6, Hailong Wang3, Qin Wang7 & Rob Wood2 .

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The international nature of our effort is clear from the list above. We have also worked with scientists and engineers at NOAA and Purdue University, as well as in Spain and Germany.

Benchmarks

Perhaps the greatest measure is that our informal “team” of scientists has grown rapidly from two people a few years ago, to now number about 30 scientists around the world —– though most are still based in the US and the UK.

Several documentaries, including the BBC, Discovery Channel, and National Geographic, have been made about our work in at least 6 countries, along with many articles in prestigious magazines. Much of this recognition, and associated involvement of world-class scientists in our work, would not have occurred, in my view, without the support from Threshold —– for which we are very grateful.

Three different, independent Global Climate Modeling studies, conducted by three different world-ranking groups, each using the highest-quality computer models, reached the same conclusion: namely that Marine Cloud Brightening would be capable of maintaining both the Earth’s average surface temperature, and perhaps even more importantly, the sea-ice cover at the poles, at roughly current values for 30 or 50 years —– even in the face of atmospheric CO2 doubling —– providing time for clean energy to be deployed globally. MCB produces preferential cooling at the poles. Other SRM techniques do not.

This assumes that MCB operates as prescribed in the global computer models. A substantial amount of further work is required before any definitive assessment of the efficacy of MCB can be made. The marine stratocumulus clouds —– which cover about a quarter of the oceanic surface —– are more complex than the global computer modeling assumes, so it will be necessary to also conduct high-resolution cloud modeling studies, and probably small-scale field experiments, to achieve a better understanding of these clouds. Paper 9 in the list below is a first step towards achieving this goal.

Also, although substantial progress has been made in the development of spray-production technology, more work needs to be done in this area. We need to develop our plans for limited-area field-testing of MCB. We are fortunate that several people in our team played leading roles in the highly successful international VOCALS field study of marine stratocumulus clouds, conducted two years ago off the coast of Chile. The technology used in that study is basically the same as will be required for MCB field-testing. We anticipate conducting a field study in 2 or 3 years time.

A critically important component of our studies is to examine the possibility that adverse consequences might accompany the deployment of MCB; if this were the case —- and if these effects were significant and could not be remedied —- then MCB should not be deployed.

The source of the greatest controversy around MCB to-date was one early study, conducted by excellent scientists from the Hadley Center (UK), which modelled seeding in only three locations, and yielded an initial conclusion that rainfall would be reduced in Northern South America. Our own global climate modeling studies did not reproduce this result. Later, a more detailed investigation by notable climate modellers (Bala, Caldeira and colleagues) found that —- unlike other SRM techniques (such as stratospheric sulphur aerosols) —- Marine Cloud Brightening produced no rainfall reduction anywhere over land. Finally, further work by the same Hadley Center group also found that if MCB was deployed in different regions from those in their earlier studies, there is no rainfall reduction in Northern South America. So, it seems likely that this problem could be resolved by making better choices of seeding location —- i.e. seeding in a variety of judiciously selected places rather than seeding heavily in only three small areas.

In principle, MCB is quite benign, especially if the dissemination of seawater particles is from wind-powered vessels, as proposed by Stephen Salter. In this case, the only raw materials needed are wind and seawater. Also, seeding could be switched off instantaneously, with the seawater particles falling back almost entirely into the oceans, within a few days.

One highly respected benchmark of success is publication of papers in peer-reviewed journals. To date, we have published 9 papers (excluding the one just submitted) on MCB research:

1. Latham, J., 1990: Control of global warming? Nature 347. 339-340.

2. J Latham and M H Smith: 1990 Effect on global warming of wind-dependent aerosol generation at the ocean surface. Nature, 347, No. 6291, 372-373.

3. Latham, J., 2002, Amelioration of Global Warming by Controlled Enhancement of the Albedo and Longevity of Low-Level Maritime Clouds. Atmos. Sci. Letters. doi:10.1006/Asle.2002.0048.

4. K.Bower, T.W.Choularton, J.Latham, J.Sahraei and S.Salter., 2006. Computational Assessment of a Proposed Technique for Global Warming Mitigation Via Albedo-Enhancement of Marine Stratocumulus Clouds. Atmos. Res. 82, 328-336.

5. J. Latham, 2007. Cooling may be possible, but we need safety data. Nature, 447, 908.

6. J. Latham, P.J. Rasch, C.C.Chen, L. Kettles, A. Gadian, A. Gettelman, H. Morrison, S. Salter., 2008. Global Temperature Stabilization via Controlled Albedo Enhancement of Low-level Maritime Clouds. Phil. Trans. Roy. Soc. A, 366, 3969-3987,doi:10.1098/rsta.2008.0137.
7. S. Salter, G. Sortino and J. Latham, 2008. Sea-going Hardware for the Cloud Albedo Method of Reversing Global Warming Phil.Trans.Roy. Soc. A, 366, 2989-4006, doi:10.1098/rsta.2008.0136.
8. P.J.Rasch, J. Latham & C.C.Chen, 2010. Geo-engineering by Cloud Seeding: influence on sea-ice & Climate System. Environ. Res. Lett. 4 045112 (8pp) doi:10.1088/1748-9326/4/4/045112
9. H. Wang, P. J. Rasch, & G. Feingold, 2011. Manipulating marine stratocumulus cloud amount and albedo: a process-modelling study of aerosol-cloud-precipitation interactions in response to injection of cloud condensation nuclei. Atmos. Chem. Phys., 11, 885?916. doi:10.5194/acpd-11-885.

Funding

The monetary funding provided through the Global Cooling fiscal project of Planetwork actually represents only a fraction of the growing support for our overall efforts. This includes in-kind support in the form of hundreds, if not thousands, of hours of computer modeling time "borrowed' from other funded projects; countless volunteer hours from scientists whose salaries are paid by universities; and in some cases from their graduate students and post docs devoted to our MCB studies and research. It is difficult to calculate precisely the monetary value of all such contributions, but a rough estimate, averaged over the past five years, is about $150K per year, but trending above that recently.

However, the actual monetary funding provided by Threshold has proved invaluable in the furtherance of our research. It has been this comparatively small amount of cash that has allowed us to meet and interact with each other face to face. It is those meetings that have allowed us to connect and grow our informal network of collaborating researchers. This has been crucial to our ability to expand the network of scientists working on this out of our shared sense of commitment. These funds have allowed us to attend conferences, meet with international collaborators, and hold discussions with people who have specialized knowledge to help further our research. As a direct result, our work has become well recognized within scientific circles and MCB was deemed by the prestigious Royal Society geoengineering panel to be one of two SRM techniques that should be supported for additional funding. Such funding has not yet been provided to our effort, but it seems increasingly likely that it will happen, especially as a distinguished panel from the Copenhagen Consensus Center chose MCB as the most promising of the SRM geoengineering ideas.