Comments from Geo-engineering Google Group (geoengineering@googlegroups.com)

Description:

Scientific and political discussion of geoengineering (to control anthropogenic global warming). Discussion is at the level of professional academic discourse. Regular topics include solar radiation management, carbon dioxide removal, climate tipping points, etc.

https://groups.google.com/g/geoengineering/c/u2b9Xb5B0C8/m/aXQia-nNDbcJ

Permafrost Insulation

12 views
Subscribe

Alvia Gaskill

Sep 4, 2008, 12:29:15 PM
I hadn't heard about this one before. It involves some kind of engineered metal foam that wicks

Mike MacCracken

Sep 4, 2008, 12:56:40 PM
If one could figure out how to keep its effects from being overwhelmed by ice, an alternative

Alvia Gaskill

Sep 5, 2008, 7:22:26 AM
to mmac...@comcast.net, petti...@yahoo.ca, Geoengineering
I added the NO! as I am Mr., not Ms. If I am understanding your concept correctly, you propose to drop these metal foam heat transfer devices from airplanes onto the permafrost areas where they will bury into the soil. The cylinders containing the metal foam also contain a heat transfer fluid, ammonia or CO2 and are painted white to reflect visible sunlight.

The difficulties of carrying out an aerial deposition program have been recently explored on the Discovery Channel Project Earth series episode where attempts were made to revegetate a denuded area via helicopter drops of seedlings. The seedlings didn't grow, but a device was eventually fabricated that could bury into the soil and a drop pattern consistent with the project goals was also achieved. Given the hardness of the Arctic soil, I think aerial deposition would be difficult. My main concern about this idea is still the cost. Covering a few thousand square feet of roads and area under oil pipelines is one thing, the thousands of square miles of land necessary to mitigate warming is another entirely. You should develop some cost estimates and see if the idea is still feasible for that reason alone.

I don't see how this material could be used in the Arctic Ocean by imbedding it in sea ice, although certain of the copper, iron and nickel foams have stated densities less than that of water and should float.

http://www.metafoam.com/iron_foams.html

----- Original Message -----
From: Pettigrew R. J.
To: agas...@nc.rr.com
Sent: Thursday, September 04, 2008 8:26 PM
Subject: Thanks for your email; some information

Dear Ms. Gaskill,

For of all, I thank you for your fast reply, and those of your colleague, Mr. MacCracken.

I am sorry, about the (NO!) which appeared near your name. I don' t know how that happened since I did not found the symbol of the squared ( ) !!

In a sense only, I am "happy" to heard you said you never heard on that! That conforts me that my concept is really new!!

On the other hand, I can have more difficulty to convince some expert to check further!

Even at the Metafoam firm, Ms. Vézina(a marketing people at first)is intrigued with that!

But, for now, it seems that I am more confident that her about the capability of their product for my concept!!

In short, the device(a vertical one, more or less as the "penetrator" designed(-- of course the engine!!)to hit the Moon by the now aborted Planet A Japanese probe in late 90s), with the metal foam wick and the thermal fluid, NH3(or CO2)hermetically in the casing able to withstand the aircraft ejection in the muddy mollisol, which can be painted in white or other high albedo coating.

The aircraft be able to carry some thousands/flight, each weighting less than 3 kg and create a grid of about 1000 to 3000 /km2 depending of the test results(and simulation)on the device capability.

Unlike those in infrastructure protection, no short delay needed for results! For ex., for a highway protection, or the TAPS pipeline, results are expected within few days at most.

In my case, the 3 chill seasons will work together with the devices, so the real results be seen in the early spring and the next early fall...

Of course, the expenses to install such a grid will be from the CO2 credits or C tax to be paid by the High Emittors.

I wait for your comments again. Thank you.

Mike MacCracken

Sep 5, 2008, 7:52:45 AM
to Alvia Gaskill, petti...@yahoo.ca, Geoengineering

Regarding putting such objects into the ground, to cool the permafrost region they would have to work only during the cold season, for during the warm season they would transmit heat down into the permafrost faster than it is being transported now. With the permafrost thawing, we know that at present the net annual flux of heat is into the permafrost, and putting in objects with better conductivity would, on first examination, thus be expected to speed the transfer of heat and thawing of the permafrost—so just the opposite of the intended effect. So, if this idea is to work, the material or the object it is made of needs to have a temperature sensitive conductivity—one that goes down as the temperature goes up so it is transporting heat out in the dead of winter and not down in the warmth of summer.

Mike MacCracken

----- Original Message -----

From: Mike MacCracken <mailto:mmac...@comcast.net>

To: Alvia Gaskill <mailto:agas...@nc.rr.com> ; petti...@yahoo.ca

Cc: Geoengineering <mailto:geoengi...@googlegroups.com>

https://groups.google.com/g/geoengineering/c/dm7DqAanhhA/m/JsjYMQKA4CQJ

snow and the future of polar ice

28 views
Subscribe

Rau, Greg

Dec 3, 2012, 4:42:16 PM
to geoengineering
Cryoscience: Snowfall brightens Antarctic future

- Charles S. Zender

  Nature Climate Change

  2,

  770–771

  (2012)

  doi:10.1038/nclimate1730

Published online

  26 October 2012

Snowpacks absorb more sunlight as they warm. The Antarctic Plateau may buck this trend over the twenty-first century as increased snowfall there inhibits the snowpack from dimming.

The colour of snow tells a remarkable story. To the human eye, snow appears white because its reflectance of visible light is uniformly high. However, its reflectance changes with astonishing abruptness at other wavelengths, and is a complex function of the exact ice crystal size and shape[1, 2]. Pristine snow is a valuable shield against global warming as it reflects up to 85% of sunlight and traps only the remainder as heat[1, 3, 4]. This is why almost imperceptible reductions in snow reflectance owing to warming and pollution[3, 5] have become a great concern. Increased heat trapping by darker snow triggers a vicious feedback cycle that speeds the greying of snow[5, 6, 7]. With temperatures increasing globally, what, if anything, will oppose the self-reinforced darkening of snow and keep it from melting even faster? Writing in *Nature Climate Change*, Picard *et al*.[8] use snow-colour measurements to deduce that fresh snowfall inhibits the

seasonal greying of snow on the Antarctic Plateau by up to 3%, and reduces summertime temperatures there by up to 4 °C. On climate timescales, the increase in Antarctic snowfall expected with twenty-first-century warming may be enough to prevent the surface from further darkening.

Antarctica's reprieve from darker snow is a welcome surprise, because the enemies of snow reflectance are time and temperature, which is projected to rise by about 3 °C this century. Much like ice cubes in a home freezer, snow crystals lose their sharp facets to duller, rounder shapes as they age[1, 9] (Fig. 1). Heat accelerates this metamorphism so that pristine, sharply faceted fresh crystals quickly grow during summer to become larger, rounder, aged snow, which absorbs more heat and reflects less sunlight[1, 5, 9]. Snow reflectance also changes during wind events (which shatter and sublimate crystals) and as a result of surface crusts and ripples. The findings reported by Picard and colleagues suggest that these secondary contributors explain less than one-third of changes in summer snow reflectance on the Antarctic Plateau. Temperature and snowfall are the main players.

The Antarctic Plateau endures long periods of polar night, during which its visible reflectance cannot be measured, so Picard and colleagues focused on the seasonal behaviour of a reflectance proxy — the snow grain size. First they teased grain-size information from the wavelength-dependent surface microwave emissions measured daily by meteorological satellites. A sophisticated model of the microwave signal travelling from the surface through the atmosphere best matches the measured signal when the snowpack is modelled as smaller, younger surface grains atop larger, inactive snow grains deposited in previous seasons.

Andrew Lockley

Dec 3, 2012, 5:03:49 PM
That leads me to wonder if we could use cloud seeding to darken Greenland, or the Arctic sea ice. A

Charlie Zender

Dec 4, 2012, 10:08:27 AM

Hi Andrew, I assume your goal in cloud seeding would be to brighten not darken the surface to cool

Andrew Lockley

Dec 4, 2012, 10:25:10 AM
to Charlie Zender, Greg Rau, geoengineering

A good dump of late spring snow could do quite a bit to help retain permafrost, too. There would be both an albedo and a thermal insulation effect.

The effect would be more marked, although more temporary, than inducing snow over permanent ice cover.

I'm really surprised this hasn't been.mentioned before, as it's pretty simple (unless I'm missing something)

A

https://groups.google.com/g/geoengineering/c/XMR75eB77c8/m/aJrf6Zp3okcJ

Seeding Sea Ice - New SRM Method

30 views
Subscribe

Veli Albert Kallio

Dec 8, 2010, 2:48:45 PM
Dear Geoengineering Group, For over a year now I have concentrated on occasional information relays

Renaud-KdeR

Dec 9, 2010, 7:10:07 AM
Dear Geoengineering Group, This reminds me the local scale geoengineering idea by Peter Flynn and S.

John Nissen

Dec 18, 2010, 5:02:38 PM
to ecolo...@gmail.com, geoengineering, John Nissen

Hi all,

There are two cycles to consider: the carbon and heat. The paper that Renaud refers to, by Zhou and Flynn [1], suggests a means to incrementally increase the downwelling in the GIN (Greenland Iceland Norwegian sea), in order to capture more CO2. This downwelling is a thermohaline circulation. Since this additional water is cooled by the atmosphere to make it sink to the ocean deep, the atmosphere is correspondingly warmed (though some of the cooling will be by radiation into space). However, in the longer term, the removal of CO2 leads to less greenhouse gas warming of the atmosphere. Their preferred method is by pumping ocean water onto the surface of sea ice in winter.

However Albert points out that the thickening of sea ice would slow melt in spring, so that more sunlight is reflected, having an immediate net cooling. If there is sufficient thickness, the ice could last through the summer, forming multiannual ice for the next year.

Thus we have a number of processes at play. Some care is needed to determine the net short and long-term effects of pumping water onto sea ice in winter. We should consider the cases when the water is saline (from the ocean) and fresh (e.g. from Russian rivers).

Note that the recent suggestion of a widely reported article in Nature [2], that CO2 emissions reduction could save the sea ice (and hence polar bears), does not take into proper account the positive feedbacks and it assumes climate responds immediately to CO2 level change, which is absurd.

Cheers,

John

[1] http://www.springerlink.com/content/pt637l16gt5r7023/fulltext.pdf

[2] http://www.nature.com/nature/journal/v468/n7326/full/nature09653.html

---

https://groups.google.com/g/CarbonDioxideRemoval/c/AXkmQwmXod0

Re: [CDR] Artificial Upwelling—A false Narrative

177 views

Subscribe

Tom Goreau

Feb 21, 2023, 5:42:27 PM

to ayesha iqbal, carbondiox...@googlegroups.com

That this kind of paper passes peer review is unbelievable!

It must have been reviewed by people who don't understand either the ocean or the carbon cycle.

They say:

The water pumped up is mostly old enough to be equilibrated under preindustrial pCO_2^{atm} levels (~275 ppm; Figure **3c**) and bringing it in contact with an elevated pCO_2^{atm} level (>400 ppm, except for the no-emission scenario) results in a carbon flux from the atmosphere into the ocean, which also increases under higher emission scenarios

The claim that deep waters are in equilibrium with paleo CO2 levels is entirely false, deep waters are highly elevated in CO2 from decomposition of organic matter in the ocean and sediments, so upwelled water degasses CO2 to the atmosphere so the net effect is the opposite of what is claimed.

Thomas J. F. Goreau, PhD
President, Global Coral Reef Alliance

Chief Scientist, Blue Regeneration SL
President, Biorock Technology Inc.

Technical Advisor, Blue Guardians Programme, SIDS DOCK

37 Pleasant Street, Cambridge, MA 02139

gor...@globalcoral.org
www.globalcoral.org
Skype: tomgoreau
Tel: (1) 617-864-4226 (leave message)

Books:

Geotherapy: Innovative Methods of Soil Fertility Restoration, Carbon Sequestration, and Reversing CO2 Increase

http://www.crcpress.com/product/isbn/9781466595392

Innovative Methods of Marine Ecosystem Restoration

http://www.crcpress.com/product/isbn/9781466557734

No one can change the past, everybody can change the future

It's much later than we think, especially if we don't think

Those with their heads in the sand will see the light when global warming and sea level rise wash the beach away

Geotherapy: Regenerating ecosystem services to reverse climate change

From: <carbondiox...@googlegroups.com> on behalf of ayesha iqbal <ayeshai...@gmail.com>
Date: Tuesday, February 21, 2023 at 5:27 AM
To: "carbondiox...@googlegroups.com" <carbondiox...@googlegroups.com>
Subject: [CDR] Artificial Upwelling—A Refined Narrative

https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2022GL101870#.Y-99E3vlde4.twitter

Authors

M. Jürchott, A. Oschlies, W. Koeve

First published: **15 February 2023**

https://doi.org/10.1029/2022GL101870

Abstract

The current narrative of artificial upwelling (AU) is to translocate nutrient rich deep water to the ocean surface, thereby stimulating the biological carbon pump (BCP). Our refined narrative takes the response of the solubility pump and the CO_2 emission scenario into account. Using global ocean-atmosphere model experiments we show that the effectiveness of a hypothetical maximum AU deployment in all ocean areas where AU is predicted to lower surface pCO_2, the draw down of CO_2 from the atmosphere during years 2020–2100 depends strongly on the CO_2 emission scenario and ranges from 1.01 Pg C/year (3.70 Pg CO_2/year) under RCP 8.5 to 0.32 Pg C/year (1.17 Pg CO_2/year) under RCP 2.6. The solubility pump becomes equally effective compared to the BCP under the highest emission scenario (RCP 8.5), but responds with CO_2 outgassing under low CO_2 emission scenarios.

Key Points

- Artificial upwelling (AU) effectiveness to draw down CO_2 from the atmosphere is strongly dependent on the future CO_2 emission scenario

- The solubility pump becomes as effective as the biological carbon pump under high emission scenarios
- Organic matter transfer efficiency decreases under AU, likely due to higher water temperatures below the ocean's surface

Plain Language Summary

Artificial upwelling (AU) is a proposed marine carbon dioxide removal (CDR) method, which suggests deploying pipes in the ocean to pump deep water to the ocean's surface. This process theoretically has several different impacts on the surface layer including an increase in the nutrient concentration, as well as a decrease in surface water temperature. Changes in the carbon cycle and associated with biological components are covered by the biological carbon pump (BCP), while changes via physical-chemical processes are covered by the solubility pump. Using numerical ocean modeling and simulating almost globally applied AU between the years 2020 and 2100 under several different atmospheric CO_2 emission scenarios, we show that AU leads under every simulated emission scenario to an additional CO_2-uptake of the ocean, but the potential increases under higher emission scenarios (up to 1.01 Pg C/year (3.70 Pg CO_2/year) under the high CO_2-emission scenario RCP 8.5). The individual contribution via the BCP is under every emission scenario positive, while the processes associated with the solubility pump can lead to CO_2-uptake under higher emission scenarios and CO_2 outgassing under lower emission scenarios.

Figure 2

Caption

Theoretical concept of the processes stimulated by artificial upwelling (black lines) and their impact on the air-sea CO_2 flux and the surface ocean (box below air-sea boundary). Arrows in the atmosphere indicate air-sea CO_2 flux direction, arrows in the ocean indicate tracer movement and colors red/blue indicate respective water temperature increase/decrease. (a) Covers the increase in primary production and export production associated with the biological carbon pump (green), (b)–(e) cover the impacts of the individual processes associated with the solubility pump.

Source: AGU

CarbonDioxideRem...@googlegroups.com.
To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/CAOyeF5uFfkFVSK7MmwKET0-u5mAJu_SdfQgjeGo3kpJ83%3DzNOQ%40mail.gmail.com.

Eelco Rohling

Feb 21, 2023, 5:56:50 PM

to Tom Goreau, ayesha iqbal, carbondiox...@googlegroups.com

Indeed, it beggars belief...

===

Prof. Eelco J. Rohling
(Ocean & Climate Change)
- 2012 Australian Laureate Fellow
- Editor in Chief, Oxford Open Climate Change
Research School of Earth Sciences
The Australian National University
Canberra, ACT 2601
Australia

Mobile: (+61) 434 667441
Tel. Office: (+61) 2 612 53857
e-mail: eelco....@anu.edu.au

personal WebURL: http://www.highstand.org/erohling/ejrhome.htm

secondary email: eelco_...@me.com

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/4C4D493B-B158-479C-8FD5-60FDBB0D058E%40globalcoral.org.

PastedGraphic-1.tiff

Tom Goreau

Feb 22, 2023, 9:32:58 AM

to Eelco Rohling, ayesha iqbal, carbondiox...@googlegroups.com

Several other artificial upwelling proposals with precisely the same mistake have been published and posted on the CDR list, and some have fooled investors out of millions of dollars.

Figure 2

Caption

Theoretical concept of the processes stimulated by artificial upwelling (black lines) and their impact on the air-sea CO2 flux and the surface ocean (box below air-sea boundary). Arrows in the atmosphere indicate air-sea CO2 flux direction, arrows in the ocean indicate tracer movement and colors red/blue indicate respective water temperature

increase/decrease. (a) Covers the increase in primary production and export production associated with the biological carbon pump (green), (b)–(e) cover the impacts of the individual processes associated with the solubility pump.

Source: AGU

Michael Hayes

Feb 22, 2023, 11:08:00 AM

to Tom Goreau, Eelco Rohling, ayesha iqbal, Carbon Dioxide Removal

Containing the discharge of both upwelling and downwelling for use in managing gasses, nutrients, thermal exchange etc likely will help reduce risks and increase practical use of the materials moved in such ways. Largely self-replicating infrastructure opens up being able to scale up, and a Biorock/HDPE combination is a largely self-replicating form of marine infrastructure.

There maybe other largely self-replicating forms of infrastructure, yet this particular combination is easily deployable today.

The Thermal Geoengineering tech is a good beginning energy focus, yet many energy conversion methods can be used. Most importantly, with a high degree of confinement the policy-related guidelines likely can be crafted rather easily.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/56C4F848-8DB3-4DAE-BBA0-684C731D3992%40globalcoral.org.

Mike Landmeier

Feb 22, 2023, 4:42:04 PM

to Carbon Dioxide Removal

Removing CO2 from the air via the ocean has nothing to do with removing CO2 from the ocean. Removing CO2 from the air via the ocean is all about managing the hydrogen ion concentration at the ocean-atmosphere interface.

I think artificial upwelling (AU) is a dead-end concept because bringing up water from the ocean's depths increases the hydrogen ion concentration at the ocean's surface. I have searched for the ocean's pH by depth and have seen a lot of data showing the pH of the ocean drops as the depth approaches 500m. Some data suggest the pH approaches 7.3 at 500m. That's a lot of hydrogen ions relative to the standard ocean pH of 8.1.

Worse still, kelp farming depends on AU to replenish nutrients consumed by the growing kelp. The whole purpose of the kelp farm when used to capture and sequester CO2 is to create alkalinity. I have seen data suggesting the pH in the water surrounding a kelp field can be as high 9.0.

AU will bring water up from the ocean's depth. This water with a pH of 7.3 will completely wipe out the water with a pH of 9.0 long before the alkaline water equalizes with the atmosphere (and captures CO2 from the air).

AU with its significant supply of hydrogen ions completely negates the kelp farm's reason to exist.

Mike Landmeier

Clive Elsworth

Feb 22, 2023, 5:06:33 PM

to Mike Landmeier, Carbon Dioxide Removal

Mike

The purpose of artificial upwelling (AU) is to bring up nutrients to enable phytoplankton productivity to increase and thereby raise the pH of the ocean surface, i.e. reduce the concentration of hydronium ions. A raised surface pH reduces pCO2 and so increases the rate of atmospheric CO2 absorption.

Some parts of the ocean do indeed have a much lower pH at around 500m depth. These tend to be areas where surface productivity is already high. As dead organic material sinks down it rots, i.e. oxidizes to carbonic acid. (But the ocean is strongly buffered by the carbonate system, so it only makes a pH difference of < 1.)

Better areas for AU are therefore those that do not already have a high phytoplankton productivity at the surface and a corresponding low pH ~ 500 m below. Many of those unproductive areas have useful nutrients a few hundred meters down.

The best driver of upwelling would be to reverse the currently increasing surface stratification being caused by its rapid warming, which is curbing surface mixing. That cooling happens naturally every time the ocean surface is shaded from the sun by a marine cloud. A benefit of increased phytoplankton growth is their DMS emissions leading to marine cloud nucleation.

It's a self-reinforcing mechanism that's not often mentioned.

Clive

From: carbondiox...@googlegroups.com <carbondiox...@googlegroups.com> **On Behalf Of** Mike Landmeier
Sent: 22 February 2023 21:42
To: Carbon Dioxide Removal <CarbonDiox...@googlegroups.com>
Subject: Re: [CDR] Artificial Upwelling—A false Narrative

Removing CO2 from the air via the ocean has nothing to do with removing CO2 from the ocean. Removing CO2 from the air via the ocean is all about managing the hydrogen ion concentration at the ocean-atmosphere interface.

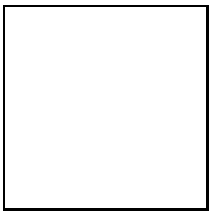

Figure 2

Caption

Theoretical concept of the processes stimulated by artificial upwelling (black lines) and their impact on the air-sea CO_2 flux and the surface ocean (box below air-sea boundary). Arrows in the atmosphere indicate air-sea CO_2 flux direction, arrows in the ocean indicate tracer movement and colors red/blue indicate respective water temperature increase/decrease. (a) Covers the increase in primary production and export production associated with the biological carbon pump (green), (b)–(e) cover the impacts of the individual processes associated with the solubility pump.

Source: AGU

~WRD1438.jpg

Sev Clarke

Feb 22, 2023, 11:32:46 PM

to Clive Elsworth, Mike Landmeier, Carbon Dioxide Removal

Clive and Mike,

Using my Buoyant Flakes concept to provide the slow-release nutrients missing from most ocean surface waters does not bring cold, CO2-rich water to the surface. The phytoplankton so nutriated would then reduce acidification of the surface waters by converting the dissolved CO2 into biomass and oxygen photosynthetically, thereby allowing more CO2 to be absorbed from the atmosphere. The activities of diel vertically migrating species, combined with the effect of sinking marine snow, would then sequester carbon in the depths. The method also obviates the likelihood of nutrient robbing and outgassing, whilst it makes use of industrial waste materials to provide sustainable nutrition - aspects akin to a circular economy.

Additional phytoplankton cause albedo enhancement of the surface waters, whilst the DMS the phytoplankton release increases marine cloud brightening - both effects cooling the waters and reducing their thermal stratification. Seaweed (*Sargassum* or kelp) may also be grown using these effects in waters otherwise too warm or too oligotrophic of the high seas. Thus, artificial upwelling may not be necessary.

Sev

Figure 2

Caption

Theoretical concept of the processes stimulated by artificial upwelling (black lines) and their impact on the air-sea CO_2 flux and the surface ocean (box below air-sea boundary). Arrows in the atmosphere indicate air-sea CO_2 flux direction, arrows in the ocean indicate tracer movement and colors red/blue indicate respective water temperature increase/decrease. (a) Covers the increase in primary production and export production associated with the biological carbon pump (green), (b)–(e) cover the impacts of the individual processes associated with the solubility pump.

Source: AGU

Michael Hayes

Feb 23, 2023, 1:51:04 PM

to Sev Clarke, Clive Elsworth, Mike Landmeier, Carbon Dioxide Removal

Sev, the use of fish chumming is typically illegal in many jurisdictions, and likely needs to be in international waters as well. Also, one can simply toss iron dust in some waters to chum fish. The actual CDR MRV numbers of both forms of chumming are likely irrelevant at scale.

Mid oceanic regenerative multi-trophic cultivation centers are needed, and additives to any 'regenerative' system will likely get closely looked at. Using largely confined infrastructure should allow for minimal input relative to output.

As a side note on high volume/low margin feed commodities and regulatory issues, there are no restrictions on animal feed ingredients and fish feed has spread many industrial toxins around the planet into many streams. The CDR value in fish feed is largely in growing the microalgae for the multi-trophic 'regenerative' feed system withing a tightly controlled infrastructure.

Sev Clarke

Feb 23, 2023, 5:45:26 PM

to Michael Hayes, Clive Elsworth, Mike Landmeier, Carbon Dioxide Removal

Mike,

Here are a few relevant facts:

- the flakes consist mainly of minerals that would be unattractive to fish and useless as chum. They contain nothing that can be regarded as nutritious to fish. Even when possibly coated with a thin coating of microalgae, the smell and taste of the ultra-slowly releasing minerals in the nearby water would probably be offputting to anything but plant life.
- chum only attracts fish where its concentration is higher than in adjacent water, so the fish know where to swim to. The flakes would be scattered over the entire regional ocean surface at a concentration of, perhaps, a few flakes per square metre. There would be no area of concentration to attract them.
- a key feature of the flakes is that they are designed NOT to provide nutrients that are sufficiently concentrated as to cause eutrophication, competitive toxin generation, and boom-bust cycling.
- the formulation of the flakes has been carefully designed to avoid industrial toxins and to keep trace metals at levels useful to life whilst never at harmful concentrations. Tests would be done to ensure that the rice husks contained no pesticide residues at levels that would be harmful in this application. Similarly, that the aluminium oxide content of the iron oxide-rich red mud were not net harmful to marine life. Most of the trace elements in the phosphatic clay waste component would likely be beneficial as they typically derive from the bodies of ancient sea life.

Cheers,

Sev

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/CABjtO1eRH4D1fgMkA17iF%2BFWye-1a-ZfHCi3yKnOmEFrHPRrBQ%40mail.gmail.com.

aoschlies

Mar 5, 2023, 6:53:47 PM

to Carbon Dioxide Removal

Our wording

"The water pumped up is mostly old enough to be equilibrated under preindustrial pCO2atm levels etc etc…"

was misleading and was intended to say that the water pumped up is mostly old enough so that it was equilibrated under preindustrial pCO2atm levels when it was formed, setting DIC^pre, which is the notation used in the paper. Subsequently, remineralized carbon, DIC^rem, has been added as also explained in the paper. In a Redfield world, any DIC^rem upwelled into a light-lit surface layer would, however, be consumed along with the consumption of also upwelled remineralized nutrients. It is thus the differences in DIC^pre that would directly impact the CO2 partial pressure difference between ambient and upwelled waters.

Hope this helps - don't blame the reviewers:)

Cheers,

-Andreas

Greg Rau

Mar 5, 2023, 7:42:43 PM

to aoschlies, Carbon Dioxide Removal

Andreas,

Thanks for clarifying. So in theory once all of the excess nutrients brought up with upwelling have been consumed (by marine photosynthesis obeying Redfield) so too will the excess CO2 brought up with upwelling be consumed. This then returns the resident CO2 (pCO2) to that

before the respiration of export production took effect = pre-industrial pCO2 (depending on water age) that is less than modern pCO2 hence a net CO2 sink is created. Interesting.

My only concern is the assumption that all of the excess nutrients brought up stay in the photic zone and are not advected below the photic zone prior to fueling photosynthesis and consuming CO2 in the C/nutrient ratio dictated by Redfield. This would leave excess CO2 unconsumed and potentially create a net CO2 source, but ocean modeling should be able to estimate this effect. Other tweaks to enhance the sink effect include upping the bio Redfield ratio e.g., through the use of N-fixing or macrophyte autotrophs. Also, adding alkalinity to such upwelling will consume CO2, leaving phytoplankton to use the excess nutrients to take up more air CO2.

Greg

--

--

Greg H. Rau, Ph.D.

Senior Research Scientist
Institute of Marine Sciences
Univer. California, Santa Cruz
https://www.researchgate.net/profile/Greg_Rau
Co-founder and manager, the Carbon Dioxide Removal Google group
Co-founder and CTO, Planetary Technologies, Inc.
510 582 5578

510 363 1519 c

Bhaskar M V

Mar 6, 2023, 9:45:42 PM

to Carbon Dioxide Removal

Is anyone working on Piping Light into Ocean Twilight Zone or even lower?

Piping Sunlight and Electric Light a few 100 meters into the Twilight Zone, or even lower, may be easier than Upwelling water.

Light is energy, Water is mass.

Handling energy is easier than handling mass.

Regards

Bhaskar

Director

Kadambari Consultants Pvt Ltd

Hyderabad. India

Ph. & WhatsApp : +91 92465 08213

https://www.linkedin.com/in/bhaskarmv/

Michael MacCracken

Mar 6, 2023, 10:24:13 PM

to Bhaskar M V, Carbon Dioxide Removal

Would the intent be to store heat energy or to stimulate additional biological activity. For the former, I'd guess the effort would far exceed the climatic benefit; if the latter, might be an interesting question for aquaculture, but again likely too small to have global carbon cycle benefits relative to the effort to sustain it.

Mike MacCracken

Bhaskar M V

Mar 6, 2023, 10:44:16 PM

to Michael MacCracken, Carbon Dioxide Removal

Mike

I was thinking of stimulating phytoplankton production in the depths of the ocean, in the twilight zone and lower, using the nutrients available there, instead of bringing up the nutrients to the photic zone.

This can be done along with the Ocean Fertilization and the missing nutrients can be fertilized in the depths of the ocean, instead of the surface of the ocean.

Promoting photosynthesis in the depths of the ocean will help reduce the amount of Carbon that is remineralised near the surface.

Any increase in photosynthesis in oceans will certainly help grow fish, if the right type of phytoplankton are grown. This is true for both surface and depths. Growing more fish in oceans will also contribute to carbon sequestration, directly and indirectly.

If we source more food from Oceans, dependance on land grown food will decrease and this frees up land and this land can be used to grow forests.

Do you have any basis for your statement:

"but again likely too small to have global carbon cycle benefits relative to the effort to sustain it"

Has anyone done even a small trial to understand the effort required, costs, benefits, etc.

The infrastructure required is quite simple, probably simpler than the Upwelling hardware.

Floating Lens and Light Pipes and

Floating Solar Panels and LED Rope Lights.

Regards

Bhaskar

Director

Kadambari Consultants Pvt Ltd

Hyderabad. India

Ph. & WhatsApp : +91 92465 08213

https://www.linkedin.com/in/bhaskarmv/

Amal Bhattarai

Mar 7, 2023, 2:21:41 AM

to Carbon Dioxide Removal

I have been looking into a CDR method via artificial-light induced primary production in the dark ocean, just below the photic layer.

Primary production in the dark, nutrient-rich water would concentrate carbon dissolved therein, creating a “void” of depleted carbon (and nutrients). Rapid sinking of dead phytoplankton once light is turned off would constitute “storage”. Re-filling the carbon void would occur from nearby sources of the now higher concentration carbon, importantly including the atmosphere…..constituting the “capture” part of the (admittedly slow) process.

Given available source of carbon in the dark waters, this method could scale indefinitely.

As a first step, a modeling study is needed; and I would be interested in collaborating on a 1D NPZD model for initial numbers. Please message me if interested !

If modeling shows promise, an experiment in near-ideal conditions under winter ice in the Arctic would be the first step.

A description and white paper are linked here: www.LIOS.one.

-Amal Bhattarai

Tom Goreau

Mar 7, 2023, 3:47:22 AM

to Bhaskar M V, Michael MacCracken, Carbon Dioxide Removal

There are vast populations of light limited Prochlorococcus and Synechococcus nanno-algae at great depth near the nutricline, where there are sufficient nutrients for them to grow faster if they had more light. They may be fussy about the light spectrum. This is an easy experiment to directly experimentally check so the costs and benefits can be based on measurements, not guesses.

Thomas J. F. Goreau, PhD
President, Global Coral Reef Alliance

Chief Scientist, Blue Regeneration SL
President, Biorock Technology Inc.

Technical Advisor, Blue Guardians Programme, SIDS DOCK

37 Pleasant Street, Cambridge, MA 02139

gor...@globalcoral.org
www.globalcoral.org
Skype: tomgoreau
Tel: (1) 617-864-4226 (leave message)

Books:

Geotherapy: Innovative Methods of Soil Fertility Restoration, Carbon Sequestration, and Reversing CO2 Increase

http://www.crcpress.com/product/isbn/9781466595392

Innovative Methods of Marine Ecosystem Restoration

http://www.crcpress.com/product/isbn/9781466557734

No one can change the past, everybody can change the future

It's much later than we think, especially if we don't think

Those with their heads in the sand will see the light when global warming and sea level rise wash the beach away

Geotherapy: Regenerating ecosystem services to reverse climate change

From: <carbondiox...@googlegroups.com> on behalf of Bhaskar M V <bhaska...@gmail.com>
Date: Tuesday, March 7, 2023 at 12:44 AM
To: Michael MacCracken <mmac...@comcast.net>
Cc: Carbon Dioxide Removal <carbondiox...@googlegroups.com>
Subject: Re: [CDR] Artificial Upwelling—A false Narrative

Mike

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/CALBeeSpRToNrQ%3DWByijai9oLrkw%3Diz4jpEcoc7vp6M0wVOtfRg%40mail.gmail.com.

Bhaskar M V

Mar 7, 2023, 5:52:54 AM

to Tom Goreau, Michael MacCracken, Carbon Dioxide Removal

Dr Goreau

Thanks.

What is the approximate depth of the nutricline?

Regards

Bhaskar

Director

Kadambari Consultants Pvt Ltd

Hyderabad. India

Ph. & WhatsApp : +91 92465 08213

https://www.linkedin.com/in/bhaskarmv/

Michael Hayes

Mar 7, 2023, 9:27:40 AM

to Bhaskar M V, Tom Goreau, Michael MacCracken, Carbon Dioxide Removal

Woods Hole has spent the last year studying the twilight zone, and I asked them to include a brief artificial deep light trial. I never heard back from them, yet I hope the idea got passed along.

Creating a network of artificial feeding sites for whales was my origional design goal as such sites would need multi-trophic aquaculture operations on a rather large scale. Lighting up the twilight zone coupled to a surface platform that grows feed fish would likely trigger a wide spectrum of wildlife accumulating in that area.

Going to gigaton scale CDR deep light operations may be difficult to justify on its own due to costs, yet combining the extra primary production from deep lights with other CDR/cooling efforts would seem to be predictable as the tech is rather simple. Some floating city designs

seem to show the use of deep lights, yet no specific mention of the deep lights being used for triggering primary production has been mentioned.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/CALBeeSq_2eMBOw%3D%3D60fjZb5qeTHV7iG9W%2BH3GOzjm4URAxR3DQ%40mail.gmail.com.

Amal Bhattarai

Mar 7, 2023, 12:13:13 PM

to Carbon Dioxide Removal

Concentrating 28 grams carbon per cubic meter in nutrient rich dark water does not require optimal choice of organisms (so long as they are willing to die, clump and sink when light is turned off!)

Experiments in algal bioreactors can determine optimal optical spectrum, intensity and frequency. Ocean-based experiments are neither easy nor cheap, but ESM ocean modeling is both…….and has moved well past the stage of “guesses”.

Greg Rau

Mar 7, 2023, 1:11:47 PM

to Carbon Dioxide Removal

With regard to increasing subsurface primary production, how does this relate to CDR if the resulting subsurface CO2 drawdown doesn't (in the near term) then contact air to effect air --> sea CO2 transfer? You would have to consider the time scale (up to 1000 yrs). of when that water eventually contacts air to deterimne how/if to award C credits.

Greg

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/0bdecafa-b252-4a7c-a1c1-654ea012b30cn%40googlegroups.com.

Mike Williamson

Mar 7, 2023, 1:17:35 PM

to Amal Bhattarai, Carbon Dioxide Removal

As an ocean engineer with more than 3 decades of experience deploying instrumentation in the deep ocean, I can attest that biofouling of any light source is likely an issue for transmission.

Mike Williamson

Williamson & Associates, Inc.

www.wassoc.com

From: carbondiox...@googlegroups.com <carbondiox...@googlegroups.com> on behalf of Amal Bhattarai <amalbh...@gmail.com>
Sent: Tuesday, March 7, 2023 9:13 AM

To: Carbon Dioxide Removal <CarbonDiox...@googlegroups.com>

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/0bdecafa-b252-4a7c-a1c1-654ea012b30cn%40googlegroups.com.

Michael Hayes

Mar 7, 2023, 1:34:18 PM

to Amal Bhattarai, Carbon Dioxide Removal

This thread started by questioning artificial upwelling. If tubes are used to trigger upwelling flow, lights used inside the tube likely will trigger primary production as the deeper water travels upward. Upwelling tubes are also known as Perpetual Salt Fountains, and their flow is rather sluggish.

Using a PSF as a photobioreactor has never been suggested within either the PSF or photobioreactor fields that I know of. I recommend that the upwelled water be temporarily captured within surface tanks to help cool ambient surface water, manage outgassing, and to help harvest the biomass.

The above senario needs a massive amount of rather large HDPE pipes and tanks, yet the PSF and biotic technologies are rather straight forward.

Michael Hayes

Mar 7, 2023, 1:56:22 PM

to Greg Rau, Carbon Dioxide Removal

Greg,

In the captured upwelling flow senario, the surface cultivation tanks can use surface air CO2 once the upwelled CO2 is used up.

The final water discharge flow can be pH adjusted as needed via abiotic means if the biotic means gets overwhelmed.

The more surface grow tanks the better for using up both aquatic and atmospheric CO2.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/1291316627.425272.1678212688078%40mail.yahoo.com.

Greg Rau

Mar 7, 2023, 2:28:36 PM

to Carbon Dioxide Removal, Mike Williamson

Thanks Mike. Biofouling can be our friend. If we have artificial, surface ocean structures/floats that attract biomass we can periodicallly harvest and sink that biomass. Because of the big chunks, this biomass C has a good chance that it makes it to the sediments before getting respired in the water column = long term C-questration from air. If lights attract BF then we have plant-derived, peel-off coating layers on the lenses that occationally shed to scuttle the attached critters. And speaking of lights, no need to do this at depth, just turn on the lights at night in surface waters so phytos crank 24/7, not 8/7. Of course you'd need to harness ocean energy to power the lights, and what better than OTEC that can also bring nutrients to the surface to fuel the bio (and cool the surface ocean). Any extra electricity can power alkalinity generation and more CDR. The Earth is saved and the human experiment gets to live on for a few more centuries, so Nobels all around? ;-)

Greg

ps Quote of the day: "We'll go down in history as the first society that wouldn't save itself because it wasn't cost-effective." Kurt Vonnegut

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/MW3PR18MB34817CC9C9006141251D00C4D2B79%40MW3PR18MB3481.namprd18.prod.outlook.com.

Michael Hayes

Mar 7, 2023, 3:25:48 PM

to Greg Rau, Carbon Dioxide Removal, Mike Williamson

We need to harvest some bio oil out of the light lens BF growth to help create more bio-oil derived HDPE tubing. Rapidly scaling up a largely self-replicating infrastructure likely is a better initial use of the biomass than simply depositing it on the seabed. A bio-plastic CDR infrastructure would be a form of C sink itself that can offer an indefinite storage time scale.

Amal Bhattarai

Mar 7, 2023, 5:17:21 PM

to Carbon Dioxide Removal

Greg,excellent questions. My calculation for a 200 meter target depth for artificial light shows carbon equilibration time is closer to 1000 days rather than 1000 years.

In perfectly still water, using a diffusivity constant value of 5e-5 cm2/s, molecular diffusion of CO2 to 200 m will take 6.3 years (11.5 days/meter).

But water is not still above 200m, and that reduces the "diffusion" time dramatically [M]. Also means carbon replenishment is faster from above than below, where water is indeed almost still. The contact with air of depleted water will also increase atmospheric CO2 diffusion and likely increase piston velocity to much more than the accepted 4 meters per day, especially including surface turbulence [M].

[M] stands for "modeling required".

I envision a 100 meter thick layer of lit volume several of square kilometers area. Lighting source would be wavelength-optimized pulsed lasers on the surface and light distribution is through cheap (1 penny per meter) optical fibers....nothing "high-tech".

The ideal situation is artificial light under arctic ice with CO2 measurement through holes in ice. That would approximate diffusion of CO2 for MRV and carbon credit measurements, and eliminates the need for CO2 molecular diffusion of hundreds of meters. [M]! [M]!

Amal Bhattarai

Mar 7, 2023, 5:18:38 PM

to Carbon Dioxide Removal

Mike, good point! Phytoplankton has an average lifetime of about a week, and artificial light all night long will reduce required growth time to concentrate local carbon to 3 days or so, and the lit volume is moved away easily for the next run. The short timeframe will reduce biofouling of optical fibers (cheap, inert glass anyway). Furthermore, operating under winter arctic ice dramatically reduces biofouling due to low levels of "bio".

Tom Goreau

Mar 7, 2023, 5:31:51 PM

to Bhaskar M V, Michael MacCracken, Carbon Dioxide Removal

The nutricline varies enormously from place to place, from very shallow to very deep, it depends on the vertical salinity and temperature profiles and the amount of wind and wave mixing, many people assume incorrectly that it is the base of the photic zone, which was determined from the larger phytoplankton before the vastly greater populations of nano plankton were discovered. People had been extracting phytoplankton with filters that the nano plankton passed right through, it took decades before people realized they had been throwing away the most abundant phytoplankton in the ocean, many of which are adapted to low light levels. Nutricline depth also is crucial for the vertical profiles of dissolved CO2 and alkalinity profiles and hence to CDR.

Thomas J. F. Goreau, PhD
President, Global Coral Reef Alliance

Chief Scientist, Blue Regeneration SL
President, Biorock Technology Inc.

Technical Advisor, Blue Guardians Programme, SIDS DOCK

37 Pleasant Street, Cambridge, MA 02139

gor...@globalcoral.org
www.globalcoral.org
Skype: tomgoreau
Tel: (1) 617-864-4226 (leave message)

Books:

Geotherapy: Innovative Methods of Soil Fertility Restoration, Carbon Sequestration, and Reversing CO2 Increase

http://www.crcpress.com/product/isbn/9781466595392

Innovative Methods of Marine Ecosystem Restoration

http://www.crcpress.com/product/isbn/9781466557734

No one can change the past, everybody can change the future

It's much later than we think, especially if we don't think

Those with their heads in the sand will see the light when global warming and sea level rise wash the beach away

Geotherapy: Regenerating ecosystem services to reverse climate change

From: Bhaskar M V <bhaska...@gmail.com>

Date: Tuesday, March 7, 2023 at 7:52 AM
To: Tom Goreau <gor...@globalcoral.org>

Michael Hayes

Mar 7, 2023, 6:07:46 PM

to Tom Goreau, Carbon Dioxide Removal

If containment is used, deep water fed grow tanks, we get to use microalgae as a H2 producer.

https://pubmed.ncbi.nlm.nih.gov/16328836/

Coupling emissions reduction and CDR while providing spot on MRV numbers will likely need a high level of containment, yet containment may not be as expensive as one would naturally initially think.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/88AC183E-E119-415F-BC61-DBB409311FC8%40globalcoral.org.

Tom Goreau

Mar 7, 2023, 6:31:44 PM

to Greg Rau, Carbon Dioxide Removal

They are still in the mixed photosynthetic layer that mixes with surface waters, but the rate of mixing is very dependent on short term high energy events, and of course slower for deeper waters.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/1291316627.425272.1678212688078%40mail.yahoo.com.

Michael Hayes

Mar 7, 2023, 6:44:57 PM

to Amal Bhattarai, Carbon Dioxide Removal

Amal, working under the ice as a form of containment is a sharp idea.

Extending this cultivation work to sea ice creation under the ice is one of my areas of interest. I realized that the tanks needed for sub-ice cultivation can also help keep super cooled brine right up under existing ice.

Using this combination of tank-based techs to create long ice ridges in thin ice regions to help collect snow, and thus build ice thickness, while operating an advanced cultivation operation is conceptually complex, yet it may be relatively technically simple.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/1fa27871-4a61-40d2-9f1c-240f808afb62n%40googlegroups.com.

Tom Goreau

Mar 7, 2023, 6:45:38 PM

to Amal Bhattarai, Carbon Dioxide Removal

Calculations using molecular diffusion coefficients do not describe the reality of turbulent eddies, and are too low to describe eddy diffusion along isopycnal (density) surfaces by a factor of a million to a hundred million (10 to the 6^{th} to 10 to the 8^{th})!

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/8c50f6d1-3047-4c32-8b6b-47a968b9759en%40googlegroups.com.

Amal Bhattarai

Mar 7, 2023, 7:38:40 PM

to Carbon Dioxide Removal

Indeed, I was responding to Gregs question by estimating an upper bound for diffusion time….in perfectly still water.

Any amount of water mixing helps speed up the carbon “void” equalization….a freebie.

It is a concern if water under the void travels up, taking the dead phytoplankton towards the surface…however this is unlikely due to the temperature gradient and further unlikely in case of water under arctic ice….where there is another freebie of a lack of isopycnal !

All of this is of course to be confirmed with a modeling study, which will be more accurate than the back of my envelope! I would be happy to pay for a couple of day’s time to a grad student to run some models. Any takers here?

Michael Hayes

Mar 7, 2023, 7:41:22 PM

to Amal Bhattarai, Carbon Dioxide Removal

I'll pitch in cash.....

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/0f1cceed-28d9-4635-be03-19a4ef17bd49n%40googlegroups.com.

Tom Goreau

Mar 7, 2023, 7:41:30 PM

to Amal Bhattarai, Carbon Dioxide Removal

Don’t forget that Antarctic phytoplankton are severely limited by lack of light in winter darkness, that’s precisely why there are so much unused surface nutrients.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/0f1cceed-28d9-4635-be03-19a4ef17bd49n%40googlegroups.com.

Amal Bhattarai

Mar 7, 2023, 7:52:07 PM

to Carbon Dioxide Removal

Exactly, although I feel the Arctic is the better location, because sunk biomass will not upwell for a very long time compared to the Antarctic.

Michael Hayes

Mar 7, 2023, 7:54:36 PM

to Tom Goreau, Amal Bhattarai, Carbon Dioxide Removal

I'm thinking that a few buoyant cultivation tanks can support one or more tanks full of super cooled brine directly up against the underside of sea ice. By keeping the super cooled brine tanks up against the bottom of the ice sheet, more ice and more super cooled brine will likely be produced.

Moving this tank farm around in circles may help create thick sea ice while cultivating a huge amount of biomass with the least amount of equipment and energy. I would advise a model of a 100 km dia sea ice/cultivation infrastructure x ~500. The Arctic international waters are not large.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/B30C931C-7DEE-4AEC-B7ED-39D13B7D866B%40globalcoral.org.

Michael Hayes

Mar 7, 2023, 7:57:57 PM

to Amal Bhattarai, Carbon Dioxide Removal

Don't sink the biomass, use it.

Survival is all about use, not waste.

To view this discussion on the web visit https://groups.google.com/d/msgid/CarbonDioxideRemoval/a695cbd8-a0b2-471a-8790-58e4d448b901n%40googlegroups.com.