False claims from geoengineers, and other recent developments in Latin America

October 10, 2023

Photo Credit: Antonio Lapa

By Anja Chalmin

Two years ago, we provided an inventory of geoengineering projects on the Latin American continent. As then, most geoengineering activities in Latin America continue to be driven or carried out by North American and European companies and research projects and/or the local fossil energy industry. The number of projects that seek to profit from carbon credits under the guise of climate-related activities has increased, particularly in the marine sector, despite scientists' warnings of disastrous effects on the marine environment. While the total number of geoengineering projects in Latin America has increased over the past two years, the number of known cancelled and discontinued geoengineering projects is now almost double the number of known ongoing and planned projects. As the interactive geoengineering map produced by ETC Group and the Heinrich Böll Foundation shows, most of the known ongoing and planned projects are located in Brazil, Chile, Mexico and Argentina. Current developments in marine, terrestrial and solar geoengineering in Latin America are outlined below.

Brazil's Petrobas is producing more oil with EOR, while trying to portray it as a "decarbonization" effort.

The Brazilian state-owned oil company Petropas has been developing the Santos Basin carbon capture & storage (CCS) project for about 15 years – with the aim of producing more oil.

The CO_2 captured at Santos Basin is used for EOR – which involves pumping pressurized CO_2 into oil reservoirs to recover remaining reserves from ageing oil fields and to extract otherwise inaccessible fossil fuels, thereby significantly increasing fossil fuel production. The oil industry developed EOR technology half a century ago to tap hard-to-reach deep oil deposits, and is now trying to market it with a climate-friendly image. The industry hides the fact that when CO_2 is injected for EOR, about a third of the injected CO_2 immediately escapes back into the atmosphere. Other drawbacks of CO_2-EOR include the fact that CO_2 capture technology is very energy-intensive, and the fossil fuels extracted by the EOR process generate countless additional emissions. There is also no guarantee that the CO_2 will remain safely underground in the long term, as tectonic plate movements can create fractures that allow the trapped CO_2 to escape, or because many fossil fuel deposits are traversed by unmapped wells.

The CCS-EOR project is located on the offshore Santos Basin pre-salt oil field, 300 kilometers off the coast of Rio de Janeiro. The project is part of a floating production, storage and offloading facility that includes CO_2 capture and injection facilities. A total of 21 CO_2 capture and injection plants are currently in operation. By December 2022,

Petrobas said it had injected 40.8 million tonnes of CO_2 into the seabed and plans to double this amount by 2025.

To date, Petrobas has carried out EOR activities in the Tupi, Sapinhoá and Lapa oil fields. By 2026, two more CO_2 capture and EOR platforms will be installed in the Búzios oil field. The Búzios oil field is another large deepwater oil field located in the Santos Basin, about 230 kilometers off the coast of Rio de Janeiro and north of the Tupi oil field. Búzios was discovered in 2010 and oil production started in 2018.

In addition, since 2022, Petrobras has been in talks with other companies in Brazil to explore the establishment of a CCS hub. The hub would capture CO_2 from industrial facilities, such as cement and steel plants, and Petrobas would use the captured CO_2 for EOR off the coast of Brazil. Petrobras is currently evaluating the possibility of a pilot project in Rio de Janeiro with a capture capacity of 0.1 million tonnes. No investment decision has yet been made.

Petrobas is also involved in CEPAC, the Brazilian Center of Excellence for Research and Innovation in Petroleum, Mineral Resources and Carbon Storage, a joint initiative with the Pontifical Catholic University of Rio Grande do Sul (PUCRS). The R&D agency was created to promote CCS and explore ways to make CCS commercially viable. CEPAC's sponsors include the Global CCS Institute and the Brazilian National Agency for Petroleum, Natural Gas and Biofuels.

Petrobas is marketing its EOR and CCS plans as decarbonization efforts – but the high energy requirements of EOR and the additional production volumes will result in significant additional emissions. As Petrobas continues to develop new oil reserves, for example in the Santos Basin, the company will continue to produce large amounts of greenhouse gases (GHG).

The World Bank and CCS development in Mexico

The World Bank CCS Trust Fund seeks to initiate programmes to accelerate the development and deployment of CCS in the Global South. It was established in 2009 with funding from the Global CCS Institute and the governments of the UK and Norway. In Mexico, the programme aimed to assess and map CO_2 sources and storage sites, support a national roadmap for CC(U)S development, and develop a pilot CO_2 capture project at a gas-fired power plant. It also provided training and capacity building for CC(U)S.

The World Bank Phase 1 project contributed to Mexico's first national technology roadmap for carbon capture, utilization and storage (CCUS), which was published in 2014 and updated in 2018. During this period, the Mexican government worked with public agencies and participants from academia and industry. There is currently no indication that the programme will be continued. The roadmap aimed to build some capacity in CCS, EOR, geological storage, monitoring and CCUS. It also announced plans for two CCS pilot projects and established a center called CEMCCUS (Centro Mexicano de CCUS), a Mexican Center for CC(U)S. In 2018, Mexico's National Institute of Electricity and Clean Energies (INEEL) was selected to lead CEMCCUS. The next update was planned for 2022, but the government that took office at the end of 2018 has not supported the continuation of these projects.

The World Bank Phase 2 project sought to develop a CCS pilot project. The national roadmap mentioned above announced plans for two pilot projects: The first pilot was to test CO_2 capture and EOR at PEMEX's Cinco Presidentes production site in Agua Dulce, located in the state of Veracruz. The captured CO_2 was to be used for EOR at the Brillante oil field. The second pilot, to assess the technical and economic feasibility of CO_2 capture, was to take place at PEMEX's 250-MW Poza Rica natural gas-fired thermoelectric power plant in the municipality of Tihuatlán. Both pilots were announced between 2019 and 2021 but have been suspended by the current Mexican government. State oil company PEMEX said it had carried out some evaluations of CCS, CCUS and EOR, but "*there are no plans for the implementation of such a project*". After being denounced for increased GHG emissions, PEMEX announced measures to reduce emissions, which again do not include CC(U)S projects.

The Mexican government has launched a Special Climate Change Programme (PECC) 2021-2024 to set the course for adaptation and mitigation measures against the negative impacts of climate change. The programme is not directly linked to the World Bank-supported roadmap, but includes the development of studies on CCS, CCUS and geological storage of CO_2. SEMARNAT, the Mexican Ministry of Environment and Natural Resources, is overseeing the implementation. There is no available information on the implementation of these studies.

CCUS – Research and development news

A proposed CCUS methanol project in Chile

Most CCUS projects in Latin America have been developed in the context of the beverage and cement industries. A new approach is the AMER project, to be developed in the Antofagasta region of northwest Chile as part of Chile's National Hydrogen Plan. The Chilean Ministry of Economy (Corfo) has selected six projects to develop green hydrogen in Chile in 2021. The Antofagasta Mining Energy Renewable (AMER) project, proposed by France's Air Liquide, aims to produce green hydrogen, capture CO_2 and produce methanol from these two feedstocks. The source of the CO_2 is not yet publicly known. According to press reports, Air Liquide, a major multinational supplier of industrial gases, has signed memorandums of understanding with EDF Renewables, methanol producer Proman, Sowitec (solar and wind energy) and Chilean fuel trader COPEC. The project is expected to be operational by 2025.

Danish CO_2 capture technology in breweries and bottlers

Brewers and bottlers, including Argentina's CCU Lujan brewery, Brazil's FEMSA, Chile's AB InBev and Puerto Rico's CCPRB, have purchased CO_2 capture systems from Denmark's Pentair Union Engineering to recover CO_2 from fermentation processes. The captured CO_2 is then purified and used to carbonate beverages. The Danish company is also responsible for the maintenance of the technical systems. The CCU brewery in Temuco, Chile, is designed to capture up to 1,500 kilograms of CO_2 per hour, according to Union Engineering. The capture process is energy-intensive and generates additional GHG, depending on the energy source. However, the CCU brewery in Temuco is scheduled to start running on one hundred percent renewable energy this year. But the main drawback of CCUS remains: once the carbonated drinks are consumed, the CO_2 is released back into the atmosphere. Read more about CCUS here.

Mexican CEMEX is taking part in CC(U)S research programs in North America & Europe

CEMEX, a global cement and building materials company, was founded in Mexico in 1906 and became a global player by the end of the last century, operating more than 1,400 cement production and mixing plants worldwide. CEMEX has been involved in various publicly funded R&D activities for the development of CCS and CCUS for about 15 years, mainly in North America and Europe. For example, CEMEX is currently involved in the pan-European research projects eCOCO2 and LEILAC, co-funded by the European Union as part of its Horizon 2020 programme. The eCOCO2 project aims to develop a scalable conversion process to produce synthetic aviation fuels from CO_2, hydrogen, and electricity. The pan-European research programme "LEILAC – Low Emissions Intensity Lime And Cement" aims to reduce CO_2 emissions in the cement and lime industry through CO_2 capture. CEMEX is a research partner in both LEILAC 1 (2009-2021) and LEILAC 2 (2020-2025).

In the US, CEMEX has implemented several projects funded by the US Department of Energy (US-DOE), such as the Balcones cement plant in New Braunfeld, Texas, and at its Victorville cement plant in California. In New Braunfeld, a US-DOE-funded project on membrane-based CO_2 capture technology ran until March 2023. Findings included that energy costs were very high and that the membrane needed further development. Since November 2022, CEMEX has been investigating a non-aqueous amine CO_2 capture technology for cement production at this site, developed by the Research Triangle Institute. The project is funded by the US-DOE with US$ 3.7 million. Since 2021, the US-DOE has been funding a project to build a pilot CO_2 capture plant at CEMEX's Victorville cement plant. The goal of the project is to identify cost-effective and scalable solutions for CO_2 capture, as well as commercially viable solutions for the use of CO_2 in the cement industry.

In February 2023, the US-DOE approved US$ 3.2 million to fund a joint R&D programme between CEMEX and Synhelion, a Swiss producer of liquid hydrocarbon fuels. The project aims to replace fossil fuels with solar energy in the production of cement clinker, a step in the cement manufacturing process. Cement clinker is made by melting limestone, clay, and other materials in a kiln at around 1,500°C. The project also intends to develop a more efficient and cost-effective CO_2 capture process. The captured CO_2 will be converted into synthetic fuel using the (energy-intensive) Synhelion technology.

In addition to the overseas collaborations mentioned above, CEMEX has entered into many other collaborations in recent years to research and develop CC(U)S for the cement industry, including agreements with BP, the CCUS companies Carbon8 and Carbon Upcycling Technologies, and the synfuel company ETFuels. There is no information available about CEMEX's research activities on CC(U)S in the Global North being implemented at

cement plants in Latin America. However, in July 2023, CEMEX announced that it had increased its stake in Carbon Upcycling Technologies (CUT) and plans to introduce CUT technology at selected cement plants in Mexico.

Further land-based geoengineering activities

German company discovers Brazilian soil as a source of income

Germany's InPlanet GmbH is spreading finely crushed silicate rock from mines for enhanced weathering on agricultural land in south-east Brazil. By March 2023, the company expects to have applied more than 1,500 tonnes of crushed rock on eleven farms. InPlanet's core business is the sale of carbon credits, for example to the Carbon[x] and Frontier carbon markets. According to InPlanet, the "*carbon will be locked away for 1000+ years*" and there are "*no negative side effects to the environment*". However, weathering processes can release pollutants such as heavy metals from mining products, which accumulate in agricultural soils. InPlanet recommends enhanced weathering for tropical regions with nutrient-poor soils. This contradicts evidence that both low and high temperatures limit weathering. Enhanced weathering poses risks to the environment and soil quality, but the potential damage is being swept under the rug in the interests of selling carbon credits.

Bio-Energy with carbon capture and storage (BECCS) in Brazil

BECCS aims to capture CO_2 from bioenergy applications and either store it with CCS or reuse it with CCUS. Large-scale deployment of BECCS would have significant negative impacts on climate, ecosystems and biodiversity, as well as profound negative social impacts. In Brazil, FS Agrisolutions is conducting feasibility studies for the development of a BECCS plant at its Lucas do Rio Verde corn-to-ethanol biorefinery complex in the state of Mato Grosso. The project involves the underground injection of captured CO_2 near the refinery. An investment decision is pending. Ten years ago, a first attempt to implement a BECCS project in Brazil failed, because the Brazilian government was unwilling to provide significant funding.

Trials with biochar in Chile

The University of La Frontera in Temuco, Chile, has been researching the use and carbon capture potential of biochar for more than a decade. The biochar is produced from agricultural and forestry feedstocks and is being tested on different soils in the agricultural region around Temuco, Chile. As with BECCS, land use is an issue for biochar if it is to be implemented on a large scale. In addition, there are conflicting views on the suitability of biochar for long-term CO_2 storage. Of all the other biochar field trials funded by donors from the Global North and conducted in seven Latin American countries until 2016, no (known) follow-on projects have emerged.

ECLAC & C2G promote the use of geoengineering in Latin America

The US-based Carnegie Climate Governance Initiative (C2G) was launched in 2017 by the Carnegie Council for Ethics in International Affairs. The C2G describes itself as "impartial" on geoengineering. The initiative's stated goal is to promote dialogue on geoengineering technologies, particularly solar radiation management, large-scale CO_2 removal, and marine geoengineering, and to develop a governance framework for solar geoengineering. To achieve these goals, C2G communicates through publications, events, podcasts, etc. Most contributions to these activities are from geoengineering advocates. C2G has suggested and sponsored several publications by the Economic Commission for Latin America and the Caribbean (ECLAC) on geoengineering technologies in Latin America. In January 2023, C2G published a joint report with ECLAC discussing and advocating for geoengineering approaches to carbon removal in Latin America.

HIF Global falsely claims to produce "CO_2-neutral" synfuel in Chile

An introduction to HIF Global

Highly Innovative Fuels Global (HIF Global), headquartered in Santjago, Chile, was founded in 2016 with the aim of developing synfuel plants around the world. The plants are expected to produce "CO_2-neutral" fuel. Subsidiaries HIF Chile, HIF USA, HIF Asia Pacific and HIF EMEA have been established. Implementation is most advanced in Chile, where the first litres of synfuel were produced in December 2022 at the HIF Chile Haru Oni project site in

the Tehuel Aike Estate, Punta Arenas, Magallanes region. According to a project description online until 2022 (https://www.haruoni.com/#/en), Haru Oni was to use wind power to produce "*CO_2-neutral*" fuel from captured CO_2, water and green energy, and to be the world's first industrial-scale plant to capture the required CO_2 directly from the air (DAC) – hence the choice of a site in the windy province of Magallanes in Chile.

Claim and Reality

In April 2023, a video from the Donut Media channel revealed that the DAC component was still missing and that the CO_2 was being delivered by truck. In the same month, HIF Global continued to claim that the plant in Chile was producing carbon-neutral gasoline, even though this is clearly not the case. HIF has since stated that the CO_2 comes from a biogenic source, possibly from the fermentation process in a brewery.

Truckloads of CO_2 are likely to be sufficient for the targeted production volume of 350 litres of synfuel per day in 2023, but not for the planned expansion to 550 million litres per year in 2027. In 2021, DAC company Global Thermostat announced that it would supply its DAC technology to Haru Oni, but this didn't materialize. In March 2023, HIF announced a possible collaboration with DAC manufacturer Mosaic Materials to test the DAC technology. The press release makes it clear that this DAC technology is (also) still under development. Given the announced targets of 55 and 550 million litres of synfuel in two and four years respectively, it is surprising that HIF is unable to clearly communicate which CO_2 feedstock it intends to use to operate the plant. However, in September 2023, the construction of a DAC plant was announced for 2024.

The energy supply for this site is also not yet secured, as a building application for a wind farm with 65 wind turbines (325 MW), submitted by HIF in February 2022, was withdrawn in October 2022 due to numerous significant deficiencies.

Poor prospects for the future of the project

Until recently, HIF and its project partners communicated that Haru Oni would use DAC technology. HIF has chosen a technology that is very energy-intensive and not yet fully developed – the newly selected DAC partner, Mosaic Materials, is currently building a DAC prototype. The announced DAC plant has not yet been built and the production target of 550 million liters of synfuel has recently been postponed from 2026 to 2027. The planned increase in current annual production by a factor of 430 to 55 million liters by 2025 and by a factor of 4,300 to 550 million liters by 2027 is unlikely because the necessary structures are not yet in place or under construction. In addition, the efficiency is not competitive with electric cars, as synthetic gasoline requires many times more renewable energy to achieve the same performance as battery electric vehicles. In addition, the ongoing operation of the internal combustion engine with e-fuels still emits exhaust gases, soot and nitrogen oxides, as well as noise.

In June 2023 HIF Global announced plans for a new eFuels project in Paysandú, Uruguay.

Marine geoengineering companies promote carbon trading – without sound science or consideration of the potential risk

In April 2023, the United Nations agreed on a treaty to protect the high seas, aiming to reverse destructive trends that threaten the health of the oceans. At the same time, the oceans are increasingly being touted as CO_2 sinks to combat global warming. The buzzword is marine geoengineering, and the business opportunities companies see on the horizon are huge.

Researchers warn that marine geoengineering could be disastrous for marine life. For example, projects to increase the carbon storage capacity of the oceans by making seawater more alkaline can have devastating effects on the marine food web. Minerals such as olivine cannot effectively increase the ocean's carbon uptake, but they can seriously disrupt the composition of marine snow, which serves as a food source for many marine species. The International Maritime Organisation (IMO) states that marine geoengineering technologies "*have the potential to cause deleterious effects that are widespread, long-lasting or severe*" and highlights that "*there is considerable uncertainty regarding the effects on the marine environment, human health, and on other uses of the ocean*".

It is a common refrain that knowledge of the oceans, including ocean cycles and ecosystems, is still very limited.

This leaves unanswered questions about the impact of marine geoengineering, and the size of the oceans makes it almost impossible to measure. On this basis, there is no way for carbon credits to safely sell marine carbon credits.

On the coasts of Latin America, the main players to date have been companies seeking to generate income from ocean fertilization, Ocean Alkalinity Enhancement (OAE) or algae carbon sequestration.

Vesta is driving the sale of Ocean Alkalinity Enhancement-based carbon credits – while still conducting field studies to prove the effectiveness of OAE.

Vesta, a US company founded in 2019, aims to test and scale OAE using olivine – a soft, green volcanic rock – on beaches. Vesta plans to mine olivine, grind it into small pebbles and spread the pebbles on beaches where wave action is expected to support the weathering process.

Since 2020, Vesta has had plans to conduct OAE field tests in two adjacent bays northwest of Puerto Plata in the Dominican Republic. The tests were to be conducted in two phases: an environmental baseline assessment in phase 1; the application of olivine and environmental follow-up assessments in phase 2. Information on the current status of the project is contradictory: the Project Vesta Advisory Committee (PVAC) website discusses the approval of phase 1. The Vesta website and other sources refer to mesocosm experiments with olivine, which according to the experiment description are not part of phase 1. Although the experiment has been planned for at least three years and may already have started, there is still no public information about the start, duration, and scale of the experiments.

The PVAC has been in existence since 2023 (possibly longer) and is based at the American University in Washington DC. The committee is mainly concerned with the experiments in the Dominican Republic, but only has members from the northern hemisphere (10) and Australia (1). The PVAC analysed Vesta's experimental design for Phase 1 and found many claims to be "*unproven*" or "*exaggerated*". It also found many inaccuracies in the experimental design and in the chemical and ecological basis of the experiments. The PVAC also stated "*that Vesta makes the impression as if they already know the outcome of the study*". Scientists and the media have previously expressed concern that Vesta is "*overselling the potential or discounting the difficulties of its approach*". Scientists have described Project Vesta as a project set up by entrepreneurs to appeal to entrepreneurs. Vesta presents itself as a public benefit corporation, but has registered "Vesta" as a protected trademark in the US. The fact that Vesta's commercial interests are paramount is also demonstrated by the sale of carbon credits, e.g. to Carbon[x] in March 2023. In addition, as of January 2023, a sales director is being sought to take Coastal Carbon Capture's carbon sales to the next level; the job posting promises unlimited growth potential and a booming market for carbon removal.

OAE poses major risks to the marine environment and has a significant carbon footprint due to the large volumes of rock that need to be mined, crushed, transported and distributed. Read more about OAR here.

Canadian company aims to dump fertilizer off the coast of Latin America

Since 2016, Oceaneos, an organization linked to previous illegal experiments in Canada, has been applying to the Chilean government for permission to test ocean fertilization with iron. Oceaneos had similar plans in Peru and Argentina. Chilean and Peruvian scientists have strongly criticized these plans – the iron fertilization experiment "*would seriously endanger national marine ecosystems and, furthermore, various fisheries*". Oceaneos' applications for the experiments were not approved. In Argentina, the negotiations became known in 2019. Since ~2021, there has been no evidence that the company continues to operate in Argentina. Oceaneos still has offices and employees in Peru and Chile. Since 2022, Oceaneos has conducted experiments on plankton and seawater chemistry off the Chilean coast, but continues to promote ocean fertilization with iron, including on several websites. As ocean fertilization violates the moratoria of the London Convention and the CBD, Oceaneos presents its activities as a method of increasing fish stocks. The owners of Oceaneos also own a fertilizer company, Soileos, which is currently gaining a foothold in Chile and whose portfolio includes the production of iron fertiliser.

Ocean fertilization can disrupt the ecological balance, for example through harmful algal blooms and increased ocean acidification. Read more about ocean fertilization here.

Fast-growing and invasive seaweed tested in Mexican waters

British company Seafields is using Mexican waters to experiment with the fast-growing and invasive marine

seaweed Sargassum. The company plans to harvest the algae, bale it, dump it in the deep sea and sell carbon credits. The algae will be fed by artificial upwelling, which involves pumping nutrient-rich water from the deep sea through pipes several hundred meters long to a rather nutrient-poor sea surface, where the sargassum will grow free floating in the water. Since 2021, Seafields has been testing sargassum, sea farm equipment and artificial buoyancy technology at several locations, including in Mexican waters. The exact location, duration and scope of the tests have not been disclosed.

US company to dump seaweed in Caribbean to sell CO_2 credits

A Californian company, Pull to Refresh, plans to use semi-autonomous ships to capture seaweed, dump it in the deep sea and sell it as carbon credits. The company promises that the carbon will be sequestered for more than a hundred years – although the basis for this promise is unclear. The first project will be in the Caribbean. The exact location, timing and size of the project has not yet been announced, but Pull to Refresh operates a vessel manufacturing factory in Panama since 2022, which could be a clue to the project's location.

UK company to sink seaweed in Caribbean to sell CO_2 credits

UK-based Seaweed Generation Ltd aims to develop robots to grow, capture and sink sargassum seaweed into the deep sea. The company has announced a first sargassum sinking pilot test in the Caribbean in 2023, with further growth in 2024, and expects "*our main source of revenue will be from carbon dioxide removal credits, thanks to sinking Sargassum into the deep ocean*". The exact location, timing and size of the project have not yet been announced. The company's scientific advisory board is made up of seven people, six from the UK and US and one from Antigua and Barbuda, which could be a clue to the location of the trial.

Research into algae biodiesel production in Argentina

Oil Fox was founded in Argentina in 1997 and has been researching microalgae biodiesel since 2000. Biodiesel has been produced since 2010, albeit with a small proportion of algae. The use of algae in biodiesel production seems to play a minor role, but Oil Fox continues to research it. Corporate sponsors include the Argentine Air Force, Dow Chemical and the mining industry.

Algae-based biofuels have been researched for many years, but it has not yet been proven that algal biomass is an economically viable source of biofuels.

Algae and artificial trees to combat urban air pollution

The Mexican start-up BiomiTech was founded in 2016 and is based in Mexico City. The company has developed an artificial tree called the BioUrban, which uses microalgae to filter CO_2, CO and NO_x from the air. There are three versions of the BioUrban. One of the artificial trees, the BioUrban 2.0, is four meters high, 2.75 meters in diameter, consists of a steel casing and contains 500 litres of microalgae solution. BiomiTech plans to increase the amount of air filtered by the BioUrban and use the waste algae as a raw material for products such as biogas and biofuels. By 2022, only a few BioUrbans had been installed, but in February 2023 it was reported that around 200 units would be installed in Latin American cities with high levels of air pollution, including Mexico City, Santiago de Chile, Brasilia and Lima.

Solar radiation management comes to Latin America pushed by the Global North

The UK-based DEGREES (**DE**veloping country **G**overnance, **RE**search and **E**valuation for **S**RM) initiative aims to promote research on Solar Radiation Management (SRM) around the globe. Since 2018, the DEGREES Modelling Fund (DMF) has provided funding to scientists in the Global South to model SRM approaches and analyze the potential benefits and impacts of SRM in their regions. This is not an initiative to fund Global South researchers on the most pressing issues in their countries, but simply to promote research on solar geoengineering, in most cases with a narrow approach of comparing the threats of climate change with the risk that solar geoengineering would pose. There is no consideration of other alternatives to meet the challenges of climate change. By providing small amounts of narrowly targeted funding to research teams in the Global South, the Degrees initiative claims to be "*the largest SRM research initiative in the world by number of scientists*", and that most of them are in the Global South.

There are now more than twenty teams around the world working with DEGREES, and most are modelling the use of Stratospheric Aerosol Injection (SAI). The modelling is based on climate models developed in the Global North: GeoMIP (Geoengineering Model Intercomparison Project) and GLENS (Geoengineering Large Ensemble Project). The studies are limited to the risks or benefits of the application of solar geoengineering compared to the risks of climate change. The research teams in Latin America focus on the following areas:

- Argentina: In Argentina, the DMF research team is based in Buenos Aires, at the University of Buenos Aires and at the Argentina National Research Council. Since 2018, the research team has been modelling possible impacts of SRM on freshwater availability and temperatures in the La Plata Basin in southeastern South America.
- Brazil: In Brazil, the DMF research team is based at the Brazil Instituto de Recursos Naturais and the Universidade Federal de Itajubá. Since 2023, the research team has been modelling possible effects of SRM on cyclones in the Southern Hemisphere
- Chile: In Chile, the DMF research team is based at the Universidad de Concepción. Since 2023, the research team has been modelling possible effects of SRM on glaciers in South America.
- Jamaica: In Jamaica, the DMF research team is based at the University of the West Indies in Mona and collaborates with the Institute of Meteorology in Cuba. Since 2018, the research team has been modelling the possible impacts of SAI on future Caribbean climate and agriculture. From 2018 to 2021, the research team worked on "*A proposal to assess the effects of SRM on future Caribbean climate*", and since 2022 on "*Caribbean agriculture under SRM: a case study in Jamaica*".

In June 2023, the Degrees Initiative launched a call for proposals for scientists in Central America, inviting applications from Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama. The applications must model and examine how the impacts of SRM compare to those of a warmed world.

Commercial solar geoengineering experiments in Mexico

Make Sunsets, Inc. was founded in October 2022 by Luke Iseman and Andrew Song and is based in South Dakota, USA. The company aims to "*deploy reflective clouds in the stratosphere*" by releasing sulfur dioxide (SO_2) particles. Balloons filled with helium and a small amount of SO_2 are supposed to rise into the stratosphere, burst and release the SO_2 particles. Based on this approach, the company has started a business selling 'cooling credits' to companies that want to avoid reducing their emissions. Make Sunsets conducted test flights with helium weather balloons and SO_2 from Baja California, Mexico, in April and in December 2022 – without the consent of the Mexican government and the surrounding communities. In January 2023, one month after the Baja California experiments became public knowledge, the Mexican government decided to put the precautionary principle and climate justice ahead of SRM experiments and banned them, setting a unique initiative in the continent and the rest of the world.

Other reasons for the Mexican government's decision were the evidence that these techniques do not reduce GHG emissions and have potential and unequal impacts on the environment, health and communities. In addition, any such action must be subject to the free, prior and informed consultation and consent of the communities or Indigenous peoples whose territories are used for such purposes. Make Sunsets has left Mexico but has since planned and carried out further experiments in the USA. Read more about the risks and funding of the experiment here.

Proposals for an international treaty to ban solar geoengineering

Since January 2022, a group of more than 400 concerned climate scientists from around the world have been calling for an International Solar-Geoengineering Non-Use Agreement, arguing that SRM poses unacceptable risks if ever implemented. The group included scientists from Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru, Trinidad and Tobago and Uruguay.

Scientists at the Intergovernmental Panel on Climate Change (IPCC) have warned that "*solar radiation modification approaches, if they were to be implemented, introduce a widespread range of new risks to people and ecosystems, which are not well understood*".

Summary table of known geoengineering projects in Latin America

Version A: countries & GE-technologies

Country	Geoengineering technologies projected/ongoing
Antigua	Algae, Weather modification
Argentina	Algae, CCUS, Ocean fertilization, Research project (SRM), Weather modification
Belize	Biochar
Bolivia	Weather modification
Brazil	BECCS, Biochar, Enhanced weathering, CCS, CCUS, Research projects (SRM, CCS), Weather modification
Chile	Biochar, CCUS, Ocean fertilization, Research project (SRM), Marine cloud brightening, Weather modification
Costa Rica	Biochar, Research project (Weather modification), Weather modification
Cuba	Weather modification
Dominican Republic	Enhanced weathering, Weather modification
Ecuador	Weather modification
Guatemala	Weather modification
Guyana	Biochar
Haiti	Biochar
Honduras	Weather modification
Jamaica	Research project (SRM), Weather modification
Mexico	Algae, CCS, CCUS, Research projects (CCS, CCUS, SRM), SAI, Weather modification
Panama	Algae, Weather modification
Peru	Artificial upwelling, Ocean fertilization, Other, Weather modification
Puerto Rico	CCUS, Weather modification
Saint Vincent	Algae
Uruguay	CCUS
Venezuela	Weather modification

Version B: countries & GE-technologies & projects

Country	Geoengineering technology	Projects (ongoing, planned, completed, cancelled)
Antigua	Algae	Seaweed Generation Ltd pilot trial
	Weather modification	Antigua Cloud Seeding Project

	Algae	Oil Fox Biodiesel
	CCUS	CCU Lujan Brewery
	Ocean fertilization	Oceaneos Argentina
Argentina	Research project (SRM)	DEGREES Initiative: Argentina
	Weather modification	Mendoza – 'Operation Hail', Mendoza hail damage mitigation, Mendoza hail suppression program
Belize	Biochar	IBI Nine Country Program – Belize Carbon Gold Project
Bolivia	Weather modification	Bolivia cloud seeding program
	BECCS	FS Lucas do Rio Verde BECCS project, Sao Paulo Project
	Biochar	NetZero Brazil – Rio Casca, NetZero Brazil – Brejetuba, Norwegian Geotechnical Institute Biochar Program: Brazil
Brazil	CCS	Petrobas Santos Basin Project, Petrobas Santos Basin Project: Tupi oil field, Petrobas Santos Basin Project: Sapinhoá oil field, Petrobas Santos Basin Project: Lapa oil field, Petrobas Santos Basin Project: Búzios oil field, Rio de Janeiro CCS pilot, Petrobas Miranga pilot trial, CEPAC – Coal bed methane trial, CCP Project at São Mateus
	CCUS	Itabirito CCUS project, QPC Quimica Methanol
	Enhanced weathering	InPlanet GmbH – Brazil
	Research projects (SRM, CCS)	CEPAC research centre in Brazil, DEGREES Initiative: Brazil
	Weather modification	Weather Modification Program in Ceará, Petrolina Seeding Program
	Biochar	Temuco Projects, IBI Nine Country Program – Chile
	CCUS	Highly Innovative Fuels Global, CCU Temuco Plant, AB InBev – Cervecería Chile, AMER project, Haru Oni pilot project
	Ocean fertilization	Oceaneos Chile
	Research project (SRM)	DEGREES Initiative: Chile
Chile	Marine cloud brightening	VOCALS-REX
	Weather modification	First cloud seeding tests in Chile, Modificacion Experimental del Tiempo Atmosferico (META), Valparaiso Cloud Seeding, Precipitation enhancement program (Andes), Precipitation enhancement program (Tarapaca,…), Rio Copiapó Programme, Cachapoal River Basin Program, Programa de Estimulación de Precipitaciones (PEP), Valle de Elqui

Costa Rica	Biochar	IBI Nine Country Program – Costa Rica
	Research project (Weather modification)	Cloud Seeding Feasibility Study
	Weather modification	Programa de Siembra de Nubes sobre Embalse Arenal
Cuba	Weather modification	Cloud seeding over Cuba, EXPerimento aleatorizado de siembra de nubes en AReas Extensas (EXPAREX), Artificial Weather Modification Project (PCMAT), Eastern Cuba cloud seeding, Campana de Lluvia Procada
Dominican Republic	Enhanced weathering	Vesta – Puerta Plata trial
	Weather modification	Increased stream flow to dams
Ecuador	Weather modification	Cotopaxi
Guatemala	Weather modification	Chixoy River Drainage
Guyana	Biochar	Guyana Environment Capacity Development Project (GENCAPD)
Haiti	Biochar	Pro-Natura Biochar trials in Haiti
Honduras	Weather modification	El Cajon Drainage Basins, United Fruit Company Cloud Seeding
Jamaica	Research project (SRM)	DEGREES Initiative: Jamaica
	Weather modification	Heritage and Mona Reservoir Seeding Program, Jamaica water supply augmentation program
Mexico	Algae	Seafields: Mexico trials, Artificial tree: BioUrban, Aquaviridis Project
	CCS	, PEMEX Carmito CCS Project, Campo Brillante pilot: CO2-EOR, Campo Brillante pilot: CO2 capture in Agua Dulce, Poza Rica pilot trial,
	CCUS	CEMEX & Synhelion, CEMEX
	Research projects (CCS, CCUS, SRM)	World Bank CCS Trust Fund: Mexico, DEGREES Initiative: Central America (inviting applications from Central America), Mexican CCUS Technology Roadmap
	SAI	Make Sunsets – Baja California
	Weather modification	Volkswagen Hail Cannons , Puebla rainfall enhancement program, State of Mexico – rainfall enhancement program, Rainfall Augmentation Programme, Toluca rainfall enhancement program, Iguala rainfall enhancement program, Ensenada rainfall enhancement program, Michoacan rainfall enhancement program, Rain stimulation over north central Mexico, Port of Ensenada
Panama	Algae	Pull to Refresh: Panama
	Weather modification	Panama Rain Enhancement Project

Peru	Artificial upwelling	CUSCO (Peru)
	Ocean fertilization	Oceaneos Peru S.A.C.
	Other	Glaciares Peru
	Weather modification	Modification Artificial Del Tiempo
Puerto Rico	CCUS	Coca-Cola Puerto Rico Bottlers
	Weather modification	Puerto Rican ‘Siembra de nubes’ – Project, Cloud seeding in southern Puerto Rico, Carraizo Dam Watershed Program
Saint Vincent	Algae	Seafields: St. Vincent trial
Uruguay	CCUS	HIF Uruguay
Venezuela	Weather modification	Programa Incremento de las Precipitaciones