Geoengineering activities in Latin America

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Photo 1: A worker lays white paint on the Peruvian Andes in a bid to get water and vegetation to return to the mountain range, © CNN
Photo 2: 'BioUrban 2.0' air purification system in Puebla, Mexico on August 7, © AFP
Photo 3: Carbon Capture, Use and Storage Technology Roadmap cover page, © Government of Mexico

by Anja Chalmin

In Latin America, since the early days of geoengineering, 90 known geoengineering projects have been conducted or are ongoing. The world map of geoengineering shows all of these projects, where we include in the broader definition of geoengineering both solar geoengineering, carbon removal, and local weather modification. The interactive world map on geoengineering, a tool generated by the Heinrich Böll Foundation and ETC Group, shows that half of the projects used weather modification technologies, such as cloud seeding. These projects aim to influence regional weather, not global climate patterns. They have been in use since the middle of the last century and are important precursors of today's geoengineering technologies. They also foreshadow the kinds of controversies that other types of geoengineering projects can trigger.

A lot of geoengineering activity is brought to Latin America by companies and projects from North America and Europe. This article describes how projects from abroad use or intend to use Latin American waters for marine geoengineering tests and other activities. It also presents Brazilian and Mexican plans for carbon capture and storage (CCS), developments in the carbon capture use and storage (CCUS) sector, research activities on solar radiation management, and the role of biomass-based geoengineering.

There is a common thread to all geoengineering projects: they promise a quick solution to climate change, but are largely hypothetical and involve major risks and unknowns. Most proposals are highly resource intensive and consume significant amounts of land and energy, which means they are not climate friendly. Since geoengineering proposals fail to address the root causes of climate change, but promise a quick fix, they threaten to delay the move away from fossil fuels. They also distract from investments in real climate solutions.

Farmers fight VW to stop anti-hail cannons and other updates on weather modification practices in Latin America

In Latin America, there are 45 projects across 17 countries that are known to have attempted to enhance precipitation or suppress hail. Most projects were carried out in Chile (11 projects) and Mexico (10 projects), followed by Cuba (5 projects). Nine other countries have tried weather modification, but only once. The first three weather modification projects were conducted in the late 1940s and more than half of the projects on record started in the 70s and 80s.

Over 50 percent of projects were discontinued after one to two years. The majority aimed to enhance precipitation and were implemented on behalf of governments, often to respond to droughts, e.g., in agricultural areas or to replenish municipal water supplies. The programmes conducted cloud seeding activities in areas from 50 km² up to 50.000 km², ground-based and airborne, usually using silver iodide (AgI) as a seeding agent. Only three of 45 known projects are still in operation today. All of the projects that attempted to increase rainfall are now discontinued. Three projects to suppress hail are ongoing.

Two of the ongoing hail suppression projects, **Mendoza Hail Damage Mitigation** and **Mendoza Operation Hail**, both publicly funded, are located in the Mendoza region of Argentina and aim to protect the extensive vineyards in this region from hail damage. A study evaluated almost 60 years of cloud seeding to prevent hail in the Mendoza region and found that it has not really achieved the goal of supressing hail. Indeed, there is no unequivocal scientific evidence that cloud seeding to prevent hail reduces the frequency of hail or the size of hailstones. The anti-hail programs are often conducted with silver iodide (AgI), using aircrafts, ground generators, and rockets. According to ECHA, the European Chemical Agency, silver iodide is very toxic to aquatic life with long lasting effects and may thus cause long-term damage to Mendoza's water bodies. ECHA recommends avoiding spills or the release of silver iodide into the environment.

The third active anti-hail project in Latin America was commissioned by **Volkswagen** (VW). In early 2018, VW installed hail cannons to prevent damage caused by hailstones to its vehicles at its site in Puebla, Mexico. Later in 2018, hundred of local farmers complained that the devices caused a drought over ~2.000 hectares of farmland during the months that should have been Mexico's rainy season. The farmers filed a suit claiming € 3.2 Million in damages from the carmaker. In response, VW said it would install anti-hail nets above the cars, which will be used as the main protection measure from hailstorms once installed. Hail cannons will serve as a secondary tool and will only be used in manual mode, when previously they had been automated.

The use of weather modification technologies has also led to disputes in Ecuador. In the Ecuadorian Province of **Cotopaxi**, the industrial broccoli producers Nintanga and Provefrut used anti-hail canons from about 2006 to 2010, aiming to disperse clouds and thus prevent damage to the crops from precipitation. According to local Indigenous and farmer communities, these measures affected the weather patterns, producing droughts, impacting their agriculture systems and their livelihoods. In response to opposition from farmers and Indigenous communities, the company was ordered by authorities to stop its seeding activities in 2010. In 2016, communities in Cotopaxi suspected that cloud seeding activities by broccoli producers were again ongoing, using new technologies such as cloud seeding with planes. In May 2016, following the complaints from hundreds of farmers, the Cotopaxi Provincial Council adopted an ordinance to prohibit the utilization of any technology that alters the natural cycles of rain.

Despite this regulation, there have been a few cases of rain cannons being used, e.g. in the south of Pujilí, Cotopaxi. At the end of 2020, protests broke out again in Cotopaxi after witnesses reported possible cloud seeding activities. As a result of the protests, a Round Table on Water (Mesa del Agua) was founded to clarify the allegations and improve the water supply in the Province.

Carbon Capture and Storage projects in Brazil and Mexico

Carbon Capture and Storage projects in Latin America are concentrated in Brazil and Mexico and combine CO_2 capture with Enhanced Oil Recovery (EOR). In Brazil, the state-owned petroleum company Petrobas (Petróleo Brasileiro S.A.) started researching CCS in 2007, in close collaboration with the Pontifical Catholic University of Rio Grande do Sul (PUCRS). Their joint venture, the Center of Excellence in Research and Innovation in Petroleum, Mineral Resources and Carbon Storage (**CEPAC)**, published the Brazilian Atlas of CO_2 Capture and Geological Storage in 2014 and analysed the potential risks, capacity and profitability of CCS. The atlas, sponsored by the Global CCS Institute, also produced a preliminary assessment on geological storage options for CO_2 in Brazil and points to the still early development phase of CCS technology and existing information gaps, such as CO_2 emissions from offshore sources. In 2011, CEPAC conducted a small-scale pilot project to enhance coalbed methane recovery by injecting CO_2 in the Charqueadas coal field in southern Brazil. Petrobas undertook further testing with CO_2-EOR and geological storage onshore, in the **Miranga pilot trial**, in Bahia state, from 2009 to 2011. At the same time, oxy-combustion CO_2-capture technology was tested in collaboration with Shell and ConocoPhillips at the Petrobras research complex in **São Mateus**, Parana state. Since 2013, Petrobas has been injecting CO_2 into the **Santos Basin** in the South Atlantic. The CO_2 is captured in the Pre-Salt oil field, about 300 km south of Rio de Janeiro, at a floating production, storage and offloading platform for natural gas and oil. The captured CO_2 is transported by vessels over 50 – 100 km and injected into the **Tupi**, **Sapinhoá** and **Lapa oil fields** at a depth of 2 – 3 km for EOR. Until 2017, about 1.5 million tons of CO_2 were captured and injected annually. This amount has doubled in the meantime and is intended to be further increased in the years ahead. The proportion of CO_2 injected into the oil fields that actually remains underground after injection is unknown. Oil industry estimates indicate that about 30 percent of the injected CO_2 return to the surface with the pumped oil. EOR with captured CO_2 comes with additional costs to the environment and generates extensive greenhouse gases: the capture process is very energy-intensive, as is the compression and ship transport of the captured CO_2. Moreover, EOR facilitates the extraction and burning of additional oil.[i]

The Mexican government designed its first national **CCUS Technology Roadmap** in 2014. This plan was updated in 2018, with the participation of academics and industry, and aims to build knowledge and expertise in the fields of CCS, CO_2-EOR, geological storage of CO_2, CCS monitoring and CCUS. The roadmap plans to establish a regulatory framework for CCS as well as CEMCCUS (Centro Mexicano de CCUS), the Mexican Center for CO_2 – Capture, Use and Storage. In May 2018, the Mexican National Institute of Electricity and Clean Energies (INEEL) was selected to lead CEMCCUS. So far there is no indication that plans for the centre have progressed since then.

The roadmap also entails plans to implement two pilot projects in the State of Veracruz. The projects will be planned and conducted by PEMEX (Petróleos Mexicanos), Mexico's national oil company, and Mexico's Federal Electricity Commission (CFE). The first pilot plans to test CO_2 – capture and EOR in the oil industry and will be located at PEMEX' Cinco Presidentes production site in **Agua Dulce**. The captured CO_2 will be used for EOR in the **Brillante** oil field, about 40 km west of Agua Dulce. The second pilot plans to evaluate the technical and economic feasibility of CO_2 – capture and will be located at PEMEX's natural gas-fired, 250-MW **Poza Rica** Thermoelectric Power Plant, in Tihuatlán municipality. The project aims to treat one percent of the Poza Rica flue gas with post-combustion capture technology and to test different types of amine-based solvents. The trial period is expected to be about nine months, with 18 tons of CO_2 captured per day. The start of both pilot projects was announced

for 2019, but so far there are no signs that the projects have commenced.

PEMEX has already gained some initial experience with CCS from the **Carmito CCS project**. This pilot-scale project was conducted in cooperation with Halliburton, a transnational company providing services and products to the oil industry. From 2004 to 2013, Halliburton operated a CO_2 capture facility at a PEMEX plant north of Reforma, in Chiapas. The captured CO_2 was used for EOR in the nearby Bateria Artesa oil field.

Mexico's national CCUS Technology Roadmap sees potential for CCS with EOR in gas processing, power generation and industry, such as cement, fertilizer, chemistry or refineries. At sites with CO_2 capture potential but no option to use the captured CO_2 for EOR, the roadmap aims to develop CCUS. The next update of the roadmap is planned for 2022.

Use of CCUS in conjunction with carbonated drinks

Carbon Capture Use and Storage (CCUS) aims to capture CO_2 and use the captured CO_2 as a feedstock in manufacturing, so that it is "stored" in manufactured goods – until it is released again by consuming the good. This applies to the use of captured carbon in carbonated drinks. Soda, sparkling water and other carbonated drinks have a very short product life cycle and the "stored" CO_2 is released back into the atmosphere within a short time. It is also important to note that the CO_2 – capture process is energy-intensive and further energy is required to purify (and transport) the captured CO_2.[ii] Although CCUS technologies promise to combat climate change or even qualify for carbon credits, it is just re-emitting greenhouse gas (GHG) emissions. And in many cases, CCUS is generating additional GHG emissions.

In Argentina, Brazil, Chile and Puerto Rico, there are initial experiences with or plans for the application of captured CO_2 in the beverage industry. In Argentina, the installation of a CO_2 capture plant is planned at the **CCU brewery in Luján**, in the province of Buenos Aires. The brewery aims to capture CO_2 from a fermentation process at the brewery and to use the captured CO_2 for carbonated drinks. The CO_2 capture technology is provided by the Danish company Union Engineering. The same technology is being used in Chile at the **AB InBrew** brewery in Quilicura and the **CCU Temuco** brewery since 2019. In Puerto Rico, Union Engineering installed its capture technology at the **Coca-Cola Puerto Rico Bottler** production site in Bayamón, in 2009. In Brazil, Air Liquide Brazil and the Coca-Cola bottler FEMSA have signed a long-term agreement for the supply of CO_2, power, and water for FEMSA's bottling plant in **Itabirito** City, 400 km north of Rio de Janeiro. CO_2 captured from exhaust gas at Air Liquide's Itabirito power plant is provided to FEMSA for the production of carbonated drinks. The CO_2 capture plant has been supplied and installed by Union Engineering in 2012.

The role of BECCS and Biofuels

The Brazilian Ministry of Science and Technology, the Global Environment Facility (GEF) and the United Nations Development Program (UNDP) conducted what they called a BECCS pilot project in the State of **Sao Paulo**, from 2013 to 2014. The pilot consisted of a small-scale ethanol biofuel production plant in the sugarcane-to-

ethanol industry. An enlargement of the facility was originally planned, but was not implemented, because the Brazilian government did not want to provide substantial funding for it.

Since 2017, Brazilian biomass is shipped to the **Drax** Power Station, a heavily subsidized BECCS project in Great Britain. The Drax project claims to save emissions by using wood pellets. This is not the case, because the wood for the pellets has to be dried, crushed, pelletized and packed in energy-intensive processes. The transport via fossil-fuel powered container ships, trucks and trains generates additional emissions.[iii]

Scientists warn that BECCS requires large areas of land, which would lead to a shortage of agricultural land, an increase in food prices and water shortages. A comparable situation unfolded in Mexico in 2007, when rising corn ethanol production in the USA led to a significant increase in the cost of food corn which is a staple in Mexico.[iv]

Argentine scientists are researching the selection of microalgae for the production of biofuels. In 2012, the Buenos Aires-based company **Oil Fox S.A.** started conducting trials with freshwater and brackish microalgae and aims to produce algae-based biodiesel and bioethanol. Flue gas emitted from a neighboring thermal power station passes through the algae culture to improve algae productivity while reducing emissions. The company's website is still online, but there is no proof that an algae-based biofuel has be successfully developed and brought to market.

Launched in 2016, the Mexican start-up BiomiTech is based in Mexico City and has developed a so-called artificial tree, named **BioUrban 2.0**. According to BiomiTech, the device filters up to 825 m^3 of air per hour and is able to capture CO_2, CO and NO_x. The filtering process is performed with microalgae – each BioUrban 2.0 contains 500 liters of microalgae solution. BiomiTech aims to produce biogas and biofuel from the algae harvest in future. So far, the company has installed five BioUrban 2.0: one each in Mexico City, Columbia and Panama, and two in Turkey. BiomiTech plans to export BioUrban to Europe, in partnership with the Spanish company Climate Trade.

In 2012, the algae producer **Aquaviridis** signed an agreement with OriginOil to develop an algae production site at its Mexicali, Mexico site. The partners aimed to feed algae with exhaust gases containing CO_2 and to extract oil from algae. Production at commercial-scale was announced for 2013, but the project has not been realized.

Initiatives from abroad trial biochar in Latin America

Between 2003 and 2016, donors from abroad funded ten different field trial series with biochar in seven Latin American countries. The International Biochar Initiative (IBI) financed and performed trials in Belize, Chile and Costa Rica from 2008 to 2012. In Belize, IBI cooperated with **Toledo Carbon**, a subsidiary enterprise of the Toledo Cacao Growers Association in the Punta Gorda region and conducted field trials on farms. In Chile, IBI cooperated with the **University of Tarapacá** and conducted field trials with biochar as well as research on the availability of local feedstock for biochar. The IBI project in **Costa Rica** cooperated with the Washington DC-based NGO Forest Trend and constructed a small-scale biochar production facility and trialed biochar on research plots.

The Global Environment Facility (GEF) Small Grant Programme demonstrated the use of biochar as a soil amendment in cocoa farming **in Belize** and at three sites in Peru **(B4SS project Peru)**. The programs were

implemented by local United Nations Development Program offices from 2012 to 2015.

Further field trials with biochar were financed by the Wake Forest University (USA) in Peru **(Kosñipata Project)**, Cornell University (USA) in **Colombia**, the Norwegian Geotechnical Institute in Brazil **(NGI Biochar)**, the Canadian International Development Agency in **Guyana** and the French embassy in **Haiti**.

At the Chilean Universidad de La Frontera in **Temuco**, various trials on biochar were conducted from 2012 to 2018, including tests in different soils in the agricultural region around Temuco.

A recent field study in Guyana confirmed that the sustainability of biochar, compared to other soil amendments, is low due to high energy consumption. As with BECCS, land consumption is also problematic for biochar if biochar is to be implemented on a large scale. In addition, estimates of whether biochar is suitable for long-term storage of CO_2 are very contradictory.[v]

Marine Geoengineering activities in Latin American waters

The only legal marine geoengineering experiment in Latin American waters and involving institutions from Latin America is **IRONEX**. This ocean fertilization experiment was carried out in two stages in the 90s, near the Galapagos Islands, 970 km west of Ecuador. The experiment to add iron to the ocean was conducted by 15 international research institutions and funded by the USA, UK and Mexico.

Planktos, a private California-based company, founded and headed by Russ George, illegally released iron into the North Central Pacific Ocean, 300 miles east of the **Hawaiian Islands**, in 2002. In 2008, Planktos wanted to conduct another experiment and had planned ocean fertilization with 100 tons of iron in the Pacific Ocean near the **Galapagos** Islands. The project was stopped due to opposition from environmental organizations and Planktos had not received approval from the United States Environmental Protection Agency for iron fertilization. In addition, the Planktos ship was banned from port by the Ecuadorian government.

Since 2016, the **Oceaneos Marine Research Foundation** is seeking permits from South American governments to release iron off the coast for ocean fertilization experiments. Oceaneos is based in Vancouver, Canada and was founded in 2014. Some of the people involved in Oceaneos are the same people who founded the Haida Salmon Restoration Corporation and collaborated on the ocean fertilisation experiment west of Canada **(HSRC)** in 2012. **Oceaneos Peru S.A.C.** is seeking permits to conduct ocean fertilisation experiments in the Peruvian Departments of Ica, Arequipa and Moquegua. In 2017, Oceaneos' application for "ocean fertilization with iron" in Peruvian waters was not approved, because of objections from Peru's Institute of the Sea. A second application was submitted in 2018 and Oceaneos was granted permission to take samples, but not to test ocean fertilization. In Chile, the **Oceaneos Marine Research Foundation** aims to release up to ten tons of iron 130 km off the coast in Coquimbo. A group of Chilean scientists criticized the plan, stating that the experiment *"would seriously endanger national marine ecosystems and, furthermore, various fisheries"*. Oceaneos ocean fertilisation plans **for Argentina** became known in 2019. Ocean fertilisation poses many risks, such as adverse effects on the marine food web, and can lead to oxygen depletion and harmful algal blooms.[vi]

Artificial upwelling is another marine geoengineering technique underway in Latin America. The German research project “Coastal Upwelling in a Changing Ocean” **(CUSCO)**, coordinated by the GEOMAR Helmholtz Centre for Ocean Research, tested the effects of varying upwelling intensities on plankton communities and biomass production in the coastal waters off Callao, in the Humboldt Current of the coast of Peru. The upwelling trials took place last spring and were conducted in so-called mesocosms (large test tubes). The experiment tested different upwelling scenarios, e.g., by adding varying amounts of nutrient-rich deep ocean water.

The Norwegian research institution SINTEF and **OceanTherm AS** propose to reduce the strength of hurricanes by cooling ocean surface waters with air-bubble curtains. This upwelling method consists of air bubbles being released from a perforated pipe lowered in the water, at 100 m to 150 m depth. While rising, the air bubbles cause the upwelling of colder water. At the surface, the colder water mixes with, and cools, the warm surface water. OceanTherm AS and SINTEF propose large-scale systems, such as installing pipes in the Gulf of Mexico or across the entire Yucatan Strait. The effects of artificial upwelling are unknown and potentially very harmful to marine ecosystems.[vii]

Glaciares Peru

Glaciares Peru, founded by Eduardo Gold in 2008, aimed to replace the melting glaciers by white paint, in order to maintain the Earth’s albedo (reflectivity) in the Peruvian Andes. Gold planned to whitewash 70 hectares on three mountain peaks in the Ayucucho region of the Peruvian Andes, using a paint made of lime, industrial egg white, sand and water. Local workers trekked up to 4.000 m and painted the dark rocks found there in order to reduce the absorption of thermal radiation by increased reflection. Painting mountaintops would negatively affect fragile ecosystems, flora and fauna.

Research on Solar Radiation Management (SRM)

Chilean and Peruvian researchers participated in a Marine Cloud Brightening Experiment in 2008. The VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment (**VOCALS-REX**) was conducted in northern Chile and studied the impacts of aerosols on clouds.

In 2018, the **Solar Radiation Management Governance Initiative (SRMGI)** and The World Academy of Sciences (TWAS, Italy) launched the DECIMALS Fund (Developing Country Impacts Modelling Analysis for SRM) to support research on SRM in the Global South. A total grant of US$ 430,000, provided and administered by TWAS, was shared between eight research teams, based in Argentina, Bangladesh, Benin, Indonesia, Iran, Ivory Coast, Jamaica, and South Africa. The program ran for two years and research teams were expected to publish their findings by the end of 2020. In **Jamaica**, **DECIMALS** is hosted at the University of the West Indies, in Mona. The research team models possible impacts of SRM on Small Island Developing States (SIDS) in the Caribbean. In **Argentina**, the DECIMALS researchers, hosted at the University of Buenos Aires (UBA) and the Argentina National Research Council (CONICET), model possible impacts of SRM on freshwater availability in the La Plata Basin in south-eastern South America.

SRM techniques, such as Stratospheric Aerosol Injection (SAI), aim to alter the Earth's radiation balance and are associated with many risks, such as disrupting rain patterns, causing extreme weather events and disrupting ecosystems.[viii] A SRM modelling study conducted in 2019 predicted positive effects for some regions but reduced precipitation for Mexico, Central America and the northern parts of Latin America. In 2018, a group of scientists demanded that developing countries must lead research into solar geoengineering, because many regions in Africa, Asia and Latin America are expected to be the most vulnerable to climate change and possibly also those most affected by geoengineering measures.

Further Information:

Geoengineering Monitor: "What is geoengineering", https://www.geoengineeringmonitor.org/what-is-geoengineering/

ETC Group and Heinrich Böll Foundation, "Geoengineering Map", https://map.geoengineeringmonitor.org/ **– using the keywords highlighted in bold, the projects described in the article can be found in the world map on geoengineering.**

Geoengineering Monitor: Technical briefings provide background information on the above-mentioned geoengineering technologies, https://www.geoengineeringmonitor.org/technologies/

Endnotes:

[i] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Carbon Capture and Storage (CCS), https://www.geoengineeringmonitor.org/2021/04/carbon_capture_storage/

[ii] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Carbon Capture Use and Storage (CCUS), https://www.geoengineeringmonitor.org/2021/04/carbon-capture-use-and-storage/

[iii] Chalmin (2020) Burning biomass is a threat to climate (and no silver bullet) – the impact of BECCS using the Drax plant, Great Britain's biggest power plant, as an example. Published in Geoengineering Monitor, https://www.geoengineeringmonitor.org/2020/12/updates-on-bio-energy-with-carbon-capture-and-storage-and-direct-air-capture-quarterly-4-part-2/

[iv] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Bioenergy with Carbon Capture & Storage (BECCS), https://www.geoengineeringmonitor.org/2021/04/bio-energy-with-carbon-capture-and-storage-beccs/

[v] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Biochar, https://www.geoengineeringmonitor.org/2021/04/biochar-technology-factsheet/

[vi] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Ocean fertilization, https://www.geoengineeringmonitor.org/2021/04/ocean-fertilization/

[vii] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Artificial Upwelling, https://www.geoengineeringmonitor.org/2021/04/artificial-upwelling/

[viii] Heinrich Böll Foundation and ETC Group (2021) Geoengineering Technology Briefing: Stratospheric Aerosol Injection (SAI), https://www.geoengineeringmonitor.org/2021/02/stratospheric_aerosol_injection/