Updates on Weather Modifications and other Technologies (Quarterly #4, Part 3)

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by Anja Chalmin

Large-scale weather modification plans continue to grow in China: This plan may develop conflicts over water or endanger Asia's biggest freshwater reserve

Weather modification has a long history in China. Since the 1950s, there has been a long series of seeding experiments and projects, mostly financed by the Chinese government. These projects aimed to enhance precipitation or suppress hail. Cloud seeding was carried out in areas up to 0,2 million km², by planes, with rockets or with artillery, mostly using silver iodide (AgI) as seeding agent. China also has frequently used cloud seeding technologies ahead of major events, e.g., to avoid rain during Olympic games' opening ceremony.[1]

In 2015, China proposed "Sky River", or Tianhe, the largest ever weather modification program worldwide at that time. Tianhe aims to channel up to 10 billon m^3 of additional rainfall into China's arid northern regions by implementing a large-scale cloud-seeding program across the Tibetan Plateau, covering an area of ~ 1.6 million km^2 with a massive weather modification network. The vast plateau will be covered with tens of thousands of fuel burning chambers that produce AgI for cloud seeding. Throughout 2018, more than 500 burning chambers have already been installed on alpine slopes in Tibet, Xinjiang and further areas, for experimental use, positioned on steep mountain ridges where upwind transports seeding particles into the clouds to induce precipitation.[2]

In December 2020, the Chinese government revealed plans to enlarge its weather modification activities, covering an area of more than 6 million km^2 – almost four times the surface of Tianhe. This new initiative aims to increase precipitation in the form of rain or snow on an area of at least 5.5 million km² on the one hand, and to reduce precipitation in the form of hail on an area of 0,58 million km² on the other hand. This expansive surface accounts for over 63 % of China's land area or almost twice the size of India. The Chinese government further revealed that it aims to develop advanced weather modification skills by 2035 and hopes to deploy an effective program, e.g., to battle droughts, control rainfall in agricultural lands or minimize losses from natural disasters. The program will be achieved by seeding clouds with particles of AgI or other chemicals to induce precipitation.[3]

The estimated costs for the Tianhe program were US$ 168 million. In 2017, China spent about the same amount to purchase cloud seeding equipment, such as four new planes and nearly 900 rocket launchers. The budget for the new program has not yet been revealed, but needs to be considerable, because China has also planned to equip satellites with devices to measure temperatures and humidity in the atmosphere, in order to support the weather

modification activities with three-dimensional atmospheric data.[4]

However, many scientists doubt the effectiveness of cloud seeding. Other scientists, internationally and nationally, question and criticize large-scale weather modification activities, because of the unknown implications on local and transnational level. The Tibetan plateau feeds most of Asia's major rivers, including Yellow, Yangtze, Mekong, Salween and Brahmaputra. It is Asia's biggest freshwater reserve and therefore of high importance for the water supply in many Asian countries. The attempt to increase the amount of rain in dry areas in northern China may exacerbate problems in countries south and south-east of China, e.g., in India, Thailand or Cambodia. Due to this, the US-based Wilson Center sees the envisaged large-scale cloud seeding activities as a possible source of conflict between China and neighboring regions.[5]

ECHA, the European Chemical Agency, provides the following assessments on the toxicology of silver iodide (AgI): very toxic to aquatic life with long lasting effects, and recommends to avoid spillage and release to the environment.[6] May cloud seeding be effective or not – the use of large quantities of AgI is likely to cause long-term damage to Asia's biggest freshwater reserve and many water bodies, that feed from it.

Marine geoengineering proposals – current developments

Large-scale Marine Cloud Brightening (MCB) trials are being planned by research groups in Australia and the USA, despite protests against these experiments. The proposed approach can be explained as follows: To create brighter clouds in order to reflect more sunlight back to space, sea water is pumped through a filter and sprayed out of small nozzles that produce minuscule water droplets. Afterwards a fan propels the microscopic droplets into the atmosphere. Theoretically, the water evaporates, leaving behind tiny particles of salt to which other water droplets can then condense to form brighter and more reflective clouds. However, MCB would not reduce the concentration of greenhouse gases in the atmosphere and undesirable effects, e.g., on weather patterns, cannot be ruled out.

The **Australian Reef Restoration and Adaptation Program (RRAP)** considers reducing bleaching stress on corals with various geoengineering measures, among them Marine Cloud Brightening (MCB).[7] In March 2020, an Australian research team tested MCB technology in the open ocean, in a southern part of the Great Barrier Reef. A coalition of 200 environmental groups protested against the experiment, e.g., because the technology does not eliminate the root causes of climate change – the combustion of fossil fuels. Despite the protests, a larger-scale trial was announced, aiming to cover an area of 400 km², with a machine ten times the size of the prototype machine used in March.[8] Daniel Harrison (Southern Cross University), who led the first MCB trial, "*estimated it would probably take 500 to 1,000 stations such as barges or platforms spraying water, or a smaller number of moving vessels, to cover the entire reef*"[9]. The Great Barrier Reef Foundation studies various SRM approaches on behalf of the RRAP and with RRAP funding. The foundation's annual workplan 2020/21 allocated AUD 4.77 million to research SRM. The foundation has close ties to Australia's largest greenhouse gas emitter BHP and further emitters from both the mining and the aviation industries – this means there are close links to a sector with a keen interest in avoiding the costs of greenhouse gas reductions and to continue with "business as usual".

In October 2020, the **Marine Cloud Brightening Project (MCBP)**, a collaboration between Washington University, the Pacific Northwest National Laboratory (PNNL), and further partners, expressed hopes "*to field-test the spray system in the next 12 to 18 months*"[10]. This hope is linked to a new initiative called Silver Lining, which

has announced that it will actively assist the MCBP with funding. With its announcement in October 2020, the initiative has provided US$ 3 million in funding for the MCBP. The MCBP changed its name twice: previously field trials were planned under the names ‘Silver Lining Project’ and ‘Silver Lining Inc.’ and were cancelled due to public protests and lack of funding.[11]

Project Vesta, aims to deploy an experimental pilot trial on enhanced weathering of olivine – a mineral rich in silicate – on tropical beaches in the Caribbean. The project has secured a local permit to take initial samples from the selected trial beaches and plans to announce the location of the test site once the experiment has been given approval. The trial will start as soon the permit and the necessary funding have been secured and will run over a period of one to two years.[12]

The EU-funded project **OceanNET** started in July 2020. The project aims to investigate the feasibility and impacts of ocean-based approaches to remove CO_2 from the atmosphere, such as ocean fertilisation, artificial upwelling or enhanced weathering. OceanNet is coordinated by the GEOMAR Helmholtz Centre for Ocean Research in Kiel, Germany and conducted in cooperation with 13 partner institutions from Norway, Germany, UK, Finland, Spain and Australia. The project plans to conduct experiments in the Geomar laboratories as well as offshore experiments off Gran Canaria (Spain) and Bergen (Norway). A timetable for the offshore experiments (conducted in so-called mesocosms, to test the effects of marine enhanced weathering) has not yet been published.[13]

The US-based **The Climate Foundation** (TCF), was founded in 2007 by Brian von Herzen with the goal to capture and sequester CO_2 by employing artificial upwelling and biochar at larger scale.

In 2020, TCF and the Medical Care Development’s International division (MCDI) announced a joint proposal for the MacArthur Foundation’s 100&Change competition, with MCDI as the lead partner. The project partners planned to establish large marine permaculture projects with floating platforms, using wave energy to upwell nutrient-rich deep ocean water for seaweed growth and CO_2 capture in coastal areas in Tanzania and Madagascar. The joint grant application was not approved.[14]

According to a TCF newsletter, the foundation has started establishing a demonstration-scale seaweed farm with wave-powered upwelling activities in a coastal area on Bohol, Philippines. TCF hopes that the further development of the farm is supported by the Philippine Department of Agriculture.[15]

In September 2020, the U.S. government agency **ARPA-E** announced funding for direct removal of CO_2 from oceanwater. Three projects aim to develop “*robust, energy efficient, and low-cost strategies for direct removal of carbon dioxide from oceanwater and other natural waters*”.[16]

In September 2020, The **Ocean-Climate Alliance (OCA)** was launched by the Ocean Climate Trust, which in turn was founded by Brad Ack. Among the ten OCA founding members are: Ocean Climate Trust, Ocean Visions, Global Ocean Trust, Foundation of Climate Restoration, The Ocean Foundation, Silver Lining, and Climate Foundation. OCA aims to advocate for massive greenhouse gas clean-up/negative emissions and plans to accelerate, develop and scale “ocean-based carbon sequestration”, e.g., ocean fertilization or enhanced weathering.[17]

In 2019, **Ocean Visions**, an OCA-member, was founded by various universities and education institutions in the U.S., with the objective to develop road maps to accelerate the development and testing of ocean-based CO_2-removal approaches, e.g., ocean alkalinity enhancement (OAE) or electrochemical methods of CO_2 capture from

seawater. In October 2020, a workshop on ocean-based CO_2-removal (CDR) was held and identified the need to move from the laboratory to field experiments. A second workshop dealt with the social and political acceptance of ocean-based CDR measures and developed, inter alia, the following goal: "*Get the language of CDR and ocean CDR right from the beginning: Conduct research on the language and messages that counter and help neutralize the geoengineering, moral hazard, and pristine ocean arguments, amongst others*".[18]

A description, e.g., of OAE, without reference to the term geoengineering, does not change the risks of OAE, e.g., to marine life and the marine food chain.

Further Geoengineering updates (selection)

In December 2020, the **Stratospheric Controlled Perturbation Experiment (SCoPEx)** announced plans to fly a test balloon in Sweden in June 2021. SCoPEx is conducted by Harvard University and part of Harvard's Solar Geoengineering Research Program. SCoPEx includes research, modelling and field testing of Stratospheric Aerosol Injection, a Solar Radiation Management (SRM) proposal.[19] Several hundred civil society organizations from around the world call for a ban of SRM, e.g., because it is likely to cause droughts, food and water shortage.

The **Carbon Drawdown Initiative Carbdown GmbH** was funded by Dirk Paessler in 2020 and is managed by Dirk Paessler and Ralf Steffens. The corporation aims to ensure that projects in the following areas are (further) developed: Direct Air Capture technologies, Enhanced Weathering with olivine or serpentine, BECCS, CO_2-based synfuels. To achieve these goals, the company grants financial support to Geoengineering companies, such as the Swiss Climeworks AG and Project Vesta, and aims to support NETs through scholarships, funding for doctoral positions or similar support efforts. In addition, the corporation is involved in public and political work: The Carbon Drawdown Initiative is founding member of the Negative Emissions Platform, an organization based in Brussels and lobbying for Geoengineering. Among the members are Climeworks, Carbon Engineering, Global Thermostat, Drax, CarbFix and Project Vesta.[20]

The **Presena glacier**, located in Northern Italy, lost over one third of its volume since 1993. For this reason, the local mountain lift company Carosello Tonale Spa started covering ski slopes with reflective sheets in 2008. Since 2008, the covered glacier area has increased from 0,03 km² to 0,1 km². The tarpaulin is made in Austria; the composition and durability of the cover material is not described in detail. One sheet measures 70 m by 5 m and costs about € 400 each, that means that the costs for the total area amount to € 0,11 million of material costs. The tarpaulin is sewed to prevent the intrusion of warm air. Afterwards it is covered with sandbags to fix it in place. Unrolling, securing and removing the reflective tarpaulin over 0,1 km² lasts six weeks at a time.[21]

The **Salk Institute for Biological Studies**, based in San Diego, California, USA, conducts its Ideal Plant Project since 2017. The project applies gene editing methods to enhance plant's capability to store atmospheric CO_2, by increasing the size of plant roots as well as the amount of suberin produced in plant roots. The Salk Institute applies this strategy to crops such as sorghum, corn, soybean, rice and wheat and announced the commercialization of the "Ideal Plant" for 2025. In November 2020, Sempra Energy, a company operating in the fossil energy sector in North America, donates US$ 2 million to the Institute.[22]

Stripe, a San Francisco based software company, announced its Stripe Climate Program in November 2020 and

with it further financial support for Biochar (Charm Industrial), CCUS (CarbonCure Technologies), DAC (Climeworks AG), and Enhanced Weathering (Project Vesta).[23]

In 2020, **Microsoft** established the **Climate Innovation Fund** and communicated that it aims to become "carbon negative" by 2030. Microsoft plans to achieve this goal through a portfolio of various technologies, among them BECCS and DAC. The Climate Innovation Fund's first investment was announced in July 2020 – a US$ 50 million investment in Energy Impact Partners' (EIP) global platform. The exact use of the funds by EIP was not yet communicated. In the same month, Microsoft launched the **Transform to Net Zero** coalition along with A.P. Moller-Maersk, Danone, Mercedes-Benz, AG, Natura & Co, Nike, Starbucks, Unilever, and Wipro, as well as the Environmental Defense Fund. The coalition "*aims to deliver guidance and business plans to enable a transformation to net zero emissions*".[24] Equinor signed a MoU with Microsoft to explore the Longship CCS project as part of Microsoft's CCS portfolio.[25]

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