Geoengineering and Climate Change

Implications for Latin America

In Brief: Some governments are exploring geoengineering as a way to reduce or delay climate change. Geoengineering could technically take climate decisions away from all but the richest countries. Computer models[1] show that stratospheric interventions to reduce sunlight and lower temperatures may benefit some temperate zones but negatively impact Latin America with important social and agricultural consequences.

Terminology:

Geoengineering is the intentional large-scale technological manipulation of earth systems (in the stratosphere or ocean or in the ground) in an attempt to delay or reduce climate change.

Solar Radiation Management (SRM) is stratospheric geoengineering to block or deflect sunlight aiming to lower Earth's temperature.

Sulfate Aerosol Injection (the most economic and technically practical SRM) spreads sulfate "dust" 15–20 km up in the stratosphere to reduce sunlight and lower temperatures. "Dust" can be blown by a battery of pipes (like an artificial volcano) or via specially outfitted aircraft. Direct cost could be as low as $700 million the first year to tens of billions of dollars per annum later.

Net Primary Productivity (NPP): NPP is an indicator of the health of the terrestrial biosphere and its ability to take up CO_2. It can also provide an estimate of the impacts of geoengineering on agriculture (Kravitz et al. 2013).

Findings: Two peer-reviewed scientific papers published in 2013[2] and 2008[3] report on four climate model scenarios of injections of stratospheric sulfate aerosol in the Southern Hemisphere (SH), Northern Hemisphere (NH), the Tropics and the Arctic. The results from the studies show that sulfate injections, could lead to major changes for Brazil in NPP and precipitation. The studies also show that in the Tropical and Arctic scenarios, changes in precipitation could occur for other regions in Latin America with increases up to 1 mm/day or decreases of up to 1 mm/day. Latin America could also experience a decrease in Surface Air Temperature in both the Tropical and Arctic scenario, both during June-Aug and Dec-Feb.

The South American Monsoon System (SAMS) has its core in the Brazilian Planalto, which contains the headwaters of major rivers flowing into the Amazon, La Plata and São Francisco basins. These basins provide most of Brazil's hydroelectric energy production and contain major agricultural areas.[4] Regions affected by the monsoon also contain South America's most populous cities[5] and any prolonged periods of increased or decreased precipitation in these regions can have significant socioeconomic impacts; particularly on agriculture and energy production. Because of the accentuated topography near the east cost of Brazil, heavy rainfall can result in flooding with damages to property and infrastructure as well as loss of lives. A lack of rainfall, on the other hand, can lead to droughts which can have negative impacts on agriculture and hydroelectric energy production. This makes the region particularly susceptible to drastic changes in climate.[6] Blasting sulfates into the stratosphere does not reduce CO_2 concentrations; it merely postpones the impact as long as the spraying continues, but can also result in additional climate change.

Policy: In 2010, the UN Convention on Biological Diversity (CBD) adopted decision X/33 – described as a de facto moratorium – requesting governments not to pursue geoengineering as a climate change strategy. Despite this, some scientists and governments continue to consider geoengineering a viable Plan B to slow climate change. Latin American governments may wish to raise this issue during the climate change Summit to be held at the UN in New York September 23 – 24, 2014.

Computer Model Scenario Results: In 2013, a study was published showing the implications sulfate injections could have on NPP and precipitation patterns. Through their model simulation[7] the authors concluded that sulfate injections into the SH could decrease precipitation in Northeastern (NE) **Brazil** by as much as 100 mm/month. Northern **Brazil**, however, could see an increase in precipitation of as much as 100 mm/month (Figure 1).

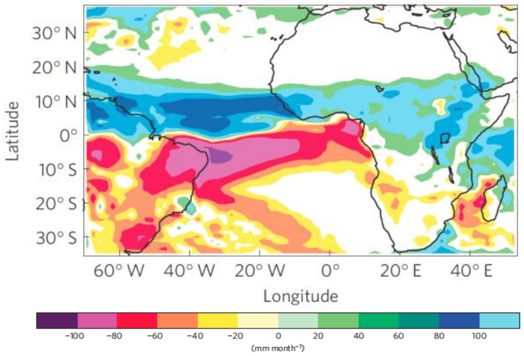

Figure 1. Showing change (color scale) of precipitation, in mm/month in a geoengineering scenario through stratospheric sulfate aerosol injections in the Southern Hemisphere. (Figure from Haywood et al. 2013)

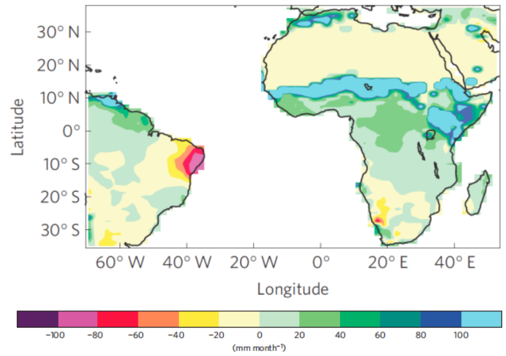

Figure 2. Showing change (color scale) of Net Primary Productivity, in percentage in a geoengineering scenario using stratospheric sulfate aerosol injections in the Southern Hemisphere. (Figure from Haywood et al. 2013)

Similar results were found regarding NPP where NE **Brazil** could see a decrease of 40-100%, but the very North could have an increase of up to 100% (Figure 2). In a scenario where sulfate injections take place in the NH, the NE region of **Brazil** could see an increase in NPP of up to 80%. The decrease could instead be shifted to the Sahel region in Africa, which could experience a decrease of 60-100% (Figure 3).

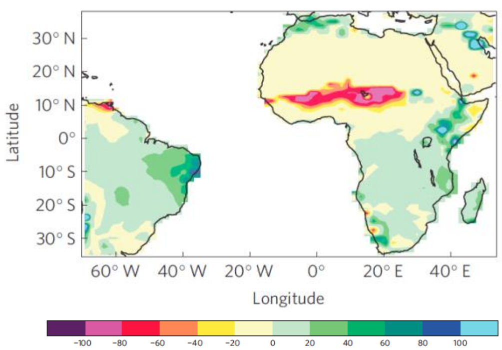

Figure 3. Showing percentage change (color scale) of net primary productivity in a geoengineering scenario in the Northern Hemisphere using stratospheric sulfate aerosol injections. (Figure from Haywood et al. 2013)

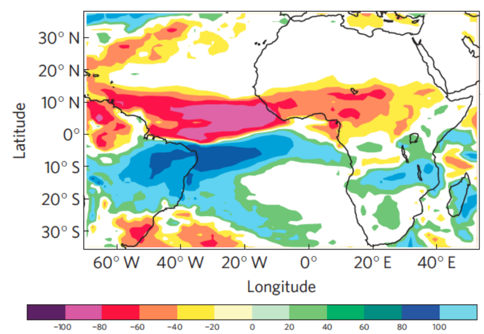

Figure 4. Showing change (color scale) of precipitation, in mm/month in a geoengineering scenario using stratospheric sulfate aerosol injections in the Northern Hemisphere. (Figure from Haywood et al. 2013)

The precipitation pattern in the NE region of **Brazil** could see major changes; in certain areas there could be an increase of up to 100 mm/month, while in others there could be a decrease of as much as 100 mm/month (Figure 4).

In a study published in 2008, two model[8] scenarios were run with injection of stratospheric sulfate aerosols in the Arctic or in the Tropics. In the Arctic scenario, precipitation could increase up to 1 mm/day in parts of **Chile**, eastern **Venezuela**, **Guyana**, **Guyane** and **Surinam** in June-Aug. However, western **Venezuela** could experience a reduction in precipitation of as much as 1 mm/day (Figure 5). In June-Aug in the Tropical scenario, **Venezuela**, **Mexico**, **Colombia, Costa Rica, Panama** and **Ecuador** could have regional decreases in precipitation of up to 1 mm/day while parts of **Mexico**, **Suriname**, **Guyana**, **Guyane** and the Northern part of **Brazil** could see an increase in precipitation of up to 1 mm/day (Figure 6). In Dec-Feb in the Arctic scenario, parts of **Mexico**, **Venezuela**, **Brazil**, **Argentina** and **Paraguay** could experience an increase in precipitation of up to 0.5 mm/day, while regions of **Brazil**, **Peru** and **Costa Rica** could experience a reduction in precipitation of up to 1 mm/day (Figure 7).

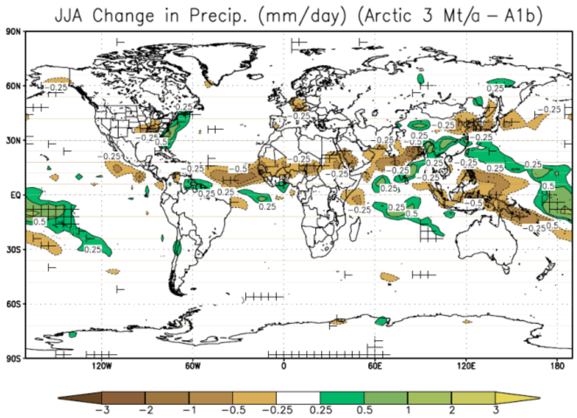

Figure 5. Showing change (color scale) of precipitation, in mm/day in a geoengineering scenario injecting stratospheric sulfate aerosol in the Arctic. The figure shows the change during June-Aug. (Figure from Robock et al, 2008)

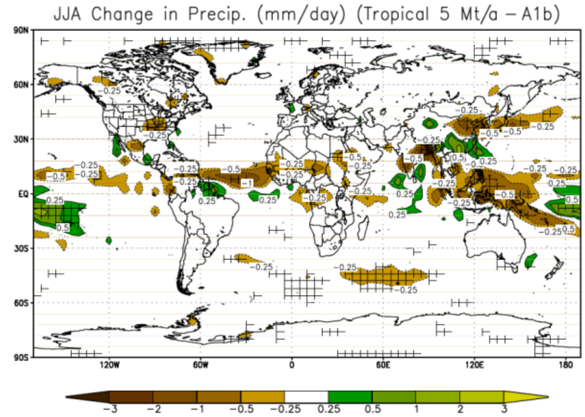

Figure 6. Showing change (color scale) of precipitation, in mm/day in a geoengineering scenario injecting stratospheric sulfate aerosol in the Tropics. The figure shows the change during June-Aug. (Figure from Robock et al, 2008)

In Dec-Feb in the Tropical scenario, regions of **Guatemala**, **El Salvador**, **Nicaragua**, **Peru**, **Brazil**, **Bolivia** and **Paraguay** could experience a decrease of up to 1mm/day, while regions of **Brazil**, **Guyana**, **Argentina** and **Suriname** could experience an increase (Figure 8).

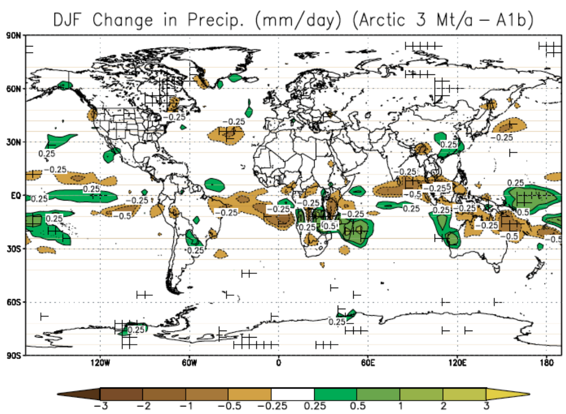

Figure 7. Showing change (color scale) of precipitation, in mm/day in a geoengineering scenario using stratospheric sulfate aerosol injections in the Arctic. The figure shows the change during Dec-Feb. (Figure from Robock et al. 2008)

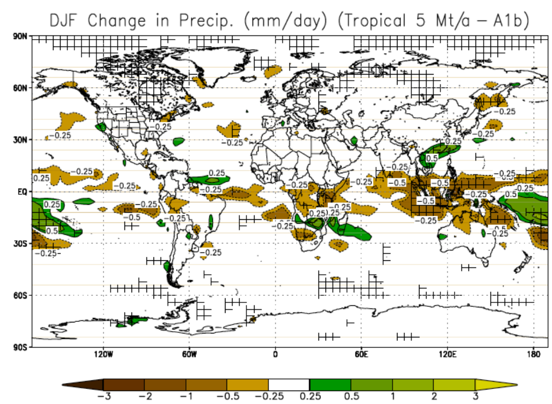

Figure 8. Showing change (color scale) of precipitation, in mm/day in a geoengineering scenario using stratospheric sulfate aerosol injections in the Tropics. The figure shows the change during Dec-Feb. (Figure from Robock et al. 2008)

Volcanic analogies: Stratospheric sulfate aerosol injection mimics volcanic eruptions that lower surface temperature by blowing sulfur into the stratosphere. In 1991 The Philippines Mt. Pinatubo blasted about 20 million tons of sulfur into the stratosphere, leading to a global average reduction in temperature of 0.4˚C. Apart from the temperature decrease major volcanic eruptions also affect precipitation patterns. In the year after the eruption of Mt. Pinatubo a substantial decrease in precipitation, and a record decrease in runoff and river discharge into the ocean was recorded.

This has led scientists to conclude that major adverse effects, including drought could arise from geoengineering by stratospheric sulfate aerosol injection since it would severely affect atmospheric fluxes and the global hydrological cycle.

(Robock et al. 2008; NSF 2010; Trenberth & Dai 2007; Haywood et al. 2013)

In both the Tropical and the Arctic scenario, during both June-Aug and Dec-Feb, the study shows that temperature could decrease in Latin America. It is worth noting that, with a few exceptions, in both the Arctic and the Tropical scenario, during June-Aug and Dec-Feb, there is little to no change in precipitation over **Europe** and **North America**.

Conclusion: Climate change is an anthropogenic phenomenon arising from the unanticipated side effects of rapid technological transformations. Without immediate action to mitigate and adapt to climate change, the impact on the people, the economy and food supply of Latin America could prove devastating. Sea levels will rise, crop yields will decline, weather patterns will be erratic and health will be at risk. In this light, geoengineering, specifically – but not exclusively – solar radiation management, can seem an inexpensive and technologically easy and effective interim quick-fix that could postpone change and buy time. But, the Band-Aid could be worse than the problem. It is, once again, an anthropogenic techno-fix with potentially powerful side effects. Computer modeling scenarios all identify very real risks. Ultimately, however, perhaps the biggest risk is that developing countries will inevitably have to turn over control of the planetary thermostat to the technologically powerful nations and industries that caused climate change in the first place. Developing countries will be exposed to changes that – by intent – will be more rapid and extreme than is predicted for climate change.

The advocates of sulfate aerosol injection argue that the costs are much less than virtually every other adaptation or mitigation strategy. This is not true. Advocates have only calculated the relatively minor costs of pumping sulfates into the stratosphere. There are huge indirect costs including the damages that will be caused by solar radiation management. The cost will shift from the adaptation and mitigation expenses that should be borne by industrialized countries to become the costs and damages of those who did not cause the problem.

About ETC Group: The Action Group on Erosion Technology and Concentration (ETC Group) is an international non-profit civil society organization established in 1977 with ECOSOC status as well as observer status with many UN agencies including UNFCCC, FAO, CBD, UNEP, and UNCTAD. ETC is headquartered in Canada with regional offices in Africa, Asia, Latin America and USA. ETCs mandate is to monitor economic, environmental and technological developments important to the well-being of marginalized peoples around the world. For further information please go to: www.etcgroup.org. ETC's director for Latin America is **Silvia Ribeiro (silvia@etcgroup.org)**

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References:

Haywood, Jim M., Andy Jones, Nicolas Bellouin & David Stephenson. 2013. Asymmetric forcing from stratospheric aerosols impacts Sahelian rainfall. *Nature Climate Change*, 3:660-665.

Kravitz, Ben, Ken Caldeira, Olivier Boucher, Alan Robock, Philip J. Rasch, Kari Alterskjær, Diana Bour Karam, Jason N. S. Cole, Charles L. Curry, James M. Haywood, Peter J. Irvine, Duoying Ji, Andy Jones, Jón Egill Kristjánsson, Daniel J. Lunt, John C. Moore, Ulrike Niemeier, Hauke Schmidt, Michael Schulz, Balwinder Singh, Simone Tilmes, Shingo Watanabe, Shuting Yang, Jin-Ho Yoon. 2013. Climate model response from the Geoengineering Model Intercomparison Project (GeoMIP). *Journal of Geophysical Research: Atmospheres,* vol. 118:8320-8332.

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Robock, Alan, Luke Oman, and Georgiy L. Stenchikov. 2008. Regional climate responses to geoengineering with tropical and ArcticSO_2 injections, *Journal of Geophysical Research*, vol. 113, D16101.

Trenberth, Kevin E. & Aiguo Dai. 2007. Effects of Mount Pinatubo volcanic eruption on the hydrological cycle as an analog of geoengineering. *Geophysical Research Letters*, vol. 34:L15702.

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[1] Although there have been many studies using models in attempts to simulate SRM scenarios, in this briefing, the aim has been to pick scenarios that are realistic and that address injection of SO_2 specifically.

[2] Haywood, Jim M., Andy Jones, Nicolas Bellouin & David Stephenson. 2013. Asymmetric forcing from stratospheric aerosols impacts Sahelian rainfall. *Nature Climate Change*, vol. 3:660-665.

[3] Robock, Alan, Luke Oman, and Georgiy L. Stenchikov. 2008. Regional climate responses to geoengineering with tropical and Arctic SO_2 injections, *Journal of Geophysical Research*, vol. 113, D16101.

[4] Silva, Viviane B.S. and Vernon E. Kousky. 2012. 05 The South American Monsoon System: Climatology and Variability (2012), In: *Modern Climatology*. Book 10. http://digitalcommons.usu.edu/modern_climatology/10

[5] Grimm, Alice M. and Marcia T. Zilli. 2009. Interannual Variability and Seasonal Evolution of Summer Monsoon Rainfall in South America. *Journal of Climate*, 22: 2257-2275.

[6] Marengo J. A., B. Liebmann, A. M. Grimm, V. Misra, P. L. Silva Dias, I. F. A. Cavalcanti, L M. V. Carvalho, E. H. Berbery, T Ambrizzi, C. S. Vera, A. C. Saulo, J. Nogues-Paegle, E. Zipser, A. Sethk, and L. M. Alvese. 2012. Recent Developments on the South American Monsoon System. *International Journal of Climatology,* 32: 1-21.

[7] The authors used the HadGEM2-ES climate model to perform two experiments that were variants of the Geoengineering Model Intercomparison Project (GeoMIP) G4 experiment. The level of sulfate aerosol injections in the experiments was 5 Tg SO_2/year.

[8] The authors used the NASA Goddard Institute for Space Studies ModelE atmosphere-ocean GCM (general circulation model) and based their experiments on a 40-year run using IPCCs A1B business-as-usual global warming scenario. The A1B is a scenario forced by greenhouse gases (CO_2, CH_4, N_2O, and O_3) and troposphere aerosols (sulfate, biogenic, and soot). The two scenarios are based on either an injection of 3 Tg SO_2/year in the Arctic or an injection of 5 Tg SO_2/year in the Tropics.