Geoengineering: The Risk of Marine Cloud Brightening

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Abstract

Background: In recent years, the overall solar radiation emissions have been extremely high due to ozone depletion from pollution. In order to prevent this unstable-climate-inducing trend, scientists proposed numerous ideas to intervene. The deliberate alteration of the climate is known as geoengineering, and is favored by many professionals. Geoengineering helps reduce the recent increase in temperature, while stabilizing the climate. Its main focus is on lowering the solar radiation emissions, mainly using reflective methods or otherwise known as solar radiation management (SRM). One specific SRM proposal is cloud whitening. Seawater would be pumped into the air creating low altitude, reflective clouds. These clouds are composed of small droplets, which contain fine salts to increase the reflectivity of solar radiation. However, some risks may be involved.

Methods: The risks of marine cloud brightening were studied by using the GeoMIP, which was available to the public. The control (land realm) dataset and the G2 experiment were used to study how MCB may cause desertification of rainforests.

Results: Using the models project=GEOMIP, model=NCAR Community Climate System Model, CCSM version 4, experiment=piControl, time_frequency=mon, modeling realm=land, ensemble=r4i1p1, version=20121024, and project=GEOMIP, model=NCAR Community Climate System Model, CCSM version 4, experiment=G2, time_frequency=mon, modeling realm=land, ensemble=r3i1p1, version=20121024, it

was found that the variables studied did not indicate potential desertification of rainforests. The data shows that the changes in the climate would not be significant enough to create major change.

Conclusion: The variables studied indicate that MCB will not create much negative change on the environment. However, with such limited amounts of data available, not all risks could be accounted for. With that being said, in order to test geoengineering without field-testing, scientists with access to more data need to study many more variables to account for all risks.

I declare that this research is my own and that I have given credit to all sources, consultants, and references used.

1.0 Review of Literature

Recent climate change due to industrialization and the intense burning of fossil fuels have led to higher contents of CO2 in the atmosphere (Schaltegger et al., 2011 and Princiotta 2011). According to charts, the CO2 levels have been higher than ever and if these trends continue, the earth will no longer be habitable (Keith, 2000). Also in recent years, the overall solar radiation emissions have been extremely high due to ozone depletion from pollution. In order to prevent this unstable-climate-inducing trend, scientists proposed numerous ideas to intervene. The deliberate alteration of the climate is known as geoengineering, and is favored by many professionals. Geoengineering helps reduce the recent increase in temperature, while stabilizing the climate (Keith, 2000). Its

main focus is on lowering the solar radiation emissions, mainly using reflective methods. Although mitigation, or the removal of greenhouse gases from the atmosphere, can stop climate change at its root, reflecting sunlight can immediately stop the effects of climate change. This type of proposal falls under the category Solar Radiation Management (SRM).

The methods proposed include space mirrors, sulfate aerosols, and cloud whitening. Scientists say that the use of space mirrors would cause numerous mini eclipses and obscure the sunlight away from the Earth. Due to the obscured sun rays, solar radiation would be reduced thus cooling the climate. They found that launching 50,000 large mirrors or trillions of DVD sized mirrors would be most effective (Angel 2006). However, those conditions are unrealistic due to high costs and high risk of satellite damage (Bewick et al., 2012). A more realistic approach is to launch a large reflector at the first Lagrange point, or, where the mirror would orbit around the sun at the same rate of the earth, resulting in a constant eclipse of sunlight (Sanchez 2011). Another SRM proposal is to inject Sulfate aerosols into the stratosphere to reflect sunlight. This method mimics how volcanoes would release aerosols in the troposphere, however, SO2 particles have a longer cooling effect in the stratosphere than those in the troposphere (Barrett et al. 2014). This strategy is very low in cost and extremely effective, however, it is very risky due to potential acid rain, accelerated ozone depletion, or severe drought (Crutzen, 2006, Tilmes et al., 2008 and Solomon et al., 2009)(Robock et al., 2009). All SRM proposals have the potential to significantly decrease incoming solar radiation, however, deploying space mirrors or sulfate aerosols create too many risks. The best SRM proposal is cloud whitening. Seawater would be pumped into the air

creating low altitude, reflective clouds. These clouds are composed of small droplets, which contain fine salts to increase the reflectivity of solar radiation. These fine droplets also whiten the clouds, which also increases its ability to obscure sunlight and reduce temperature increases (Neukermans et al. 2014). This method is effective, low cost, and low risk which makes it an ideal proposal to put in effect. In addition, this proposal is currently backed by Microsoft, making it another ideal and realistic innovation that will most likely take place in the near future (Alterskjær 2013). While these SRM and CDR techniques seem realistic and necessary, governance is a big issue. There is a current need for governance of research involving large scale field testing (Victor, 2008). However, not enough risks are known to even put it to the test. With this being said, scientists have run many climate modeling simulations to try and account for all possible risks.

2.0 Research Questions and Hypothesis

Research Question

Can marine cloud project have long-term negative effects on rainforests in the southern hemisphere that lead to desertification?

Hypothesis

H1: If marine cloud brightening it put into effect, then it will have negative affects on rainforest ecosystems.

Ho: If marine cloud brightening is put into effect, then it will have positive affects on rainforest ecosystems.

3.0 Methods

GeoMIP Datasets

In order to study the effects of marine cloud brightening without field experimentation, it's necessary to analyze the climate modeling projects done by scientists; specifically, the scenarios created in the GeoMIP (Kravitz et al., 2011). The control model "project=GEOMIP, model=NCAR Community Climate System Model, CCSM version 4, experiment=piControl, time_frequency=mon, modeling realm=land, ensemble=r4i1p1, version=20121024" which deals with the land based changes in the climate, was compared with the "project=GEOMIP, model=NCAR Community Climate System Model, CCSM version 4, experiment=G2, time_frequency=mon, modeling realm=land, ensemble=r3i1p1, version=20121024."

4.0 Data Analysis and Results

The data was analyzed by importing the datasets from the G2 experiment and the control experiment into Panoply, which converted the sets into visual representations of the effects of MCB. As shown in figures 1-3, the variables used are the temperature of the soil, the water content of the soil and the evaporation of the canopy before and after SRM was put into effect. Figure s1.1 and 1.2 show the temperature of the soil before and after MCB is put into place. Figures 2.1 and 2.2 show the water content of the soil before and after the application of MCB. And lastly, figures 3.1 and 3.2 show the evaporation from canopy layer.

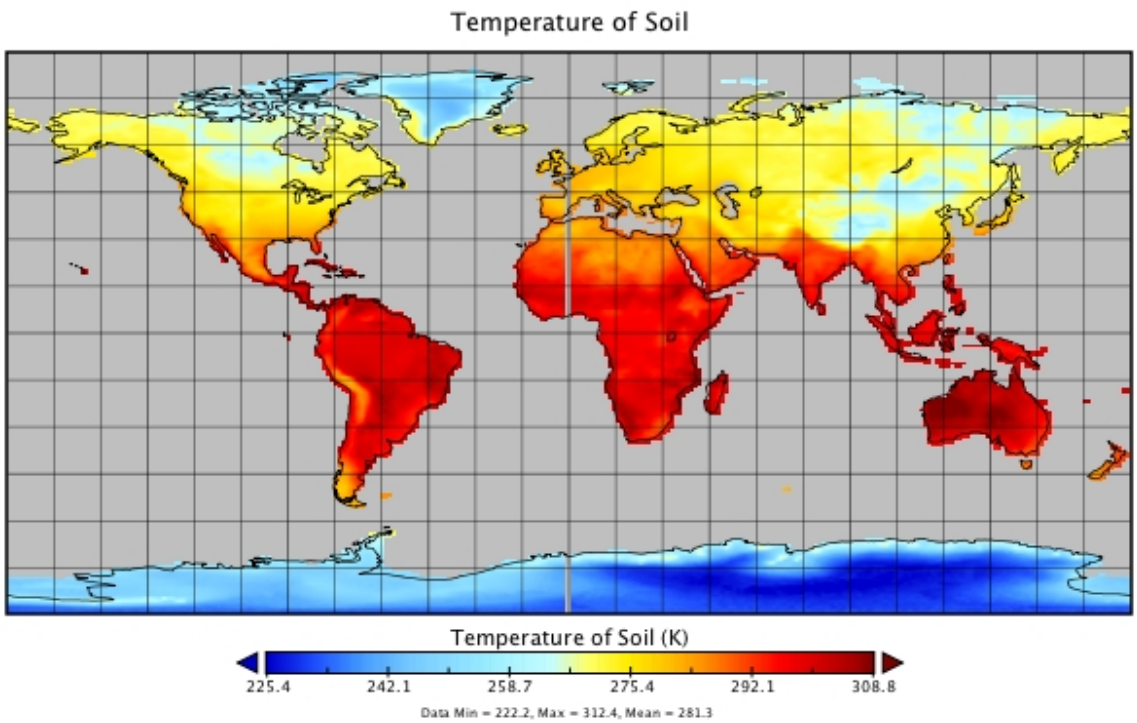

Figure 4.1.1

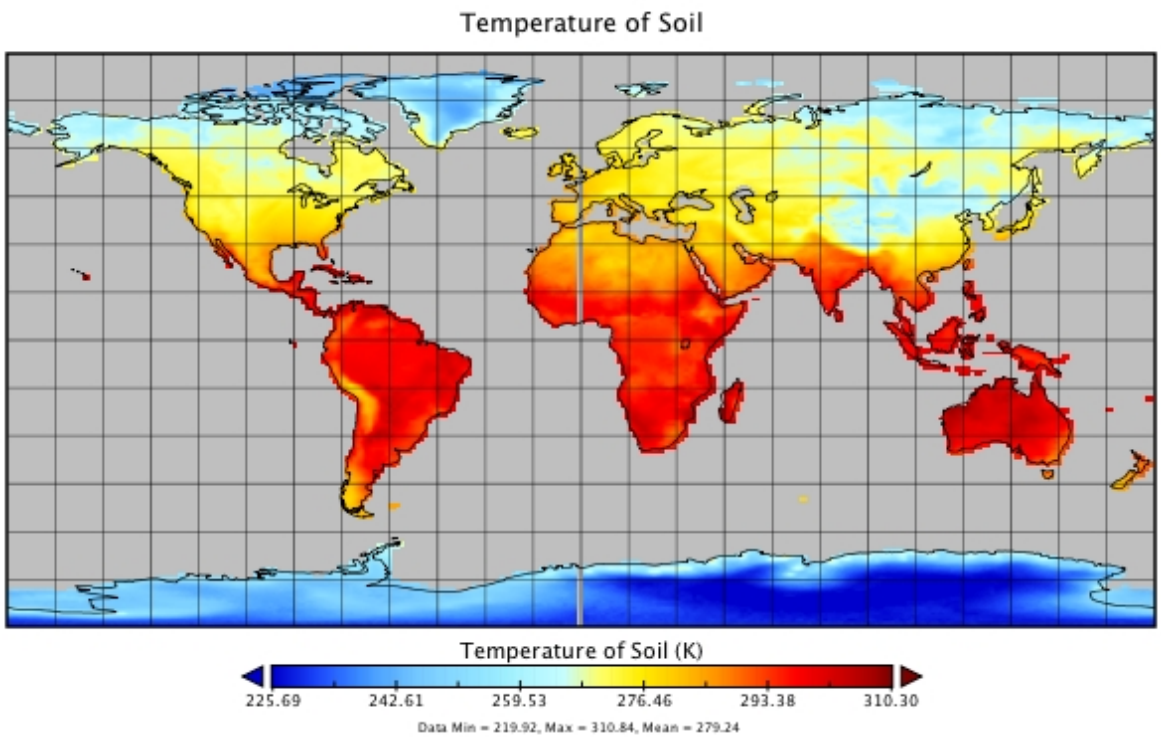

Figure 4.1.2

4.1 The significance of the temperature of soil

Near the amazon rainforest, the temperature goes from roughly 27°C to 17°C. Though 10°C seems like a significant change, it is still within a healthy range of temperatures that promote plant growth (WMO 2007). Therefore, this variable alone won't contribute to any negative effects of MCB.

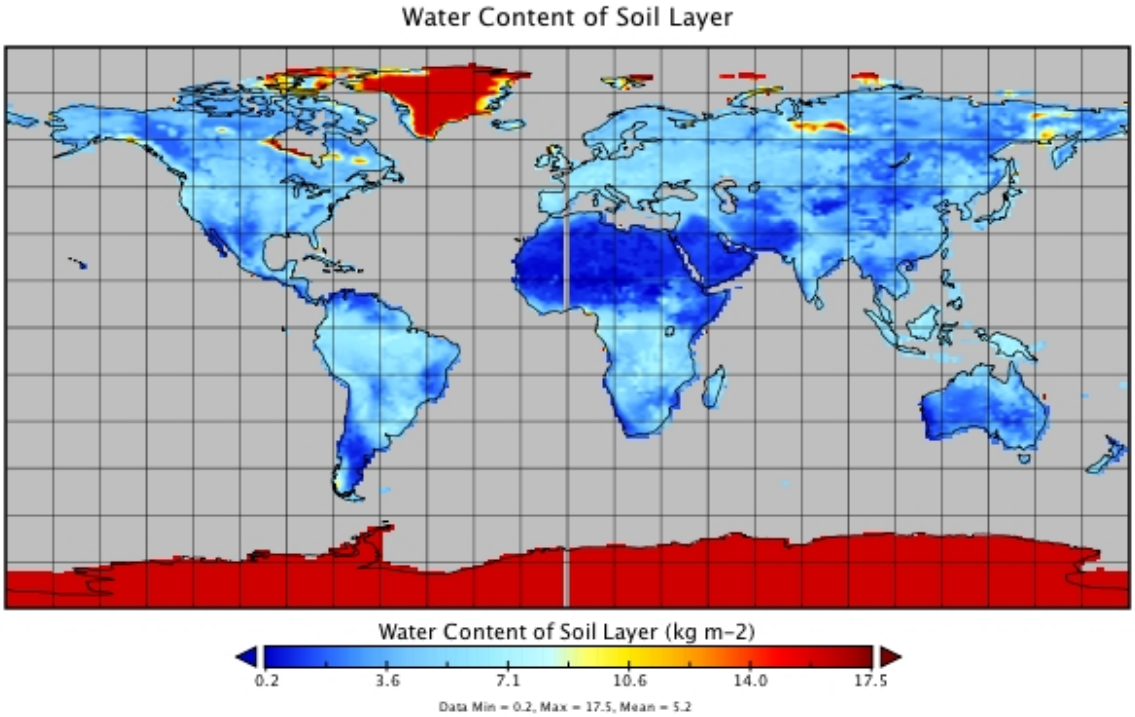

Figure 4.2.1

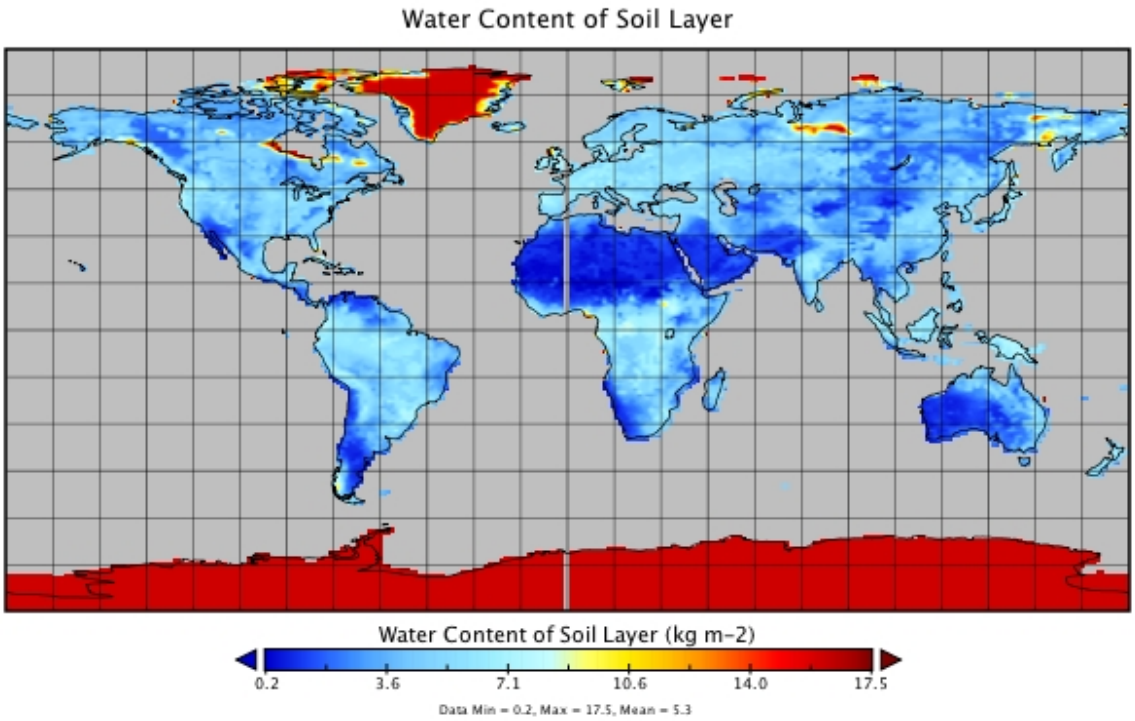

Figure 4.2.2

4.2 The significance of water content of soil

When there is not enough water in the soil, small changes in the soil moisture can cause large changes in the matric potential. Therefore, the uncertainty of matric potential increases while the water content of the soil decreases (Jones et at,. 2013). Also, the respiration rates of plants in the amazon rainforest will decrease if the water content decreases (Davidson et al., 2000) With that being said, the implementation of MCB should decrease the water content in the soil, however in Figure 2 the plot shows that the change is not significant enough to make a difference in the soil respiration; therefore decreasing the chance of desertification due to MCB.

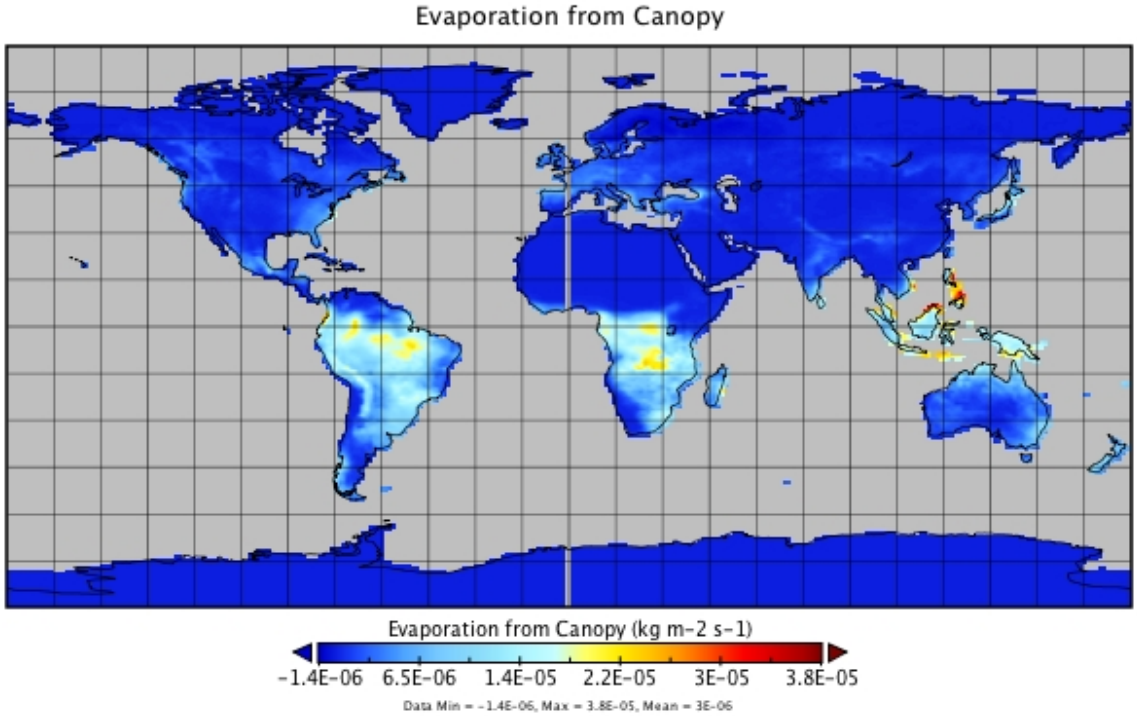

Figure 4.3.1

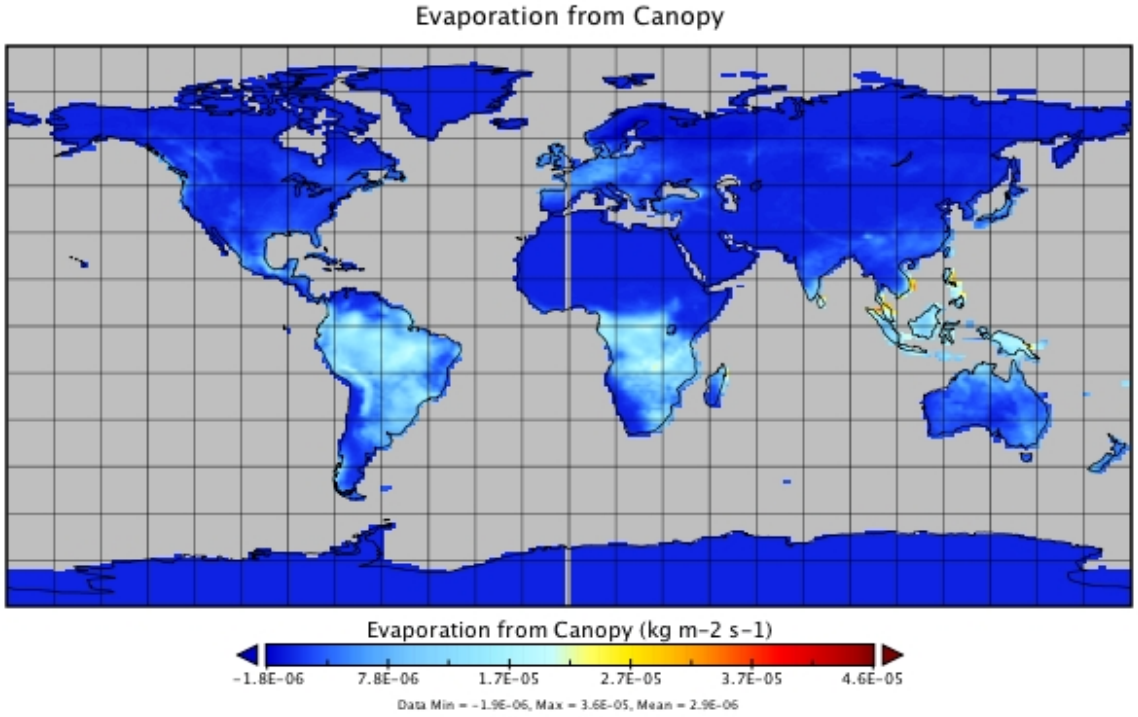

Figure 4.3.2

4.3 The significance of the evaporation from canopy

After SRM was theoretically applied, there was a large difference in the evaporation from canopy in the amazon rainforest; roughly a 40% decrease after SRM was put into effect (Figures 3.1 and 3.2). Since the evaporation rate is decreasing, the atmosphere won't gain the moisture, which then leads to less cloud formation (or moisture in the atmosphere) and overall less rainfall (Cui et al,. 2006). This is more concerning than the other two variables because as the name implies, rainfall is necessary in a rainforest. With dramatically less evaporation, there could be an alarming lack of rainfall to keep tropical rainforests healthy. The extent of how much precipitation would decrease and what effect it could have can be found in other climate models that are not available to the public.

5.0 Discussion

It is hard to say whether SRM can definitely cause desertification of tropical rainforests with only one dataset. Unfortunately, other simulations were not available to the public. But on a basic level, disregarding proper programing and software, the GeoMIP doesn't show MCB could have dramatic negative effects on rainforests. However, in order to properly account for the risks, it is important to use different simulations that account for different variables.

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