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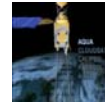
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Whiter Clouds Could Mean Wetter Land

ScienceDaily (June 29, 2010) — One proposed emergency fix to halt global warming is to seed clouds over the ocean to make them more reflective, reducing the solar radiation absorbed by the Earth. But the scheme could also change global rainfall patterns, raising concerns of water shortages on land. A new study by the Carnegie Institution, in collaboration with the Indian Institute of Science, suggests that altered atmospheric circulation under the scheme in fact could increase monsoonal rains and cause the continents to become wetter, not drier, on average.

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Whitening clouds over the ocean to reflect sunlight is one of several geoengineering schemes proposed to counter global warming. The whitening would be accomplished by reducing the size of the water droplets making up the clouds. "Rain clouds, which have big droplets, tend to be grey and absorb sunlight, whereas clouds with smaller droplets tend to be white and fluffy and reflect more sunlight to space," says co-author Ken Caldeira of the Carnegie Institution's Department of Global Ecology. "In practice this could be done by shooting a fine spray of seawater high into the air, where the tiny salt particles would create condensation nuclei to form small cloud droplets."

To test the climate consequences of doing this, Caldeira and his coauthors* used a computer simulation of the global climate system in which atmospheric carbon dioxide concentrations were set at approximately twice that of present day. Cloud droplets over the oceans in the model were reduced in size to make the clouds more reflective. Clouds over land were unaltered. As expected, the whitened clouds reflected more solar radiation and offset the warming effect of the high carbon dioxide levels.

What surprised the researchers, however, was that the model showed that the oceanic clouds caused the land surface to become cooler and wetter on average. In previous climate simulations diminishing solar radiation by geoengineering had reduced precipitation on land. "The drying of the continents has been a major concern with regard to geoengineering," says Caldeira. But in the model the runoff from the continents increased by 7.5% globally, with the effect being strongest in the tropics.

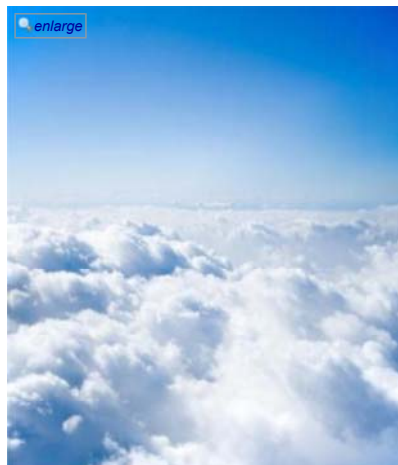
The researchers concluded that the increased precipitation over land was driven by changes in air circulation, similar to the monsoonal pattern that determines rainfall in parts of Asia. "Monsoons occur when air masses over land are warmer than air masses over the ocean, and this draws in cool, moist air from over the ocean which then drops rain over the land," says Caldeira. In the simulations, the reflective oceanic clouds preferentially cooled the air over the oceans relative to land, setting up a monsoonal air flow.

Caldeira stresses that their study, in which all marine clouds worldwide were uniformly whitened, cannot be used to predict the geographic patterns of rainfall that might develop as a result of geoengineering. "In real life, there are only certain parts of the ocean in which you could make the cloud droplets smaller," he says. Areas downwind of land, such as off the east coast of the United States, are already laden with particles of dust and pollution, so adding more particles will not significantly change cloud cover. "An actual deployment would be much patchier than in our study, and the result would therefore be somewhat different. But our basic result calls into question previous assumptions about the impact of this geoengineering scheme. It merits further investigation."

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White clouds as seen from above. One proposed emergency fix to halt global warming is to seed clouds over the ocean to make them more reflective, reducing the solar radiation absorbed by the Earth. But the scheme could also change global rainfall patterns, raising concerns of water shortages on land. (Credit: iStockphoto/Tammy Bryngelson)

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1. G. Bala, Ken Caldeira, Rama Nemani, Long Cao, George Ban-Weiss, Ho-Jeong Shin. **Albedo enhancement of marine clouds to counteract global warming: impacts on the hydrological cycle.** *Climate Dynamics*. 2010; DOI: [10.1007/s00382-010-0868-1](https://doi.org/10.1007/s00382-010-0868-1)

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