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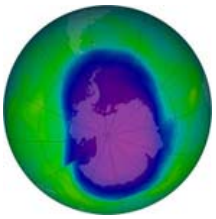
Injecting Sulfate Particles into Stratosphere Could Have Drastic Impact on Earth's Ozone Layer

25 April 2008



Earth's ozone hole, shown in blue, could be exacerbated by some geoengineering efforts to mitigate climate change. Click to enlarge. Credit: NASA

A much-discussed geoengineering approach to offset global warming by injecting sulfate particles into the stratosphere would have a drastic impact on Earth's protective ozone layer, according to a new study led by Simone Tilmes of the National Center for Atmospheric Research (NCAR) in Boulder, Colo.

The research concluded that such an approach would delay the recovery of the Antarctic ozone hole by decades and cause significant ozone loss over the Arctic. The ozone layer is critical for life on Earth because it blocks dangerous ultraviolet radiation from the Sun.

The study results are published online in the journal *Science Express*. The research was funded by the National Science Foundation (NSF), NCAR's principal sponsor, as well as by NASA and other agencies.

> *Our research indicates that trying to artificially cool off the planet may be a perilous endeavor. While climate change is a major threat, this solution could create severe problems for society.*
>
> —Simone Tilmes

Climate scientists, concerned that society is not taking sufficient action to prevent significant changes in climate, have studied various geoengineering proposals to cool the planet and mitigate the most severe impacts of global warming. One of the most-discussed ideas is to regularly inject large amounts of sun-blocking sulfate particles into the stratosphere. The goal would be to cool the climate, much as sulfur particles from large volcanic eruptions have cooling impacts.

Since volcanic eruptions temporarily thin the ozone layer in the stratosphere, Tilmes and her colleagues looked into the potential impact of geoengineering plans on ozone. They used an empirical relationship between ozone depletion and chlorine activation to estimate how sulfate particle injection might influence polar ozone.

The study concluded that an injection of sulfur large enough to compensate surface warming due to the doubling of CO_2 would cause a drastic increase in the extent of Arctic ozone depletion during the next century for cold winters and would cause a considerable delay, between 30 and 70 years, in the expected recovery of the Antarctic ozone hole.

> *This study highlights another connection between global warming and ozone depletion, which had been thought of as separate problems but are now increasingly recognized to be coupled in subtle, yet profoundly important, ways.*
>
> —co-author Ross Salawitch, the University of Maryland

To determine the relationship between sulfates and ozone loss, the authors used a combination of measurements and computer simulations. They then estimated future ozone loss by looking at two geoengineering schemes—one that would use volcanic-sized sulfates, and a second that would use much smaller injections.

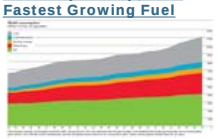
The study found that injections of small particles over the next 20 years could reduce the ozone layer by 100 to 230 Dobson Units. The average thickness of the ozone layer in the Northern Hemisphere is 300 Dobson Units. (A Dobson Unit is a common measure of ozone.) For large particles, the loss would range from 70 to

From the Dashboard

US Sales of Hybrids Down 6% in July 08

US sales of hybrids were down 6% in July 2008 year-on-year, for a new vehicle market share of 2.4% ofr the month.

Global Energy Consumption Up; Coal Fastest Growing Fuel



The ongoing strength of world economic growth last year, despite financial market turmoil which began in August, continued to support global energy consumption. Although Growth in primary energy consumption slowed in 2007 compared to 2006, but at 2.4% it was still above the 10-year average for the fifth consecutive year, according to the BP Statistical Review of World Energy. Coal remained the fastest-growing fuel, but oil consumption grew slowly.

US VMT Down 1.8% in April; Sixth Straight Month of Declines

US vehicle miles traveled (VMT) dropped 1.8% in April, for the six monthly decline in a row. Total estimated VMT for the month was 245.9 billion miles. Moving 12-month total shown.

Sales of Cars Pass Trucks Three Months Running

Car sales in May exceeded truck sales for the third month in a row, with the gap between the two widening each of those months.

New US Hybrids in April Pass 3% Market Share

Reported sales of hybrids broke past a 3% share of new vehicle sales in April 2008.

150 Dobson Units. The larger figure is correlated with colder winters.

In the Antarctic, the sulfate injections would not significantly reduce the thickness of the already depleted ozone layer. Instead, they would significantly delay the recovery of the ozone hole.

The authors caution that the actual impacts on ozone could be somewhat different than estimated if atmospheric changes led to unusually warm or cold polar winters. They also warn that a geoengineering project could lead to even more severe ozone loss if a volcanic eruption took place at the same time.

> *Clearly much more research needs to be conducted to determine the full implications of geoengineering before we may discuss seriously the injection of sulfate aerosols into the stratosphere.*
>
> —co-author Rolf Müller, the Jülich Research Center, Germany

Recovery of Antarctic ozone hole may amplify warming

A separate study by CU-Boulder, the National Oceanic and Atmospheric Administration (NOAA) and NASA suggests that a full recovery of the stratospheric ozone hole could modify climate change in the Southern Hemisphere and even amplify Antarctic warming.

While Earth's average surface temperatures have been increasing, the interior of Antarctica has exhibited a unique cooling trend during the austral summer and fall caused by ozone depletion, said Judith Perlwitz of the Cooperative Institute for Research in Environmental Sciences, a joint institute of CU-Boulder and NOAA.

> *If the successful control of ozone-depleting substances allows for a full recovery of the ozone hole over Antarctica, we may finally see the interior of Antarctica begin to warm with the rest of the world.*
>
> —Judith Perlwitz

Perlwitz is lead author of a new study on the subject to be published 26 April 26 in *Geophysical Research Letters*. Co-authors include Steven Pawson and Eric Nielson of NASA's Goddard Space Flight Center in Greenbelt, Md., and Ryan Fogt and William Neff of NOAA's Earth System Research Laboratory in Boulder. The study was supported by NASA's Modeling and Analysis Program.

The authors used a NASA supercomputer model that included interactions between the climate and stratospheric ozone chemistry to examine how changes in the ozone hole influence climate and weather near Earth's surface.

The study authors calculated that when stratospheric ozone levels return to near pre-1969 levels by the end of the 21st century, large-scale atmospheric circulation patterns now shielding the Antarctic interior from warmer air masses to the north will begin to break down during the austral summer. The circulation patterns are collectively known as a positive phase of the Southern Annular Mode, or SAM.

The scientists found that as ozone levels recover, the lower stratosphere over the polar region will absorb more harmful ultraviolet radiation from the sun. This could cause air temperatures roughly 6 to 12 miles above Earth's surface to rise by as much as 16 degrees Fahrenheit, reducing the strong north-south temperature gradient that currently favors the positive phase of SAM, said the research team.

The supercomputer modeling effort also indicated that ozone hole recovery would weaken the intense westerly winds that currently whip around Antarctica and block air masses from crossing into the continent's interior. As a result, Antarctica would no longer be isolated from the warming patterns affecting the rest of the world.

NASA's Pawson said ozone recovery over Antarctica would essentially reverse summertime climate and atmospheric circulation changes that have been caused by the presence of the ozone hole.

> *It appears that ozone-induced climate change occurred quickly, over 20 to 30 years, in response to the rapid onset of the ozone hole. These seasonal changes will decay more slowly than they built up, since it takes longer to cleanse the stratosphere of ozone-depleting gases than it took for them to build up.*
>
> —Steven Pawson

The seasonal shift in large-scale circulation patterns could have repercussions for Australia and South America as well. Other studies have shown that the positive phase of SAM is associated with cooler temperatures over much of Australia and increased rainfall over Australia's southeast coastline.

During late spring and early summer, the positive phase of SAM also is associated with drier conditions in South America's productive agricultural areas like Argentina, Brazil, Uruguay and Paraguay, said Perlwitz. If ozone recovery induces a shift away from a positive SAM, Australia could experience warmer and drier conditions while South America could get wetter, she said.

But just how influential a full stratospheric ozone recovery will be on Southern Hemisphere climate largely depends on the future rate of greenhouse gas emissions, according to the *GRL* authors. Projected increases in human-emitted greenhouse gases like carbon dioxide will be the main driver for strengthening the positive phase of SAM.

> *In running our model simulations, we assumed that greenhouse gases like carbon dioxide would double over the next 40 years and then slowly level off. If human activities cause more rapid increases in greenhouse gases, or if we continue to produce these gases for a longer period of time, then the positive SAM may dominate year-round and dwarf any climatic effects caused by ozone recovery.*
>
> —Judith Perlwitz

NASA's High-End Computing Program provided the Columbia supercomputer resources at the NASA Ames Research Center in Moffett Field, Calif.

Resources

- Simone Tilmes, Rolf Müller, Ross Salawitch; The Sensitivity of Polar Ozone Depletion to Proposed Geoengineering Schemes; *Science Express* DOI: 10.1126/science.1153966

April 25, 2008 in Climate Change, Geoengineering | Permalink | Comments (10) | TrackBack (0)

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COMMENTS

This idea of injecting sulphur particles was suggested by Paul Crutzen. It's truly insane.

Not only does it destroy the ozone layer, previous research also shows that it would destroy agriculture and drastically alter the hydrological cycle (precipitation patterns) and would thus lead to more rapid warming (because of the destruction of the carbon cycling capacity of biomass on land and in water). It would also destroy our food and fuel production and thus threaten the survival of societies.

Yes, even a Nobel Laureate like Crutzen seems to be capable of suggesting idiotic things, now and then.

See:

GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L15702,
doi:10.1029/2007GL030524, 2007

Effects of Mount Pinatubo volcanic eruption on the hydrological cycle as an analog of geoengineering

The problem of global warming arises from the buildup of greenhouse gases such as carbon dioxide from burning of fossil fuels and other human activities that change the composition of the atmosphere and alter outgoing longwave radiation (OLR). One geoengineering solution being proposed is to reduce the incoming sunshine by emulating a volcanic eruption. In between the incoming solar

sunshine by emulating a volcanic eruption. In between the incoming solar radiation and the OLR is the entire weather and climate system and the hydrological cycle. The precipitation and streamflow records from 1950 to 2004 are examined for the effects of volcanic eruptions from El Chichón in March 1982 and Pinatubo in June 1991, taking into account changes from El Niño-Southern Oscillation. Following the eruption of Mount Pinatubo in June 1991 there was a substantial decrease in precipitation over land and a record decrease in runoff and river discharge into the ocean from October 1991–September 1992. The results suggest that major adverse effects, including drought, could arise from geoengineering solutions.

http://www.agu.org/pubs/crossref/2007.../2007GL030524.shtml

Posted by: Jonas | Apr 25, 2008 5:49:57 AM

Hopefully this idea will die out, but I still have a question about what happens when these sulfate particles drift back to the surface. What will they do to the chemistry of terrestrial ecosystems? Equally important, how would they affect the performance of photovoltaic cells and concentrating solar facilities?

Could a buying ourselves a little time on warming preclude our ability to eliminate non-renewable energy? That would be tragic.

Posted by: jlw | Apr 25, 2008 7:33:22 AM

Fortunately, this has been suggested only in theory and at that Crutzen made it clear a non-volatile highly reflective substance (not sulphate) would need to be identified before any geo-engineering effort.

This, like the iron in the oceans CO2 sink - is equally absurd in light of the increasing disclosures about CO2-based warming. A solution without a problem.

Posted by: sulleny | Apr 25, 2008 7:36:31 AM

I would not say it was "insane" but rather expectations by some that it would be a perfect fix were of course wrong. Could it work, possibly, could it present more problem then it could fix, probably.

Posted by: Ben | Apr 25, 2008 7:36:40 AM

Governments have forced reductions in sulfur emissions from power plants, industry and motor vehicles for a very good reason: sulfuric acid is bad for human health, livestock health, crop health and certain buildings (e.g. gothic cathedrals made from limestone). Anything spewed high into the atmosphere eventually comes down as acid rain.

Indeed, any particles that are transported into the atmosphere eventually come down. European motorists occasionally discover a layer of ultra-fine sand from the Sahara desert on their cars.

Pretty much the only way artificial global cooling could work is if large quantities of dust were orbiting the planet - hardly a realistic prospect. Moreover, it would have to be replenished regularly, there's a reason the outer planets feature rings, not shrouds.

Besides, RAF Fylingdales in the UK already tracks some 10,000 items of space junk - and those are just the larger bits. Thanks to the high relative velocities, even a spec of dust can do significant damage to a satellite.

Posted by: Rafael Seidl | Apr 25, 2008 8:04:33 AM

"Recovery of Antarctic ozone hole may amplify warming"

Is it just me or did everyone miss the second half of the post?
A 16 deg F increase in temp during the antarctic summer will cause massive increases in icecap melting. I'm not arguing for keeping the ozone hole, but this part seems just as important as rebutting sulfur particle injection.

Posted by: allen_xl_z | Apr 25, 2008 8:50:11 AM

Well allen, that part did stick with me as well.
-
It certainly explains a bit on why the Ant-Arctic seems to be staying relatively frosty.
By comparison, some scientists figure the Artic might be completely gone in the next 5 years.
-
The real catch-22 of course being that Chlorofluorocarbons, (i.e. CFCs), the stuff that caused the Ozone hole in the first place, are also extremely potent greenhouse gases. That can be up to 30,000x more potent than CO2.

Posted by: GreyFlcn | Apr 25, 2008 3:40:26 PM

The problem with this "study" is that it isn't actually a study at all. It is several tweaked runs of a computer model. Models are not the reality. They are a masturbatory substitute for the real thing.

Posted by: Al Fin | Apr 27, 2008 8:01:56 AM

iftwub prbjxuy gurvosw glhbpsajk defno xonkjsq larh

Posted by: gvywze axsmydnj | May 28, 2008 1:44:36 AM

Increase in atmospheric carbon dioxide is undoubtedly increasing climate warmth. However I suspect that an even greater affect on warmth is the baring of soil by increase in annual crop acreage, roads, buildings, grazing, and desertification. You may see an article that discusses this in more detail in http://charles_w.tripod.com/climate.html

Posted by: Charles Weber | Aug 27, 2008 6:57:31 PM

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