Storms may speed ozone loss above the United States

Injection of water vapour makes ozone layer sensitive to global warming and geoengineering.

Jeff Tollefson

26 July 2012

Summer thunderstorms across the United States inject water vapour far higher into the atmosphere than was previously believed, promoting a cascade of chemical reactions that could pose an increased threat to Earth's protective ozone layer as the climate warms.

James Anderson, an atmospheric chemist at Harvard University in Cambridge, Massachusetts, and his colleagues made the discovery while investigating the origins of high-altitude cirrus clouds — thin and wispy formations that blanket the sky and trap heat, contributing to the greenhouse effect.

Anderson's team expected to see summer storms supply cirrus clouds by pumping water vapour up to an average altitude of about 14 kilometres. Instead, the researchers report today in *Science*[1], about half of the storms that they studied injected vapour to altitudes of between 15 and 20 kilometres.

Rick D'Elia/Corbis

Summer storms in the United States inject water into the atmosphere at altitudes up to 20 kilometres, accelerating ozone-destroying reactions.

"We were shocked," says Anderson. "Standard, run-of-the-mill Midwestern thunderstorms are far more capable of injecting water vapour into the stratosphere than we once thought."

There are significant implications for stratospheric ozone, which shields the Earth from ultraviolet radiation. Ozone can be destroyed by reactions with chlorine and water — and the rates of those reactions are governed mainly by temperature and the presence of water vapour. If, as expected, storm activity increases owing to global warming, says Anderson, the proportion of water in the stratosphere will increase, leading to accelerating destruction of stratospheric ozone — and an increase in the amount of ultraviolet radiation reaching Earth.

Climate calculations

Andrew Dessler, an atmospheric scientist at Texas A&M University in College Station, says that further observations are needed to understand all the implications. "I'm not at all surprised that this happens," he says, "but I think a challenge is really going to be quantifying all aspects of the problem" including the frequency of the water-vapour injections and any resulting stratospheric chlorine reactions.

The affected area of the stratosphere — between 15 and 20 kilometres in altitude — contains about 20% of the total stratospheric ozone, and Anderson says that the water-vapour injections could provide conditions for rapid ozone destruction similar to those that scientists have been investigating for decades in Antarctica and more recently in the Arctic.

Currently, water vapour occupies about 5 parts per million by volume (p.p.m.v.) of the affected parts of the stratosphere. If that were to increase to 12 p.p.m.v., up to 25% of the ozone in the affected zone could be destroyed within a week. If water-vapour content climbed to 18 p.p.m.v., about 35% of the ozone could be destroyed in the same time frame.

Kerry Emanuel, a climatologist at the Massachusetts Institute of Technology in Cambridge, says that the study adds urgency to an issue that his profession has yet to clear up: how will storms respond to climate change? "We really don't know the answer to that," he says. "This is a surprisingly under-developed field."

Geoengineering risk

The study also raises questions about geoengineering — the concept of manipulating the environment to mitigate climate change. One method of geoengineering currently being considered would involve pumping sulphate aerosols into the stratosphere to reflect sunlight back into space and cool the planet. But sulphate particles also act as catalysts for ozone-destroying reactions, so such a scheme could speed the reactions. "The worst cocktail you can think of is to inject a combination of sulphur and water into the stratosphere, and that is exactly what would be happening," says Anderson. "Nature would be injecting the sulphates.”

David Keith, a geoengineering expert at Harvard, says that the findings do not necessarily mean that geoengineering should be discarded. The increased risk from water vapour and sulphates must be weighed against the fact that chlorine levels in the atmosphere are dropping as a result of successful implementation of the Montreal Protocol, which phases out production of ozone-depleting substances, says Keith. Early calculations, he adds, suggest that the two effects could roughly cancel each other out in the future.

Anderson and Keith are now discussing ways to conduct atmospheric experiments using a balloon or aircraft to understand the chemistry, including risks posed to ozone by additional water vapour and sulphates in the stratosphere. Their plans sparked a brief media frenzy last week, when a news report surfaced suggesting that the researchers intended to conduct a geoengineering experiment within a year. Both say that this is untrue: the experiment would be much broader than just geoengineering and is still in the discussion and modelling phase. It would also need to go through a full suite of public-funding and regulatory approvals before it moves forward.

“In my view we must simply know more, and knowing more means knowing the risks,” says Keith. “And you cannot know the risks just by computer modelling.”

Nature | doi:10.1038/nature.2012.11063

References

1. Anderson, J.G., Wilmouth, D. M., Smith, J. B. & Sayres, D. S. *Science.* http://dx.doi.org/10.1126/science.1222978 (2012).