Complex impact of large wildfires on ozone layer dynamics unveiled

July 12 2024

Credit: Vladyslav Dukhin from Pexels

In a revelation that highlights the fragile balance of our planet's atmosphere, scientists from China, Germany, and the U.S. have uncovered an unexpected link between massive wildfire events and the chemistry of the ozone layer. Published in *Science Advances*, this study reveals how wildfires, such as the catastrophic 2019/20 Australian bushfires, impact the stratosphere in previously unseen ways.

The ozone layer, a crucial shield protecting life on Earth from harmful ultraviolet (UV) radiation, has been on a path to recovery thanks to the Montreal Protocol. This landmark international treaty, adopted in 1987, successfully phased out the production of numerous substances responsible for ozone depletion.

Over the past decades, the ozone layer has shown significant signs of healing, a testament to global cooperation and environmental policy.

However, the stability of this vital atmospheric layer is now facing a new and unexpected challenge. During the 2019/20 Australian wildfires, researchers observed a dramatic increase in stratospheric aerosols—tiny particles that can influence climate, health and atmospheric chemistry.

Utilizing advanced satellite data and numerical models, the research team successfully demonstrated the impact of wildfires through a novel phenomenon: the smoke-charged vortex (SCV).

"The SCV is a powerful, smoke-laden whirlpool that transports wildfire emissions into the stratosphere, reaching altitudes of up to 35 kilometers," explained Prof. Hang Su from the Institute of Atmospheric Physics at the Chinese Academy of Sciences, one of the corresponding authors of the study.

"This process led to at least a doubling of the aerosol burden in the southern hemisphere's middle stratosphere. These aerosols, once reaching such high altitudes, initiated a series of heterogeneous reactions that impacted ozone concentrations."

The international team discovered that these wildfire-induced aerosols facilitated heterogeneous chemical reactions, which paradoxically led to both ozone depletion and ozone increase at different atmospheric layers.

While the lower stratosphere experienced significant ozone loss, they found that the enhanced chemical reactions on aerosols at higher altitudes, i.e., the middle stratosphere, lead to increase of ozone. In Southern Mid-Latitudes, this complex interplay managed to buffer approximately 40% (up to 70%) of the ozone depletion observed in the lower stratosphere in the following months of the mega-bushfire events.

So why does this matter?

"Our study demonstrates an unexpected and crucial mechanism, by which the absorbing aerosols in wildfire smoke, such as black carbon, can induce and sustain enormous smoke-charged vortices spanning thousands of kilometers," said Prof. Yafang Cheng, another corresponding author from the Max Planck Institute for Chemistry.

"These vortices can persist for months, carrying aerosols deeply into the stratosphere and affecting the ozone layer in distinct ways at different altitudes. This highlights the need for continued vigilance and research as climate change progresses."

The ozone layer's role in filtering UV radiation is crucial for protecting all life forms on Earth. The Montreal Protocol's success in reducing ozone-depleting substances was a monumental achievement, but the new findings highlight that natural events, exacerbated by climate change, pose additional risks to this fragile layer.

With the increasing frequency and intensity of wildfires driven by global warming, the formation of SCVs and their impact on the stratosphere could become more common, threatening the delicate balance of the ozone layer.

This study opens new avenues for research into how wildfire and other climate-driven events might influence stratospheric chemistry and ozone dynamics in the future.

More information: Chaoqun Ma et al, Smoke-charged vortex doubles hemispheric aerosol in the middle stratosphere and buffers ozone depletion, *Science Advances* (2024). DOI: 10.1126/sciadv.adn3657. www.science.org/doi/10.1126/sciadv.adn3657

Provided by Chinese Academy of Sciences