

Climate damage caused by growing space tourism needs urgent mitigation

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Published today in the journal *Earth's Future*, researchers from UCL, the University of Cambridge and Massachusetts Institute of Technology (MIT) used a 3D model to explore the impact of rocket launches and re-entry in 2019, and the impact of projected space tourism scenarios based on the recent billionaire space race.

The team found that [black carbon](#) (soot) particles emitted by rockets are

almost 500 times more efficient at holding heat in the atmosphere than all other sources of soot combined (surface and aircraft)—resulting in an enhanced climate effect.

Furthermore, while the study revealed that the current loss of total ozone due to rockets is small, current growth trends around [space tourism](#) indicate potential for future depletion of the upper stratospheric [ozone layer](#) in the Arctic in spring. This is because pollutants from solid-fuel rockets and re-entry heating of returning spacecraft and debris are particularly harmful to stratospheric ozone.

Study co-author Dr. Eloise Marais (UCL Geography) said: "Rocket launches are routinely compared to [greenhouse gas](#) and air pollutant emissions from the aircraft industry, which we demonstrate in our work is erroneous.

"Soot particles from [rocket launches](#) have a much larger climate effect than aircraft and other Earth-bound sources, so there doesn't need to be as many rocket launches as [international flights](#) to have a similar impact. What we really need now is a discussion amongst experts on the best strategy for regulating this rapidly growing industry."

To calculate the findings, the researchers collected information on the chemicals from all 103 rocket launches in 2019 from across the world, as well as data on reusable rocket and space junk re-entry. They also used the recent demonstrations by space tourism entrepreneurs Virgin Galactic, Blue Origin and SpaceX and proposed yearly offerings of at least daily launches by Virgin Galactic to construct a scenario of a future formidable space tourism industry.

These data were then incorporated into a 3D atmospheric chemistry model to explore the impact on climate and the ozone layer.

The team show that warming due to soot is 3.9 mW m^{-2} from a decade of contemporary rockets, dominated by emissions from kerosene-fuelled rockets. However, this more than doubles (7.9 mW m^{-2}) after just three years of additional emissions from space tourism launches, due to the use of kerosene by SpaceX and hybrid synthetic rubber fuels by Virgin Galactic.

The researchers say this is of particular concern, as when the soot particles are directly injected into the [upper atmosphere](#), they have a much greater effect on climate than other soot sources—with the particles 500 times more efficient at retaining heat.

The team found that, under a scenario of daily or weekly space tourism rocket launches, the impact on the stratospheric ozone layer threatens to undermine the recovery experienced after the successful implementation of the Montreal Protocol.

Adopted in 1987, the Montreal Protocol global ban on substances that deplete the ozone layer is considered one of the most successful international environmental policy interventions.

Study co-author Dr. Robert Ryan said: "The only part of the atmosphere showing strong ozone recovery post-Montreal Protocol is the upper stratosphere, and that is exactly where the impact of rocket emissions will hit hardest. We weren't expecting to see ozone changes of this magnitude, threatening the progress of ozone recovery.

"There is still a lot we need to find out about the influence of [rocket](#) launch and re-entry emissions on the atmosphere—in particular, the future size of the industry and the types and by-products of new fuels like liquid methane and bio-derived fuels.

"This study allows us to enter the new era of space tourism with our eyes

wide open to the potential impacts. The conversation about regulating the environmental impact of the space launch industry needs to start now so we can minimize harm to the [stratospheric ozone](#) layer and climate."

More information: Robert G. Ryan et al, Impact of Rocket Launch and Space Debris Air Pollutant Emissions on Stratospheric Ozone and Global Climate, *Earth's Future* (2022). [DOI: 10.1029/2021EF002612](https://doi.org/10.1029/2021EF002612)

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