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Research in Graubünden

Rockets and the ozone layer

Why the space boom is creating new environmental challenges

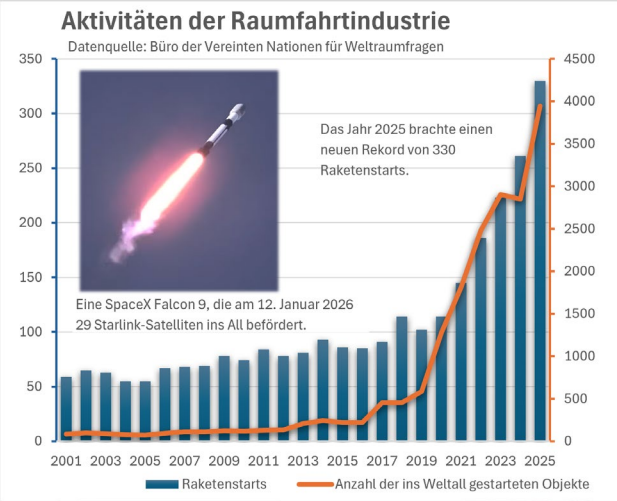

Figure 1 The rocket industry has experienced strong growth for six years and continues to expand. Graphic: Courtesy of the authors; image SpaceX Falcon 9: SpaceX (https://www.spacex.com/launches/sl-6-97)

The view of the night sky is changing. More and more satellites are orbiting the Earth, driven by a rapidly growing space industry. While satellites provide essential services such as communication, navigation and Earth observation—services that have become indispensable in everyday life—science is increasingly focusing on the less visible consequences: the impact of rocket launches on the atmosphere, particularly on the ozone layer.

The ozone layer in the stratosphere protects life on Earth from harmful UV radiation. At the end of the 20th century, it was severely damaged by long-lived chemicals such as chlorofluorocarbons (CFCs), most visibly in the form of the ozone hole over Antarctica. Thanks to the Montreal Protocol and the associated ban on these substances, the ozone layer is slowly recovering. However, it will take several more decades before pre-industrial conditions are restored.

During rocket launches, gases and particles are released directly into the middle and upper atmosphere. Unlike air pollution near the ground, these emissions are not removed by rain or clouds and can persist for long periods of time. Atmospheric circulation then distributes them globally, far beyond the regions where the launches take place. A climate model developed at ETH Zurich and at the Physical-Meteorological Observatory Davos (PMOD/WRC) shows that emissions from increasing rocket activity could place additional stress on the recovering ozone layer. Although the effects are smaller than the historical damage caused by CFCs, even minor disturbances can delay its recovery.

The impact of rockets on the ozone layer depends strongly on the type of propulsion used: solid rocket motors release large amounts of chlorine, which directly destroys ozone, whereas cleaner propellants such as liquid oxygen and hydrogen place significantly less strain on the ozone layer. So far, however, these more environmentally friendly propulsion systems are only rarely used.

Another source of uncertainty comes from the satellites themselves. Most burn up when re-entering the atmosphere, releasing pollutants such as metal particles and nitrogen oxides. Their effects on the ozone layer and on cloud formation have only recently begun to be studied. From 2026 onwards, the EU-funded project SLICE will investigate the environmental and climatic impacts of space launches. Four Swiss research institutions, including PMOD/WRC, are involved. The aim is to establish a sound scientific basis for risk assessments and for any regulations that may be required.

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Experience with the Montreal Protocol shows that global environmental problems can be solved when science, politics and industry work together. In the new era of spaceflight, the same foresight and coordination are needed to permanently protect our most important natural shield: the ozone layer.

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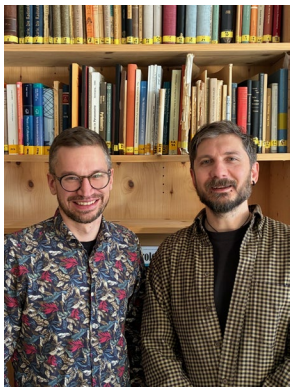

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