



### Perspective Blog - May 2023

## Rocket Exhaust: The Need for Proper Regulations

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*There are an increasing number of rocket launches every year and with that comes a greater risk to the environment and human health. The space sector's unique reach into the heights of the atmosphere means the environmental impact of rocket launches must be given special consideration. The standards for aviation cannot simply be transplanted into the space industry, as has been done so far.*

At SpaceX's Starship April 20th launch, the launch pad was left with a large crater, and dust and debris were propelled into areas as far as 10.5 kilometers (6.5 miles) away<sup>1</sup>. Most of Port Isabel, TX was covered in thick dust, and a 1.4-hectare (3.5-acre) fire was ignited in a Boca Chica national wildlife refuge<sup>2</sup>. The Federal Aviation Administration (FAA) is launching an emergency "mishap" investigation since nothing of this extent was anticipated in the environmental assessment conducted pre-launch<sup>3</sup>. But debris and fire are not the only effects rocket launches can have on the environment. With the growth of the space industry, more long-term and cumulative symptoms will begin to appear if we do not adequately assess and regulate rocket emissions.

The FAA, as the primary regulating body in the United States for rocket launches, requires compliance with National Environmental Policy Act (NEPA) standards. The main impacts of rocket exhaust on the environment come from the emission of aerosols and particulate matter, such as black carbon and alumina particles, and greenhouse gases, such as water vapor and



*A massive cloud of dust and debris was kicked up by the launch, resulting in a nearby minivan (left corner of image) being struck by a piece of rubble.*



*Damage at site of fire sparked by the launch.*

<sup>1</sup> Photo by @LabPadre via Storyful, Wall Street Journal, <https://www.wsj.com/video/spacex-starship-launch-engulfs-car-in-rapid-unscheduled-flying-debris/60D099FE-6E05-4038-A2F3-7B9D21BFCD1B.html>

<sup>2</sup> Photograph by Coastal Bend Bays and Estuaries Program, Texas Public Radio, <https://www.tpr.org/environment/2023-04-27/photos-spacex-is-grounded-after-rocket-explosion-caused-extensive-environmental-damage>

<sup>3</sup> Steve Gorman, Joey Roulette, and David Shepardson, "Debris blast from SpaceX launch renews environmental questions," (Reuters, 2023).

carbon dioxide. There are also several compounds that can make air at Earth’s surface hazardous to humans, such as nitrogen oxides and hydrogen chloride. It is important to note that although SpaceX is facing the most scrutiny at the moment, they are not the only ones contributing to rocket-produced pollution: other leading US-based producers of black carbon include Lockheed Martin (in addition to SpaceX) while chlorine and aluminum oxide are produced by NASA rockets and hydrogen oxides by Blue Origin<sup>4</sup>. The table below lists common rocket launch byproducts and their impacts on human health and the environment.

Impacts	Pollutants
Human health <ul style="list-style-type: none"> <li>Respiratory and cardiovascular issues when ingested.</li> <li>Promote the formation of harmful ground-level ozone<sup>5</sup>.</li> </ul>	Black carbon Hydrogen chloride Nitrogen oxide
Global climate change <ul style="list-style-type: none"> <li>Addition of greenhouse gases even more potent than carbon dioxide<sup>6</sup>.</li> <li>Aerosols absorb heat and increase temperature<sup>7</sup>.</li> </ul>	Aluminum oxide Black carbon Methane Water vapor
Other atmospheric disruptions <ul style="list-style-type: none"> <li>Possible floods and droughts due to altered cloud formation and precipitation patterns<sup>8</sup>.</li> <li>More harmful radiation reaches the surface through holes in the ozone layer<sup>9</sup>.</li> </ul>	Aluminum oxide Black carbon

Unfortunately, due to a lack of rocket-specific pollutant research, standards from other transportation sectors are often used instead, even where inappropriate due to the differences between engines, fuels, and where transportation takes place. For example, black carbon is especially significant in the space industry because rocket engines emit much more of it than airplane engines do and at altitudes where the atmosphere is particularly sensitive to its effects. Differences between rocket and aviation pollutants are not limited to black carbon, and in the FAA 2022 review<sup>10</sup> of SpaceX’s Boca Chica launch site it is stated that “rocket engine combustion emissions are not subject to limitations on production or use because the EPA has not set emissions standards for rocket engines.” In fact, “at present, no methodology exists that would enable estimating the specific impacts (if any) that this change in [greenhouse gases] would produce locally or globally.”

<sup>4</sup> Martin Ross and James A. Vezza, “The Policy and Science of Rocket Emissions,” (The Aerospace Corporation, 2018).

<sup>5</sup> Federal Aviation Administration, “Guidelines for compliance with the national environmental policy act and related environmental review statutes for the licensing of commercial launches and launch sites,” (2001).

<sup>6</sup> Tereza Pultarova, “The environmental impact of rocket launches: The ‘dirty’ and the ‘green’,” (Space.com, 2021).

<sup>7</sup> The Aerospace Corporation, “What’s the Impact of the Space Industry on Climate Change?” (2022).

<sup>8</sup> Climate & Clean Air Coalition, “Black carbon,” (2017).

<sup>9</sup> National Ocean and Atmospheric Administration, “Projected increase in space travel may damage ozone layer,” (2022).

<sup>10</sup> Federal Aviation Administration, “Final Programmatic Environmental Assessment,” (2022), 45-52.

Just because there is no solid understanding of the impacts of rocket exhaust does not mean there are no real-world problems that can arise from them. **Rocket engine emissions must be included in environmental reviews of rocket launches and regulatory policies must be updated to provide the best possible environmental protection.** Together, these will lay the foundation for a more Earth- and human-friendly space industry.

**Author Bio:** Barbara Milewski is an undergraduate student in Atmospheric Sciences at University of Washington. She is interested in the role weather and climate play in human society and activities, especially in the aviation and space industries.

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