Smarter flight decisions can cool the planet, UC Irvine study shows

Reducing plane contrails, emissions can mitigate climate impact without undue sacrifice.

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“This is a win for both science and society,” says lead author Michael Prather, UC Irvine professor of Earth system science, in a 2008 photo.

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- Researchers led by a UC Irvine professor developed a new tool to measure aviation's impact on climate when making tradeoffs.
- Cutting aircraft contrails or nitrogen oxide emissions can offset small increases in carbon dioxide.
- The Global Warming per Activity tool enables users to develop decision risk curves that help policymakers make smarter, climate-friendly choices.

rvine, Calif., July 2, 2025 — A new study led by a University of California, Irvine scientist reveals that airlines can make smarter tradeoff decisions to cut aviation's warming impact. The NASA- and National Science Foundation-supported research, published online today in *Nature*, offers hopeful news for the future of air travel and climate action.

Civil aviation contributes to global warming through several factors: carbon dioxide from fuel, nitrogen oxides that affect ozone and methane levels, and the formation of lingering condensation trails. Each of these plays a role in trapping heat in the atmosphere. Historically, efforts to reduce one of these climate offenders have often increased another, leading to tough decisions for the aviation industry.

But now, researchers led by Michael Prather, a professor of Earth system science at UC Irvine, have created a new decision-making tool that gauges the full climate impact of each aviation activity, including the uncertainties. Called Global Warming per Activity, the metric measures how long and how strongly each component affects the atmosphere – whether it lasts hours or a century. The key is having quantified uncertainties in all these elements, allowing users to formulate a decision risk curve calculating the probability that a given tradeoff will be successful in mitigating climate change.

"We have always tried to build uncertainty quantification into our climate assessments," Prather said. "But this new decision tool uses the information to provide accurate risk quantification for climate tradeoff decisions."

For instance, rerouting flights to avoid conditions that produce contrails might result in slightly increased fuel consumption. However, if those contrails are significantly reduced, there could be a net positive effect on the climate.

The study found that if aviation choices lead to even a 3 to 5 percent reduction in contrails or NO_x emissions, they can outweigh a 1 percent increase in CO_2 emissions

over a 100-year period. In other words, carefully chosen strategies that increase fuel use slightly can actually *reduce* the long-term climate impact of flying. This approach has only been applied to climate change damage and has not addressed tradeoffs in terms of economic costs (such as more fuel per flight).

The method can empower airlines and regulators to make smarter decisions that benefit everyone. And while previous models often struggled to compare the effects of short-lived and long-lived pollutants, GWA allows for more accurate, activity-based comparisons – helping the aviation industry find the least harmful options for reducing climate change.

“This is a win for both science and society,” Prather said. “Our findings show that we don’t have to choose between reducing carbon emissions and tackling other warming pollutants. We can find a balance that leads to meaningful progress.”

By quantifying the likelihood of a positive climate outcome, the study presents a new approach to evaluating tradeoffs with confidence, even in the face of uncertainties. The risk curves provide policymakers and airline planners with a clearer understanding of the priorities and potential consequences of their actions.

The implications reach beyond aviation. The GWA tool could also help assess the climate impacts of other industries – like shipping, agriculture or manufacturing – where different types of emissions compete and interact, Prather said.

About UC Irvine’s Brilliant Future campaign: Publicly launched on Oct. 4, 2019, the Brilliant Future campaign aims to raise awareness and support for the university. By engaging 75,000 alumni and garnering $2 billion in philanthropic investment, UC Irvine seeks to reach new heights of excellence in student success, health and wellness, research and more. The School of Physical Sciences plays a vital role in the success of the campaign. Learn more at https://brilliantfuture.uci.edu/uci-school-of-physical-sciences.

About the University of California, Irvine: Founded in 1965, UC Irvine is a member of the prestigious Association of American Universities and is ranked among the nation’s top 10 public universities by *U.S. News & World Report*. The campus has produced five Nobel laureates and is known for its academic achievement, premier research, innovation and anteater mascot. Led by Chancellor Howard Gillman, UC Irvine has more than 36,000 students and offers 224 degree programs. It’s located in one of the world’s safest and most economically vibrant communities and is

Orange County’s second-largest employer, contributing $7 billion annually to the local economy and $8 billion statewide. For more on UC Irvine, visit www.uci.edu.

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