Aviation emissions' impacts on air quality larger than on climate, study finds

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New research from the Massachusetts Institute of Technology (MIT) has quantified the climate and air quality impacts of aviation, broken down by emission type, altitude and location.

The MIT team found that growth in aviation causes twice as much damage to air quality as to the climate.

Writing today in IOP Publishing's *Environmental Research Letters*, they examine how this damage can be mitigated, and provide consistent comparative assessments of aviation emissions trade-offs, considering both climate and air quality impacts.

The lead researcher on the study, Dr. Sebastian Eastham, from the Laboratory for Aviation and the Environment in MIT's Department of Aeronautics and Astronautics, said: "Aviation emissions are an increasingly significant contributor to anthropogenic climate change. They cause five per cent of global climate forcing.

"When you consider the full flight, which includes emissions from takeoff, cruise and landing, aircraft emissions are also responsible for around 16,000 premature deaths a year from impaired air quality. This is small compared to other sectors, being only around 0.4% of the total deaths attributed annually to global air quality degradation, but is often overlooked in policy analysis."

"The challenges for aviation sector decision makers wanting to reduce these impacts are the trade-offs between different emission types, and their impacts in different locations."

Historically, attempts to address the climate and air quality impacts from aviation have been through changes in policy, technology, and/or operations—improvements to fuel efficiency; more stringent emissions standards; market-based measures to reduce CO2 emissions; or the introduction of sustainable aviation fuels.

But the study notes reducing one type of emission can come at the cost of increasing another, either in absolute terms or by limiting potential

reductions offered by new technology.

Dr. Eastham explained: "We could decrease NOx emissions by designing engines with lower combustor temperatures. However, the resulting loss in thermodynamic efficiency would mean we need to burn more fuel, meaning more CO2. These are the types of trade-offs that need to be quantified, and our study offers a fast way for decision makers to do this.

"We developed a set of metrics for comparing the climate and air quality impacts of aviation emissions at all flights stages, by estimating the social costs per unit of emitted pollutant. The cost metrics are broken down by flight phase—cruise, landing and take-off—and by the geographical region of emission, both per kg of emission and per kg of fuel burn."

The research team applied the metrics to evaluate the effects of a global expansion in aviation, consistent in magnitude with its current annual growth. They then used this as a benchmark for three scenarios.

First, they considered a growth scenario with fuel efficiency increases and reductions in NOx emissions factors consistent with 10-year goals. Second, they evaluated the trade-offs between the climate and air quality impacts of engine-based NOx emissions reductions. Finally, they re-assessed the climate and air quality trade-offs of jet fuel desulphurisation.

Dr. Eastham said: "Our results show three components are responsible for 97 per cent of climate and air quality damages per unit aviation fuel burn: air quality impacts of NOx at 58 per cent; climate impacts of CO2 at 25 per cent; and climate impacts of contrails at 14 per cent. It is important to note that the vast majority, around 86 per cent in fact, of the NOx impacts on air quality are due to the emissions from cruise as

opposed to the landing and takeoff cycle. These components—cruise NOx emissions, CO2 emissions, and contrails—are therefore primary targets for future strategies to reduce the atmospheric impacts of aviation emissions.

"To reduce the climate impacts of aviation, measures aimed at reducing CO2 emissions and contrails are likely to have the greatest net climate benefit. In contrast, we found that 94 per cent of air quality impacts are driven by NOx. This suggests that measures aimed at reducing NOx emissions during cruise could lead to the greatest net benefits, even if they cause a small but uncertain climate NOx disbenefit and a small decrease in fuel efficiency.

"Finally, we found the air quality impacts of aviation emissions significantly exceed the climate impacts, with air quality impacts being 1.7 to 4.4 times higher than the climate impact per unit of fuel burn. This must be contrasted to ground-based industries, where post-combustion emissions control and access to cleaner fuels is widespread. For example, the climate impacts of the US power sector are of similar magnitude as the air quality impacts following significant declines in co-pollutant emissions over the past 15 years. This points towards potential political and technological opportunities for reducing the atmospheric impacts of the aviation sector."

More information: Marginal Climate and Air Quality Costs of Aviation Emissions, *Environmental Research Letters* (2019). DOI: 10.1088/1748-9326/ab4942

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