Aviation contributes 3.5% to the drivers of climate change that stem from humans

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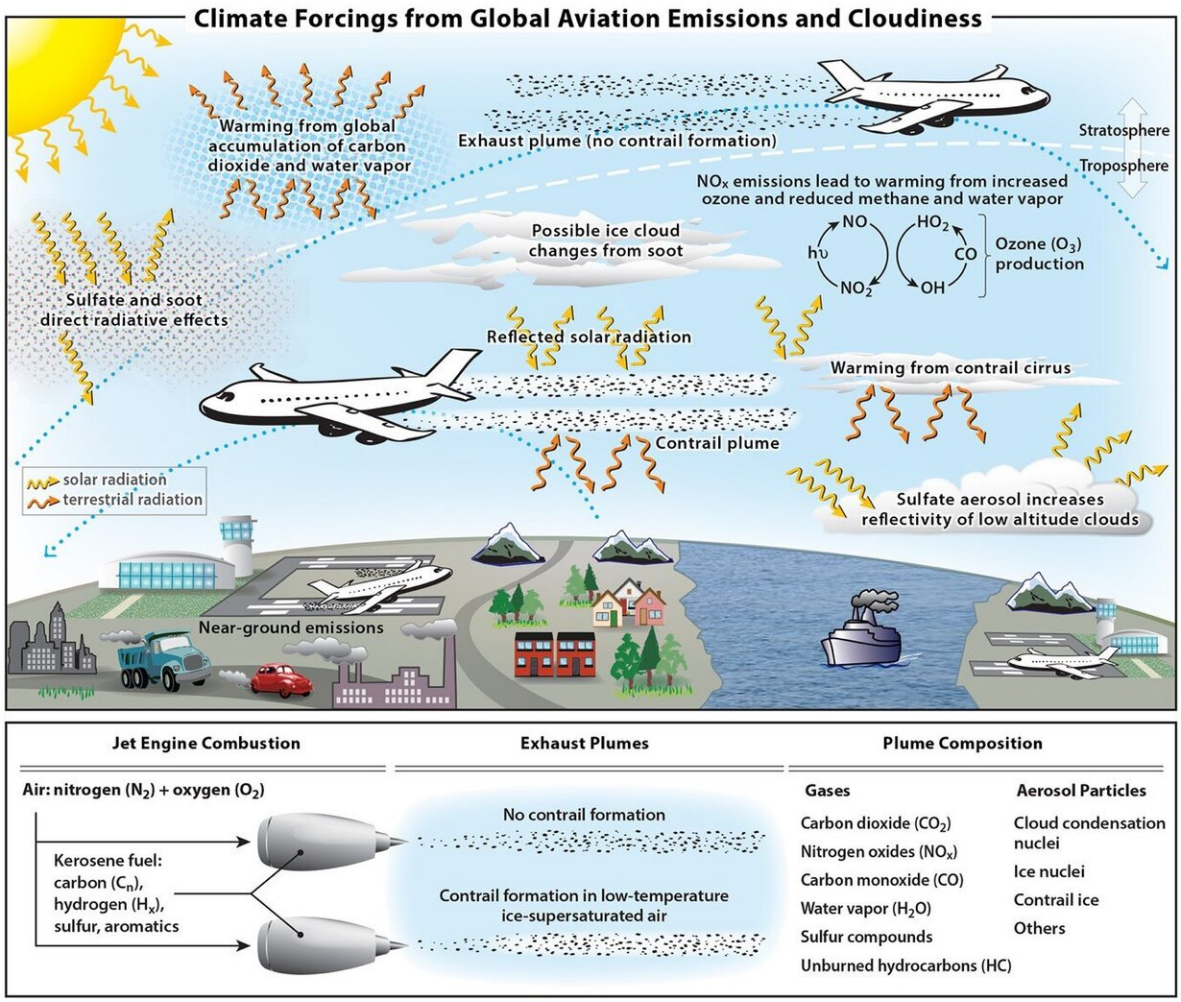

Climate forcings from global aviation emissions and cloudiness. Credit: Manchester Metropolitan University

Aviation has been calculated to be 3.5 percent of all human activities that drive climate change, new research shows.

A new international study provides unprecedented calculations of the impact of aviation on the climate from 2000 to 2018 to produce the most comprehensive insight to date.

The findings show that two-thirds of the impact from aviation is attributed to non-carbon dioxide emissions and the rest from CO_2.

The research was led by the UK's Manchester Metropolitan University, in collaboration with numerous academic and research institutions across the globe, over the past five years

The analysis—published in the journal *Atmospheric Environment* - is the first of its kind since 2009 and will be of significant use to stakeholders such as policymakers, industry bodies and non-government organisations.

Researchers evaluated all of the aviation industry's contributing factors to climate change including carbon dioxide (CO_2) and nitrogen oxide (NOx) emissions, and the effect of contrails and contrail cirrus—clouds of ice crystals created by aircraft jet engines at high altitude.

This was analysed alongside the water vapour, soot, and aerosol and sulfate aerosol gases—fine particles suspended in the air—found in the exhaust plumes emitted by aircraft engines.

The study is unique because it is the complete first set of calculations for aviation that uses a new metric introduced in 2013 by the Intergovernmental Panel on Climate Change.

This metric is called 'effective radiative forcing' (ERF) and represents

the increase or decrease since pre-industrialisation times in the balance between the energy coming from the sun and the energy emitted from the earth, known as the earth-atmosphere radiation budget.

Using the new ERF metric, the team found that contrail cirrus' impact is less than half than that estimated previously but still the sector's largest contribution to global warming, by reflecting and trapping escaping heat from the atmosphere.

Carbon dioxide emissions represent the second largest contribution but unlike the effects of contrail cirrus, CO_2's effect on climate lasts for many centuries.

Lead author Professor David Lee, Professor of Atmospheric Science at Manchester Metropolitan University and Director of its Centre for Aviation, Transport, and the Environment research group, said: "Given the dependence of aviation on burning fossil fuel, its significant CO_2 and non-CO_2 effects, and the projected fleet growth, it is vital to understand the scale of aviation's impact on present day climate change, especially in view of the requirements of the Paris Agreement to reach 'net zero' CO_2 emissions by around 2050.

"But estimating aviation's non-CO_2 effects on atmospheric chemistry and clouds is a complex challenge for contemporary atmospheric modeling systems.

"It is difficult to calculate the contributions caused by a range of atmospheric physical processes, including how air moves, chemical transformations, microphysics, radiation, and transport."

The scientists undertook a comprehensive analysis of individual aviation ERFs to provide an overall ERF for global aviation for the first time.

Similar studies were conducted in 1999, 2005 and 2009 but this is the most current and most extensive, with lots of the details in the science having changed and matured.

Professor Lee added: "The new study means that aviation's impact on climate change can be compared with other sectors such as maritime shipping, ground transportation and energy generation as it has a consistent set of ERF measurements."

Credit: CC0 Public Domain

Dr. Laura Wilcox, an atmospheric scientist at the University of Reading

and NCAS, contributed the assessment of water vapour impact to the study. She said: "There are many different components of aviation's large impact on climate change, but the positive side of that is it provides us with many ways we can make changes to mitigate it.

"This massive assessment demonstrates the magnitude of the climate change impact of aviation, and confirms that urgent action is needed to reduce the environmental impact of all travel to avoid very serious impacts to our way of life in the future."

Professor Lee and his team calculated that the cumulative CO_2 emissions of global aviation throughout the course of the industry's entire history—defined as between 1940 and 2018—were 32.6 billion tonnes.

Approximately half the total cumulative emissions of CO_2 were generated in the last 20 years alone, attributed largely to the expansion of the number of flights, number of routes and fleet sizes, particularly in Asia, though partially offset by improvements in aircraft and jet engine technology, larger average aircraft sizes and increasing efficiency in the use of aircraft capacity to fit more passengers in the same space.

The research team estimated the figure of 32.6 billion tonnes accounted for 1.5 percent of total CO_2 emissions ever at that point.

And when the non-CO_2 impacts were factored in, aviation's was calculated to be 3.5 percent of all human activities that drive climate change.

The researchers noted that while the 2016 Paris Agreement on climate change does include domestic aviation in individual country's reduction targets, it does not address international aviation, which accounts for 64 percent of air traffic.

Unlike direct emissions of non-CO_2 greenhouse gases, such as nitrous oxide and methane from sources such as the agricultural sector, aviation's non-CO_2 effects are not covered by the former Kyoto Protocol.

Professor Lee added: "It is unclear whether future developments of the Paris Agreement or International Civil Aviation Organization negotiations to mitigate climate change, in general, will include short-lived indirect greenhouse gases like nitrogen oxides, contrail cirrus, aerosol-cloud effects, or other aviation non-CO_2 effects.

"Aviation is not mentioned explicitly in the text of the Paris Agreement, which says total global greenhouse gas emissions need to be reduced rapidly to achieve a balance between man-made emissions and sinks of greenhouse gases in the second half of this century.

"As the COVID-19 pandemic changes, aviation traffic is likely to recover to meet projected rates on varying timescales, with continued growth, further increasing CO_2 emissions and, of course, historical emissions of CO_2 take many centuries to be removed.

"Therefore, reducing CO_2 aviation emissions will remain a continued focus in reducing future man-made climate change, along with aviation's non-CO_2 contribution."

The study suggests solutions that include re-routing flights to avoid creating contrail cirrus but the trade-off is a longer flight path and more fuel burnt, producing more greenhouse gas emissions.

The team also noted how changes to combustion technology to reduce NOx emissions can increase CO_2 emissions.

Co-author David Fahey, Director of the Earth System Research

Laboratories at the United States' National Oceanic and Atmospheric Administration, and a Visiting Professor at Manchester Metropolitan University, said: "This study is a great example of an international collaboration to clarify how human activities cause climate change.

"Our assessment has strengthened the scientific foundation of the role of aviation in the climate system and established a framework for future assessments.

"Our assessment will aid decision makers and the industry in pursuing any future mitigation actions while protecting this important sector from any inaccurate assertions concerning its role in the climate system."

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