It's about more than just CO_2

Aviation must reduce its *total impact* on climate

Aviation's total climate impact is caused by more than just CO_2. Burning kerosene at altitude also generates contrails, induced cloudiness and NO_x derivatives, that although short-lived, are estimated to contribute far more to global heating than all the accumulated aviation CO_2 to date. Even though this has been known for years, non-CO_2 impacts have been dismissed by industry, governments and the International Civil Aviation Organization (ICAO) as being too scientifically uncertain to warrant necessary action.

This has led to a public perception of aviation being a relatively small problem, a chronic lack of serious research and development to investigate solutions, and ineffective regulation of aviation's climate impact[1]. Non-CO_2 impacts are not accounted for in any reporting systems or regulations: the national greenhouse gases (GHG) inventory submissions to the UNFCCC; the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), nor the EU Emissions Trading System (ETS). In addition, all current endeavours to "decarbonise" aviation disregard those impacts. Neither biofuels, synthetic fuels nor hydrogen would eliminate the main non-CO_2 contributors to global heating.

Mindful that non-CO_2 impacts constitute the majority of aviation's climate heating impact and, unmitigated, prejudice against achieving of Paris Agreement goals and increase the risk of reaching climate system tipping points, it is important that they are fully acknowledged and that immediate action be taken to mitigate them.

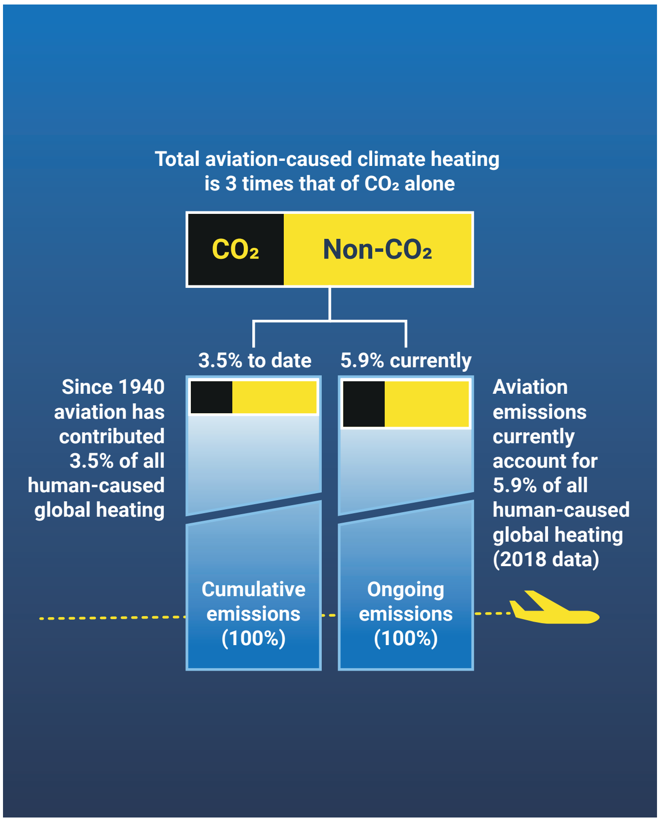
Scientific research on aviation's climate impacts needs to be stepped up, but a recent study by 21 of the most renowned scientists in the field[2] has resolved important uncertainties that existed about the magnitude of the non-CO_2 impacts of aviation, and has set the ground for action. Further inaction by governmental regulators cannot be justified.

THE FACTS

1. TOTAL AVIATION-CAUSED CLIMATE HEATING IS 3 TIMES THAT OF CO_2 ALONE.

As stated by the IPCC already in 1999, persistent contrails and aviation induced cirrus (AIC), as well as NO_x derivatives, although short-lived, contribute significantly more to global heating than aircraft CO_2 emissions alone. Aviation's contribution to today's global heating, measured as Radiative Forcing (RF)[3] from 1750 until today, has been estimated by the IPCC and the estimate is regularly updated by academic researchers.

In September 2020, 21 scientists prominent in the field published a reassessment taking into account the Effective Radiative Forcing (ERF) of non-CO_2 components. Their study concludes that today's total climate impact of aviation is about 3 times greater than the impact alone of all the accumulated CO_2 emitted by aircraft and remaining in the atmosphere since flying began. This effective radiative forcing, caused by the accumulated CO_2 together with the short-lived non-CO_2 components which reappear everyday that flights continue, has contributed about 3.5% to the total anthropogenic global heating, one third from CO_2 and two thirds from non-CO_2.



The study also assessed **the immediate and likely future impact of current aviation activity** using a newly developed method[5] that combines the heating effects of short-lived non-CO_2 contributors and long-lived CO_2. The researchers established that **for the year 2018, total CO_2 emitted by aircraft was 1 Gt, while the non-CO_2 heating impacts represented the equivalent of emitting a further 2 Gt CO_2 that year.** They concluded that *"aviation emissions are currently warming the climate at approximately three times the rate of that associated with aviation CO_2 emissions alone"*. In other words, **a flight's CO_2 impact must be tripled in footprint calculators**, in GHG reporting systems and in national emissions inventories.

2. CURRENTLY (2018), FROM OIL WELL THROUGH FLIGHTS, AVIATION ACCOUNTS FOR 5.9% OF ALL HUMAN-INDUCED CLIMATE HEATING.

For years, the aviation industry claimed that the sector was responsible for only 2% of man-made carbon emissions[6] – a number consistently cited to downplay the need for action. In fact, aviation's CO_2 emissions alone are significantly higher – amounting to 2.4% of all human-caused carbon emitted globally in 2018 according to this latest study, and 2.9% in total when CO_2 emissions from the production and distribution of jet fuel are included[7]. Then, adding on flying's non-CO_2 climate impacts, we calculate that aviation's on-going contribution reached 5.9% of the heating effect of all the annual human-caused greenhouse gas emissions in 2018[8].

This is immense, especially when considering that **this impact is caused by a very small portion of people who actually fly**: over 80% of the global population have never taken a flight[9] while the top 10% of global income earners use 75% of air transport fuel[10].

3. CUTTING AIR TRAFFIC REDUCES NON-CO_2 CLIMATE IMPACTS IMMEDIATELY.

The need to multiply CO_2 emissions by 3 to account for non-CO_2 is a consequence of the strong growth of the traffic. If air traffic was steady, then fuel efficiency gains aside, the daily heating impact of short-lived contrail cirrus and NO_x derivatives on the atmosphere would be largely constant, while the CO_2 would continue to accumulate and, even if all aviation were to cease, keep on heating for hundreds of years. Conversely, if air traffic were reduced, then the short-lived non-CO_2 impacts would similarly decrease and **the reduction in heating would be equivalent to withdrawing large quantities of CO_2 from the atmosphere**[11]. Hence, any effort to reduce traffic, combined with measures to mitigate non-CO_2 impacts, will be extremely rewarding if these efforts are sustained.

4. TECHNICAL AND OPERATIONAL MITIGATION OF THE NON-CO_2 IMPACTS OF AVIATION IS POSSIBLE BUT BEING RESISTED.

Apart from the needed reduction in flights, it is also possible to eliminate or reduce some of aviation's non-CO_2 contributions to global heating through operational or technological improvements:

- Research shows that a lot of contrail formation could be avoided by **adapting flight trajectories to meteorological conditions and avoiding night flights**[12]. The benefit on climate would be immediate. The small CO_2 fuel burn penalty that might result could be addressed by stronger measures to reduce CO_2 emissions overall.
- The adoption of lean-burn engine technology already available could reduce CO_2 while further **reducing NO_x emissions**[13].
- **Limiting soot emissions** from aircraft engines can reduce the formation of contrails and induced cirrus[14].

The mitigation of CO_2 remains, of course, essential too.

WHAT NEEDS TO BE DONE

1. **Non-CO_2 impacts have to be fully accounted for by the industry, by institutions and governmental bodies and by UNFCCC within the framework of the Paris Agreement.**
2. **Known measures to mitigate non-CO_2 impacts, such as contrail avoidance and the adoption of lean-burn low NO_x engines, must be pursued immediately in addition to CO_2 mitigation.**
3. **Research and development of operational and technological improvements that give the reduction of non-CO_2 impacts as much importance as those of CO_2 must be intensified and funded[15].**
4. **Air traffic must not be allowed to return to pre-Covid-levels. Accordingly, bailouts, subsidies, tax exemptions, and the construction and expansion of airports must cease. Governmental measures for a deep, sustained reduction of flights and for substituting alternatives like rail travel and renewably-powered ships must be quickly implemented.**

END NOTES & LITERATURE

[1] Bill Hemmings (2019): Why is aviation's true climate impact being kept under the radar?: https://www.transportenvironment.org/newsroom/blog/why-aviation%E2%80%99s-true-climate-impact-being-kept-under-radar

[2] Lee, D.S., Fahey, D.W., Skowron, A., Allen, M.R., Burkhardt, U., Chen, Q., Doherty, S.J., Freeman, S., Forster, P.M., Fuglestvedt, J., Gettelman, A., De León, R.R., Lim, L.L., Lund, M.T., Millar, R.J., Owen, B., Penner, J.E., Pitari, G., Prather, M.J., Sausen, R., Wilcox, L.J. (2020): The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, Atmospheric Environment: https://doi.org/10.1016/j.atmosenv.2020.117834

[3] Radiative forcing is directly related to the temperature response of the atmosphere.

[4] See Lee et al., footnote 2, Abstract

[5] GWP* method: see Lee et al., footnote 2, 6. Emission equivalency metrics

[6] IATA (2020): Working towards ambitious targets: https://web.archive.org/web/20200818061729/https://www.iata.org/en/programs/environment/climate-change/

[7] Lee et al., footnote 2 (2. Global aviation growth) estimate that current (2018) CO_2 emissions from aviation represent approximately 2.4% of anthropogenic emissions of CO_2 (including land use change). In addition to this, upstream CO_2 emissions related to the production and distribution of jet fuel (WTT = Well to tank) amount to about 20% of the CO_2 resulting from its combustion (The emission factor used for scope 3 reporting is +20% in France and +21% in the UK : http://www.bilans-ges.ademe.fr/, https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018)

[8] This ratio of 5.9% should not be confused with the 3.5% quoted above. They are different: the latter measures the contribution of aviation to the global heating we observe today extending back to account for all aviation CO_2 emitted from its beginning to the present day, while the former assesses the contribution of aviation to today's global GHG emissions and its likely future heating impact if nothing changes.The difference between them reflects aviation's growing share in global GHG emissions. Details of the calculation: 5.9% is our own calculation based on CO_2 equivalent emissions for 2018 from published data:
3.3 / (54 + 2.1) = 3.3 / 56.1 = 5.9% (Uncertainty range: 3.1, 7.7%)
Numerator (aviation) : 3.3 Gt CO_2-e*, i.e. 3 times the 1.03 Gt CO_2 emissions (Lee et al., footnote 2, Table 5) + 0.2 Gt for WTT (footnote 7)
Denominator (total anthropogenic): 54 Gt CO_2-e* + 2.1 Gt CO_2-e* non-CO_2 of aviation that are not presently accounted for in worldwide GHG emissions.; 54 Gt CO_2-e* (based on GWP100*) was derived from the standard GWP100 based estimate of 56 Gt CO_2-e (https://www.pbl.nl/sites/default/files/downloads/pbl-2020-trends-in-global-co2-and-total-greenhouse-gas-emissions-2019-report_4068.pdf) by adjusting methane emissions by -2 Gt CO_2-e (Allen M.R. et al. (2018): A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation: https://www.nature.com/articles/s41612-018-0026-8, Fig 2)

[9] Boeing CEO (2017): Over 80% of the world has never taken a flight. We're leveraging that for growth: https://www.cnbc.com/2017/12/07/boeing-ceo-80-percent-of-people-never-flown-for-us-that-means-growth.html ;
IEEP (2019): Linking aviation emissions to climate justice: https://ieep.eu/news/linking-aviation-emissions-to-climate-justice

[10] Roberts (2020): Why rich people use so much more energy: https://www.vox.com/energy-and-environment/2020/3/20/21184814/climate-change-energy-income-inequality

[11] In 2018 there were 67 Gt of CO_2 equivalent of non-CO_2 short-lived components above our heads, i.e. twice the quantity of CO_2 emitted by aviation since 1940 (According to Lee et al., footnote 2, the net ERF of non-CO_2 terms was 66.6 mW/m² in 2018 and 1 mW/m² is equivalent to 1 Gt CO_2).

[12] Teoh, R., Schumann, U., Majumdar, A., Stettler, M. (2020): Mitigating the Climate Forcing of Aircraft Contrails by Small-Scale Diversions and Technology Adoption: https://pubs.acs.org/doi/abs/10.1021/acs.est.9b05608 ;
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Royal Aeronautical society (2020): Greener by design 2018–2019, Atmospheric science (p. 16–21): https://www.aerosociety.com/media/12007/greener-by-design-report-2018-2019.pdf ;
Scheelhaase, J.D. (2019): How to regulate aviation's full climate impact as intended by the EU council from 2020 onwards: https://www.sciencedirect.com/science/article/abs/pii/S096969971830334X

[13] CE Delft (2008): Lower NO_x at Higher Altitudes - Policies to Reduce the Climate Impact of Aviation NO_x Emission: https://www.cedelft.eu/publicatie/lower_nox_at_higher_altitudes/916

[14] The soot number emission reductions by 50% lead to a significant decrease in contrail cirrus optical depth and coverage, leading to a decrease in radiative forcing by approximately 15%. See Bock, L., Burkhardt, U. (2019): Contrail cirrus radiative forcing for future air traffic: https://acp.copernicus.org/articles/19/8163/2019/

[15] The Roadmap to True Zero: Targeting not only CO_2 but aviation's total environmental impact: https://www.greenaironline.com/news.php?viewStory=2733

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