BALPA Briefing: The effect of aircraft induced cloudiness on climate change and the feasibility of mitigation/avoidance strategies

1. How are contrails formed?

Water vapour, soot and particulates plus turbulence from aircraft engines can, in certain atmospheric conditions, trigger the formation of "contrails"; line-shaped clouds that are a familiar and easily identified marker of aviation activity. Contrails will not be formed in all conditions: dependent on the temperature and relative humidity of the air mass flown through they may not be created at all; dissipate after a short time; or persist and grow over several hours.[1]

2. How do contrails impact climate change?

A small number of contrails will, due to specific atmospheric conditions such as ice super saturated regions, spread out and form sheets of persistent, long lasting cirrus clouds. Flights in persistent contrail conditions are responsible for vast majority of warming: a study in 2020 found that just 2.2% of flights are responsible for roughly 80% of contrail energy forcing.[2]

These contrails turned long lasting clouds reflect heat back to the earth's surface that would otherwise have radiated into space. They can also reflect back heat from the sun, preventing it reaching the earth. The latest scientific studies estimate that the former effect outweighs the latter significantly, meaning that induced cloudiness has a net warming effect.

The magnitude of the warming effect has been estimated to be 55-60% of the total global warming effect from aviation, albeit with a significant level of uncertainty. By contrast, the release of carbon dioxide from routine engine use is estimated to be responsible for just 35% of aviation's contribution to global warming. This means that if the median estimate is correct, induced cloudiness has around 50% *more* impact on global warming than all the carbon dioxide released by aircraft worldwide.[3]

3. Can anything be done about this?

The atmospheric conditions for formation of persistent induced cloudiness are limited in both area and height, meaning that relatively small changes to the route flown by aircraft could cause large reductions in energy forcing.

All aircraft have an optimum altitude for them to fly at, based on their type, weight and the wind speed, but they can also fly at other altitudes with minimal increase in fuel burn, meaning that they could potentially climb or descend to avoid such formation areas. Such changes to optimal flight paths are normal to avoid flying over thunderstorms for safety reasons. The same study estimated that diverting 1.7% of flights could reduce energy forcing by 59%.

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[1] United States Environmental Protection Agency, "Aircraft Contrails Factsheet"
[2] Teoh et al, "Mitigating the Climate Forcing of Aircraft contrails by Small-scale diversions and Technology Adoption"
[3] D.S. Lee et al, "The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018"

4. **How can you identify the high-impact flights?**

Atmospheric modelling can to a large extent predict the areas where induced cloudiness could form; there are companies who have created models and are in the process of validating their data. Militaries have developed this knowledge for tactical reasons for decades.

It would also be possible, though to our knowledge is not yet being trialled anywhere, to collate aircraft measurements of atmospheric conditions, pilot observation of contrail formation and persistence, and satellite imagery to monitor the actual formation and persistence of contrails.

An international system that generated both predictions of contrail formation regions and validated this data with real time observations could identify contrail formation regions with a high degree of accuracy. Standard weather data for commercial aviation is collated in similar ways routinely.

5. **How could this data be used to reduce contrail energy forcing?**

Two approaches are currently being trialled and appear to have potential. The first is based with air traffic control, and uses both predictions and observations of contrail formation to make tactical (i.e. during the flight) changes to aircraft routing. This was trialled in Maastricht ATC area, but results were limited by the small number of flights operating during the Covid-19 pandemic.[4]

The second is operator-based and uses predictions of contrail formation areas to create flight plans which avoid these as far as possible. This approach is currently being trialled by commercial companies in partnership with airlines[5].

6. **Conclusions and policy recommendations**

- With the prime cause of aviation's contribution to global warming now thought to be aviation-induced cloudiness as opposed to from carbon emissions, research must be rapidly undertaken to establish a more definitive understanding of this new science.
- If this science is matured and operationalised through a collaboration of academia, business and Government, aviation's contribution to global warming could be radically reduced at very little cost. Rarely will there be an opportunity to make such a major environmental improvement at such low cost and difficulty[6].
- There is still some practical scientific work required to prove this concept, but the UK has both world-leading scientific[7] and operational[8] expertise to carry out the research.
- *We therefore urge the government to make the necessary funding and resources available to conduct a conclusive trial as soon as possible, and to act on the findings rapidly.*
- The non-CO2 effects of aviation, and how to minimise their impact, should take a front seat in the formation of policy around aviation and climate change, including the Jet Zero work.

BALPA would be delighted to discuss this with you further. Contact Oli Melzack, Communications and External Relations Officer via communications@balpa.org.

[4] Eurocontrol, "Reducing the impact of non-CO2 climate impact: EUROCONTROL MUAC and DLR partnering on contrail prevention"
[5] https://www.businessweekly.co.uk/news/cleantech/satavia-and-etihad-sign-historic-green-aviation-alliance
[6] Updated analysis of the non-CO2 climate impacts of aviation and potential policy measures pursuant to the EU Emissions Trading System Directive Article 30(4), S. Arrowsmith, D.S. Lee, B Owen et al. (2020). https://tinyurl.com/rhjb57u
[7] The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. Lee et al. Atmospheric Environment (2021): https://tinyurl.com/3kmrjazd
[8] DecisionX: Net Zero. Satavia (2020). https://tinyurl.com/b96539s4