Towards Addressing Aviations Non-CO_2 Climate Impacts

CE Delft

Committed to the Environment

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1 Introduction

Aviation has different impacts on the climate. While the EU and ICAO have started to address the impacts of CO_2-emissions, the other impacts remain unaddressed directly. This note argues that they should be addressed in line with established European policy as well as because of the precautionary principle.

2 Climate impacts of aviation

Aviation impacts the climate in several ways (Lee, et al., 2010 ; Brasseur, et al., 2016). As they combust fossil fuels, aircraft emit CO_2 (carbon dioxide) which has a well-known impact. Aircraft also emit NO_x (nitrogen oxides) which leads to higher concentrations of O_3 (ozone) in the atmosphere and lower concentrations of CH_4 (methane). The former has a short-lived warming effect, the latter a longer-lived cooling effect. In addition, aircraft emit SO_2 (sulphur dioxide) which leads to the formation of sulphate aerosols, soot, and water vapour. Under certain meteorological circumstances, aircraft induce the formation of contrails which can evolve into cirrus clouds. In addition the soot and sulphur emissions can impact on cloud properties.

In terms of radiative forcing, the non-CO_2 climate impacts of aviation are estimated to be about as large as the impacts of CO_2. In other words, the cumulative effect of the non-CO_2 impacts on the current climate is about as large as the cumulative effect of aviation CO_2-emissions. (Note, however, that radiative forcing is not a good metric for designing policies as it tends to measure the impact of past activities rather than influence future activities, and so does not fully account for the different lifetimes of the CO_2 and non-CO_2 impacts).

3 Current policies to address aviation's climate impact

The policy response to CO_2 and non-CO_2 climate impacts of aviation has been markedly different. In 2005, the European Commission proposed to include CO_2-emissions of aviation into the EU ETS and the European Union has adopted legislation in 2008 to implement this policy from 2012 onwards. ICAO agreed in 2016 an offsetting scheme for aviation CO_2-emissions that exceed the 2020 emissions level. The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) will require airlines on most routes to acquire offsets to compensate for emissions over 2020 levels as from 2021.

In contrast with these policies to address CO_2-emissions, no policies have been adopted to address the other climate impacts directly (some impacts may be reduced indirectly as they are correlated with CO_2-emissions). Although the Directive to include aviation in the EU ETS, 2008/101/EC, states in a preamble that 'all impacts of aviation should be addressed to the extent possible' and announces 'legislation to be proposed by the Commission in 2008' to deal with the climate impact of NO_x-emissions, policy proposals have not been made, even though a 2008 study for DG MOVE showed that it was feasible to do so (CE Delft, et al., 2008) and several other studies have highlighted the desirability (Barrett, et al., 2010) and the positive environmental impacts (Scheelhaase, et al., 2016) of such policies.

The Directive states furthermore that by '1 December 2014 the Commission shall … give consideration to … developments in scientific understanding on the climate change impacts of contrails and cirrus clouds caused by aviation with a view to proposing effective mitigation measures' and report this to the European Parliament and the Council.

Other policies to address the non-CO_2 climate impacts have, to our knowledge, not been proposed, although some policies to reduce aviation's impact on local air quality may have reduced the climate impacts as well, such as LTO NO_x-standards and standards for the smoke number of engine emissions, which may have reduced cruise NO_x- and PM-emissions as well.

The Monitoring and Reporting Mechanism of the EU requires the Commission to 'biennially assess aviation's overall impact on the global climate including through non-CO_2-emissions or effects' (EU, 2013). Results of such an assessment do not appear on the DG CLIMA website nor on the website of the European Environmental Agency.

We have not been able to locate written sources on the reasons why the European Commission has not followed up on the instruction to propose policies to address NO_x-emissions or why other bodies such as ICAO have not acted on these other climate impacts, so we can only speculate. Possible reasons include:

- The level of scientific understanding of some of the non-CO_2 climate impacts is lower than that of the CO_2 climate impacts (Lee, et al., 2010), even though in recent years the level has improved for several impacts (SA, 2014).
- Cruise NO_x-emissions are harder to quantify than CO_2-emissions as they depend on the altitude and pressure (Schulte, et al., 1997). The climate impacts of these emissions vary even more, depending on the altitude and latitude of the flight (Skowron, et al., 2013 ; Köhler, et al., 2013).
- Contrail and cirrus formation also depends on atmospheric circumstances on specific routes.
- In new engine design, there is a trade-off between NO_x-emissions and fuel efficiency. As a consequence, policies to limit NO_x-emissions could, in the long run, have a detrimental impact on CO_2-emissions (SA, 2014).
- It may have been politically inexpedient to propose policies for the non-CO_2 climate impacts when policies to address the CO_2 climate impacts had not been fully accepted and implemented.

Most publications of industry organisations do not mention non-CO_2 climate impacts of aviation (ATAG, 2015a ; ACI, et al., 2013 ; Airbus, 2013). Insofar as NO_x-emissions are discussed, they are presented in the context of LTO-emissions, i.e. in an air quality framework (ATAG, 2015b).

4 Reasons for addressing non-CO_2 climate impacts of aviation

In view of the impact of aviation's non-CO_2-emissions on climate, there are good reasons to implement policies to address them. The uncertainty about the exact size of the impact is not a valid argument to postpone action when the precautionary principle applies. This section shows that this appears to be the case.

In its communication on the Precautionary Principle, the European Commission (EC, 2000) states that the precautionary principle can be invoked to take action when the following criteria are met:

1. It should be "considered within a structured approach to the analysis of risk which comprises three elements: risk assessment, risk management, risk communication. The precautionary principle is particularly relevant to the management of risk".
2. "Potentially dangerous effects deriving from a phenomenon, product or process [should] have been identified".
3. "Scientific evaluation does not allow the risk to be determined with sufficient certainty".

Each of the criteria has been met for non-CO_2 climate impacts of aviation:

- There exists a well-established EU policy to deal with emissions causing climate risks in general, as is evident from the 2020 climate and energy package and the 2030 climate and energy framework, for example. This policy underlies the EU ETS and effort sharing, as well as policies aimed at for example fluorinated greenhouse gases. The EU policy contributes to a global policy framework within the UNFCCC.
- The potentially dangerous effects of climate emissions, including aviation NO_x-emissions, have been identified, but there is ongoing discussion about the size of the impact.
- Although it is clear that the non-CO_2 climate impacts add to the global temperature increase, the level of scientific understanding of the aviation non-CO_2 impacts is still considered too low to calculate the risks exactly (Lee, et al., 2010). Moreover, there is an ongoing discussion about the relevant metric for comparing long-term and short-term climate impacts which is in itself not a scientific but rather a political decision because it depends on the type of risk that a society is willing to accept.

5 Possible policies to address non-CO_2 climate impacts

Potential policies to address non-CO_2 climate impacts differ for the various impacts because different impacts can be mitigated by different measures which require different policies. This section presents high-level descriptions of possible policies to address the climate impacts of NO_x-emissions, black carbon and particulate matter; and contrails and cirrus cloudiness.

NO_x-emissions can be reduced by taking measures that reduce fuel use in general (e.g. flying shorter distances, non-engine efficiency improvements such as weight reduction, wingtips and engine wash), or by increased use of engines with lower NO_x-emissions either through changed deployment of the existing fleet or through acquisition of new aircraft. In the latter case, the trade-off between CO_2- and NO_x-emissions in engine design has to be taken into consideration because both have climate impacts.

In order to reduce distances, amongst others, the EU has organised the Single European Sky packages. Other measures to reduce NO_x-emissions could be incentivised, in line with the recommendations of CE Delft, et al. (2008) with a NO_x charge. A NOx charge is a charge on the NOx emissions of aircraft departing from EU airports, calculated on the basis of certified LTO NO_x-emissions of the engines of the aircraft. A charge would also have the advantage that external costs of aviation are internalised and the demand for flying deviates less from its socially optimal level.

Black carbon and particulate matter emissions can be reduced by using better fuels. In particular, fuels with a lower share of aromatics, like synthetic fuels and many renewable fuels, create fewer particulates and especially less soot (Rojo, et al., 2015). Therefore, policies that induce the use of these fuels will reduce the climate impacts of black carbon and particular matter, although it should be noted that there are still important uncertainties on the relation between fuel and emissions and between emissions and contrails (Gierens, et al., 2016). Moreover, the current availability of these fuels is limited because of the low demand.

The impact of **contrails and cirrus clouds** could be reduced by climate-optimised flight routing as a measure to reduce the atmospheric impact of aviation (DLR (Coordination), 2014). In fact, models could probably be developed that take into account all non-CO_2 climate impacts and which could be used to calculate flight routes with the minimal climate impact (Grewe, et al., 2017).

It appears that most policies described here, with the possible exception of the NO_x charge, require a better scientific understanding of the climate impacts. It would therefore be advisable to provide additional funding for research in this area. This is also in line with the European Commission's recommendations on invoking the precautionary principle, i.e. that a share of the proceeds could be spent on research to reduce the uncertainty about the size of the impacts (EC, 2000).

To an extent, policies could be used to both start addressing the climate impact and raise revenue for more research, e.g.:
- A share of the NO_x charge could be used to fund research into climate-optimised flight routing.
- A per-passenger charge could be levied to fund research into climate-optimised flight routing and innovation in sustainable low-carbon fuels. The charge would not directly incentivize reducing the climate impact of aviation, but it would internalize a share of the external costs.
- If the share of auctioning for aviation in the EU ETS increases, the NER400 innovation fund could be opened to fund production facilities for sustainable low carbon fuels with a low aromatics content. The non-CO_2 climate impacts that are not related to the type of fuel do not require investments at the moment so they do not fit the NER400 innovation fund.

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