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En route to sustainable aviation: from climate science to mitigation policies

Abstract

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Update on scientific knowledge of the impacts of aviation on climate: impacts of CO_2 emissions and "non CO_2" effects

Aviation affects the climate through CO_2 emissions and a set of non-CO_2 effects: contrail cirrus formation, nitrogen oxide (NO_2) emissions, which perturb ozone and methane, and aerosol emissions.
While the climate effect of CO_2 is well understood, non-CO_2 effects remain uncertain. Among them, contrail cirrus is estimated to be the largest contributor to aviation's net Effective Radiative Forcing (ERF). Contrails form in cold, ice-supersaturated regions, which frequently occur at cruise altitude, and can spread into extended contrail cirrus. Like natural cirrus, they warm the climate system through a strong greenhouse effect. However, this warming effect is partly offset by a (cooling) sunshading effect, and atmospheric adjustments also contribute to reduce the ERF of contrail cirrus.

In this presentation, we will discuss the processes relevant to non-CO_2 aviation effects, with a focus on contrails and atmospheric adjustment effects. We show that these adjustments are sensitive to microphysical assumptions and properties of ice crystals. This impacts the contrail cirrus ERF and of the ERF-to-RF ratio which can be estimated with climate models. These uncertainties have direct consequences for mitigation, which relies on accurate per-flight estimates of contrail radiative effects. Several strategies are being considered, from adjusting flight schedules to the targeted use of sustainable aviation fuel or hydrotreated kerosene on flights likely to form warming contrails. Their effectiveness hinges on the properties of fresh contrails, contrail radiative impact, contrail–contrail interactions and atmospheric adjustments, as well as on the quality of ice-supersaturation forecasts. We will discuss the sensitivity of different contrail mitigation strategies to existing uncertainties and whether these can be mitigated. Finally we conclude with a research roadmap to reduce the uncertainties that matter most.