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The analysis of the climate mitigation potential in terms of O_3-Radiative Forcing from aviation NO_x using O_3 algorithmic climate change functions

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Aviation contributes to 3.5% of anthropogenic climate change in terms of Effective Radiative Forcing (ERF) and 5% in terms of temperature change. Aviation climate impact is expected to increase rapidly due to the growth of air transport sector in most regions of the world and the effects of the COVID-19 pandemic are expected to only have a temporary effect on this growth. While efforts have been made to curb CO_2 emissions, non-CO_2 effects that are at least equally significant according to recent research, require more attention. The EU Horizon 2020 project ClimOp considers a comprehensive approach to tackling the climate impact of aviation using novel operational measures. One such measure is climate-optimised flight planning, where small deviations can be made in aircraft trajectories to minimise their overall climate impact. Algorithmic Climate Change Functions (aCCFs) are used to estimate the climate impact of local non-CO_2 effects such as nitrogen oxide (NO_x) emissions (via ozone (O_3) formation and methane (CH_4) depletion), aviation water vapour (H_2O) and contrails using weather variables directly as inputs. By using these functions in an air traffic optimisation module, climate sensitive regions are detected and avoided leading to climate-optimised trajectories. Here, we focus specifically on evaluating the effectiveness of reducing the aviation NO_x induced climate impact via O_3 formation, using only O_3 aCCFs for the optimisation strategy. This is achieved using the chemistry climate model EMAC (ECHAM5/MESSy) and various submodels. A summer and winter day, characterised by high spatial variability of O_3 aCCFs are selected, following which, air traffic over the European airspace is optimised with respect to climate as well as operating cost. The air traffic is laterally and vertically optimised separately to enable an evaluation of the horizontal and vertical pattern of O_3 aCCFs. It is shown that despite the significant impact of the synoptic situation on the transport of emitted NO_x, the climate-optimised flights lead to lower O_3 Radiative Forcing (RF) compared to the cost-optimised flights. The study finds that while O_3 aCCFs can reduce the climate impact, there are certain discrepancies in the prediction of O_3 impact from aviation NO_x emissions, as seen for the selected summer day. Although the aCCFs concept is a rough simplification in predicting future pathways of emissions and subsequent climate impact, we could show that it enables a reasonable first estimate. Further research is required to better describe the aCCFs allowing an improved estimate in O_3-RF reduction for optimisation approaches.