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Investigation of aviation emission impacts on global tropospheric chemistry and climate using a size-resolved aerosol-chemistry model

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Aviation is responsible for 3% of global anthropogenic CO_2 emissions, but 2-14% of anthropogenic induced climate warming due to contributions from short lived climate forcers. The global civil aviation fleet is projected to double by 2026 in relation to a 2006 baseline and so will play a substantial role in future climate change. Uncertainty in the net impact of aviation on climate is largely due to uncertainty in the impacts of aviation emissions on ozone and aerosol.

To study the impact of aviation emissions we use the GLOMAP-mode global aerosol microphysics model coupled to the 3-D chemical transport model TOMCAT. GLOMAP-mode has been extended to include treatment of nitrate aerosol. We include a full suite of non-CO_2 aviation emissions (including NOX, SO_2, HCs, BC and OC) in the model. We combined the simulated changes in ozone and aerosol with a 3D radiative transfer model to quantify the radiative effect due to aviation non-CO_2 emissions.

We find that aviation emissions increase O_3 concentrations by up to 5.3% in the upper troposphere (UT), broadly matching previous studies. Black carbon (BC) and organic carbon (OC) concentrations increase by 26.5% and 14.6% respectively in the UT, whereas nitrate aerosol is reduced in some regions due to co-emission of NOX and SO_2 In the UT, aviation emissions increase both total aerosol number as well as the concentration of particles greater than 70 nm diameter (N70). Entrainment of these particles into the free troposphere results in aviation emissions also increasing N70 in the boundary layer, causing a cooling through the first aerosol indirect effect.

We explore differences in these responses compared with those simulated when using the recommended aviation emissions from CMIP5 (5th Climate Model Intercomparison Project), which only include NOX and BC emissions. Our results suggest that aviation emissions of SO_2 and HCs neglected by CMIP5 produce important effects on ozone, aerosol number, and N70. We suggest CMIP5 models are potentially over estimating the warming effect of aviation emissions, because they do not include SO_2 emissions from aviation. Finally, we discuss the implications of these results for desulphurisation of aviation fuels