On the Understanding of Aircraft Condensation Trails and Prediction Capability

Executive Summary

The aviation industry negatively impacts the climate, with sector emissions resulting in a net warming of the planet. Non-CO2 emissions are estimated to contribute more to the total radiative impact on the climate than CO2 emissions. Contrails are the most significant climate forcer within the category of non-CO2 emissions. Contrails are generally formed from aircraft engine exhaust emissions when flying in regions of the atmosphere where the environmental conditions are favourable for their formation (cold and humid). Contrails will persist and possibly spread out into thin (cirrus) cloud in areas where the ambient atmosphere is above a critical humidity. These contrails and contrail cirrus affect the planet's radiation balance and can potentially result in a detrimental (warming) impact on the climate, acting to trap heat in under certain conditions. The Met Office prediction capability of regions of the atmosphere conducive to contrail formation and persistence is described. Key parameters within the calculations required for this prediction are poorly quantified, leading to uncertainty in the contrail forecast. A non-exhaustive review of recent literature highlights the challenges faced within the scientific community in trying to reduce this uncertainty, to enable operators and air navigation service providers to consider mitigation strategies by reducing or avoiding flight in these regions of the atmosphere. Increased coverage of in-situ water vapour measurements would enable more extensive validation of existing predictive capabilities to be assessed, and potentially enable improvements in related forecasting processes. Involvement in coordinated activities with industry and academia, such as contrail avoidance trials or studies, will accelerate research and development within this domain. Furthermore, considering alternative approaches to traditional forecasting methods such as through the provision of probabilistic output and/or exploiting machine learning techniques may help reduce uncertainty, and should be explored in future development work. An open question remains on the most appropriate metric to describe the impact of contrails and contrail cirrus on the climate, and how well this can be quantified, which is of relevance to understand should mitigation strategies wish to be confidently adopted in the future. It must be noted that a rapidly evolving landscape exists in terms of research, policymaking, commercial activity, and stakeholder commitment, thus the contents of this paper may quickly become outdated.