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Title

Investigating the influence of turbofan engine design on climate for a short-to-medium-range flight network

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Abstract

The climate impact of aviation is mainly due to the emission of species such as CO_2, water vapour, NO_x, soot, and contrails [1]. The trend in the development of the civil turbofan engine has been to reduce fuel consumption, which reduces CO_2 and H_2O emissions, but the consequent NO_x emissions may increase for a given combustion technology [2]. The NO_x emissions contribute to increased warming effects mainly via tropospheric O_3 enhancement. Further, the soot emissions and their effect on the formation of contrails is a complex issue, which requires detailed analysis. It is estimated that these non-CO_2 effects contribute more significantly than CO_2 warming [1]. Hence, there are existing trade-offs not only in emissions but their associated climate effects as well. It is essential to take a comprehensive approach to evaluate the impact of engine development trends on the environment by considering all relevant climate factors to inform future engine design trends.

The conventional engine design paradigm is driven by the minimization of fuel consumption. While this reduces the costs of the flight and also the climate impact due to CO_2 emissions, the overall climate impact might not be minimized by this strategy. This paper investigates this aspect to provide guidelines for future engine developments. Through this research, we aim to highlight the perspective of climate impact and investigate the key role it will play in climate-friendly engine design and the related future development framework of the existing turbofan engine architecture. To achieve ambitious aviation-related climate goals, propulsion system design must take into account the associated climate impact as well. The design of an aircraft engine is a complex endeavour, where several factors are at play. These include not only the design of the system but the operating environment as well. Therefore, it is necessary to consider the related climate impact, as non-CO_2 effects are dependent on geographical location and altitude [3].

This research aims to present a holistic view of aircraft engine design and its impact on the climate. Towards this end, the sensitivity of the climate effects w.r.t changes in engine design is analyzed. The effects of changes in the operational parameters on the sensitivity are also assessed. Both the CO_2 and the non-CO_2 effects are included. Predictive models have been developed to assess aircraft performance and engine emissions. These models are applied to determine the key engine performance and emission parameters across subsets of global flight networks for short-to-medium range missions. The resultant climate effects are analyzed in the state-of-the-art climate assessment tool, AirClim [4], [5]. Key results, such as trade-offs between fuel and emissions, and emissions and their respective impact are analyzed.

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