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The role of computational methods to predict pollutant and GHG emissions from future supersonic civil aircraft using biofuels or H_2

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The world's aviation industry is currently facing two major challenges, namely the need to reduce the carbon footprint and to facilitate the predicted increase in air traffic gradually leading to congested air corridors. The first of these issues can, in principle, be managed by replacing the fossil jet fuel with sustainable jet fuel or hydrogen whereas the second requires new flight routes and longer flight times resulting in increased fuel consumption and emissions which is undesirable. A possible alternative, at least for long-haul flights, may be to use turbine-based combined cycle dual mode ramjet engines, [1], that, if successful, may provide a path to reduce both the issues with congested air corridors (by flying at a higher altitude) and the emission problems (by using hydrogen) and at the same time reduce travel times for long-haul routes. In the EU H2020 project MORE&LESS, [2], this concept is investigated experimentally and computationally by a consortium of fifteen research institutes and universities.

In this paper we will demonstrate how high-fidelity numerical simulations using reacting Large Eddy Simulations (LES), [3], together with pathway-centric reaction mechanisms can be used to accurately predict both spray combustion in jet engines and H_2-air combustion in dual mode ramjet engines. In the paper to be presented results from both jet engine combustion and dual mode ramjet combustion will be described and compared with experimental data. Specifically, we will target the influence of the liquid fuel chemical composition and properties at different operating conditions for the jet engine applications, and flame stabilization for dual mode ramjet combustion. Good agreement between simulation results and experimental data is obtained if the engine description, reaction mechanism, subgrid physics as well as numerical methods and resolution are of high quality. The amount of data from such high-fidelity simulations is extremely large and comprehensive and requires specialized tools for analysis. Such data sets may contain information about physical process not yet completely known to us, or about how different physical processes interact in manners not yet understood.

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