EGU22-689
EGU General Assembly 2022

Reducing aviation emissions: investigating time minimal and fixed time trajectories for transatlantic flights.

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With full satellite coverage of transatlantic flight routes now a reality, situational awareness is no longer a limiting factor in planning trajectories. This extra freedom allows us to consider moving from the current Organised Track System to Trajectory Based Operations, in order to limit fuel use and thus reduce emissions.

In all parts of this research, flights between New York and London, from 1st December, 2019 to 29thFebruary, 2020 are considered. Average daily winds and temperatures are taken from a global atmospheric re-analysis dataset.

We first use optimal control theory to find the minimum time trajectories through daily wind fields. The aircraft is assumed to fly at Flight Level 340 with airspeeds ranging from 200 to 270 m s^{-1}. Since fuel burn and greenhouse gas emissions are directly proportional to the product of time of flight and airspeed, this quantity, air distance, is used as a measure of route fuel efficiency. Minimum time air distances are compared with actual Air Traffic Management tracks, giving potential savings ranging from 0.7 to 16.4%.

However, minimum time routes are not always practical. Airlines and airports require trajectories that will minimize fuel burn and thus carbon dioxide emissions, whilst adhering to a rigid timetable. To address this we again apply optimal control theory, but this time to find minimum fuel routes through the same wind fields.

The control variable is expressed as a set of position-dependent aircraft headings, with the optimal control problem solved through a reduced gradient approach. A second formulation is considered, wherein both heading angle and airspeed are controlled. By comparing fuel burn for each of these scenarios, the importance of airspeed in the control formulation is established.

Thus large reductions in fuel consumption and emissions are possible immediately, by planning time or fuel minimal trajectories, without waiting decades for incremental improvements in fuel-efficiency through technological advances.