Project 020 Development of NAS-Wide and Global Rapid Aviation Air Quality Tools

Massachusetts Institute of Technology

Project Lead Investigator

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University Participants

Massachusetts Institute of Technology (MIT)

- PIs: Steven R. H. Barrett
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 007, 018, 025, 032, and 041
- Period of Performance: August 19, 2014, to August 31, 2020 (via no-cost extension)
- Tasks for current period (September 1, 2019, to August 31, 2020)
    - No additional funding was provided for the project for this reporting period. All tasks were previously finalized, but outreach was conducted on the following Task:
    1. Provide surface air quality analysis and quantify the effects of aviation on surface air quality.

Project Funding Level

$800,000 FAA funding + $50,000 Transport Canada funding = $850,000 total sponsored funds, of which only the FAA-funded portion requires matching funds. Sources of match are that same $50,000 Transport Canada funding (it constitutes both matching funds itself and sponsored funds that do not need to be matched), plus approximately $215,000 from MIT, and third-party in-kind contributions of $114,000 from Byogy Renewables Inc. and $421,000 from Oliver Wyman Group.

Investigation Team

- PI: Professor Steven Barrett, MIT (All tasks)
- Co-PI: Dr. Raymond L. Speth, MIT (All tasks)
- Co-investigator: Dr. Florian Allroggen, MIT (All tasks)
- Research scientist: Dr. Sebastian Eastham, MIT (All tasks)
- Postdoctoral associate: Dr. Irene Dedoussi, MIT (All tasks)
- Graduate student: Guillaume Chossière, MIT (All tasks)

Project Overview

The aim of this project is to develop tools that enable the rapid assessment of the health impacts of aviation emissions. The focus of the project is aviation-attributable particulate matter ≤2.5 μm ($PM_{2.5}$) and ozone on the National Airspace System (NAS)-wide and global scales. These tools allow for rapid policy analysis and scenario comparison. The adjoint method on which these tools are based provides a computationally efficient way of calculating sensitivities of an objective function with respect to multiple model inputs. The project enhances existing tools in terms of the domains and impacts covered, and in terms of uncertainty quantification. The enhanced tools support the FAA in its strategic vision to reduce the health impacts of aviation emissions and allow for detailed and quantified policy analyses.

For the current reporting period, no additional funding was provided, and the project team finalized all tasks in previous years. During the current period, the team led some additional outreach efforts and finalized the documentation of the project and its results.

Task 1 – Provide Surface Air Quality Analysis and Quantify the Effects of Aviation on Surface Air Quality

Massachusetts Institute of Technology

Objective

The objective is to apply the tools developed under ASCENT Project 20 to quantify the surface air quality impacts of aviation. This Task was completed during the no-cost extension.

Research Approach

This project provides a set of metrics which can be used directly to perform rapid policy assessment. Previous MIT research found that aviation emissions result in ~16,000 premature deaths annually due to impaired air quality (Eastham & Barrett, 2016; Yim et al., 2015). When aiming to reduce these impacts and those from climate change, decision makers often face trade-offs between different emission species or impacts in different times and locations. To inform rational decision-making, the sensitivity data computed for ASCENT Project 20 were applied to compute aviation's marginal air quality impacts per tonne of species emitted, while accounting for the altitude and chemical composition of the emissions. Uncertainty in chemistry transport modeling was incorporated using scaling factors based on prior literature. Uncertainty in climate, health impact, and economic factors was also quantified.

Milestone

The task has been completed and a paper published in the past and current reporting period (Grobler et al., 2019).

Major Accomplishments

We found that air quality impacts accounted for 64% of combined climate and air quality impacts, based on fuel burn in 2015, and that the majority of these impacts were associated with cruise-level NO_x emissions. A sensitivity study was conducted to find the contribution of each of the uncertain Monte Carlo input variables to the observed output variance. We found uncertainty in climate sensitivity and the DICE (Dynamic Integrated Climate-Economy model) damage function to be the largest drivers of total output uncertainty.

A detailed description of the research approach and results can be found in a paper which was published as a result of work under both ASCENT Projects 20 and 21 (Grobler et al., 2019).

Publications

Peer-reviewed journal publications:

Grobler, C., Wolfe, P.J., Dasadhikari, K., Dedoussi, I.C., Allroggen, F., Speth, R.L., Eastham, S.D., Agarwal, A., Staples, M.D., Sabnis, J. & Barrett, S.R.H. (2019). Marginal climate and air quality costs of aviation emissions. *Environmental Research Letters*, 14 114031, https://doi.org/10.1088/1748-9326/ab4942

Outreach Efforts

Presentations:

- A summary of the paper approach and results were presented to the FAA (November 2019).
- Presented at Aerospace Europe conference in Bordeaux in February 2020.
- Presented at the fall ASCENT meeting (September 2020) for winning Joseph Hartman best paper award

FAA funding was acknowledged in all presentations.

Student Involvement

The outreach activities were completed by Carla Grobler (PhD student, MIT).

Plans for Next Period

N/A

References

Eastham, S. D. & Barrett, S. R. H. (2016). Aviation-attributable ozone as a driver for changes in mortality related to air quality and skin cancer. *Atmospheric Environment*, doi:10.1016/j.atmosenv.2016.08.040.

Grobler, C., Wolfe, P. J., Dasadhikari, K., Dedoussi, I. C., Allroggen, F., Speth, R. L., Eastham, S. D., Agarwal, A., Staples, Sabnis, J., & Barrett, S. R. H. (2019). Marginal climate and air quality costs of aviation emissions. *Environmental Research Letters*, 14 114031, https://doi.org/10.1088/1748-9326/ab4942.

Yim, S. H. L., Lee, G. L., Lee, I. W., Allroggen, F., Ashok, A., Caiazzo, F., Eastham, S. D., Malina, R. & Barrett, S. R. H. (2015). Global, regional and local health impacts of civil aviation emissions. *Environmental Research Letters*, 10 034001.