Project 022 Evaluation of FAA Tools: Aviation Portfolio Management Tool (APMT)

University of Illinois at Urbana-Champaign

Project Lead Investigator

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University Participants

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- P.I.: Dr. Donald Wuebbles
- FAA Award Number: 13-C-AJFE-UI-040
- Period of Performance: October 1, 2024, to September 30, 2025
- Tasks:
  1. Revisiting High-speed Civil Transports and Their Potential Effects on Ozone and Climate
  2. Assisting International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) with preparation of various reports concerning emissions from the aviation sector

Project Funding Level

Support from the Federal Aviation administration (FAA) over this time period was about $200,000, with an additional $200,000 in matching in-kind support from the German Aerospace Center (DLR), Germany.

Investigation Team

Dr. Donald Wuebbles (P.I.), All Tasks
Swarnali Sanyal and Dharmendra Singh (postdoctoral students), responsible for conducting studies and performing analyses using the Community Earth System Model (CESM) Whole Atmosphere Community Climate Model (WACCM), a 3-dimensional (3D) atmospheric climate-chemistry model

Task 1 - Revisiting High-Speed Civil Transports
Task 2 – Assisting ICAO

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Major Goals

This project utilizes state-of-the-art modeling and technical knowledge to analyze the potential global environmental effects of aircraft and to perform analyses that underpin the development of analytical tools that can assess the costs and benefits to inform decision making on technology development. The studies rely on state-of-the-art models of the earth system that can provide useful scientific input for considerations by decision makers. The analyses in the project will aid decision making by translating complex models into simpler tools for use in cost-benefit analyses.

Objectives

To quantify the costs and benefits of using advanced aircraft and engine technologies, the FAA uses tools that are underpinned by state-of-the-art technical knowledge. These tools are used to inform decision making by providing the benefits and costs of various options that could enable technology development. The overall objective of this project is to enhance our understanding of the relationships between subsonic and proposed supersonic aircraft and the atmospheric state, and the development and evaluation of the capabilities, limitations, and uncertainties of metrics and simple models (e.g., Aviation Portfolio Management Tool [APMT]) to assist decision makers. This project will use state-of-the-art geophysical models of the earth system that fully represent tropospheric and stratospheric processes to evaluate the costs and benefits of technologies that could advance subsonic aviation and enable supersonic aviation. Specific project goals include the following: (1) science-based evaluation of analytical tools used by the FAA, (2) development of ideas and concepts for the next-generation treatment of aviation's effects on the earth system, (3) updated evaluation and analyses of the science of aviation effects on atmospheric composition, and (4) evaluation of potential environmental effects from assumed fleets of supersonic commercial and business jet aircraft to compare with their benefits in terms of decreased time for air travel.

Research Approach

The study uses the state-of-the-art WACCM that is part of the range of models within the CESM, developed through community-coordinated efforts by the National Center for Atmospheric Research (NCAR). The version of the WACCM used here has 66 layers from the ground to above the mesosphere and provides a comprehensive treatment of tropospheric and stratospheric (and above) chemical processes. The WACCM is one of the most advanced models worldwide for studying atmospheric processes and one of the few with a complete representation of stratospheric and mesospheric processes and higher; for example, it is one of very few models to represent the quasi-biennial oscillation that is important to stratospheric ozone. It has a comprehensive treatment of gas phase, particle based, and heterogeneous chemistry. This makes the WACCM ideal for the study of the environmental impacts from supersonic and subsonic aircraft.

Results & Discussion

Various companies and academic institutions have been actively considering the designs of supersonic aircraft. As these new designs are developed, the environmental impact on ozone and climate of these realistic fleets needs to be explored. Using emissions for two different supersonic commercial aircraft designs and associated mature fleets from the Massachusetts Institute of Technology (MIT), models for atmospheric physics and chemistry were run at the University of Illinois and at MIT. Analyses of the resulting derived effects on the atmosphere were then completed, and we have now completed a joint journal paper.

New sensitivity studies have been started to examine the effects of different parameters on the ozone and radiative forcing effects from supersonic transport (SST) fleets.

Analyses of the radiative forcing for contrail formation and contrail cirrus for the current commercial aviation fleet and the projected 2035 aviation fleet were analyzed using the global atmospheric model. A journal article has now been completed.

For the ICAO, Dr. Wuebbles coauthored three reports for the ICAO Impacts and Science Group (ISG), one based on the contrail workshop and another on nitrogen oxides (NO_x) emissions from aviation, and he co-led one report that updates understanding of potential environmental impacts of supersonic aircraft. All three reports were published by ICAO in Spring 2025.

Milestones

- Completed new studies of supersonic fleets, and our results are being evaluated for comparison with similar modeling studies made by MIT for the potential impacts on ozone and climate of several fleets of supersonic aircraft based on aircraft designs made by MIT. A journal article is being completed.
- Completed and published a review of contrail science.
- Completed and submitted special reports to ICAO.

Publications

Peer-Reviewed Journal Publications

Singh, D. K., Sanyal, S., & Wuebbles, D. J. (2024). Understanding the role of contrails and contrail cirrus in climate change: A global perspective. *Atmospheric Chemistry and Physics, 24*(16). doi:10.5194/acp-24-9219-2024

Singh, D. K., & Wuebbles, D. J. (2025). Aviation contrail climate forcing through 2035: Implications for sustainable aviation pathways. *Earth's Future,* submitted.

Sanyal, S., Oh, L. J., Kulkarni, R., Eastham, S., and Wuebbles, D.J. (2025) Ozone and Climate Impacts of Future Supersonic Aircraft: A Multimodel Evaluation with WACCM and GEOS-Chem. *Earth's Future*, submitted.

Written Reports

Eastham, S. D., Wuebbles, D. J., Sparrow, V. W., Rhodes, D., Grewe, V., Baughcum, S. L., Delhaye, D., & Penanhoat, O. (2025). *I.03 Update on Understanding of Potential Impacts of Supersonic Aircraft*. Special report for the International Civil Aviation Organization (ICAO), The United Nations, Montreal.

Lee, D. S., Dickson, N., Altuntas, O., Arunachalam, S., Barrett, S., Baughcum, S., Bonne, N., Block, A., Boehm, A., Brons, R., Burkhardt, U., Carter, W., Catalano, F., Claro, G., Delhaye, D., Eastham, S., Gettelman, A., Goobie, S., Johansson, D., Kagaya, R., Kanji, Z., Kärcher, B., Kim, B., de Leon, R. R., Manneville, A., Marizy, C., McDonald, T., Medvedev, Y., Miller, C., Moore, R., Mwangi, F., Ngo, D., Owen, B., Rollins, A., Stettler, M., Stromatas , S., Swann P., van Velthoven, P., Voigt, C., Wells, N., Wuebbles, D., & Yin, F. (2025). *CAEP Impacts and Science Group (ISG) Contrail Science Workshop Report*. Special report for the International Civil Aviation Organization (ICAO), The United Nations, Montreal.

Prashanth, P., Hauglustaine, D., Arunachalam, S., Eastham, S., Grewe, V., Miake-Lye, R., Skowron, A., Speth, R., Turgut, E. T., Van Velthoven, P., & Wuebbles, D. (2025). *I.01 Air Quality and Climate Impacts Interdependencies and Trade-Offs of Aviation Emissions*. Special report for the International Civil Aviation Organization (ICAO), The United Nations, Montreal.

Outreach Efforts

- Presented at ASCENT Meetings in Fall 2024 and May 2025.
- Presented at the FAA Air Emissions Characterization Roadmap meeting in May 2025.
- Presented at U.S. Department of Energy PRE-TRAILS workshop on aviation emissions in October 2024.
- Participated (Dr. Wuebbles) in ICAO ISG meetings (monthly).

Awards

None.

Student Involvement

Three postdoctoral students, Swarnali Sanyal, Rachana Pradhan, and Dharmendra Singh, were responsible for the analyses and modeling studies within the project and leading the initial preparation of the project reports.

Plans for Next Period

- Complete any revisions required by external reviewers to publish the SST and the contrail papers.
- Use the results from this study to inform the development of Aviation Portfolio Management Tool – Impacts Climate (APMT-IC) for supersonic impacts (ASCENT Project 058).
- Update analyses of subsonic aircraft fleets for current and projected future time periods.
- Complete sensitivity analyses of potential supersonic aircraft fleets to enhance understanding of the envelop of potential impacts on ozone and radiative forcing from such aircraft.
- Dr. Wuebbles is co-leading the development of a new report on contrails for ICAO that updates the current scientific understanding of contrails, contrail cirrus and the interactions between aerosols and clouds. This report will be developed throughout 2026, with the aim of completing and submitting the report to ICAO by June 2027.