Project 022 Evaluation of FAA Climate Tools: APMT

University of Illinois at Urbana-Champaign

Project Lead Investigator

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University Participants

University of Illinois at Urbana-Champaign
P.I.(s): Dr. Donald Wuebbles

- Period of Performance: December 15, 2015 to December 15, 2016
- Task(s):
    1. Evaluate version 23 of APMT
    2. Provide Feedback on plans for APMT version 24
    3. Complete journal articles with Stanford and NCAR based on prior FAA supported modeling studies

Project Funding Level

Support from the FAA over this time period was almost $38,900, with an additional $18,900 in matching support, including about $10,000 from the University of Illinois, but also as in kind support from Reading University.

Investigation Team

Dr. Donald Wuebbles: project oversight
Dr. Arezoo Khodayari (post doc; most recently on subcontract) and Jun Zhang (graduate student): analyses of APMT and 3-D atmospheric climate-chemistry modeling analyses

Project Overview

The primary objective of this project is to evaluate the capabilities of the APMT-I model, particularly the Climate module, to ensure this FAA policy analysis tool uses the current state of climate science. Regional climate impacts of aviation will also be evaluated when available. In 2016, we also completed several journal papers based on prior work.

Task 1: APMT-I Climate Evaluation and Review of Requirements Document

Objective(s)

In this project, we act as a resource to FAA for analyses relating to metrics and to model development and evaluation of FAA modeling tools and datasets, with special emphasis on testing the Aviation Environmental Portfolio Tool (APMT) model and the further development and evaluation of its climate component to ensure that the underlying physics of the model is addressed properly. A specific focus of this project is on analyses of zonal and regional effects of aviation on climate and testing the resulting incorporation of such effects within APMT. As such, we want to make sure the APMT linking of aviation emissions with climate impacts and the representation of the various components of the cause-effect chain (i.e., from emissions to climate effect) properly represents the state-of-the science.

Research Approach

We have focused on evaluating the climate component of the Aviation Environmental Portfolio Tool (APMT) for three main aspects of the model, mainly its treatment of carbon dioxide and the carbon cycle, short-lived species, and NOx-related impacts. The project evaluates the APMT components relative to state-of-the-art modeling that fully considers the physics and chemistry important to the various processes. Our aim is to ensure that the physics and chemistry underlying the treatments in APMT are addressed properly.

Milestone(s)

Milestone	Milestone reached
Evaluation of the newly developed APMT version 23.	Report to the FAA by June 30, 2016
Feedback on plans for APMT version 24	Report to the FAA by December 15, 2016

Major Accomplishments

Most relevant to this project is a special report (Zhang and Wuebbles, Evaluation of FAA Climate Tools: APMT, June 2016) sent to the FAA. This report evaluates the climate component of the current version of the Aviation Environmental Portfolio Tool (APMT) for three main aspects of the model, mainly its treatment of carbon dioxide and the carbon cycle, short-lived species, and NOx-related impacts. Our aim is to ensure that the physics and chemistry underlying the treatments in APMT are addressed properly based on our and others published modeling studies. Our major findings include the following. Small changes are needed in the carbon cycle treatment to assure accuracy relative to current carbon cycle models. The indirect effect of aerosols and the stratospheric water vapor induced by methane oxidation should be included in the short-lived species. Furthermore, the method used to calculate the radiative forcing (RF) of short-lived ozone should be revised. The radiative forcing of nitrates should be added to the NOx-related emissions effects. As a result of making these changes, APMT should be better able to link the various components of aviation emissions with climate impacts relative to the findings from ACCRI.

Publications

Zhang and Wuebbles, Evaluation of FAA Climate Tools: APMT. Report for the FAA, June 2016

Outreach Efforts

ASCENT Advisory Committee Meeting – September 27-28, 2016 (Presentation)
Tools/Analysis Coordination Meeting – November 22, 2016 (Presentation)
Bi-weekly meeting with project manager Daniel Jacob

Awards

None

Student Involvement

Graduate Student: Jun Zhang
Ms. Zhang is responsible for the analyses and modeling studies within the project, and leading the initial preparation of the project reports.

Plans for Next Period

1. Based on existing published papers and reports, plus our own global modeling studies, evaluate APMT version 24 when it becomes available.
2. Using the CESM chemistry-climate model, update our earlier analyses of regional effects from aviation based on latitude bands.
3. Evaluate the GTP concept for aviation that is being developed by the CICERO research team,

4. As in our past projects with the FAA, we will also continue to act as a resource for the FAA in questions and issues associated with atmospheric chemistry, composition, and climate. This scope of work may be modified as necessary through the consultation with the FAA Program Managers.

Each of these studies should result in a report to the FAA and possibly resulting journal papers.

Task 2: Three-dimensional atmospheric climate-chemistry modeling studies for aviation effects on climate and air quality

Objective(s)

The aim in this work was to further evaluate the much more complex 3-D chemistry-climate model to further our understanding of the chemistry and climate effects from aviation emissions. As part of this effort we used CAM5-Chem, the atmospheric component of Community Earth System Model (CESM), and did a series of studies to evaluate aviation impact both on surface air quality in 2006 and on climate in 2050.

Research Approach

We have completed the studies modeling of aviation effects on global atmospheric composition and on climate we did with FAA support that were published as FAA reports and have now been rewritten and updated for journal publication.

Milestone(s)

Completed journal papers referenced below.

Major Accomplishments

We have contributed to the journal paper led by Andrew Gettleman investigating the effects of aviation cruise emissions on climate in 2050. The study found that a growth in the climate impact of aviation by 2050, including positive radiative forcing from contrails up to ~80mWm^{-2} and enhanced upper tropospheric and lower stratospheric ozone (O3), due to nitrogen oxide (NOx) emissions of ~60mWm^{-2}. Changes in methane (CH4) forcing resulting from changes in the CH4 lifetime induced by aviation are estimated at -25mWm^{-2} in 2050.

We have also contributed to a report lead by Mark Jacobson investigating the effects of aviation cruise emissions on air quality. This study found that all models (Three-dimensional chemical-transport models (CTMs) and Climate Response Models (CRMs)) show increases in near-surface ozone (0.4 to 1.9% globally), perturbations in the Northern Hemisphere that are highest in winter (when ambient ozone levels are lower and potentially of not as much concern to human health compared to the higher ozone in the summer months).

We are also revising a paper for journal publication that expands the understanding the sensitivity of aviation emissions on ozone to levels of background lightning effects on nitrogen oxides.

Publications

Cameron, M. A., M. Z. Jacobson, S. R. H. Barrett, H. Bian, C. C. Chen, S. D. Eastham, A. Gettelman, A. Khodayari, Q. Liang, D. Phoenix, H. B. Selkirk, N. Unger, D. J. Wuebbles, and X. Yue, 2016: Inter-comparative study of effects of aircraft on surface air quality. *J. Geophys. Res.*, submitted.

Gettelman, A., C.-C. Chen, M. Z. Jacobson, M. A. Cameron, D. J. Wuebbles, and A. Khodayari, 2016: Coupled chemistry-climate effects from 2050 projected aviation emissions. *Atmos. Chem. Phys.*, submitted.

Khodayari, A., D. Phoenix, and D. J. Wuebbles, 2016: Sensitivity of NOx emissions from lightning on the production of aviation-induced ozone. *J. Geophys. Res.*, being revised.

Outreach Efforts

Results presented at various meetings in 2015, but none in 2016.

Awards

None

Student Involvement

Former post-doc Arezoo Khodayari has been responsible for the analyses and modeling studies within the project, and leading the initial preparation of our portions of the project reports.

Plans for Next Period

Project largely completed except for further revisions to the papers towards journal publication.