FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Health Impacts Quantification for Aviation Air Quality Tools/Modeling Airport-Related Air Pollutant Concentrations and Health Impacts

ASCENT Project 18

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Motivation

- Impact of aviation emissions on public health can vary widely across airports, given differences in population patterns, meteorology, and other factors, but the extent of this variability has not been characterized
- Development of airport-specific/regional health damage functions would allow for the health implications of any combination of emissions to be rapidly assessed, an important attribute for a dynamic policy analysis tool
- Increasing interest in whether aircraft arrival emissions can contribute significantly to ultrafine particulate matter (UFP) concentrations at appreciable distances from the airport

Objectives

- Long-term
  - Analyze health benefits of alternative policy measures using CMAQ-DDM outputs and associated health damage function models
  - Apply advanced statistical techniques to quantify contribution of flight arrivals to UFP concentrations at varying distances from an airport

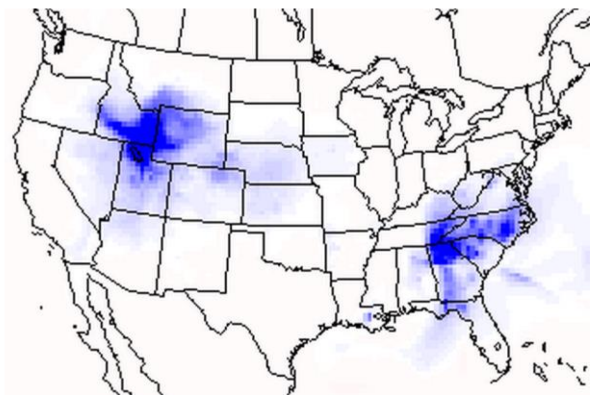
- Near term
  - Finalize health damage functions for defined geographic aggregates (census divisions, national)
  - Work with FAA to develop candidate policy scenarios and “what if” analyses to evaluate with health damage function models
  - Identify candidate data set amenable to analyses of UFP contributions from flight arrivals, execute data use agreement

Outcomes and Practical Applications

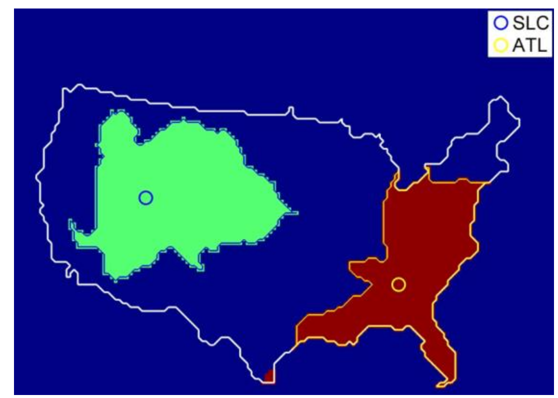
- Outcomes
  - Contribute to the development of tools that will enable the rapid assessment of exposure and mortality/morbidity risk due to aviation-attributable $PM_{2.5}$ and ozone, across a wide range of aircraft emissions scenarios
  - Refined statistical approaches for isolating contributions of flight arrivals to ambient pollutant concentrations
- Practical applications
  - Rapid assessment tools for policy-makers considering various potential aviation policy scenarios
  - Improved understanding of aviation impacts in terms of air quality and public health

Approach

- CMAQ-DDM associated $PM_{2.5}$ and O_3 concentrations with precursors for groups of geographically disperse airports
- Image segmentation technique used to separate emissions from airports within each group



CMAQ-DDM Output before image segmentation processing



Post-image segmentation processing

- Health damage functions calculated as mortality risk per thousand tons of emitted pollutants for each airport
- Regression models created to explain between-airport variability.

Schedule and Status

- Spring/Summer 2015: Aviation health damage function models completed, regression models constructed
- Fall 2015: Completion of health damage function models for defined geographic aggregates; selection of policy scenarios and "what if" analyses; identification of dataset for arrival contribution analysis
- Spring 2016: Completion of statistical analysis of arrival contributions to UFP, manuscript comparing damage functions across source sectors
- Summer 2016: Completion of policy analysis manuscript

Recent Accomplishments and Contributions (1 of 2)

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Primary $PM_{2.5}$ Precursors:

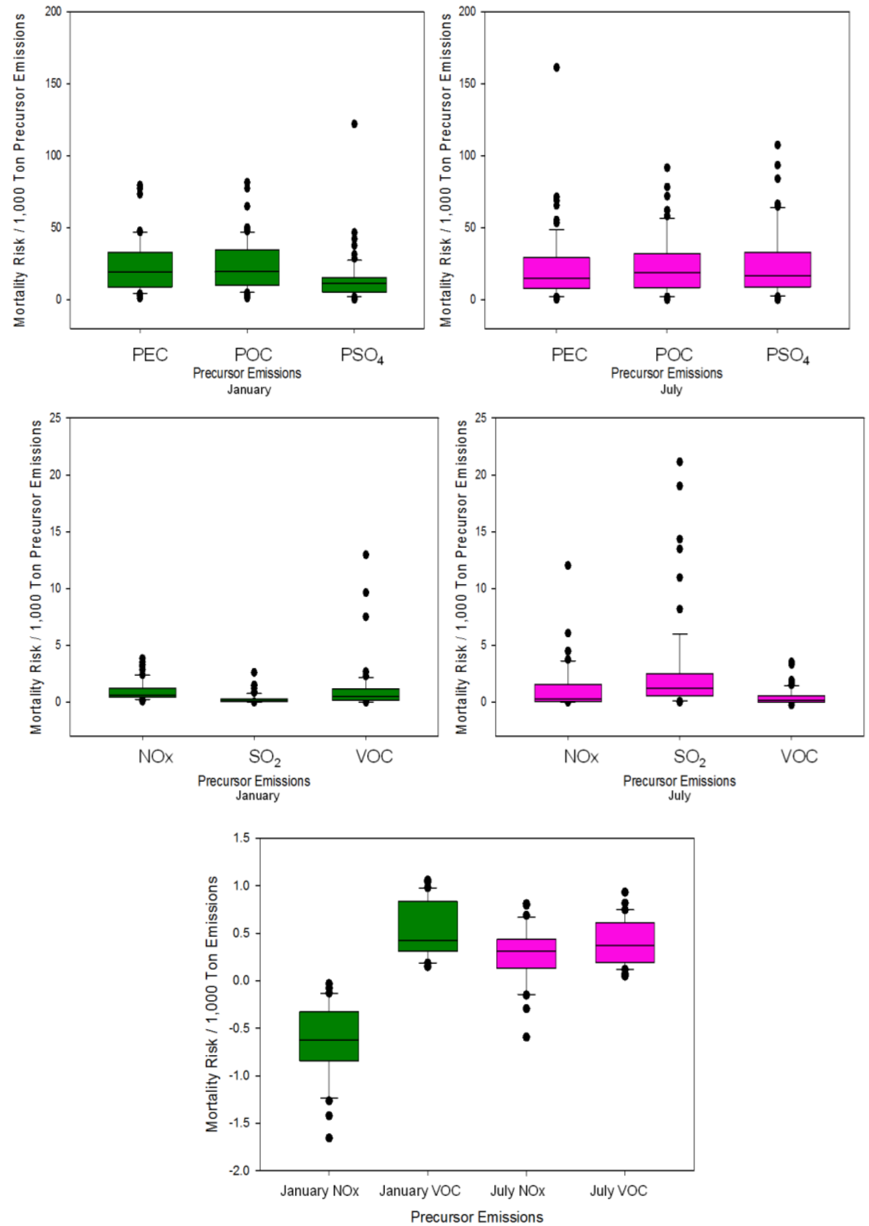
- Lack of variability between seasons as expected
- Higher in magnitude than secondary $PM_{2.5}$ precursors

Secondary $PM_{2.5}$ Precursors:

- Variability between seasons
  - SO_2 greater in July due to favorable particle formation conditions
  - VOC higher in January as particles are more stable in cooler weather

O_3 Precursors:

- Airports tend to be in urban areas, which are VOC-limited. Without enough VOC, increase in NOx will decrease O_3 formation in cooler weather
- In VOC-limited areas, increase in VOC increases O_3 formation



Recent Accomplishments and Contributions (2 of 2)

- Regression models created with physically interpretable predictors for each precursor-pollutant pair:
  - Primary $PM_{2.5}$: Downwind population within 100 km, "upwind" population within 100-500 km
  - Secondary $PM_{2.5}$: Population terms, SO_4/NH_4 ratio
  - O_3: Population terms, VOC/NOx ratio, temperature > 65° F
- *Preliminary values:* Health damage functions calculated for census divisions (mortality risk per 1000 tons)

Census Division	PEC	POC	PSO4	NOx	SO2	VOC	O3 NOx	O3 VOC
East North Central	28.80	30.28	19.92	1.35	1.84	0.80	0.17	0.93
East South Central	20.60	20.56	16.49	0.88	1.30	0.36	0.52	0.60
Middle Atlantic	38.58	41.24	35.24	0.68	1.03	0.77	0.13	0.72
Mountain	6.27	6.47	5.31	0.27	0.32	0.32	0.17	0.11
New England	17.77	20.00	14.06	0.54	0.79	0.35	0.32	0.33
Pacific	32.43	33.63	30.07	1.00	1.20	0.68	0.16	0.82
South Atlantic	25.60	25.89	20.99	1.12	0.96	0.33	0.47	0.46
West North Central	15.55	17.93	13.69	1.37	0.85	0.85	0.17	0.66
West South Central	13.36	13.04	10.61	0.32	0.86	0.38	0.33	0.44

Interfaces and Communications

- External
  - Presentation of CMAQ-DDM work at International Society of Exposure Science conference
  - Connection with other CMAQ-DDM modeling effort led by Levy and Arunachalam for power plants, residential combustion
  - Presentations for AEC Roadmap, External Tools working group
  - Forthcoming collaboration with air pollution monitoring study
- Within ASCENT
  - Direct collaboration with ASCENT Project 19 (UNC) on CMAQ-DDM runs for health impact analyses

Summary

- Summary statement
  - Airport-level health risk modeling has been successful and can provide the foundation for rapid analyses of the impact of airspace redesign, operational changes, or other changes in emissions patterns across the U.S. on public health
  - Comparisons with other source sectors will provide context and insight about exposure predictors
  - Formal analysis of arrival contributions to UFP will shed light on published literature and inform future field studies
- Next steps
  - Policy/"what if" analyses, identification of UFP dataset
- Key challenges/barriers
  - Determining appropriate policy scenarios to analyze
  - Developing and incorporating novel scientific insight regarding population exposures or health outcomes

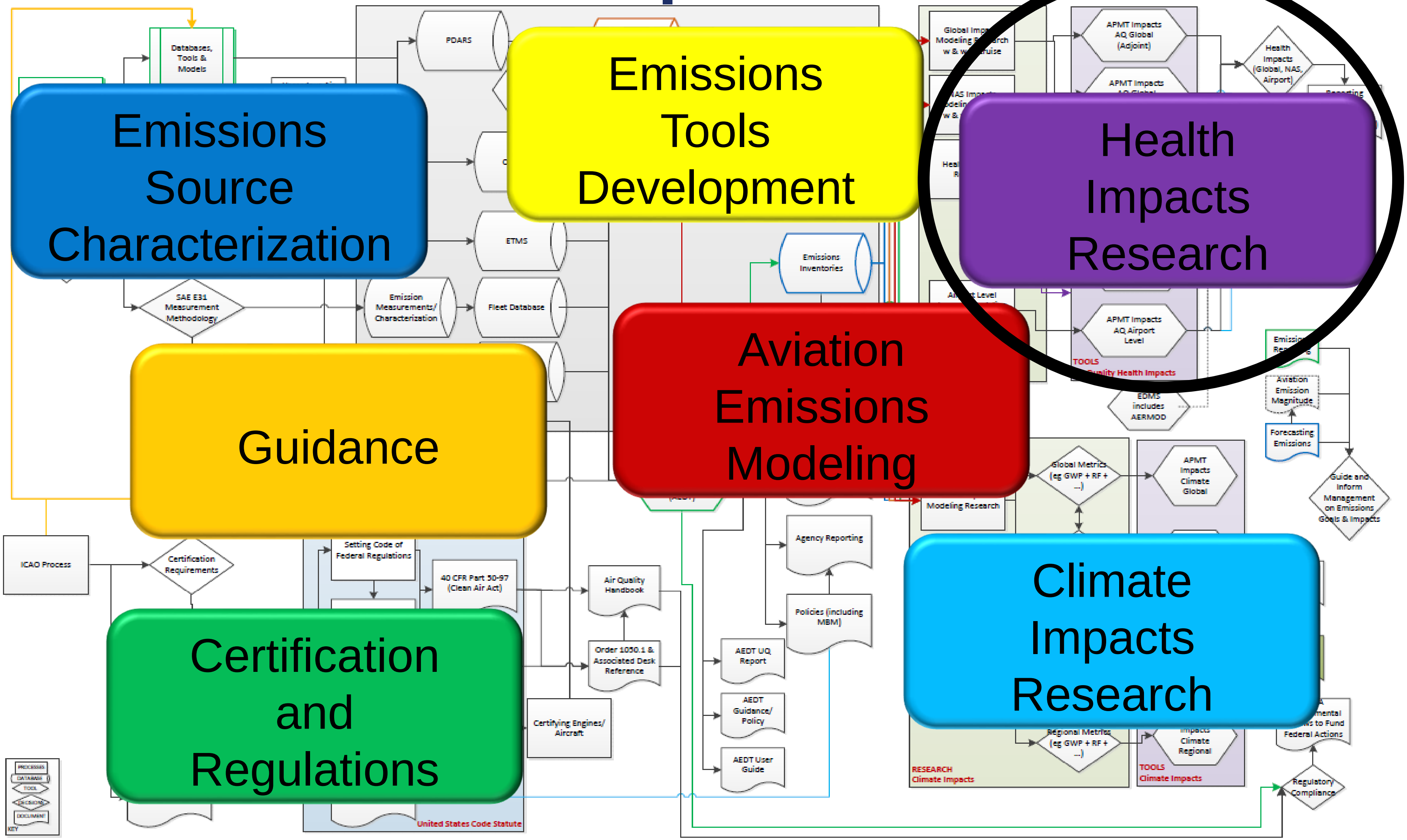
References

- Penn SL, Arunachalam S, Boone S, Kamai E, Levy JI. Modeling variability in air pollution-related health damages from individual airport emissions. Presented at the International Society for Exposure Science annual meeting, October 2014.
- Penn S. Modeling Contributions of Major Sources to Local and Regional Air Pollutant Exposures and Health Effects. Ph.D. dissertation, Boston University School of Public Health, Boston, MA, September 2015.
- Penn SL, Boone S, Harvey B, Heiger-Bernays W, Tripodis Y, Arunachalam S, Levy JI. Modeling variability in air pollution-related health damages from individual airport emissions. Submitted September 2015.

Contributors

- BUSPH: Jonathan Levy, Stefani Penn, Elizabeth Kamai, May Woo
- ASCENT Project 19 collaborators (UNC, Arunachalam and colleagues)

Emissions Roadmap



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