FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Modeling Airport-Related Air Pollutant Concentrations and Health Impacts

Project 18

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ASCENT
AVIATION SUSTAINABILITY CENTER

Motivations

- Impacts of air pollutant emissions on public health can vary widely across pollutants, source types, and geographic locations, but the extent of this variability and the influential factors have not been well characterized
- Multiple recent publications have concluded that aircraft arrival emissions can contribute significantly to ultrafine particulate matter (UFP) concentrations at appreciable distances from the airport, but it is unclear whether the findings are physically interpretable and robust

Objectives

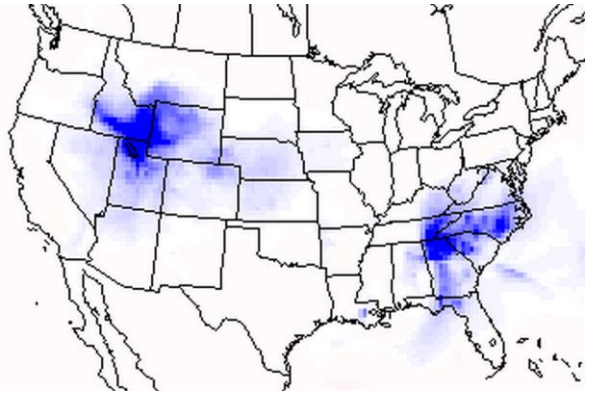
- Near-term
  - Complete source sector health damage function comparative analysis
  - Complete regression models for 1-second average UFP and PDARS data at short-term convenience sample site
  - Develop field protocols for forthcoming UFP monitoring campaign
- Long-term
  - Measure UFP concentrations at strategically selected sites near arrival flight paths and quantify the contribution of flight arrivals to measured concentrations
  - Develop insights about factors influencing health damage per unit emissions, and use those insights to inform optimal pollution control strategies

Outcomes and Practical Applications

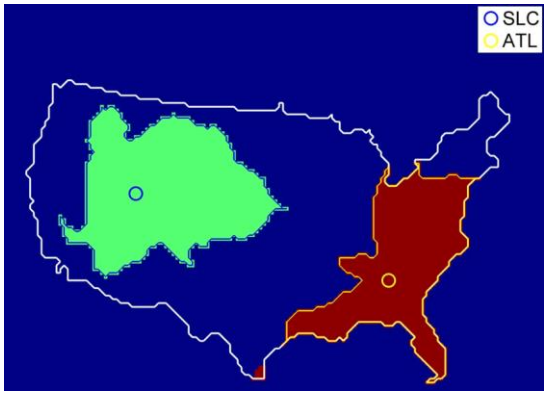
- Outcomes
  - Contribute to the development of tools that will enable the rapid assessment of exposure and mortality/morbidity risk due to $PM_{2.5}$ and ozone from multiple source sectors
  - Refined statistical approaches for isolating contributions of flight arrivals to ambient pollutant concentrations
- 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 – Health damage functions

- 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
- Analogous modeling conducted for power plants and residential combustion
- Comparative analysis focused on subset of states with sufficient emissions

Approach – UFP/PDARS analysis

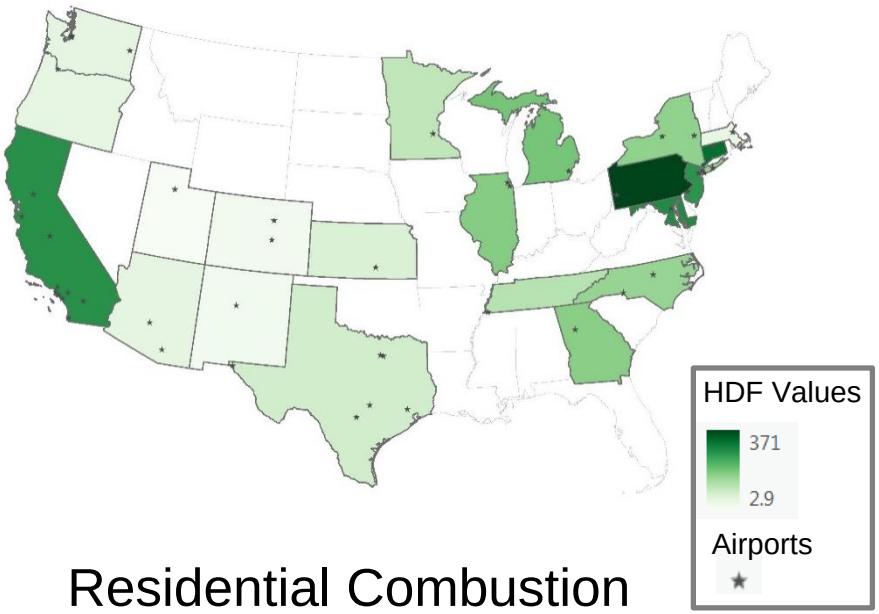
- UFP measured in spring of 2011 at site in Dorchester, MA, 6.5 km southwest of Logan Airport and 25 m due east of I-93
  - Data collected for another study, shared by Tufts researchers
  - Proximity to major highway not likely to confound analyses based on 1-second average concentrations (but potentially problematic for longer averaging times)
- PDARS data gathered for flight arrivals on 4R/4L, which would take flights approximately over the monitoring site
- Developed regression models predicting 1-second average UFP as a function of flights at various geographic locations, wind speed/direction, time of day, day of week
  - Distance terms represent a combination of time lag and distance effects
  - Models included dummy variables for geographic location; two-dimensional generalized additive models being developed
    - Shaded grid cells on results figure reflect magnitude of regression coefficient

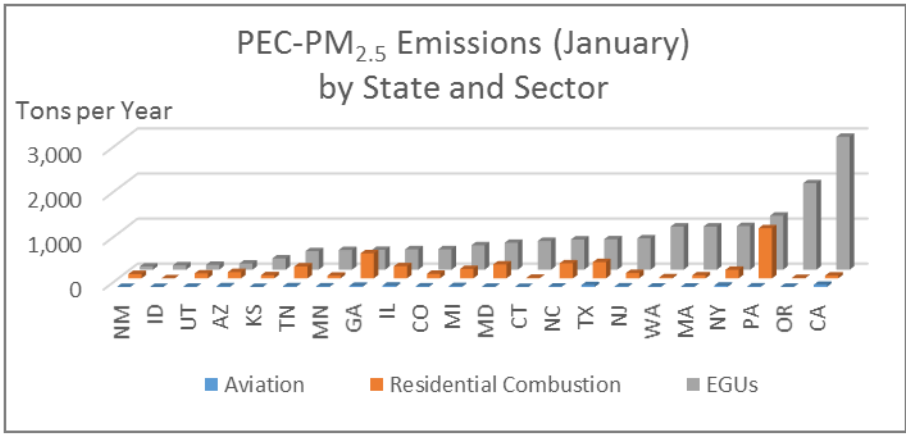
Schedule and Status

- Fall 2016: Completion of Logan Airport UFP/PDARS analysis, completion of core source sector statistical comparisons, site selection for field campaign
- Winter 2016/2017: Development of all field monitoring protocols and initiation of monitoring campaign, submission of UFP/PDARS and source sector comparative manuscripts
- Spring/Summer 2017: UFP monitoring campaign and preliminary statistical analyses

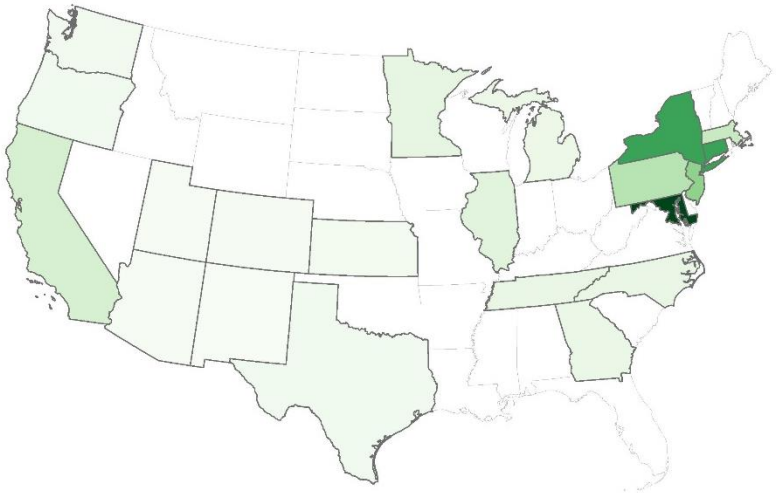
Recent Accomplishments and Contributions – HDF (PEC Jan)

Aviation





Residential Combustion



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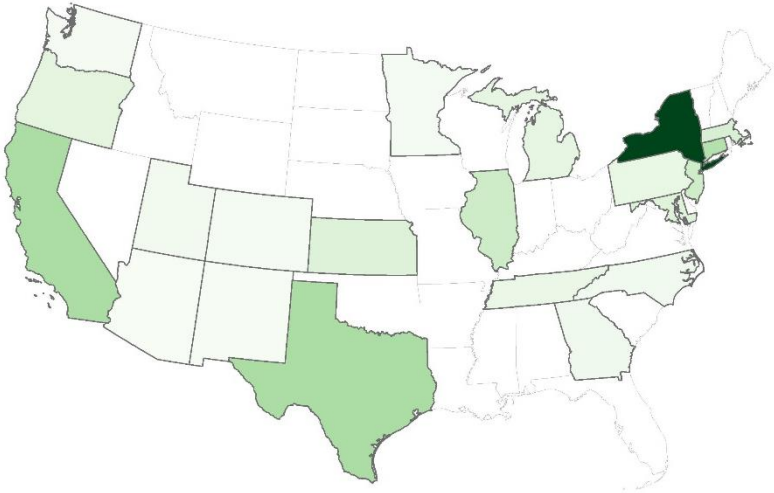
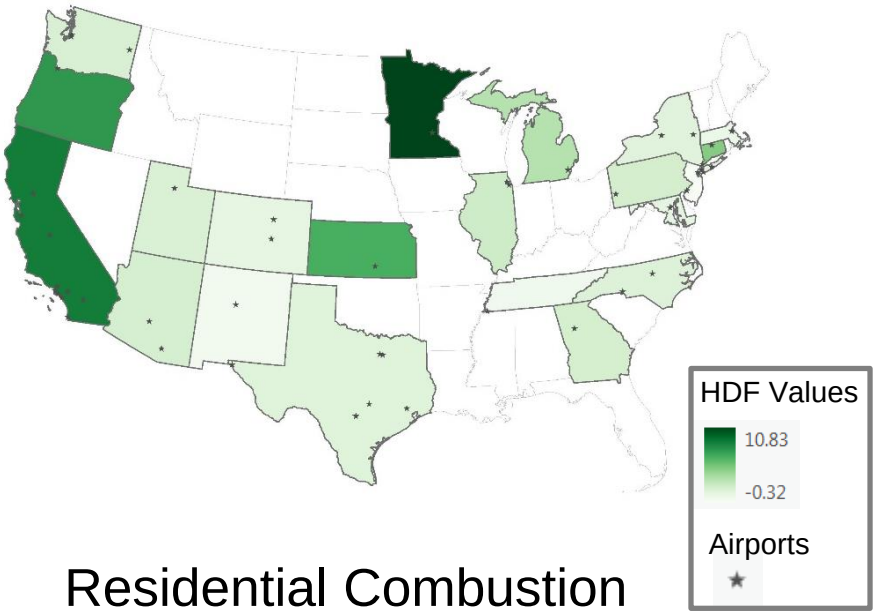
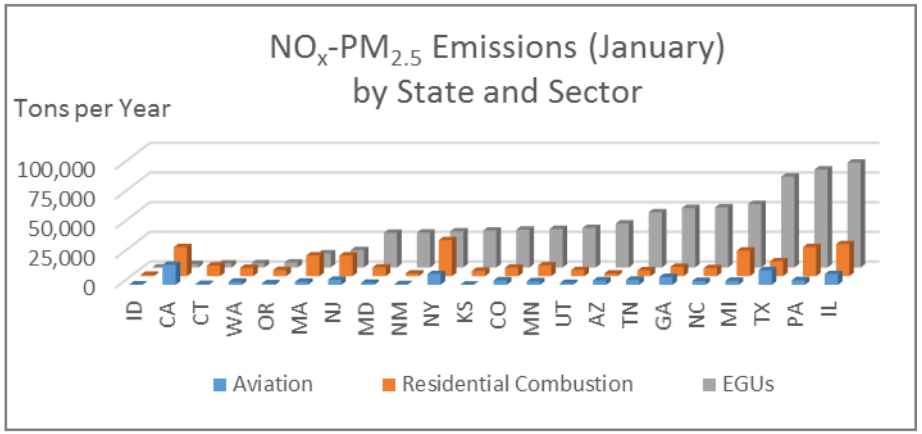


Recent Accomplishments and Contributions – HDF (NOx-$PM_{2.5}$ Jan)

Aviation





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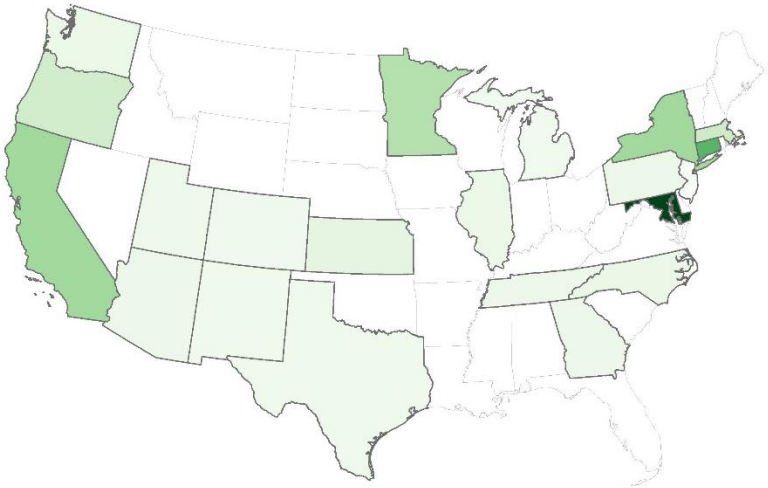

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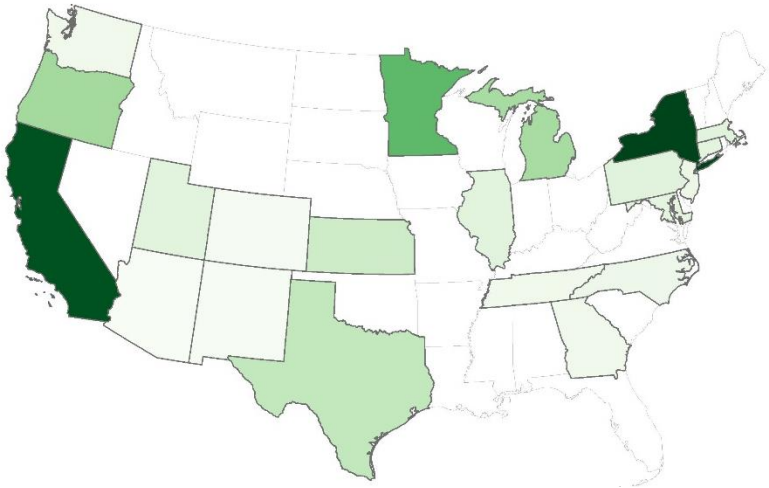
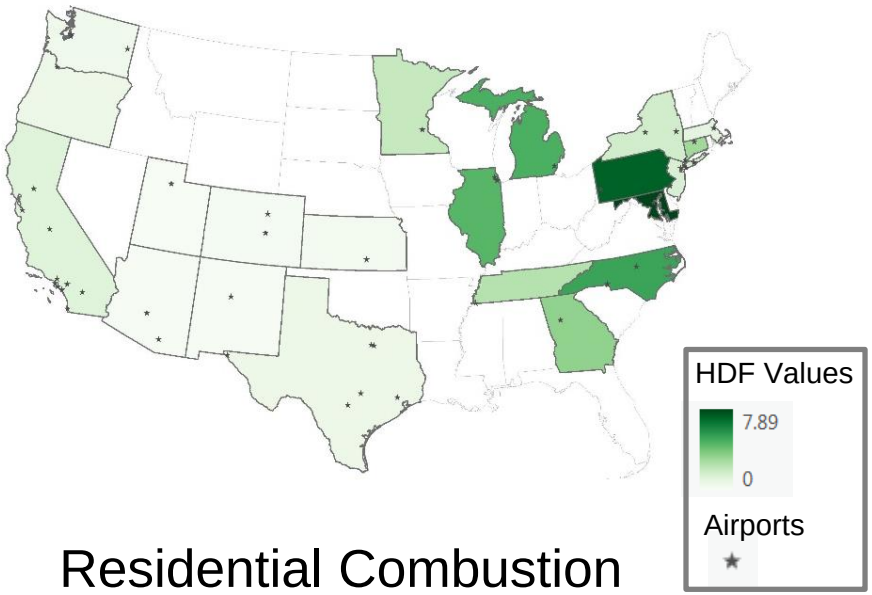
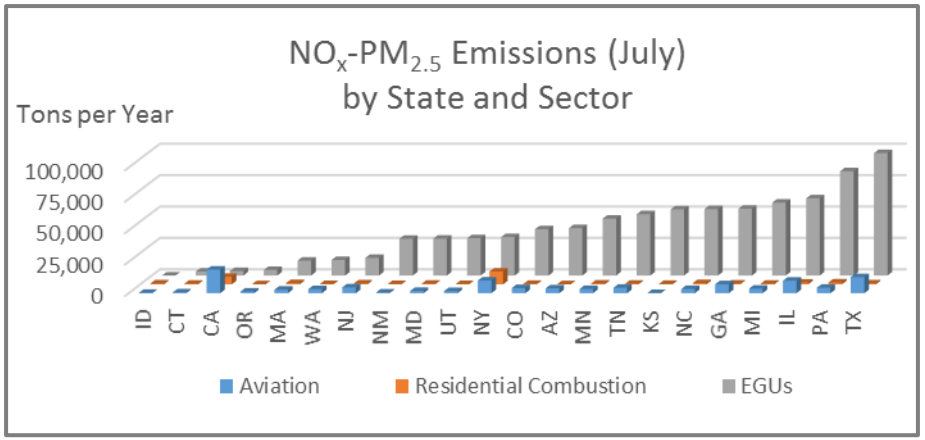


Recent Accomplishments and Contributions – HDF (NOx-$PM_{2.5}$ Jul)

Aviation





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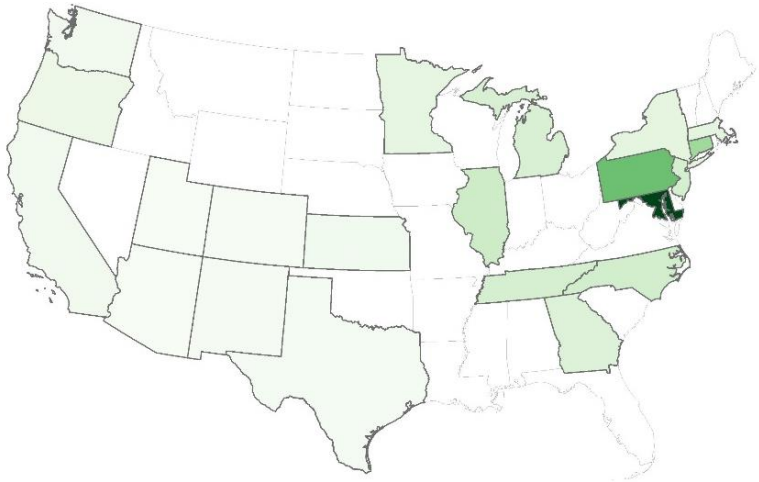

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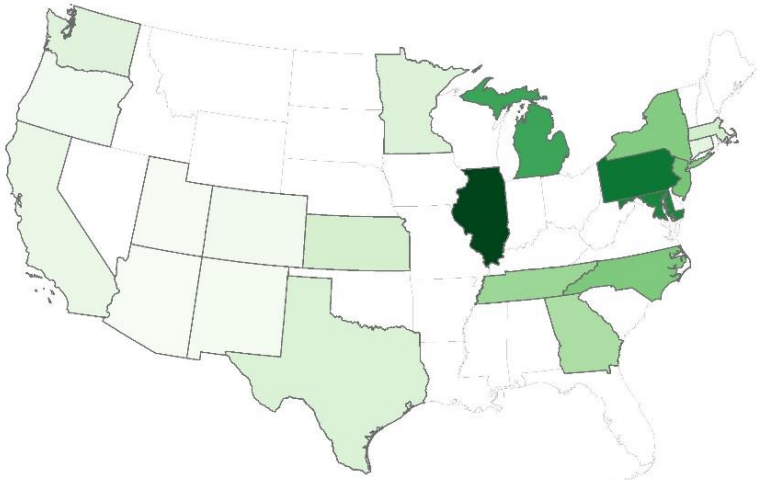
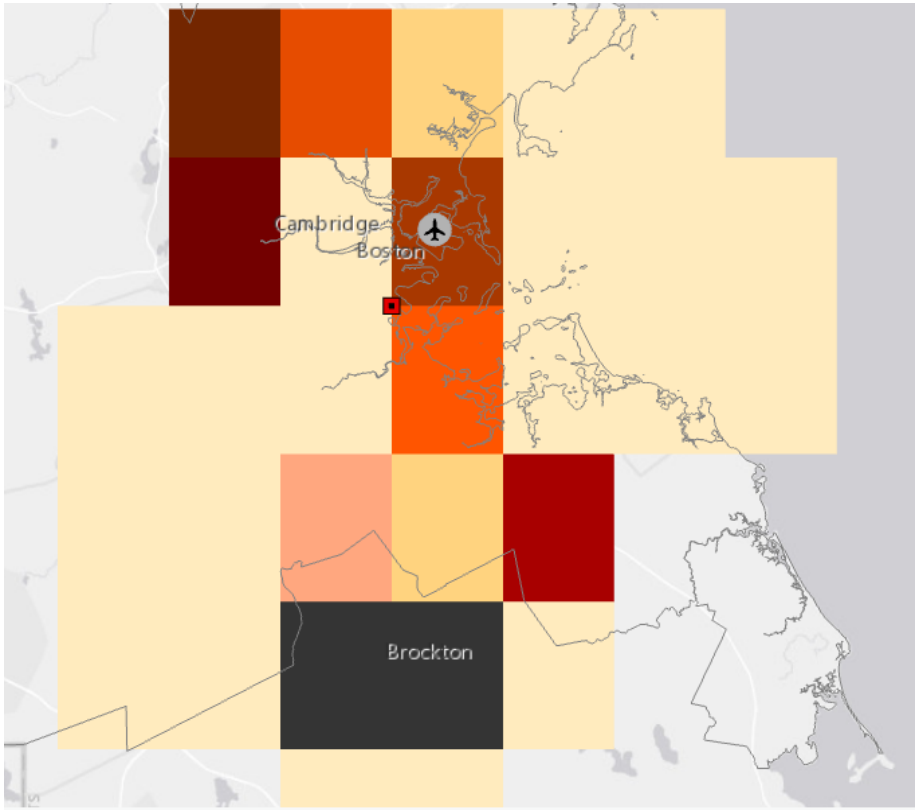
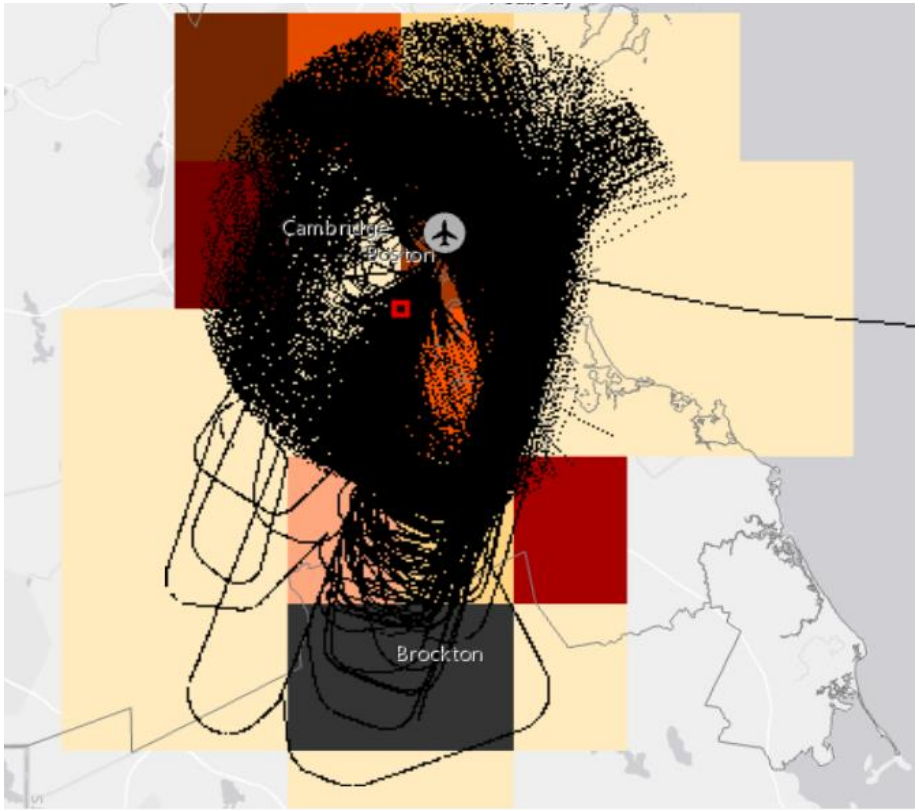
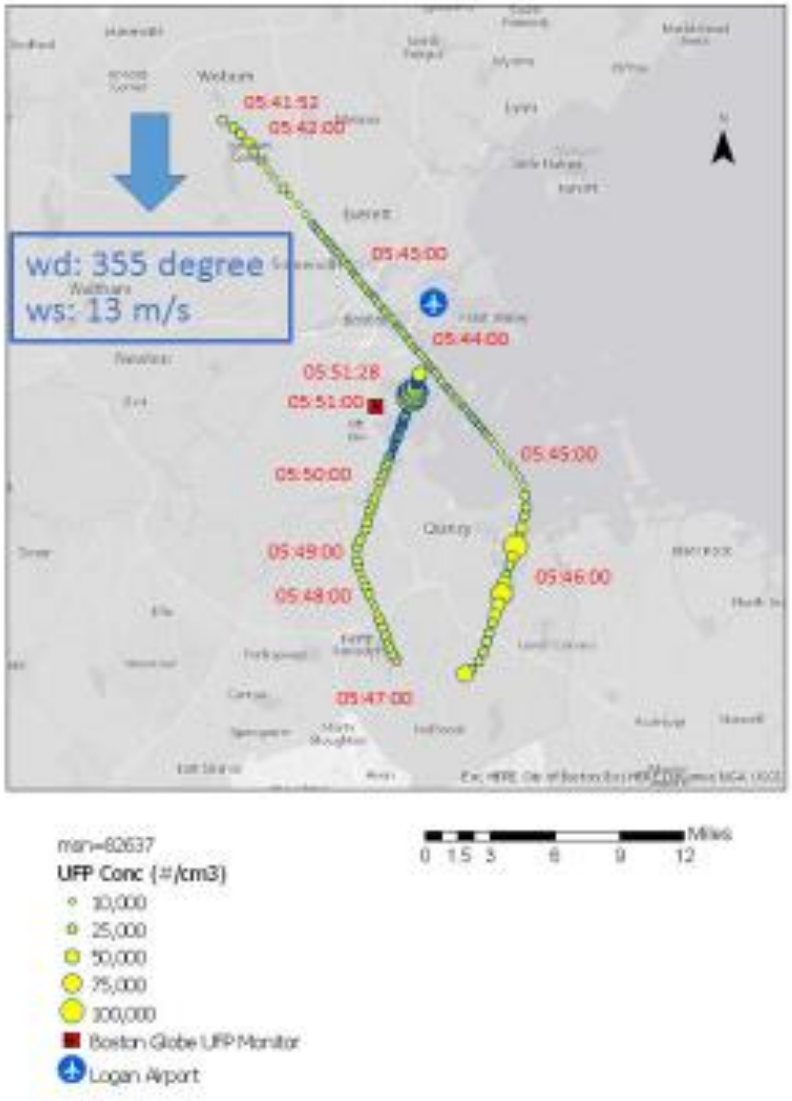


Recent Accomplishments and Contributions – UFP/PDARS





Recent Accomplishments and Contributions – UFP/PDARS



Publications

- 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. Under review.
- Penn SL, Arunachalam S, Woody M, Heiger-Bernays W, Tripodis Y, Levy JI. Estimating state-specific contributions to $PM_{2.5}$- and O_3-related health burden from residential combustion and electricity generating unit emissions in the United States. Environ Health Perspect, in press.
- Underhill LJ, Penn SL, Boone S, Arunachalam S, Levy JI. Modeling the health benefits of local and regional emission control policies in the US aviation sector. To be presented at ISES 2016.
- Kim CS, Levy JI. Magnitude and spatial patterns of ultrafine particulate matter associated with aircraft arrivals near Boston Logan Airport. To be presented at ISES 2016.

Summary

- Summary statement
  - Geographically resolved health damage function modeling can provide interpretable source sector comparisons and the foundation for future policy analyses
  - Contributions of aircraft arrivals to UFP concentrations are complex to characterize and vary greatly in time and space, and ultimately require fit-for-purpose monitoring and appropriate statistical analyses
- Next steps
  - Completion of source sector and UFP/PDARS manuscripts, initiation of field campaign
- Key challenges/barriers
  - Developing physically interpretable insights about arrival contributions
  - Considering air pollution impacts within a broader exposure/health context

Acknowledgements

- BUSPH: Jonathan Levy, Stefani Penn, May Woo, Lindsay Underhill, Chloe Kim, Yorghos Tripodis
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- PDARS data: Bao Tong and Nicole Didyk (FAA)
- UFP monitoring data: John Durant (Tufts)