FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Development of Aviation Air Quality Tools for Airport-Specific Impact Assessment

Project 19

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Fall Advisory Board Meeting
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Alexandria, VA

ASCENT
AVIATION SUSTAINABILITY CENTER

Motivation

Previous PARTNER work showed that Aviation-attributable health impacts due to $PM_{2.5}$ will be ~6x in 2025 compared to 2005

- Woody et al, 2011, Levy et al, 2012

Recent measurement campaigns at several airports have shown significant levels of Ultrafine Particulate Matter (UFP) due to aircraft LTO operations at LAX, Boston, Amsterdam, Rome, Tianjin, etc.

- Hudda et al 2014, 2016; Staffogia et al, 2016; Ren et al, 2016

- FAA's Aspirational Goal: Achieve an absolute reduction in aviation emissions induced "significant health impacts"
- For ICAO's Committee on Aviation Environmental Protection (CAEP) tools to assess global aviation-attributable health impacts needed

➢ In both cases, science-based tools are required to report year-over-year changes in health impacts

➢ Need to identify airport-specific trends in adverse health impacts for developing mitigation strategies

Objectives

- Long term
  - Develop tools for AQ and health impacts reporting and analyzing potential aviation policy scenarios for FAA and ICAO CAEP
- Near term
  - T1: Adapt modeling tools to estimate AQ impacts due to aviation emissions NAS-wide to facilitate year-to-year reporting and scenario analysis
  - T2: Develop implementation of advanced sensitivity tools in CMAQ (such as the Decoupled-Direct Method [DDM]) to allow for individual airport-related AQ and health impact characterization, informing a more dynamic modeling tool
  - T3: Assess/quantify changes in aviation-attributable UFP, and compare with new field campaign at Boston Logan airport
  - T4: Develop new modeling framework for dispersion modeling of aircraft sources during LTO cycles

Schedule and Status

- Task 1: NAS-wide analyses **[Nearing Completion]**
  - With revised AEDT inputs, implement new higher resolution framework for 2011, 2015
  - Assess impacts of changes in $PM_{2.5}$ size distributions [**Completed]**
- Task 2: Airport-specific analyses
  - Develop 1st and 2nd order sensitivities for NAS-wide and select airports[**Completed**]
  - Develop non-linearity ratios and impacts on non-attainment for O_3 and $PM_{2.5}$ **[Completed]**
  - Migrate to new 2015 platform @ 12x12km resolution **[Ongoing]**
- Task 3: Perform monitor-model comparisons of UFP from Boston Logan airport
  - Using SCICHEM **[Ongoing]**
  - Using CMAQ **[Yet to Start]**
- Task 4: Develop new framework for dispersion modeling **[Yet to start]**

Task 1 Objective

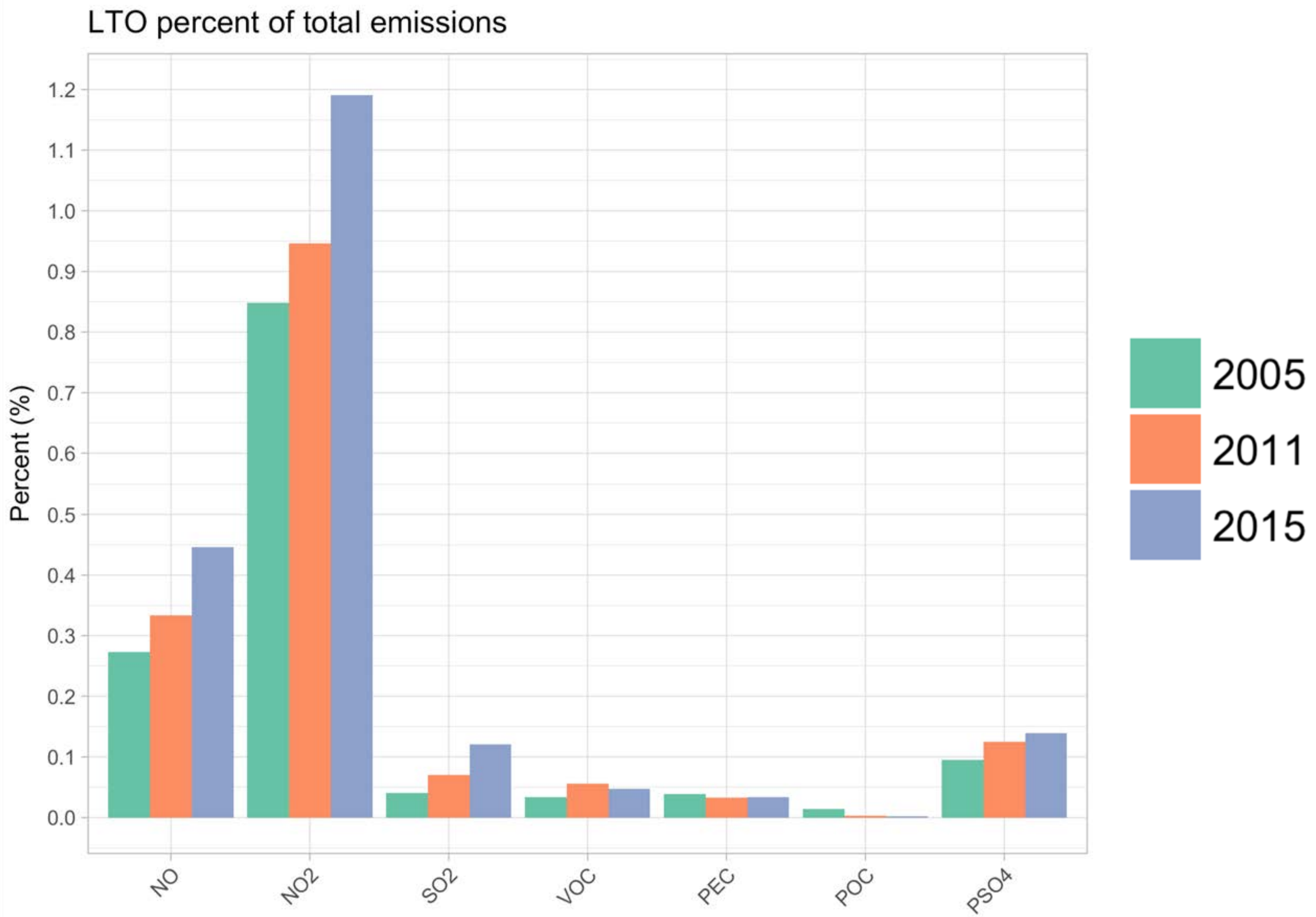
Develop NAS-wide modeling platform for the years 2011 and 2015 at fine resolution of 12x12 km

- Accomplishments from last meeting:
  - 2015 meteorology data created from downscaling MERRA
  - 2015 NEI-based emissions processed
  - 2015 LTO aircraft emissions processed from AEDT
  - 2015 modeling has been run for entire year with CMAQv5.2.1
- CMAQ model configuration
  - 2011: CMAQv5.1 with CB05 chemistry at 12x12 km resolution
  - 2015: CMAQv5.2.1 with CB6 chemistry at 12x12 km resolution
- New higher resolution application for the entire U.S.
  - 12x12-km instead of 36x36-km in prior work
  - Over 10x increase in computational resources
- Results compared across 3 years: 2005, 2011, and 2015

Task 1 Results

Emissions

Excluding PEC, POC, and VOC species, domain-wide LTO emissions as a percentage of total emissions increases over each model year

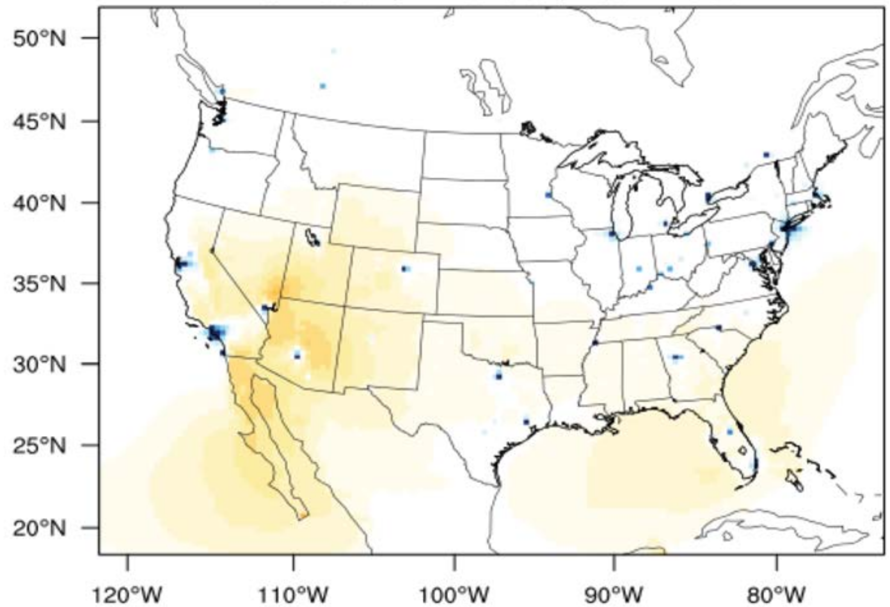


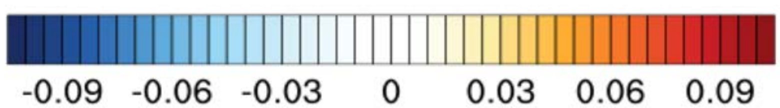
VOC pertains to only compounds that are directly emitted from aircraft (i.e. does not include species like isoprene) and 2005 grid cell resolution is 36x36 km while 2011 and 2015 are 12x12 km

Task 1 Results

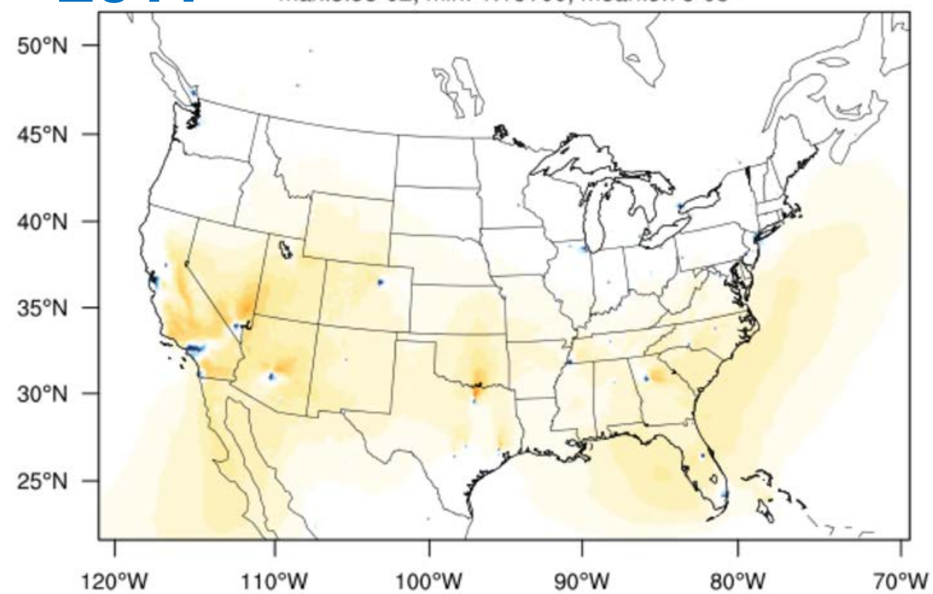
O_3 Concentrations

2005 max:4.8e-02, min:-5.2e-01, mean:7.7e-03

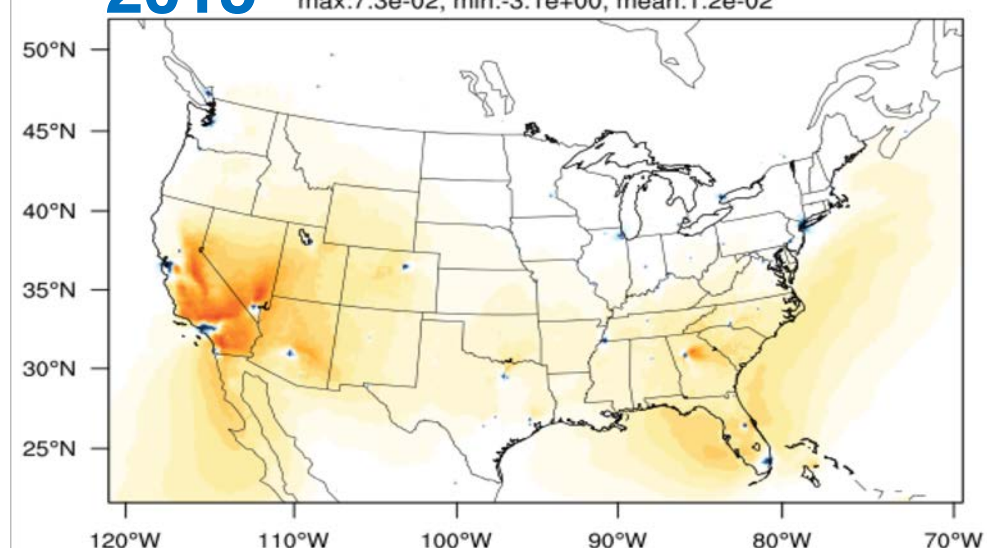


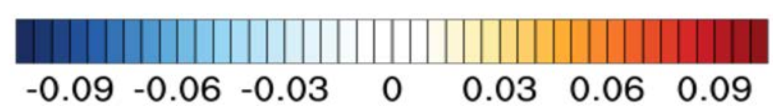


2011 max:5.9e-02, min:-1.1e+00, mean:9.7e-03



2015 max:7.3e-02, min:-3.1e+00, mean:1.2e-02





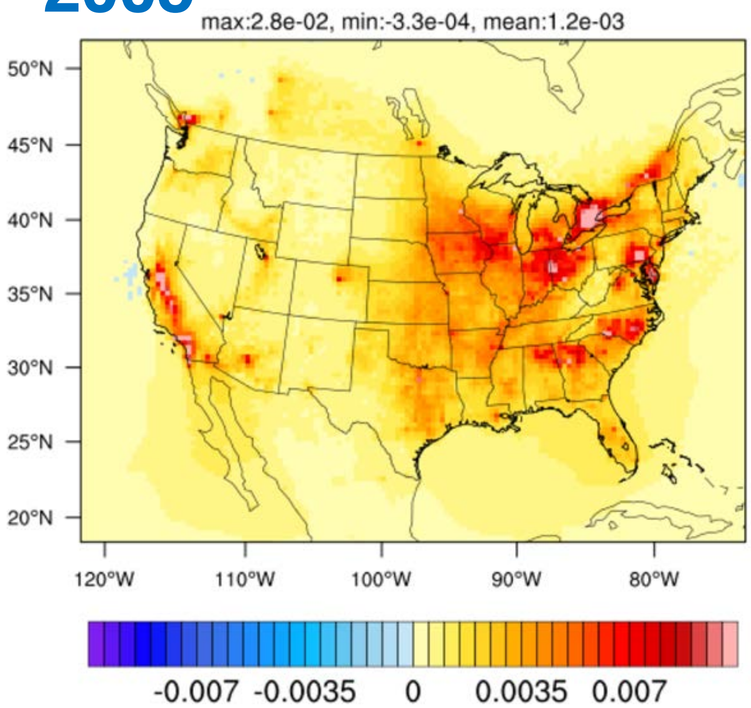
Annual averages of LTO contributions show gradual increases in formation of O_3

Greatest increase in O_3 concentrations in the central valley of California seen in 2015

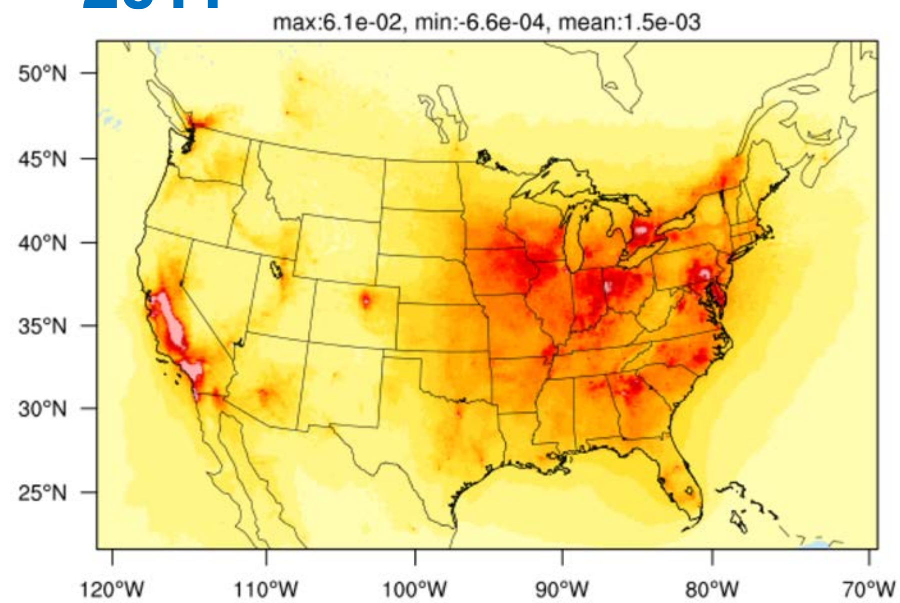
Task 1 Results

PM$_{2.5}$ Concentrations

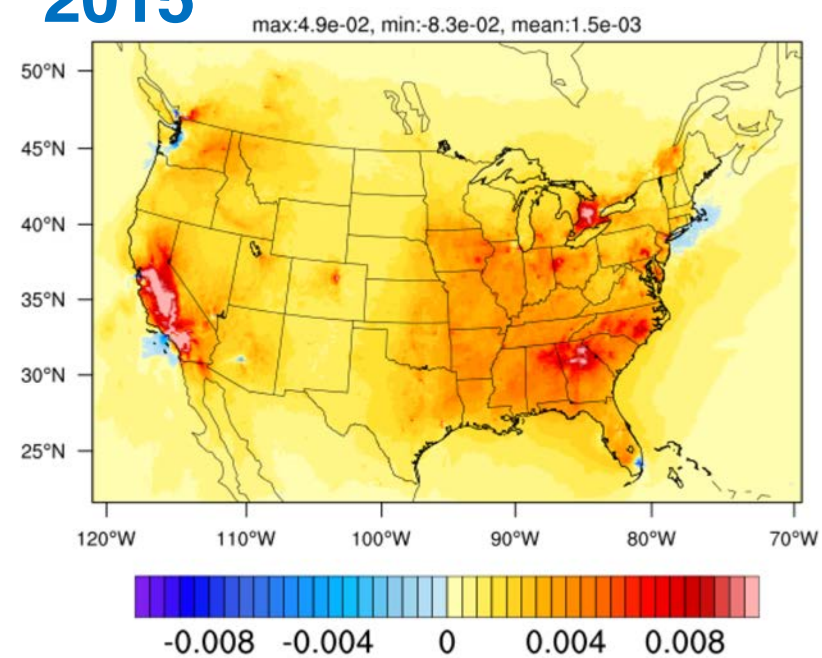
2005



2011



2015



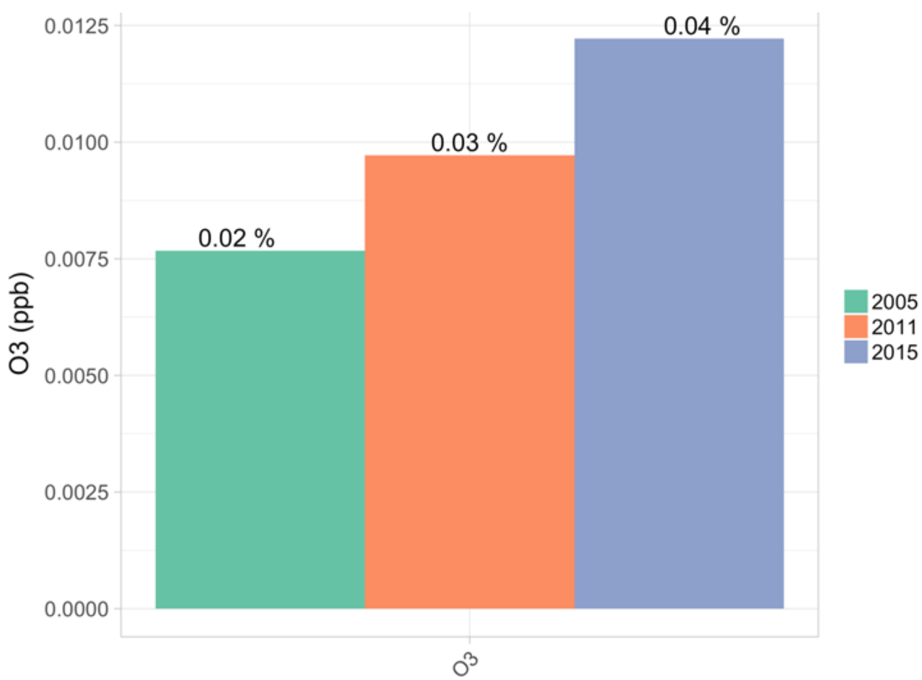
Annual averages of LTO contributions show impacts on PM$_{2.5}$

Domain-wide PM$_{2.5}$ concentrations increase over the three modeled years

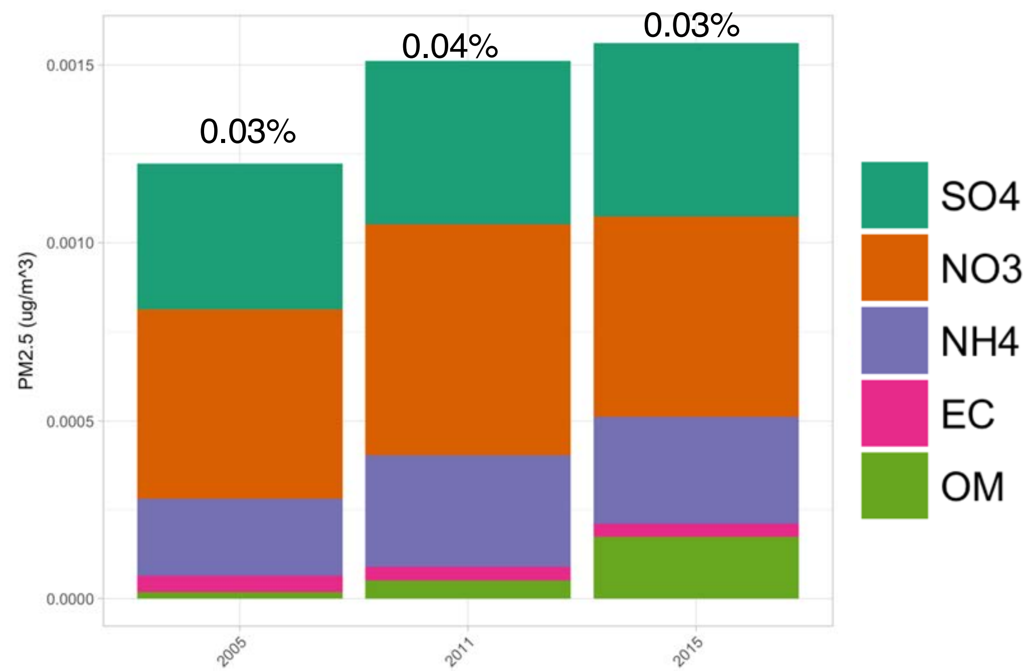
Task 1 Results

Domain-wide Concentrations

O_3



$PM_{2.5}$

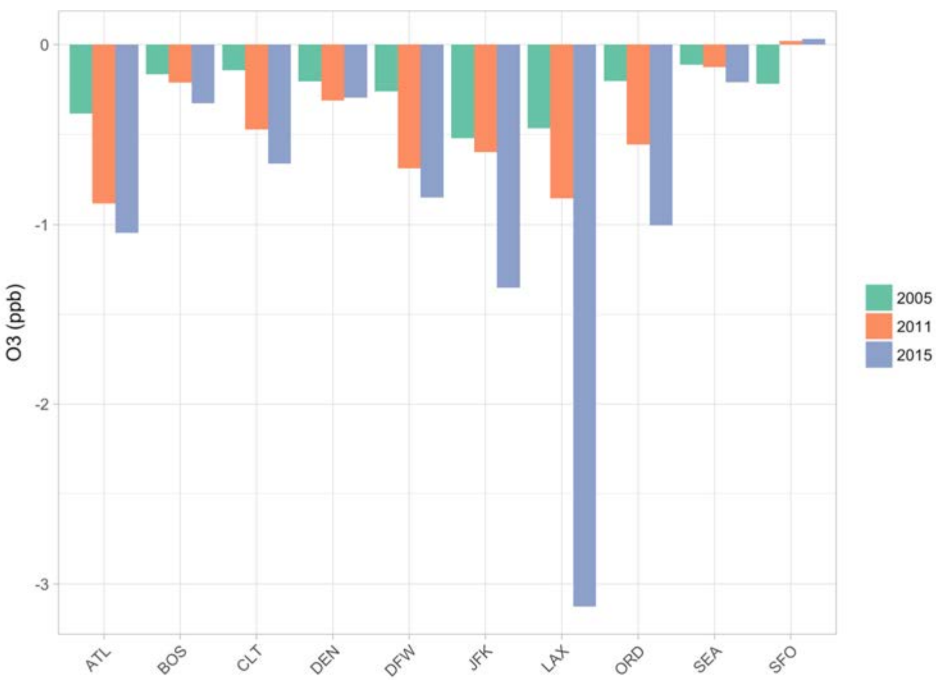


Domain-wide averages of aviation-attributable O_3 and $PM_{2.5}$ show increasing trajectory over the three model years

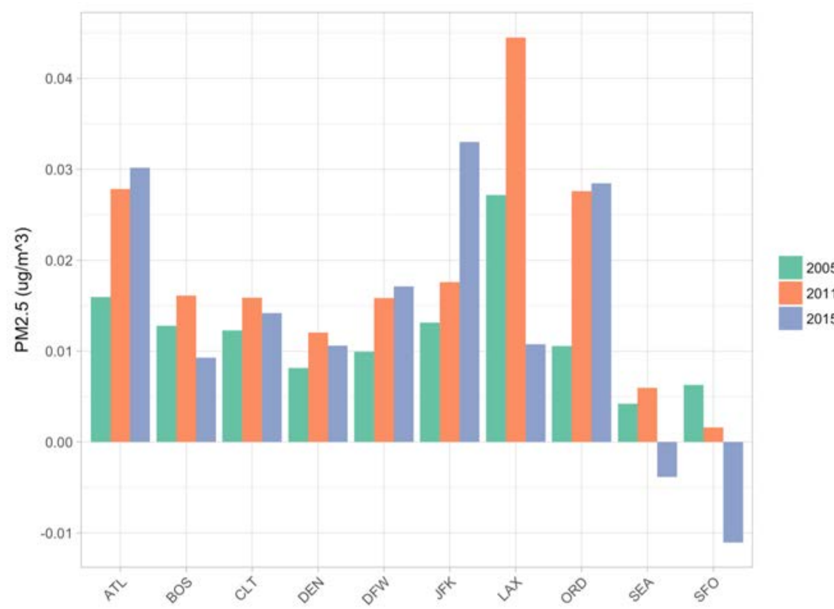
Task 1 Results

Concentrations at airport-containing grid cells

O_3

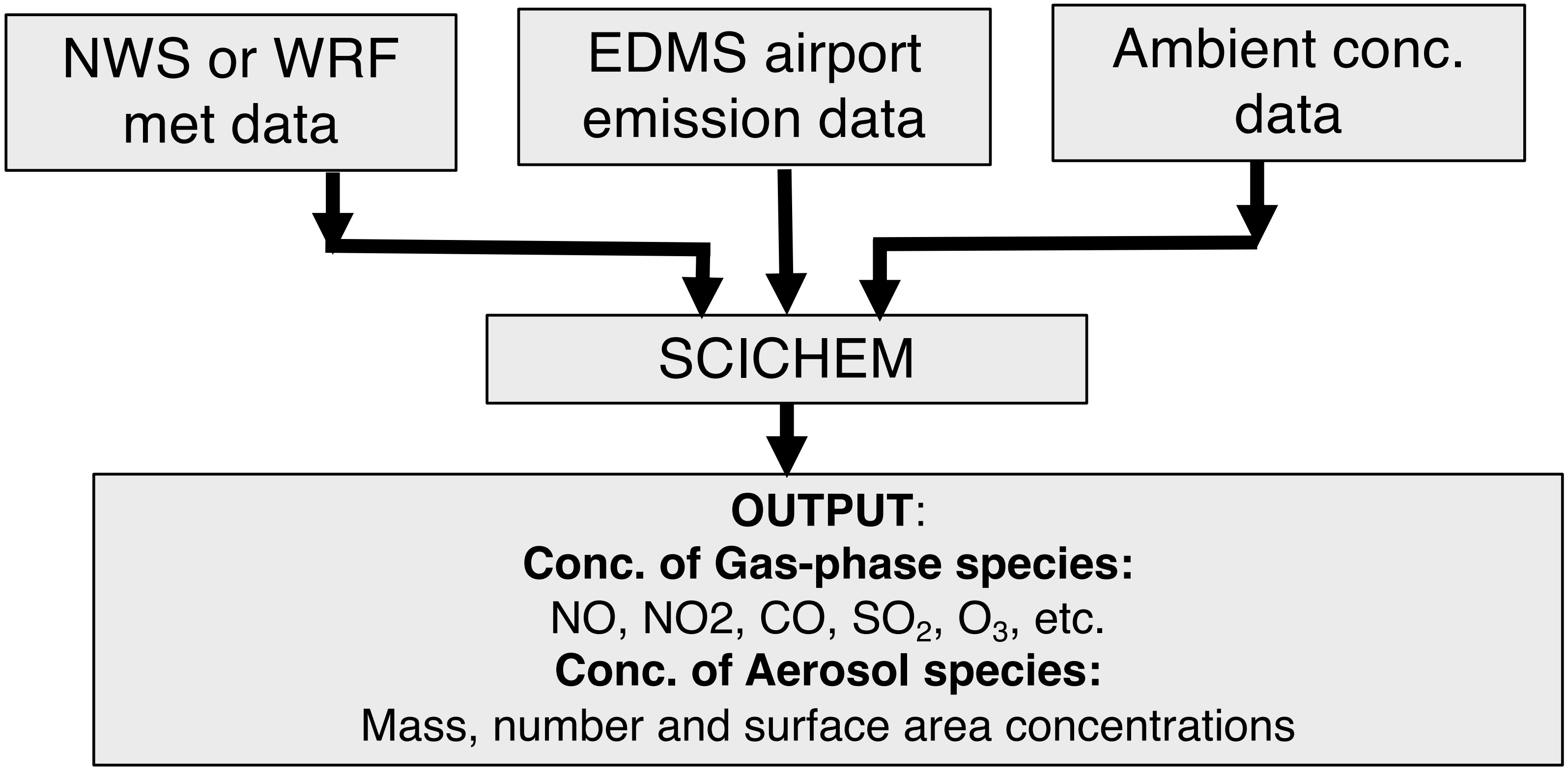


$PM_{2.5}$



- Increases in NO_X emissions over the model years results in a larger O_3 titration effect at airport-containing grid cells
- $PM_{2.5}$ increases seen in most airport grid-locations

Task 3: Approach using SCICHEM

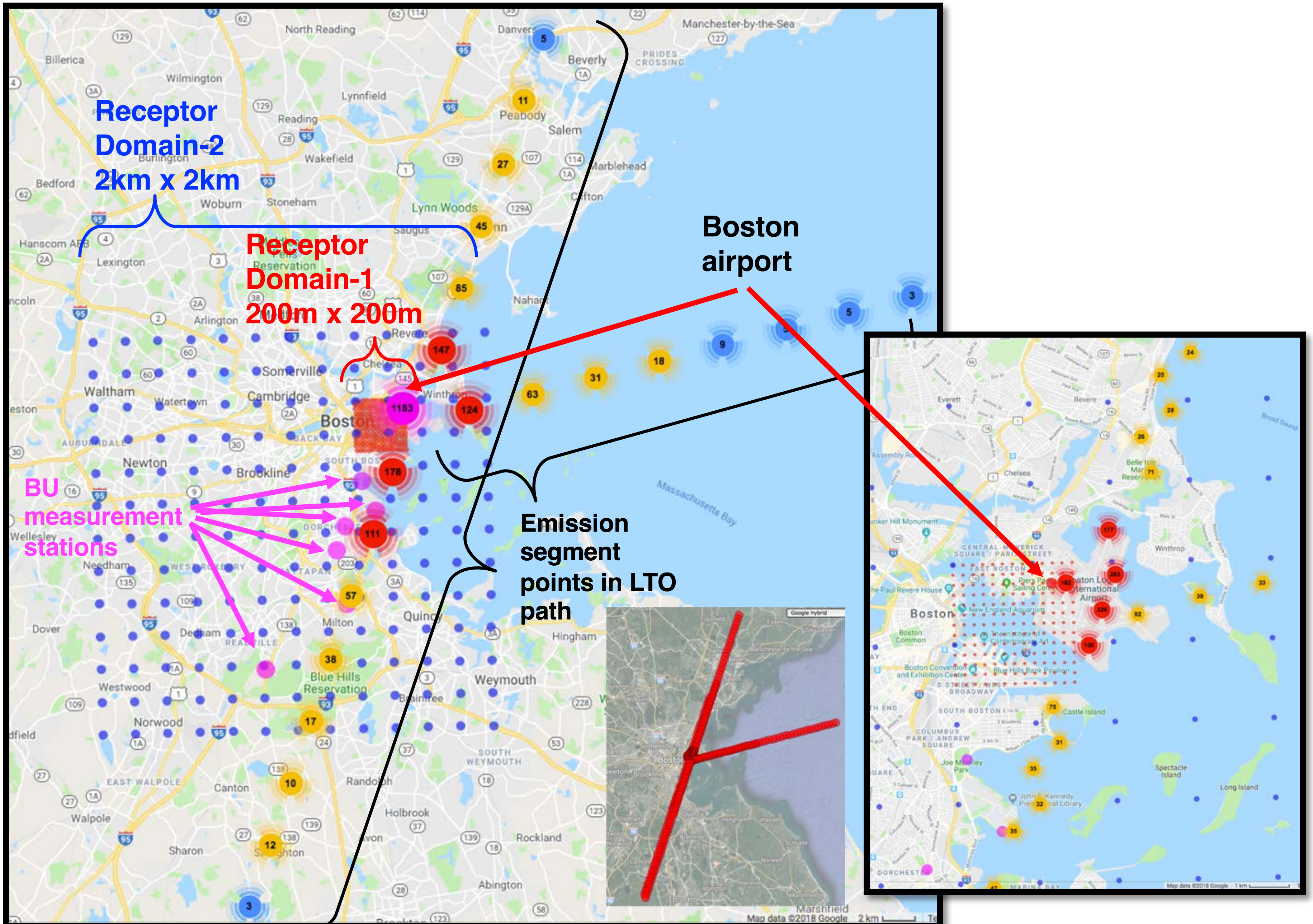


- Receptor domains at two resolutions centered on Boston Logan (BOS)
  - Receptor domain1: 250m x 250 m (13 x13 grid points) including BOS terminal
  - Receptor domain2: 2km x 2km (13 x13 grid points) including BOS terminal and six BU measurement stations

- PNC will be simulated by 2 methods :
  1) Simple approximation method without aerosol microphysics
  2) Detailed method with aerosol microphysics (nucleation and coagulation)

- Testing and code modifications in progress

Task 3: Modeling domain for SCICHEM



Task 4: New Dispersion Modeling Framework

- Objective
  - Demonstrate that a robust, improved pollutant dispersion model for aircraft can be developed for U.S. regulatory compliance purposes
- Known limitations
  - Several studies have shown limitations with AERMOD – the current local scale dispersion model used for airport-level assessments
  - Problems identified in issues related to:
    - Source representation: area vs. volume
    - Lack of plume rise for hot buoyant plumes
    - Limited treatment of chemistry, etc.
- Next steps
  - Perform comprehensive literature review including various modeling approaches – line, puff, line-puff, etc. – in existing models
  - Review current approaches for developing airport-level emissions inventories in AEDT/AERMOD
  - Develop initial design of new framework for new modeling approach
    - Include itemized list of research tasks needed to develop framework

Summary

- Summary statement
  - Modeled impacts of LTO emissions on the formation of O_3 and $PM_{2.5}$ predicts an increase in domain-wide O_3 and $PM_{2.5}$ from 2005 to 2015 while a decrease in O_3 and $PM_{2.5}$ is predicted at some airport-containing grid cells
  - SCICHEM modeling framework being developed
- Next steps
  - Use a previously completed assessment of aviation-attributable health impacts for a base year 2005 and future projected year 2025
  - Compare estimates from explicitly modeled years (2011, 2015) with interpolated estimates from the previous 2005 to 2025 trajectory to dynamically assess efficacy of modeling system for projecting trajectory of air quality and health impacts
- Key challenges/barriers
  - Renewal of funding to continue assessment, and develop dispersion modeling framework for local AQ

Interfaces and Communications

- External
  - Multiple presentations at Annual CMAS Conference, 2017 and 2018 (upcoming) in Chapel Hill
  - Additional presentations:
    - ITM Conference, October 2017 and May 2018
    - ISES Conference, October 2016, 2017
    - ANERS Conference, April 2017
    - AAAR Conference, October 2017
    - NC-BREATHE Conference, March 2018
  - National Aviation University, Kyiv, Ukraine
- Within ASCENT
  - ASCENT NOI 18 (BU) and 20 (MIT)

Contributors

- UNC: S. Arunachalam, C. Arter, M. Chowdhury, B.H. Baek, D. Yang
- BU: Jonathan Levy, Kevin Lane and team
- U.S. DOT Volpe Center for AEDT inventories
- U.S. EPA: Alison Eyth for NEI inventories