ASCENT Project 019

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

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Cost Share Partner: LAWA, EDF, EU-AVIATOR

Objective:

- Develop new aircraft dispersion model (ADM) for assessing local air quality due to aircraft sources during LTO cycles

Project Benefits:

- Improved characterization of air quality due to aircraft sources in the vicinity of the airport
- Directly feeds into AEDT development
- Support for NEPA Analyses, and Health Impact studies
- Inputs for ICAO-CAEP Impacts Science Group (ISG)

Research Approach:

Focus on 3 aspects of LAQ Modeling

- Source characterization
- Physical Processes
- Chemical Processes

Develop a series of options for testing and implementing in a 2-year timeline

- Prototype and preliminary evaluation at LAX for Winter 2012
- Apply to other case studies in the US and EU

Major Accomplishments (to date):

- ADM Prototype developed, evaluated against LAX
- Identified role of meteorology and plume rise in aircraft dispersion
- Draft manuscript focusing on role of meteorology in aircraft plume dispersion prepared
- Active engagement with EPA OAQPS and OTAQ

Future Work / Schedule:

- Continue evaluation for Summer 2012 (Summer 2021)
- Implement chemical conversion (Fall 2021)
- Evaluate at other airports (Spring 2022)
- Finalize v1 of ADM for FAA (Summer 2022)

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Treatment of Plume Rise from Area Sources

- Each area is a modeled as a set of line sources, perpendicular to the wind. Number of line sources is increased until successive contribution of the area source to a receptor is within a specified error
- Vertical dispersion is modeled with the numerical solution of

$$u(z)\frac{\partial C}{\partial x} = \frac{\partial}{\partial z}\left(K\frac{\partial C}{\partial z}\right)$$

1. Provides excellent description of near surface releases
2. Avoids assumption of Gaussian vertical distribution
3. Eddy diffusivity can be adjusted to account for buoyancy induced mixing

- A "typical" aircraft inside an area source is modeled as a point source of buoyancy

$$h_p = \left[\left(\frac{r_0}{\beta}\right)^3 + \frac{3}{2\beta^2}\left(F_m + \frac{1}{2}F_b t^2\right)\right]^{1/3} - \left(\frac{r_0}{\beta}\right)$$

r_0 = Initial plume radius

$\beta = 0.6$

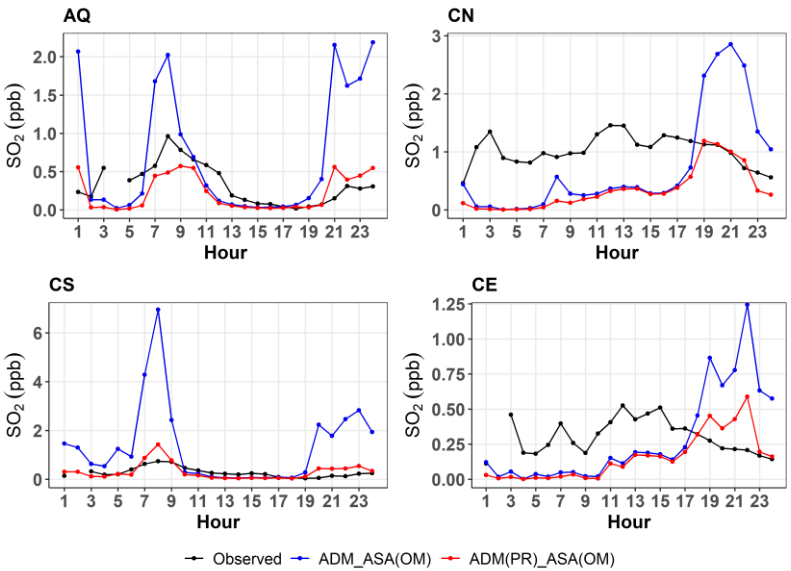
F_m = Momentum flux

F_b = Buoyancy flux

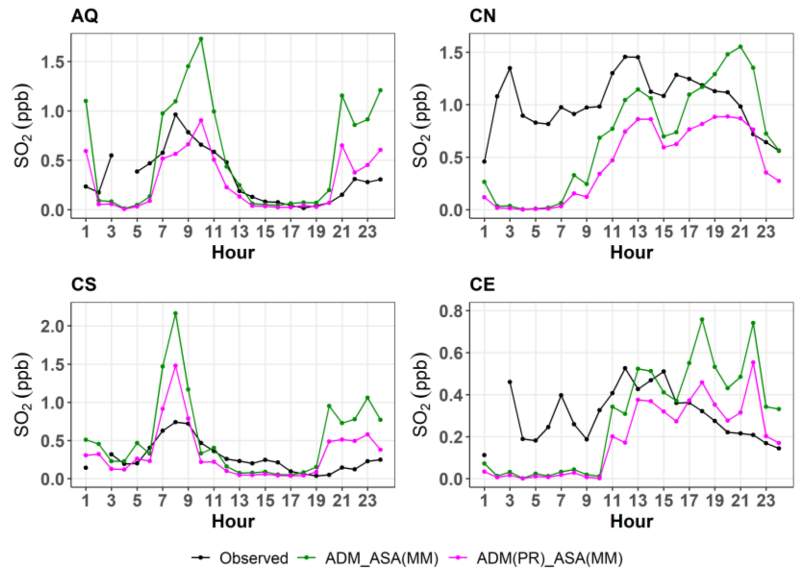
$t = x / U$

ADM Model Performance at LAX – February 2012 (Only aircraft sources)

Original Meteorology



Improved Meteorology



ASA – AEDT SEGMENT AREA
OM – ORIGINAL MET
MM – MODIFIED MET
ADM – AIRPORT DISPERSION MODEL
PR – PLUME RISE

Overpredictions at higher end reduced at all receptors with use of plume rise for area sources

Improved meteorology enables reproducing observed diurnal patterns

ADM Model Performance at LAX – February 2012 (Only aircraft sources)

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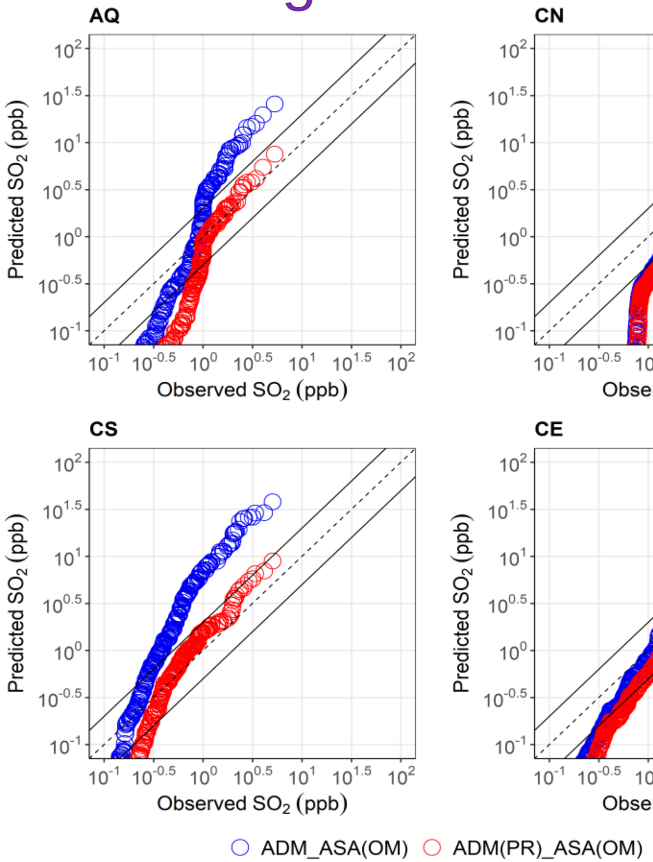

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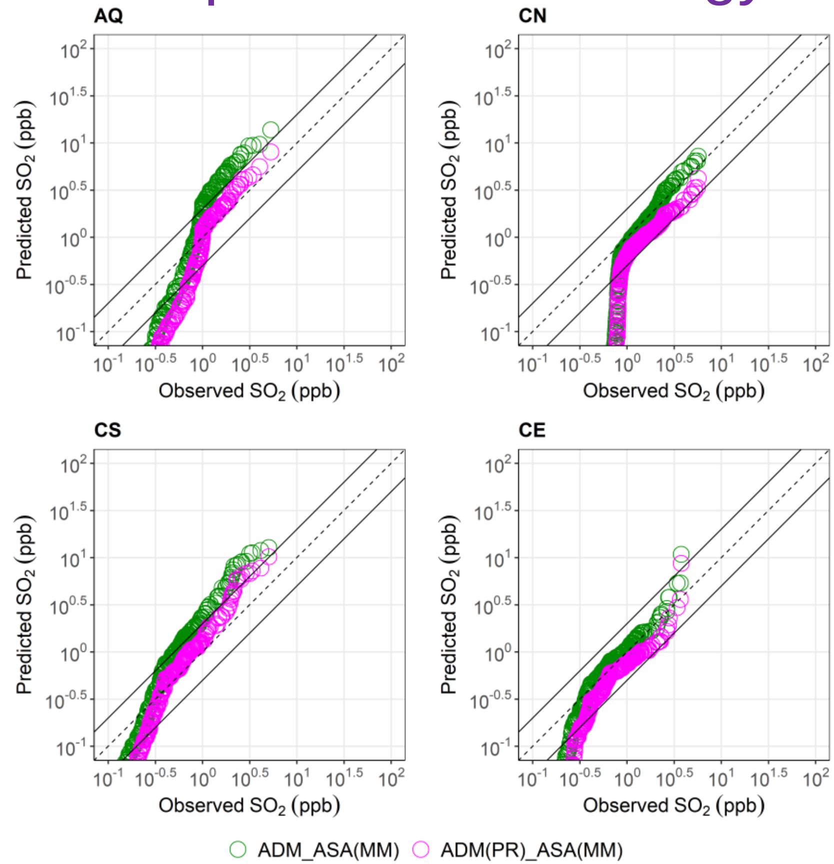

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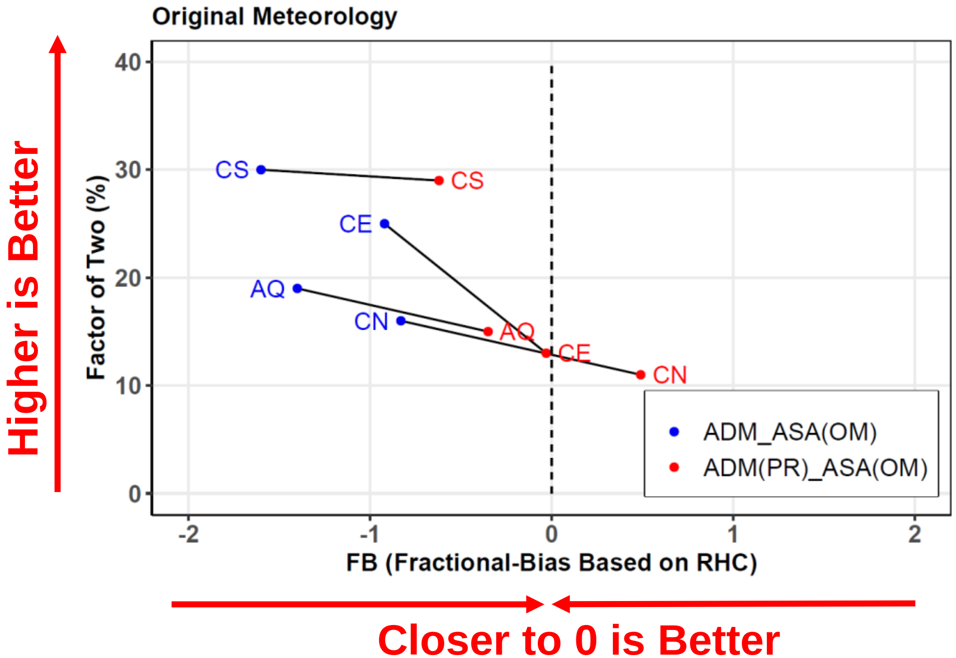

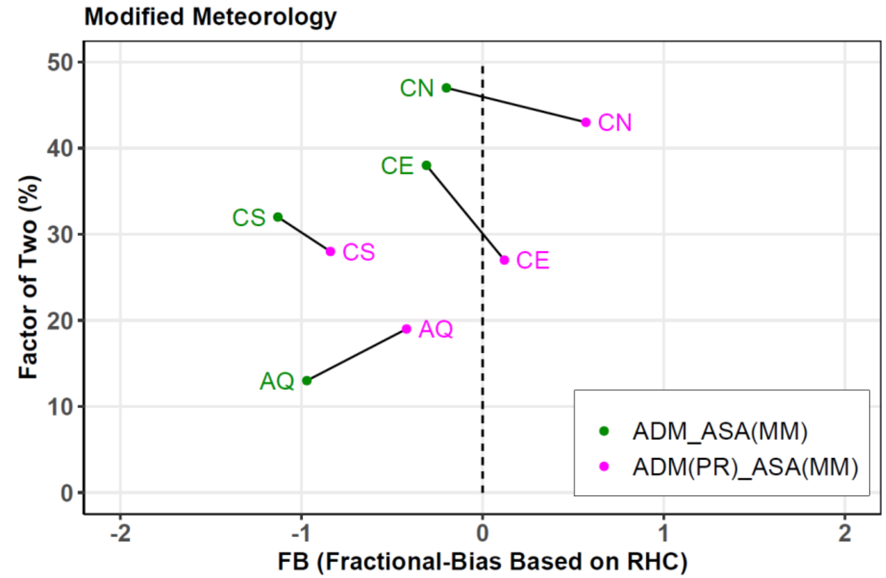

FB: Fractional Bias
FAC2: Fraction of predictions within a factor of 2
RHC: Robust Highest Concentrations

EPA recommended measures of model performance show improvement with enhanced meteorology and use of plume rise

Summary

- ADM code restructured to improve readability and facilitate conversion to other languages
- Input and output formats formalized for different source types
- Line Thermal Model for runways tested; approximations inadequate when wind is parallel to runway
  - Replaced with area sources
- Surface sources treated as area sources
- Airborne sources treated as point sources with initial horizontal plume corresponding to aircraft wingspan
- Plume rise from area sources treated with point source model from typical aircraft in area source. Source-receptor distance is the mean of the distances from the source
- Started implementing simplified chemical conversion based on the Generic Reaction Set (GRS) mechanism
- Continued engagement with the EPA during model development