

Development of an Interface for the Emissions and Dispersion Modeling System (EDMS) Within SMOKE

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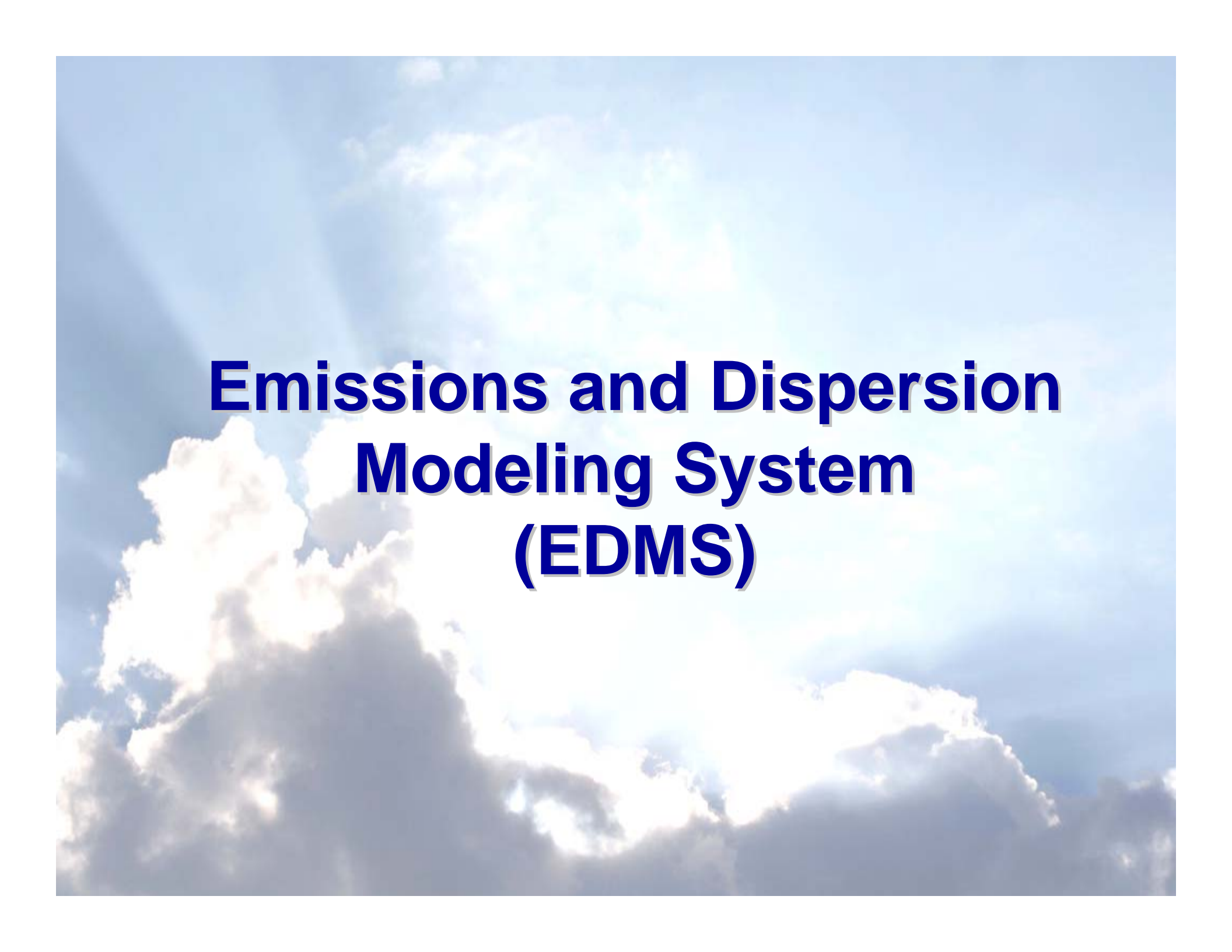
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PROJECT MOTIVATION

- Aviation emissions have the potential to affect ambient levels of air pollutants
- About 150 airports in the United States lie within non-attainment of the NAAQS for one or more of the various criteria air pollutants
- There are known emissions of air toxics from aviation activities that could have adverse health effects
 - Critical to understand exposure to air toxics to protect public health
- Capability of EDMS model is limited to dispersion of non-reactive air pollutants
- Current representation of aviation emissions in existing air quality models includes several simplified assumptions
 - Need to improve representation of aviation sources in air quality models from 2-d to 3-d

PROJECT OBJECTIVES

- Develop new interface EDMS2Inv to process aviation emissions through SMOKE
 - Convert EDMS AERMOD ready output to an hour-specific inventory format for SMOKE
- Process vertically distributed emission from EDMS into the appropriate model layers aloft through SMOKE
- Enhance representation of emissions from aviation sources in AQ model
- Help in designing and assessing new sensitivity scenarios to assess the impacts of the rapid growth of aviation sector in U.S.



**Emissions and Dispersion
Modeling System
(EDMS)**

EDMS

- FAA's Emissions Dispersion and Modeling System
 - used for emissions inventory calculation and concentration modeling for airport sources
- Emphasis on aviation sources (aircraft, auxiliary power units, ground support equipment)
- Motor vehicle and stationary sources also considered using EPA's NONROAD and MOBILE6 models
- Typically used to model a single airport
- Locations and sizes of sources are required
 - Runways, taxiways, gates, queues (dynamic)
 - Roadways, parking facilities
 - Stationary sources and training fires

EDMS

Study Setup : Tutorial Study [X]

General | Units of Measure | Domain

Airport Name: HAGERSTOWN REGIONAL-RICHARD A HENSON F
Airport ID: HGR [v] State: MD
Study Year: 2003 [v] Elevation: 703 (ft)
Default Taxi Time: 26 (mins) (EPA default)
Mixing Height: 1000 (ft) Average Yearly Temp: 52 (°F)

Study Type
 Emissions Only Emissions & Dispersion

System Aircraft Times in Mode Basis (for Emissions Inventories)
 Performance Based EPA/ICAO Defaults

GSE Modeling Basis
 LTO Based Population Based

MOBILE Model
Version: 6.2 [v] Diesel Fuel Sulfur Content: 340 (ppm)

Study Info: Sample Emissions & Dispersion Study [v]

Study Created: Tuesday, September 28, 2004

OK Cancel Apply Help

EDMS: Aircraft Activity

- Precise fleet mix and number of aircraft
 - Airframe and engine
 - Over 2,300 aircraft-engine combinations
- Number of aircraft LTOs (Landing and Takeoffs) and Touch and Gos
- Aircraft weight
- Aircraft approach angle : 3°-5°
- Total taxi and queue time per LTO
- Aircraft engine emission factors stored in EDMS are from
 - ICAO(International Civil Aviation Organization) databank
 - Engine manufacturers
- 4 power settings are modeled:
 - Idle, Takeoff, Climb out, Approach

EDMS

- In the dispersion mode, hourly concentrations are calculated
 - Requires hourly operational data for all sources
- Estimates both criteria and hazardous air pollutants
- Research version of EDMS used for this project can estimate emissions aloft up to 10,000 feet
 - Publicly released version estimates only up to 3,000 feet
 - Airport activity data from 2005 for ATL, 2002 for ORD, and 2004 for PVD
- 73 commercial aircraft types included for ATL, 109 for ORD, 144 for PVD
 - Currently, all sources are lumped when processed through EDMS, and cannot be distinguished when ready to model in SMOKE
 - 6 modes included (Start-up, Taxi-out, Take-off, Climbout, Approach, Taxi-in)

Sources Modeled by EDMS

Source Category	Operation Mode	AERMOD Source ID	Common parameters
Commercial Aircraft	Landing Takeoff Landing-runway Takeoff-runway Taxiway	L##X#### T##X#### RL##[C T]#### RT##[C T]#### TW#####	
Ground Support Equipment	GSE for aircraft GSE populations (EPA NONROAD)	GATE_###	
Auxiliary Power Units	On-board Taxiing	GATE_###	<ul style="list-style-type: none"> ●Location (x,y,z) ●Dimension (width, length, angle) ●Elevation height
Roadways	Vehicle moving (EPA MOBILE6)	RD#####	
Parking Facilities	Vehicle idling Vehicle moving (EPA MOBILE6)	PARKA###	
Stationary Sources	Generators Incinerators Fuel tanks Aircraft deicing etc. (EPA NONROAD)	STAT_###	
Fires	Training fires	FIRE_###	

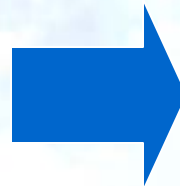


SMOKE Modeling System

SMOKE

■ Emissions inventory

- Usually annual data
- Reported by source (may be county or coordinate)
- By inventory pollutant (criteria, toxics)



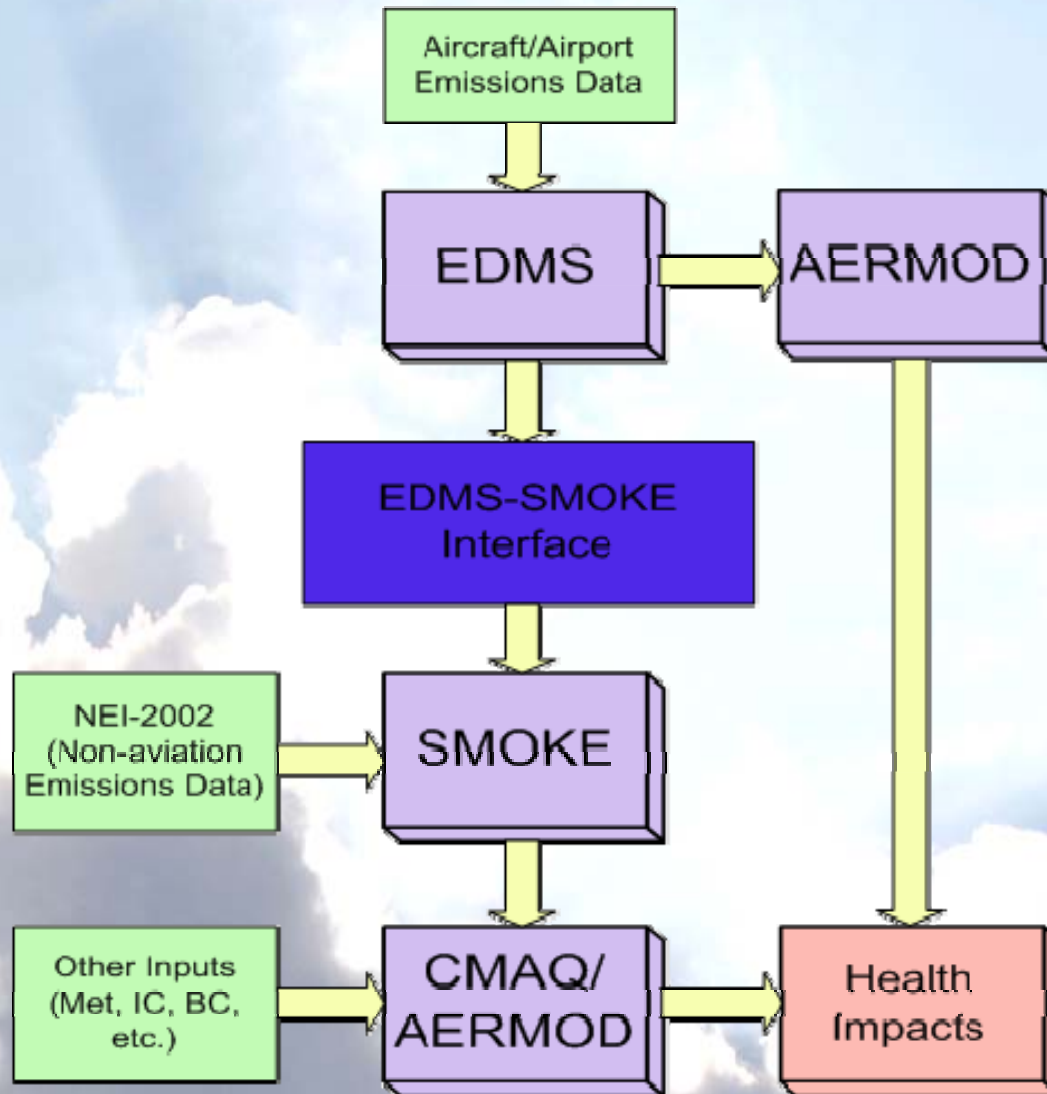
■ Air quality model input

- Hourly
- Gridded
- By model species
- May be 3-D file (layered)

SMOKE : Airport Sources

- Currently treated as nonroad/point source at the county level
- If county has 2 or more airports, all are lumped into one estimate
 - Difficult to identify particular airports represented by FIPS code
 - Difficult to isolate impact of a single airport on local-to-regional air quality
- If a given airport straddles 2 counties, potential for emissions to be allocated to the wrong county
- Optional : Area to Point processing using Lat/Lon coord.
- All emissions are allocated only to the air quality model's surface layer
 - Aircraft emissions due to take-off and landing activities are misrepresented spatially
- Most often, these are annual or seasonal estimates, and then have uniform daily/weekly/monthly temporal profiles

Overview Data Flow





SMOKE/EDMS Interface (EDMS2Inv)

Study Airports

- Atlanta Hartsfield – ATL
- Chicago O'Hare – ORD
- Providence T.F. Green – PVD
- Commercial Aircraft (SCC: 2275020000)
- CAPs only
(NO, NO₂, CO, THC, Speciated PM2.5 (PEC, POC, PSO4) using FOA V3.0)
- Emissions reported up to 10,000 ft at heights corresponding to the air quality model

SMOKE

- **Point source characteristics**
 - Country, state, and county
 - Latitude and longitude
 - SCC
 - Plant ID
 - Point ID
 - Stack parameters = 'blank' or zero

EDMS2Inv

- Treat all aviation sources as point source in SMOKE
- Assign **FIPS codes**
- Assign Airport_AERMOD IDs to **Plant ID**
- Assign Source IDs to **Point ID**
- Convert relative coordinates of all aviation sources from EDMS to **Lat./Lon.** coordinate
- Convert g/s/m^2 to **short Ton/hr**
- Convert elevation height (ft) to **meter**
- Convert unit of NO_2 in NO equivalency to mass in NO

EDMS2Inv

- Convert unit of THC in CH₄ equivalency to mass in C
- Convert THC to TOG
- Compute NONHAPTOG = TOG – All 25 HAPs
 - for integrated CAPs and HAPs processing
- Create a master (annual) inventory (PTINV) including source characteristics (FIPS, SCC, PlantID, PointID)
- Create an hour-specific aviation emission inventory (PTHOUR).
- Current version assumes that all emissions are from commercial aircraft
 - Will update future version to use a cross-reference table that maps EDMS/AERMOD based source IDs to NEI's SCC codes
- Can process multiple pollutants (CAPs and HAPs) for multiple airports at the same time

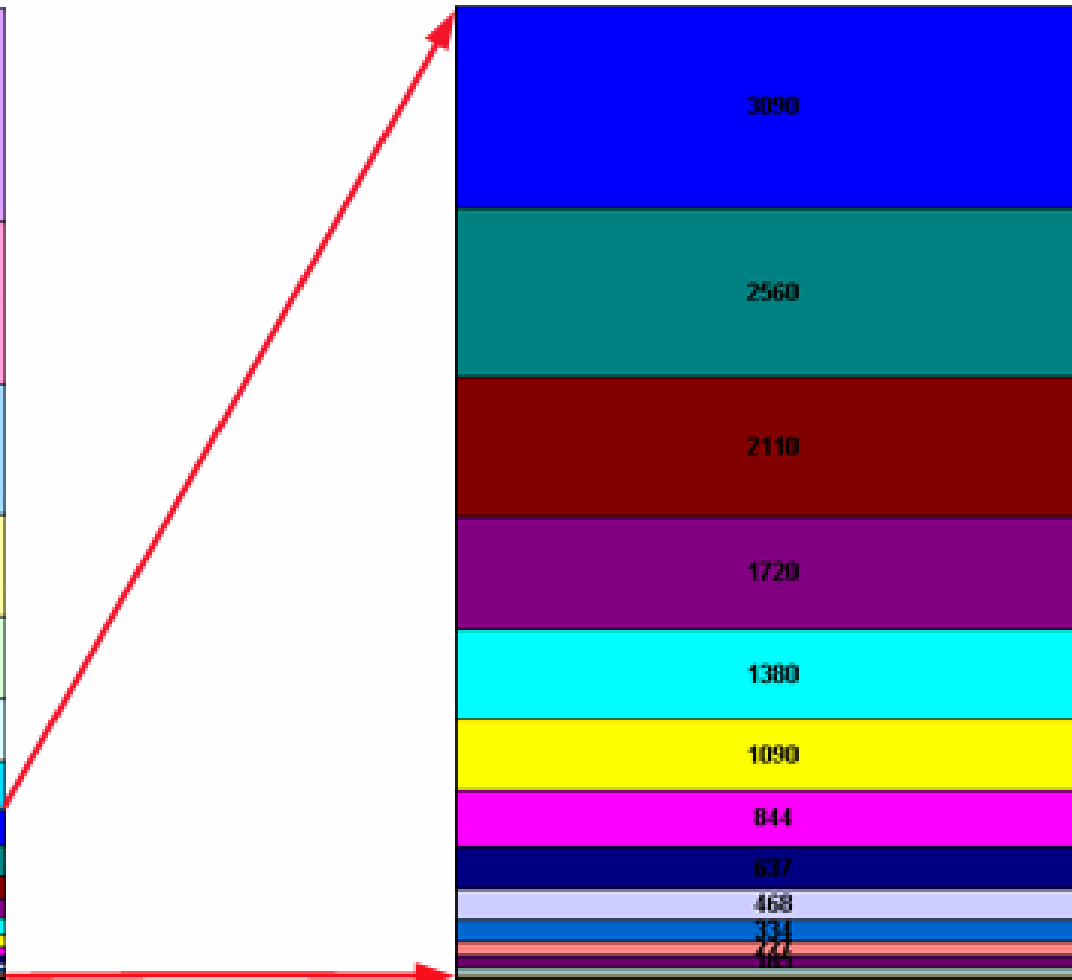
EDMS2Inv → SMOKE

- Create hour-specific aviation emissions from PTINV and PTHOUR generated from EDMS2Inv
- Minor updates made to existing SMOKE programs such as Smkinven and Laypoint
 - Assigns aircraft emissions provided at various heights into the corresponding vertical layer of CMAQ
- To be used in nested CMAQ application over the Eastern U.S.

Layer Structure

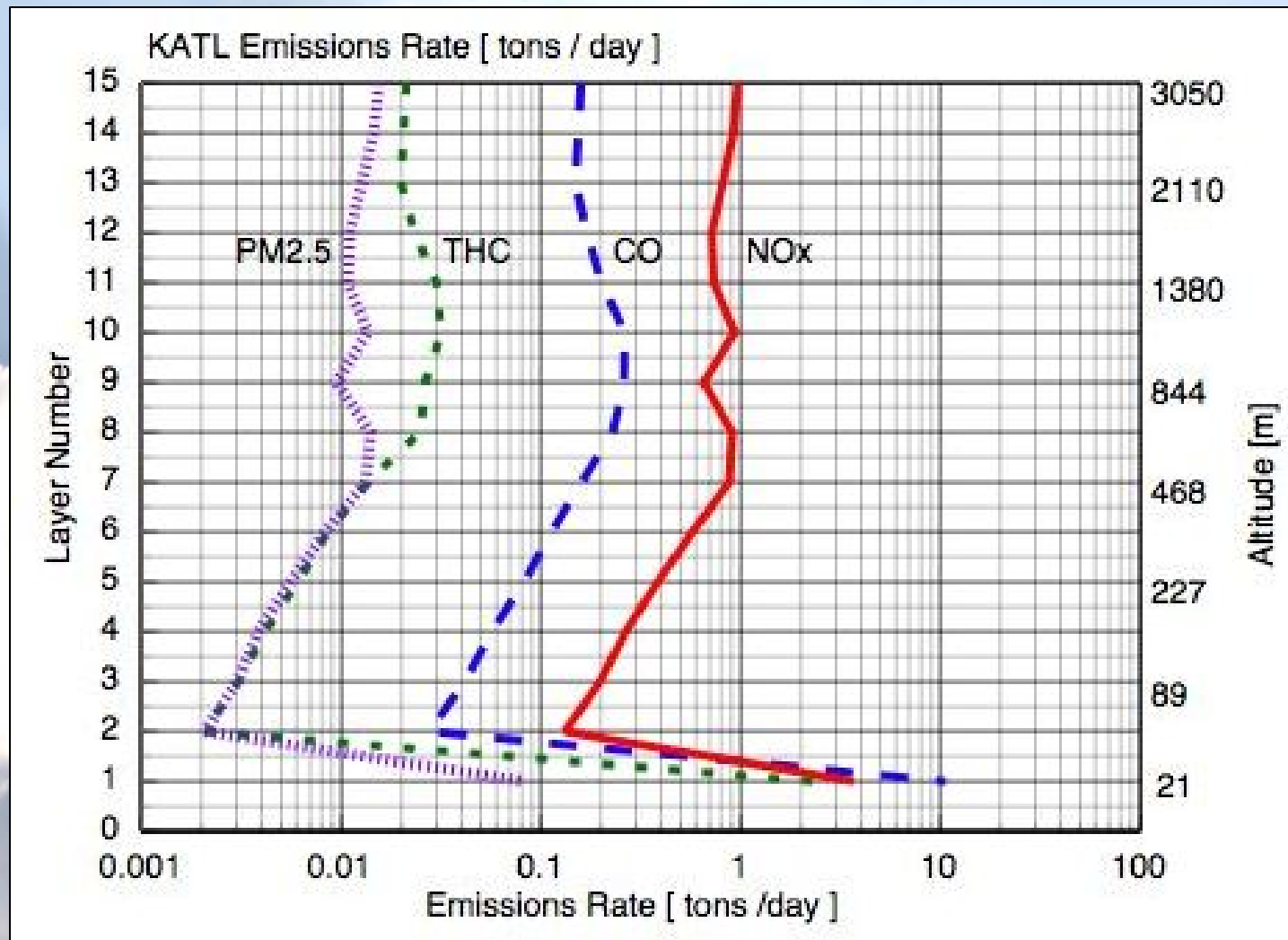


CMAQ Layers (22)

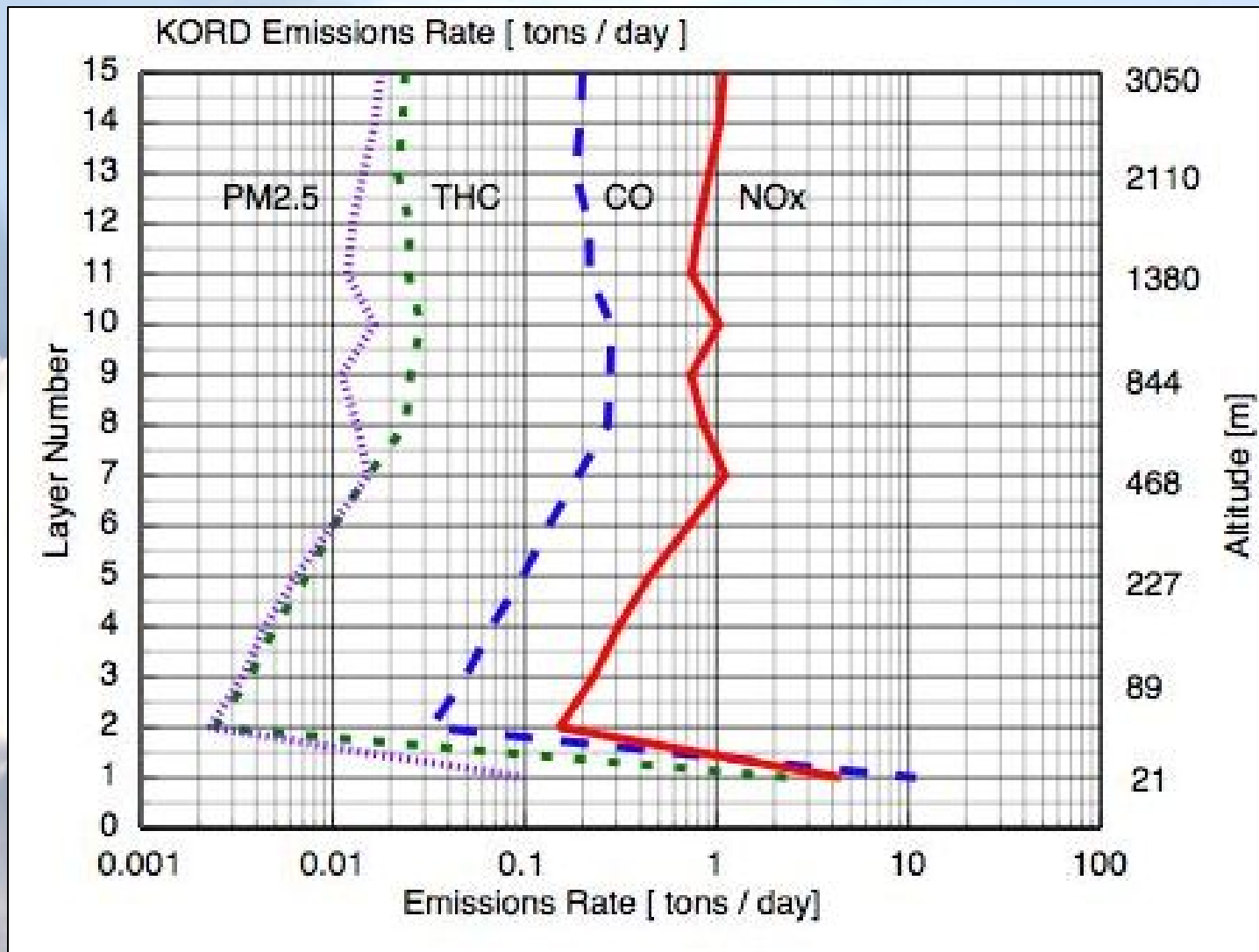


Aircraft Data in First 15 Layers (up to 10,000 feet)

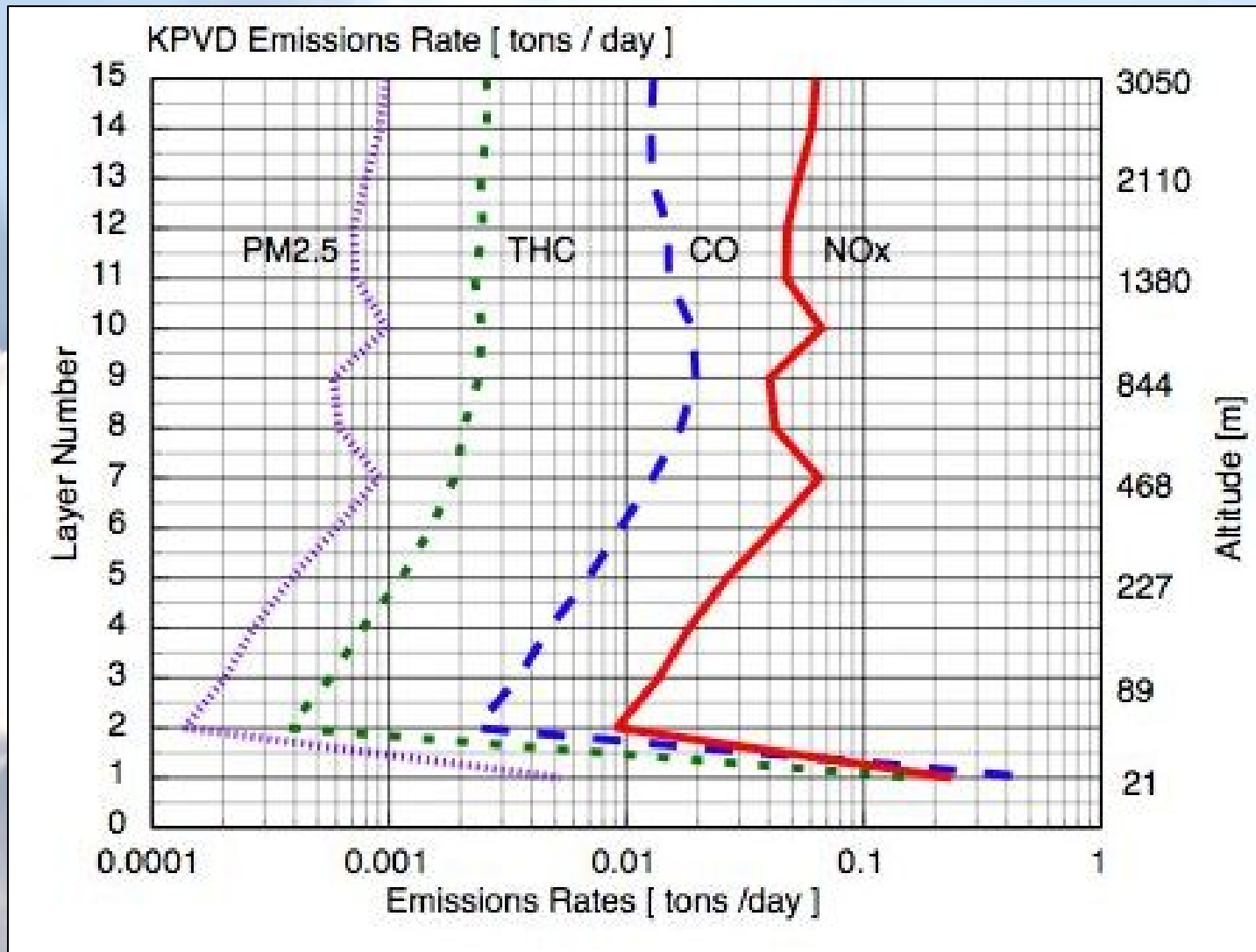
Atlanta Hartsfield – KATL



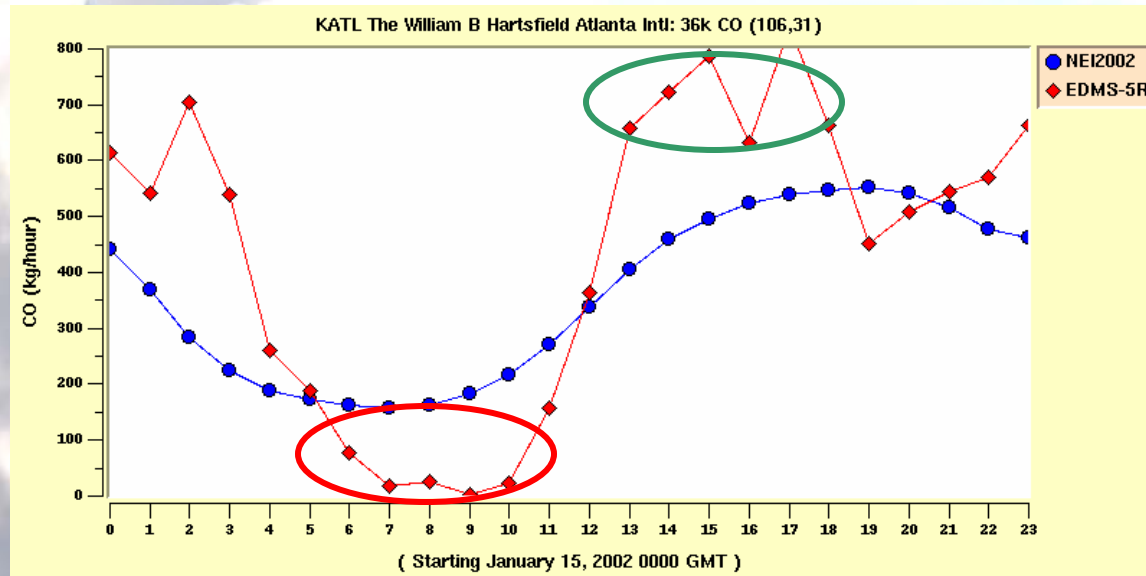
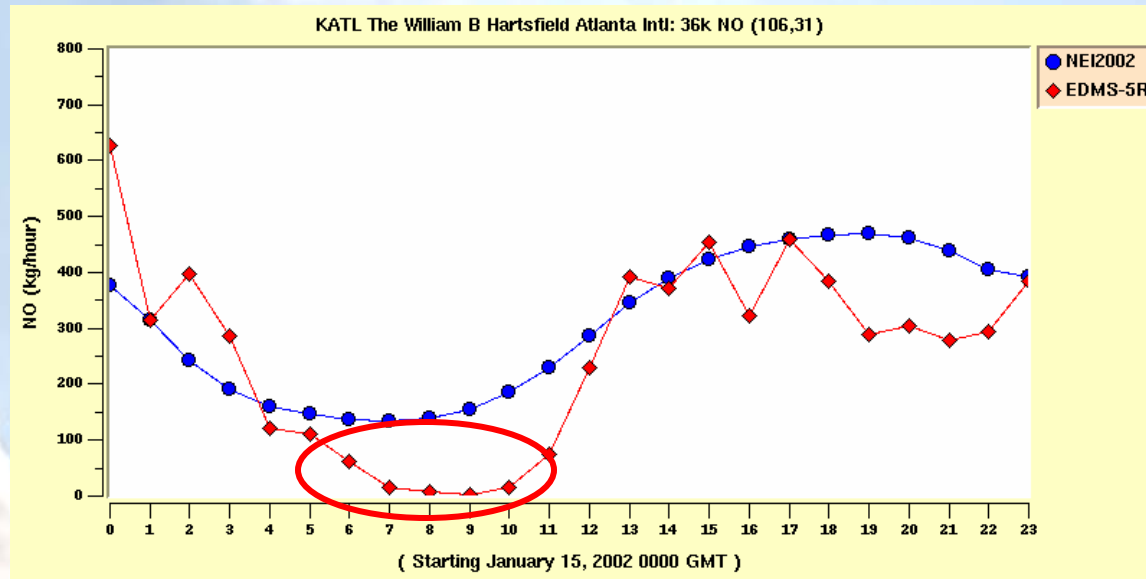
Chicago O'Hare – KORD



Providence T.F. Green – KPVD



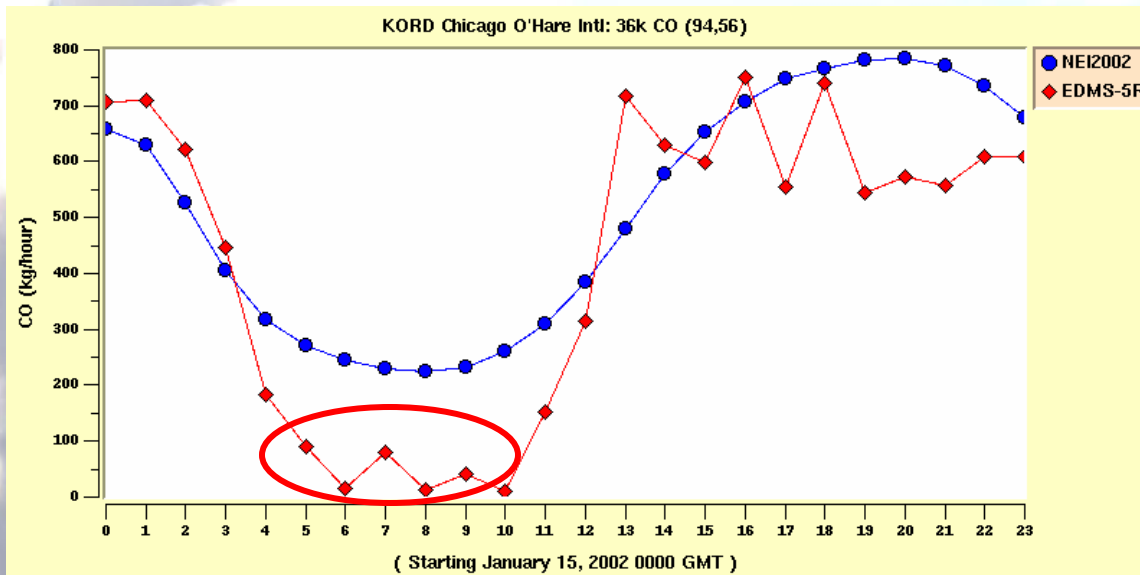
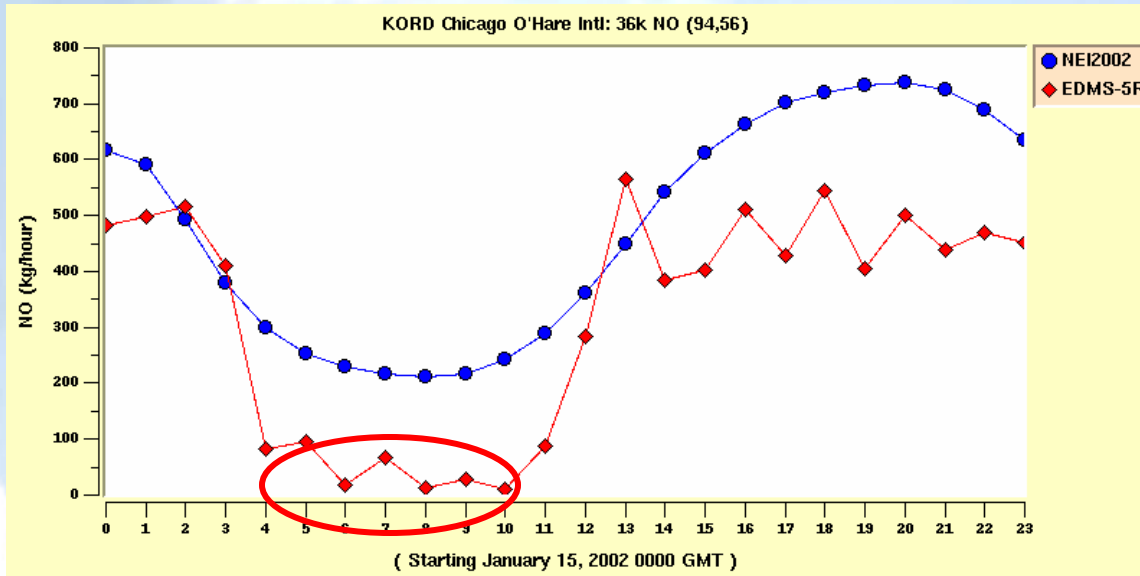
Atlanta Hartsfield – KATL



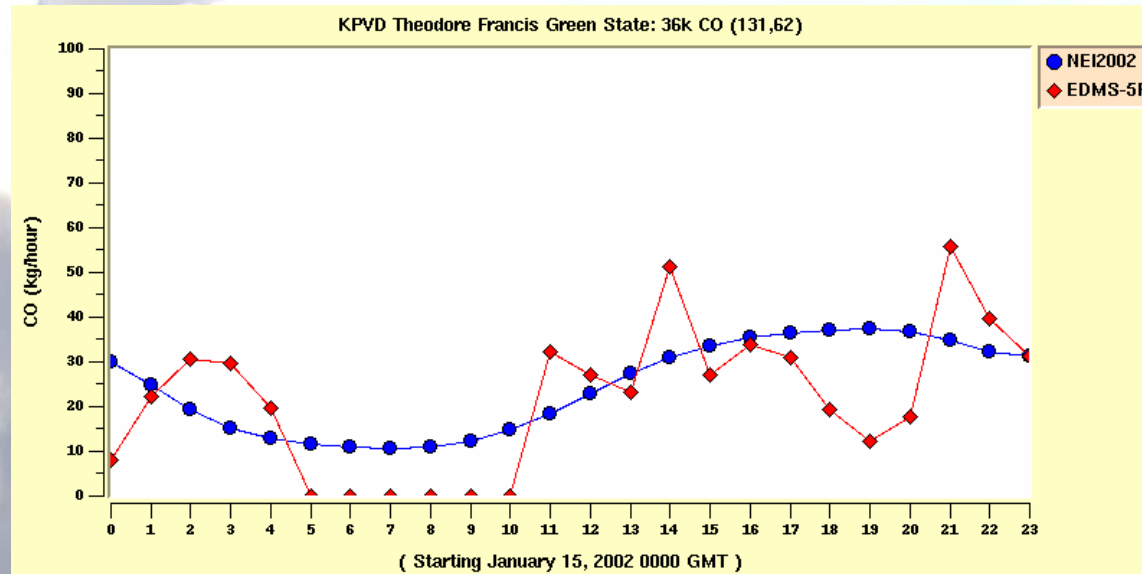
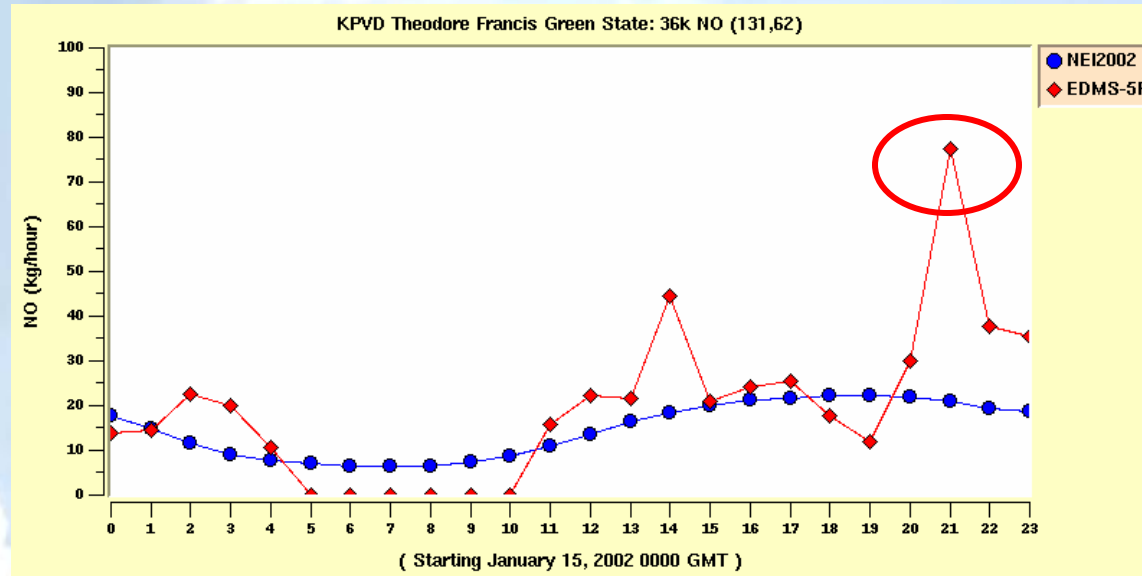
NOTE

- Input data (such as flight activity info) and version of EDMS used in NEI aircraft emission calculation may be different than what are used in our analysis
- These differences could be potential cause of variations shown here
- This relative comparison of emissions also indicates need to correctly account for and represent aviation emissions in the air quality analysis

Chicago O'Hare – KORD



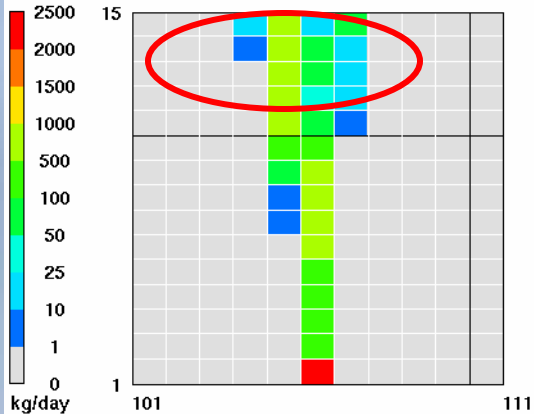
Providence T.F. Green – KPVD



Atlanta Hartsfield – KATL

Daily Total NOx

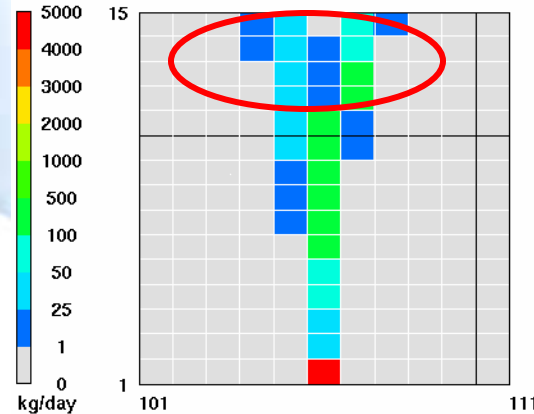
Layers 1-15 Vertical Cross Section
EDMS-sR Data for KATL



January 15, 2002 0:00:00
Min= 0 at (101,1), Max= 3488 at (106,1)

Daily Total CO

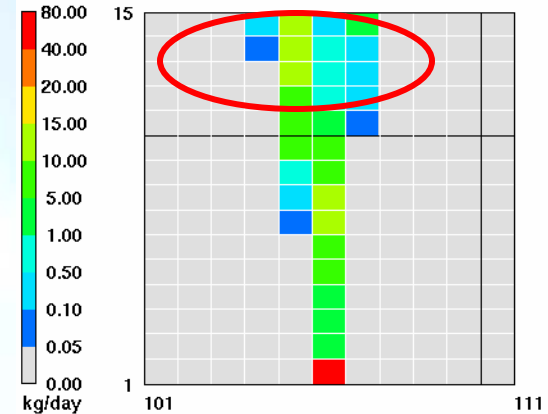
Layers 1-15 Vertical Cross Section
EDMS-sR Data for KATL



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Daily Total PM2.5

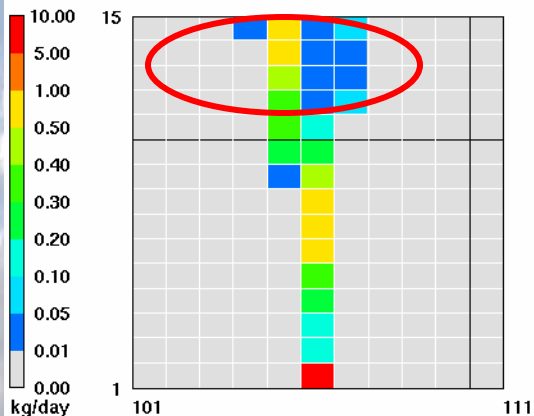
Layers 1-15 Vertical Cross Section
EDMS-sR Data for KATL



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Daily Total POA

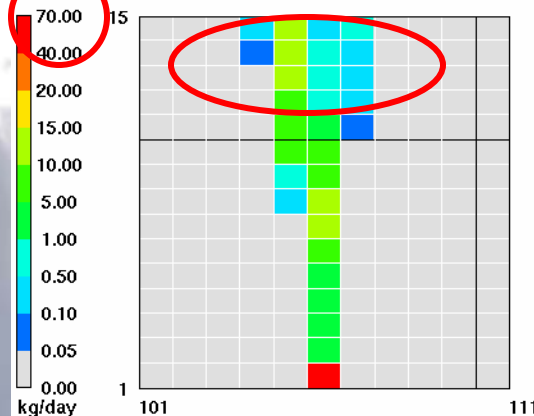
Layers 1-15 Vertical Cross Section
EDMS-sR Data for KATL



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Daily Total PEC

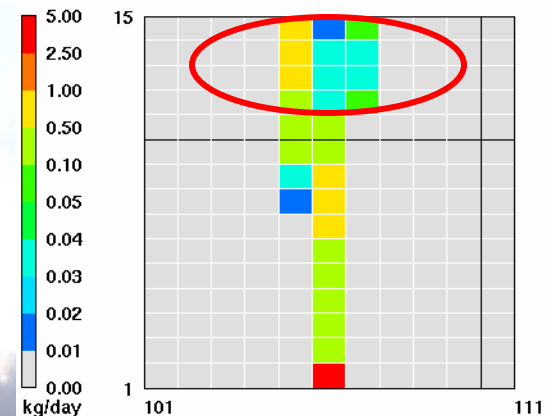
Layers 1-15 Vertical Cross Section
EDMS-sR Data for KATL



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Daily Total PSO4

Layers 1-15 Vertical Cross Section
EDMS-sR Data for KATL

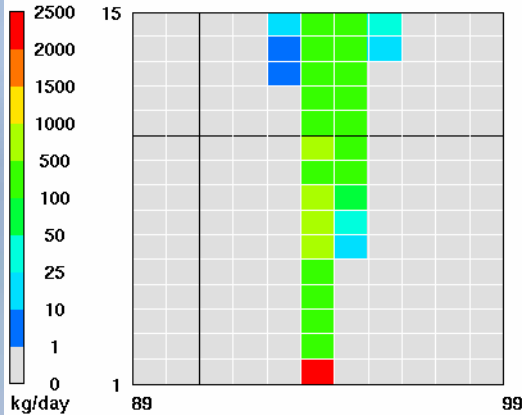


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Chicago O'Hare – KORD

Daily Total NOx

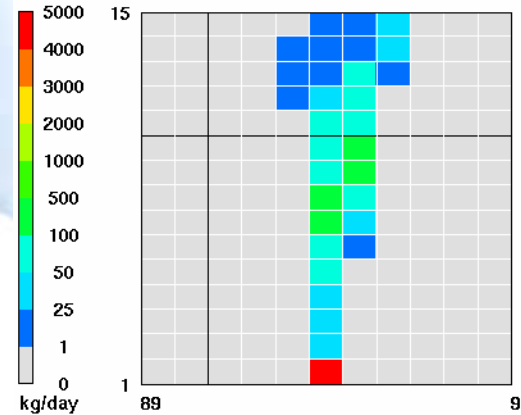
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KORD



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Daily Total CO

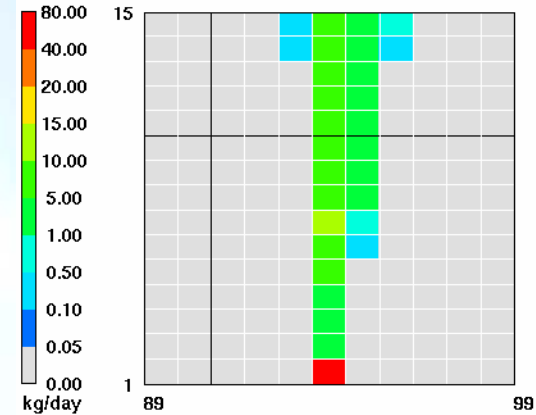
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KORD



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Daily Total PM2.5

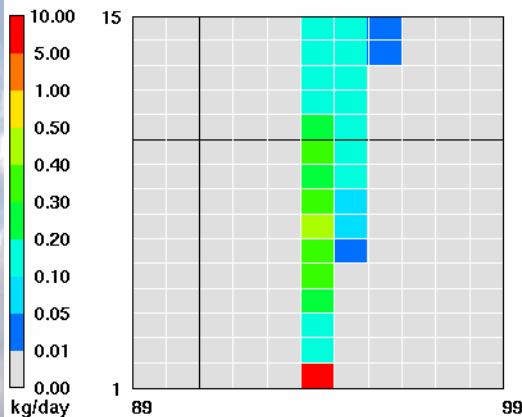
Layers 1-15 Vertical Cross Section
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Daily Total POA

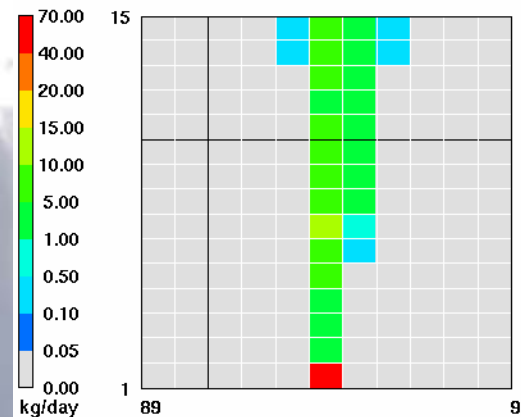
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KORD



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Daily Total PEC

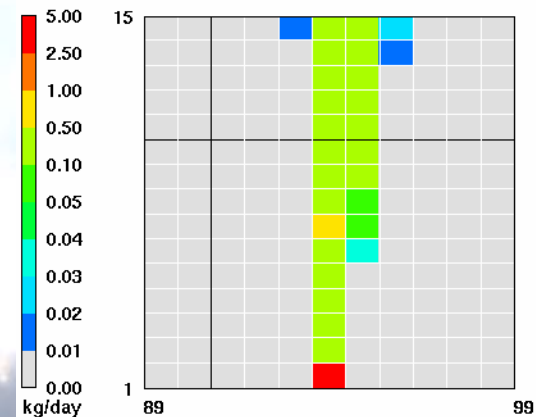
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KORD



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Daily Total PSO4

Layers 1-15 Vertical Cross Section
EDMS-5R Data for KORD

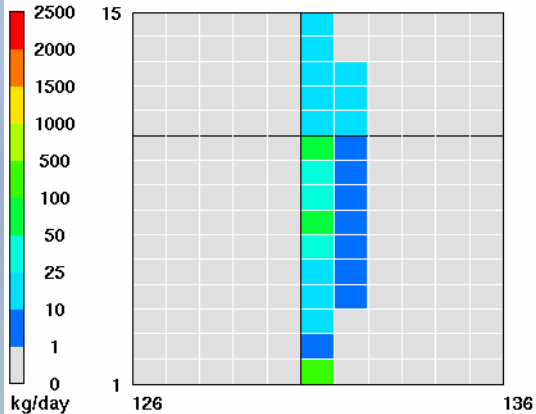


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Providence T.F. Green – KPVD

Daily Total NOx

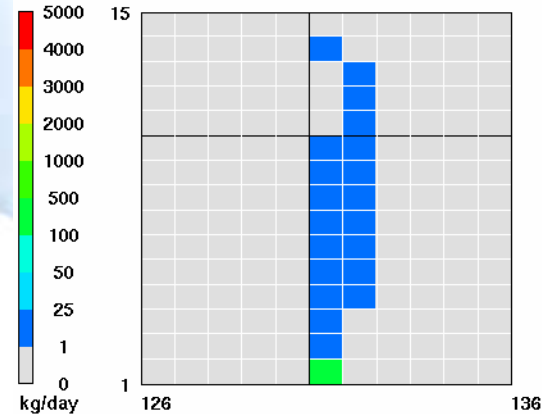
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KPVD



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Daily Total CO

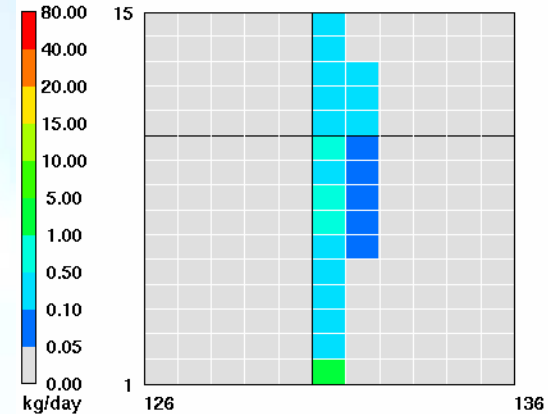
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KPVD



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Daily Total PM2.5

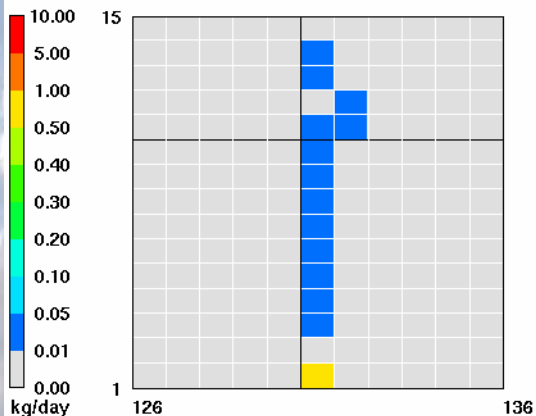
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KPVD



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Daily Total POA

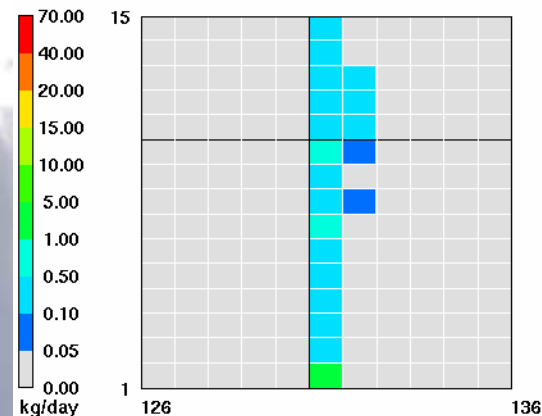
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KPVD



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Daily Total PEC

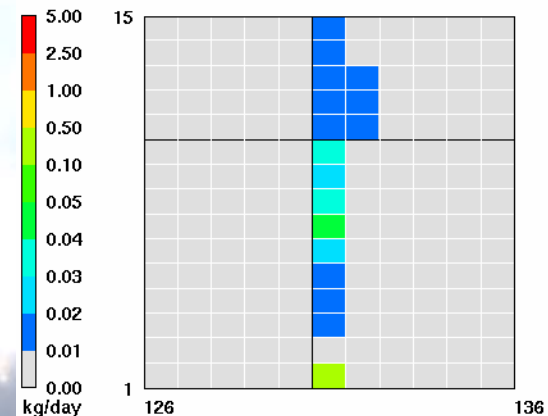
Layers 1-15 Vertical Cross Section
EDMS-5R Data for KPVD



January 15, 2002 0:00:00
Min= 0.00 at (126,1), Max= 4.09 at (131,1)

Daily Total PSO4

Layers 1-15 Vertical Cross Section
EDMS-5R Data for KPVD



January 15, 2002 0:00:00
Min= 0.00 at (126,1), Max= 0.33 at (131,1)

Conclusions

- **New capability (EDMS2Inv) to enable detailed characterization of airport/aircraft emissions in air quality models**
 - Spatially enhanced representation of emissions by allocating emissions into the appropriate CMAQ modeling layers aloft up to 10,000 ft height
 - Temporally enhanced representation by allocation hourly EDMS emissions into CMAQ model instead of using default uniform temporal profile
 - Can process multiple pollutants and multiple airports at the same time
 - Can be expanded to process CAPs and HAPs together for integrated processing
- **New approach will assist in comprehensive assessment of impact of these emissions on local-to-regional scale air quality and potential health impacts**
 - Currently developing nested CMAQ application using emissions

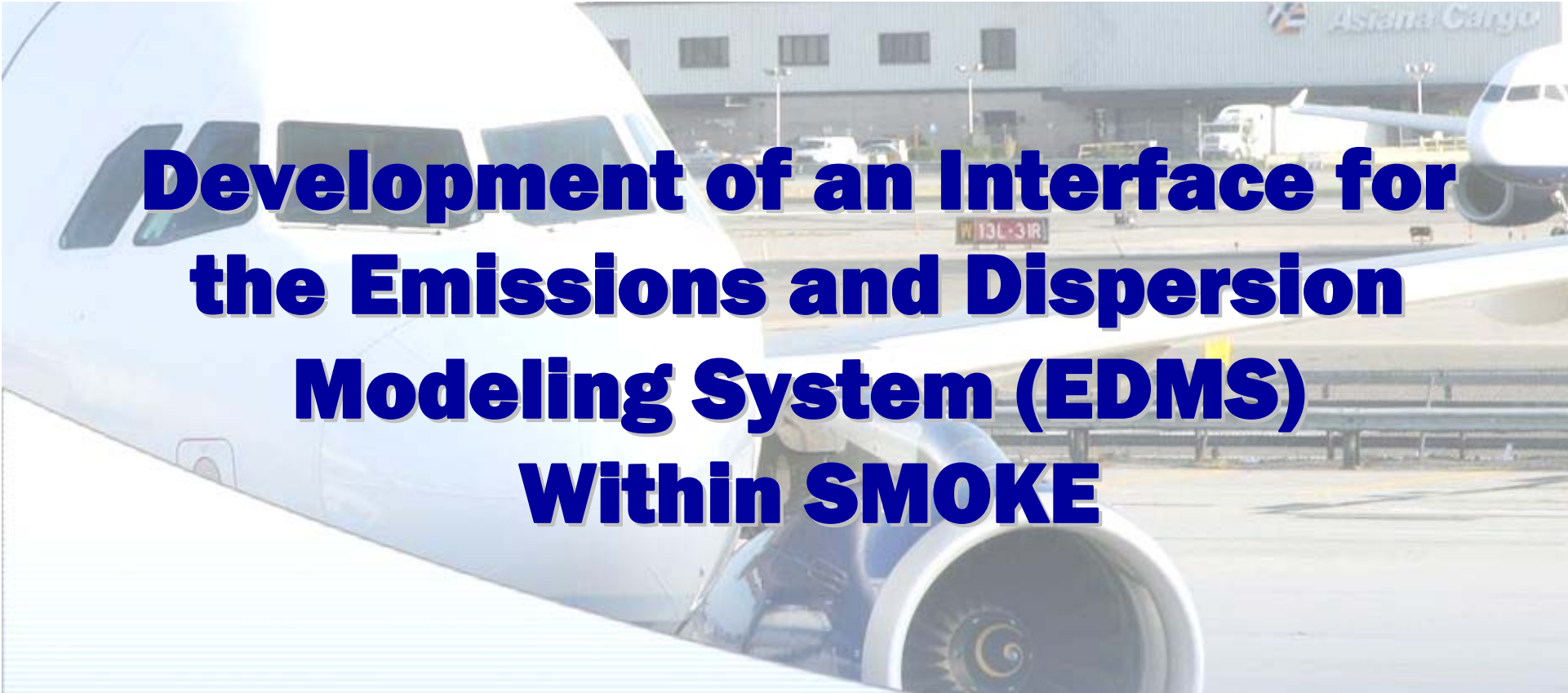
Acknowledgments

- **FAA** : Mohan Gupta, Ralph Iovinelli
- **U.S. EPA**: Marc Houyoux, Madeleine Strum
- **CEMPD** :



- This work was funded by the FAA, under Grant No.03-C-NE-MIT, Amendment No. 027, and on contract DTFAWA-05-C-00044. The Local Air Quality project is managed by Dr. Mohan Gupta





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EDMS : Other Sources

- **Ground support equipment fleet**
 - Either as an airport population or associated with a specific aircraft
 - Default GSE assignments are available for all aircraft
- **GSE Inputs**
 - Fuel type, operating time, HP, and load factor
 - Defaults provided
- **APU assignment and operating time for each LTO**
 - A default is also available for applicable aircraft