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Partnership for AiR Transportation Noise and Emission Reduction

An FAA/NASA/TC-sponsored Center of Excellence

Energy Policy Act Study

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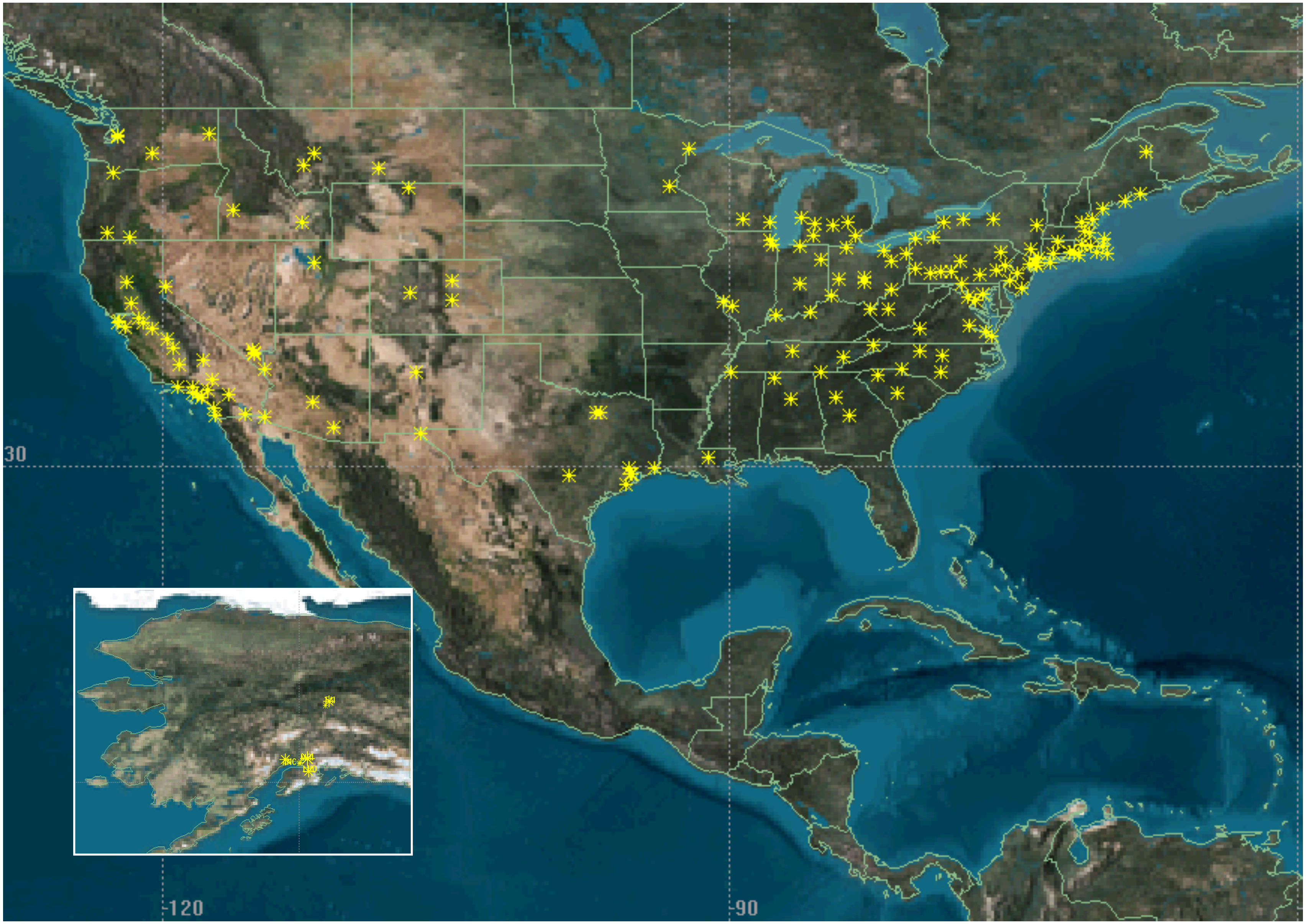
Motivation

Energy Policy Act of 2005
H.R. 109-90, Sec. 753

Requires FAA and EPA to:

- Conduct a study to identify the impact of aircraft emissions in non-attainment areas
- Identify ways to promote fuel conservation to enhance fuel efficiency and reduce emissions
- No later than one year after initiation of the study, issue a report to Congress that describes the results of the study and recommends ways to reduce fuel use and emissions affecting air quality

Airports located in non-attainment and maintenance areas



Objectives

focus of presentation

1. Generated a baseline emissions inventory for **148 U.S. airports** out of 150 currently located in non-attainment and maintenance areas
   - CO, THC, NOx, SOx, Non-volatile PM2.5, Volatile PM2.5
   - Two airports dropped due to insufficient operations data
2. Estimated change in ambient air quality due to aircraft emissions using CMAQ with EPA/EDMS emissions inventories (**325 airports** representing 95% U.S. jet ops with filed flight plans)
   - Assessed health impacts (with US EPA BenMAP)
3. Determined relationship between congestion/delays and emissions per operation (**3 airports studied in-depth**)
   - Estimated pool of achievable benefits for **115 airports** with BTS data
4. Assessed potential for FAA initiatives to improve operations and local air quality (**Various airports**)

Generation of baseline emissions inventory

- Research version of FAA's Emissions Dispersion Modeling System (EDMS) v. 5.0.2 used to compute aircraft emissions inventories
- Conducted APU utilization survey
- No existing database of aircraft PM EI's
  - Area of continuing scientific research
  - Developed and utilized version of PM FOA (First Order Approximation Method) specific to EPAct (FOA3a) to model primary non-volatile and volatile PM

FOA3a (EPACT) vs. FOA3

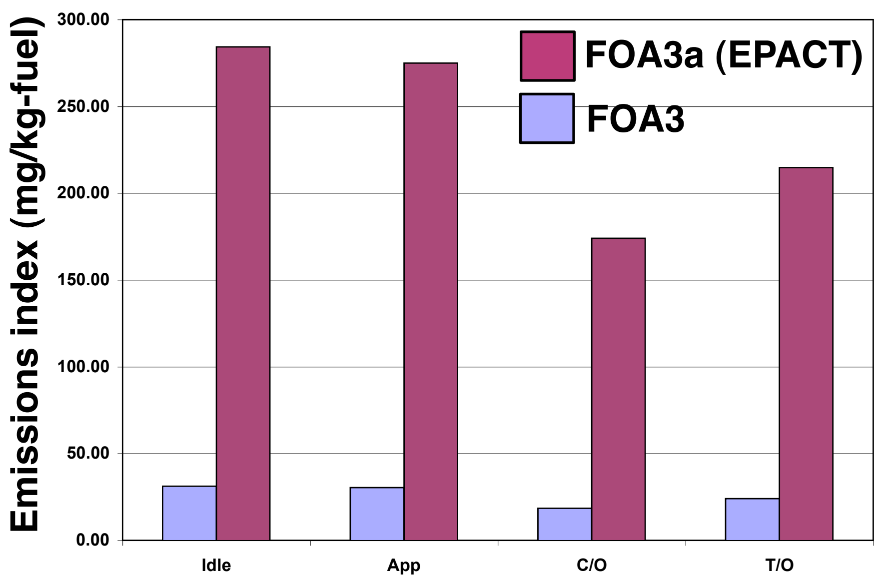
- FOA3a (EPAct) > FOA3 by a factor of 1.6 to 9.4.
  - Due to conservativeness of prediction in FOA3a and treatment of bypass ratios.

Ratio (FOAEPAct/FOA3.0)

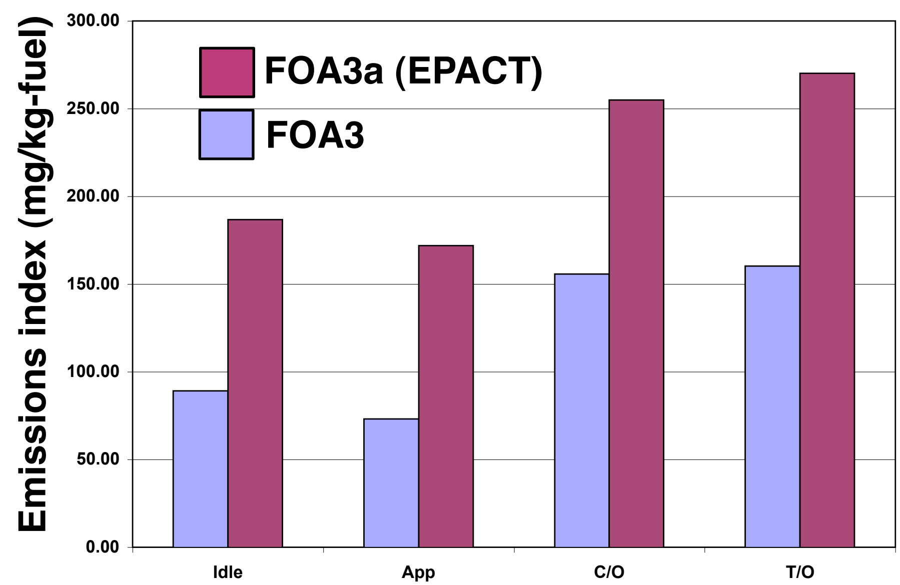
PW4158	6.14	6.50	6.71	6.31
CFM56-3B-2	6.40	7.16	7.89	7.25
GE90-77B	9.10	9.05	9.40	8.95
RB211-535E4	2.10	2.35	1.64	1.69

MIN	1.64
MAX	9.40

GE90-77B



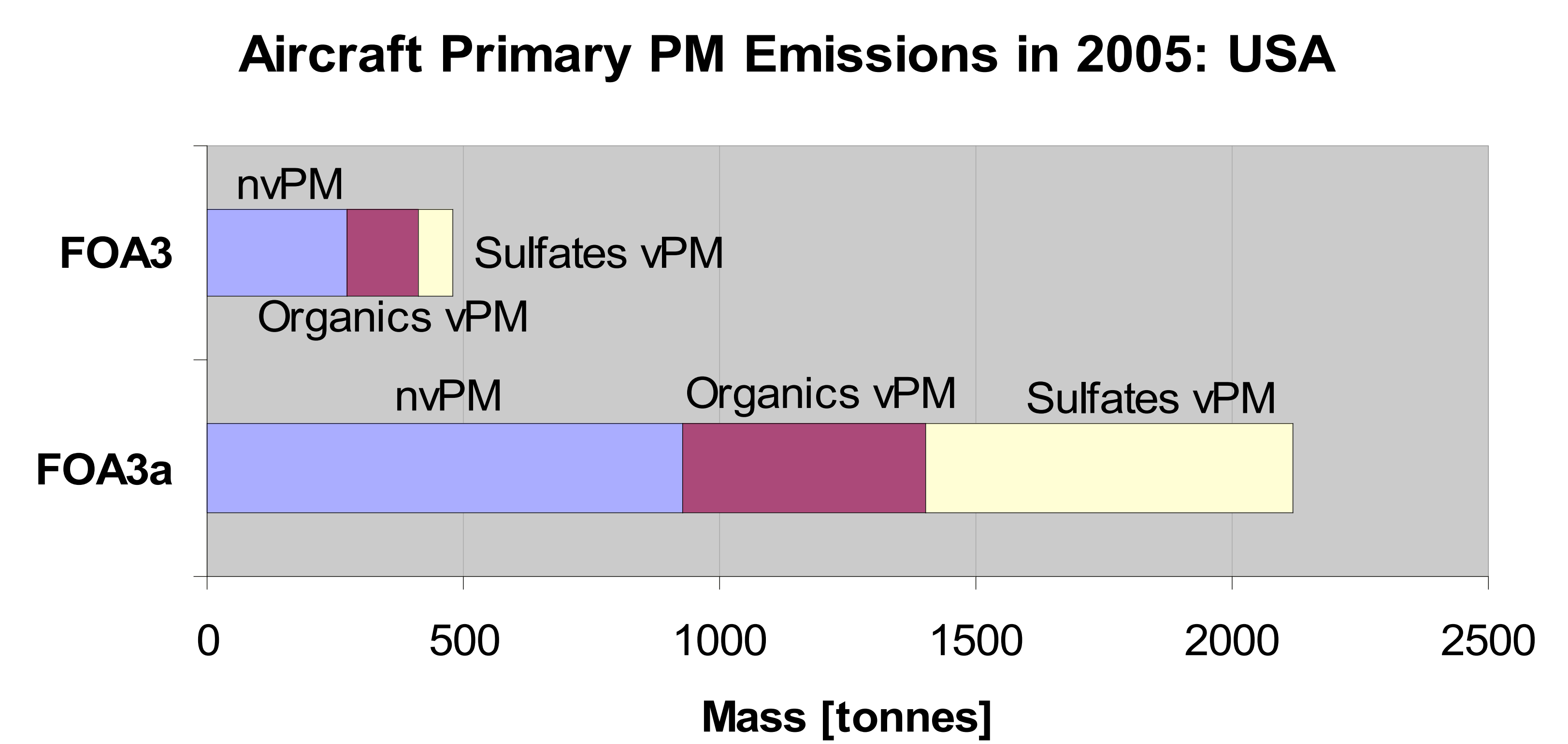
RB211-535E4



Preliminary results, do not cite or quote

PM emissions models

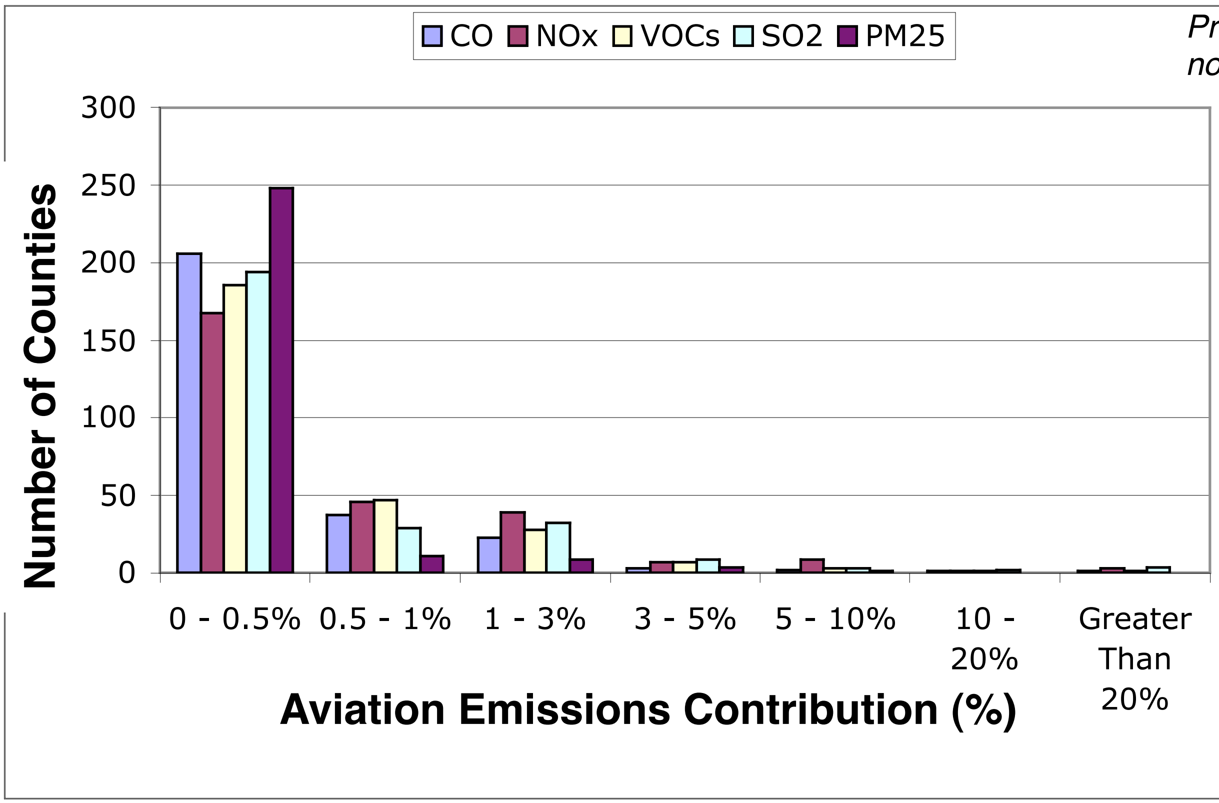
- After the EPACT study, we ran the same inventory but with FOA3
- Note, the EPACT study also had a 20% error (low) in SOx emissions
  - The impact on health estimates is roughly equal in magnitude (and opposite) to the difference between the two primary PM methods (because of the importance of secondary aerosols)



Preliminary results, do not cite or quote

Contribution of aircraft LTO emissions to county inventories

Aircraft emissions (June 2005 –May 2006)	CO	NO_x	VOCs	SO_x	$PM_{2.5}$
As a percentage of 2001 U.S. national emissions inventory	0.17%	0.40%	0.23%	0.06%	0.03%
Average of percentage of 2001 U.S. inventories in counties with commercial service airports	0.43%	1.14%	0.58%	0.26%	0.16%
Average of percentage of 2001 U.S. inventories in Metropolitan Statistical Areas	0.43%	1.16%	0.58%	0.26%	0.17%



Preliminary results, do not cite or quote

Contribution to inventories (aircraft emissions below 3000 ft AGL)

National average, and 10 metropolitan statistical areas with the highest contribution of aircraft emissions to total inventory

Metropolitan Statistical Area	%CO	%NO_x	%VOC	%SO_x	%$PM_{2.5}$
Washington, DC-MD-VA-WV	3.8%	17.1%	6.2%	22.5%	2.5%
Philadelphia, PA-NJ	3.0%	5.3%	4.8%	0.6%	1.9%
New York, NY	1.7%	6.7%	2.1%	2.0%	1.9%
Newark, NJ	1.3%	5.9%	1.8%	2.9%	1.4%
Memphis, TN-AR-MS	1.1%	3.3%	2.5%	0.5%	1.1%
Denver, CO	1.0%	4.5%	2.3%	3.5%	0.9%
San Francisco, CA	1.4%	9.1%	1.9%	36.0%	0.9%
Fort Worth-Arlington, TX	1.1%	5.4%	1.4%	16.0%	0.8%
Minneapolis-St. Paul, MN-WI	0.5%	2.3%	0.9%	0.8%	0.8%
Chicago, IL	0.6%	2.8%	0.7%	0.8%	0.7%
National Average	0.4%	1.2%	0.6%	0.3%	0.2%

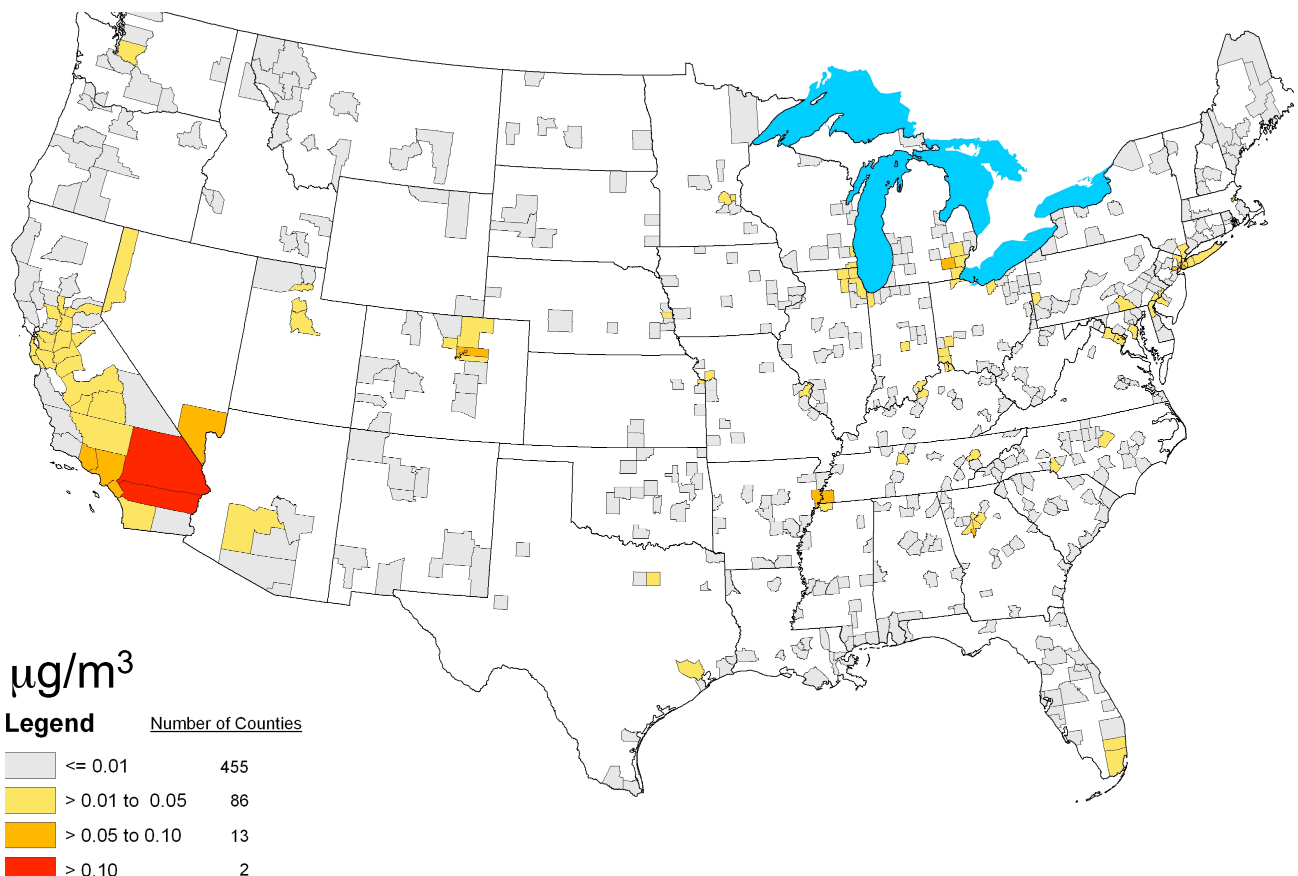
Preliminary results, do not cite or quote

Relationship between emissions and ambient pollution levels

- EPA completed detailed air quality modeling of the U.S. with and without commercial aviation using CMAQ
  - Quantified impacts of emissions from aviation activities on local air quality in the U.S.
  - Used 2005 EDMS emissions for aviation
  - Used 2001 baseline emissions from EPA National Emissions Inventory
  - CMAQ peer-reviewed by EPA in 2003; version 4.5 used for EPAct study
  - MM5 weather model
  - GEOS-CHEM global atmospheric chemistry model
  - 36 km grid, hourly simulation

Aircraft contributions to ambient PM concentrations

	With aircraft emissions (µg/m^3)	With aircraft emissions removed (µg/m^3)	Percent Change
Non-Attainment Areas	17.76	17.75	-0.06%
All Counties	12.60	12.59	-0.08%



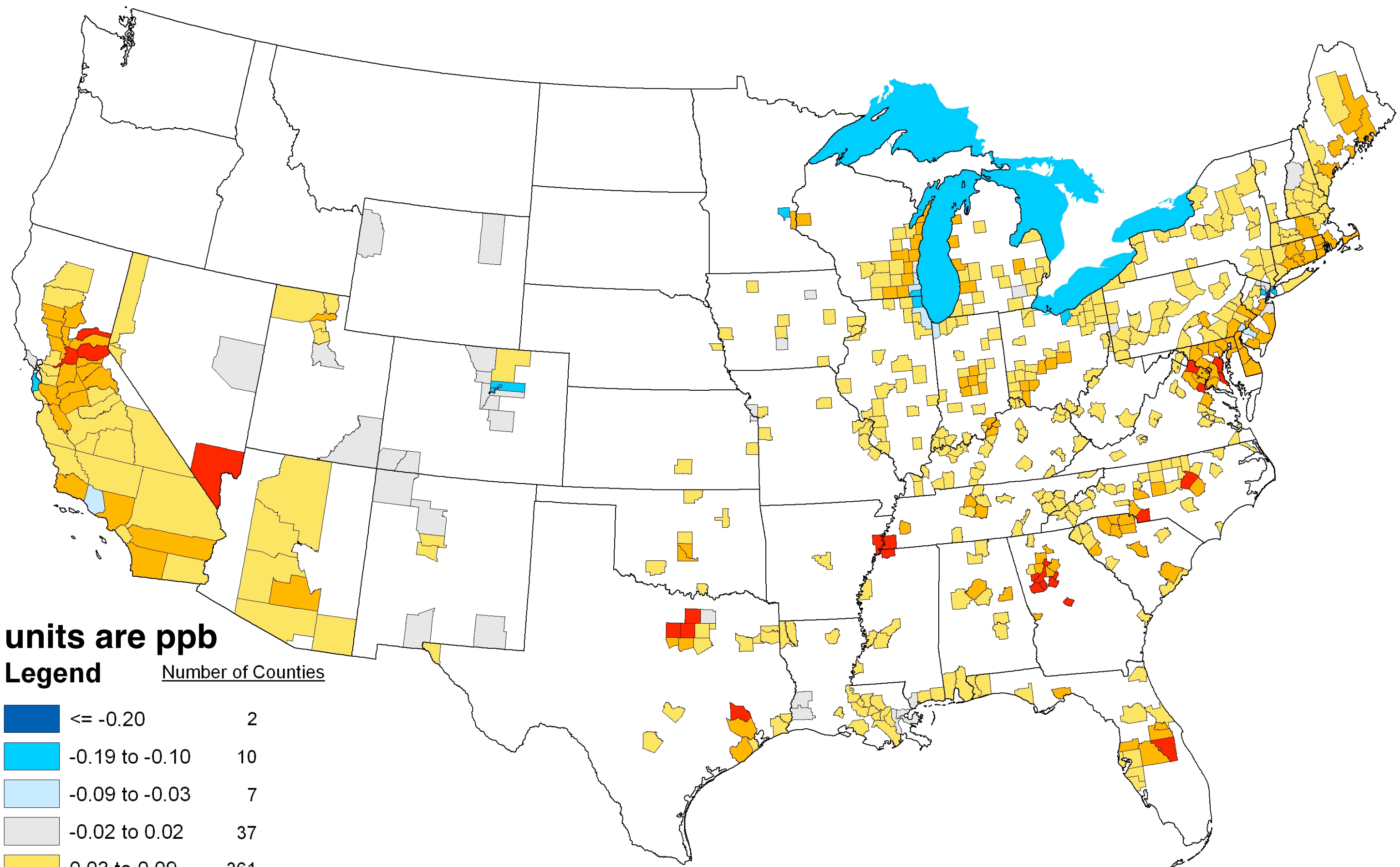
- Aircraft contribution to PM concentration 0.06% on average
- Ranged from 0% to 0.5% by county
- National ambient air quality standard is 15 µg/m^3
- Strong regional differences in impacts

Preliminary results, do not cite or quote

Change in CMAQ estimated daily max 8h ozone (due to addition of commercial aircraft)

Aircraft contribution 0.12% on average

-0.3% to 0.6% by county



units are ppb

Legend

	Number of Counties
<= -0.20	2
-0.19 to -0.10	10
-0.09 to -0.03	7
-0.02 to 0.02	37
0.03 to 0.09	361
0.10 to 0.19	129
>= 0.20	25

benefits ↑ ↓ detriments

Preliminary results, do not cite or quote

$PM_{2.5}$ premature mortality, 2001 continental US population

CRF Author	Point Est.	90% C.I.	PWD
Pope et al. 2002 (Adults age 30 and over)	**160**	64, 270	0.014

•Estimate is very likely **less than 0.6% of total yearly incidences due to poor air quality in the U.S.**

•2,300,000 baseline (all causes) premature deaths in year 2000 for adults age 30 and over in US

• Implementation of EPA's Tier 2 rule (regulation of gasoline sulfur and passenger car/truck engine standards), Heavy Duty Diesel Rule, and Nonroad Diesel Rule estimated to prevent a combined 25,000 yearly premature deaths by 2020-2030

• Powerplant emissions estimated to be responsible for 24,000 yearly premature deaths (Hill, 2005)

$PM_{2.5}$ premature mortality, 2001 population: regional distribution

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10 counties with the highest PM mortality impacts

Rank	County	State	Incidences	Percent of Total
1	Los Angeles	CA	28	18
2	Orange	CA	8	5
3	San Diego	CA	6	3
4	San Bernardino	CA	5	3
5	Cook	IL	5	3
6	Riverside	CA	4	3
7	Nassau	NY	4	3
8	Alameda	CA	4	2
9	Queens	NY	3	2
10	Kings	NY	3	2
	All other counties		94	57

Note CARB (2004) estimate of 6500 premature deaths per year in California due to poor air quality

Preliminary results, do not cite or quote

Ozone premature mortality, 2001 continental US population

CRF Author	Point Est.	90% C.I.	PWD
Bell et al. 2004	-0.4	-0.2, -0.6	-0.0013
Bell et al. 2005	-1.6	-0.9, -2.3	-0.0013
Ito et al. 2005	-1.8	-1.2, -2.4	-0.0013
Levy et al. 2005	-4.8	-3.5, -6.0	-0.0059
No causality	0	0, 0	0

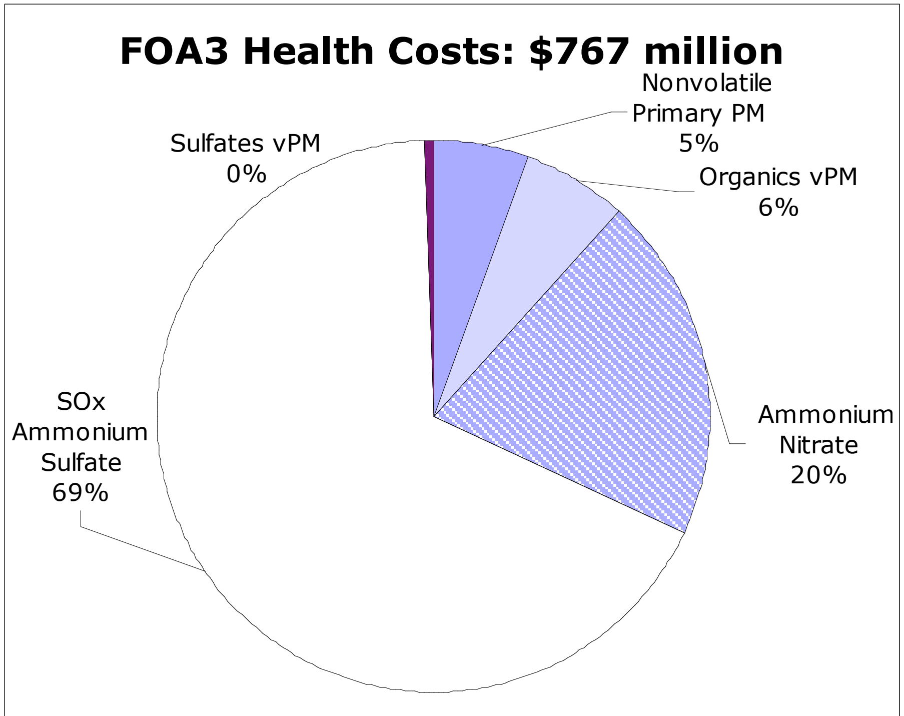
CRF: Concentration-Response Function

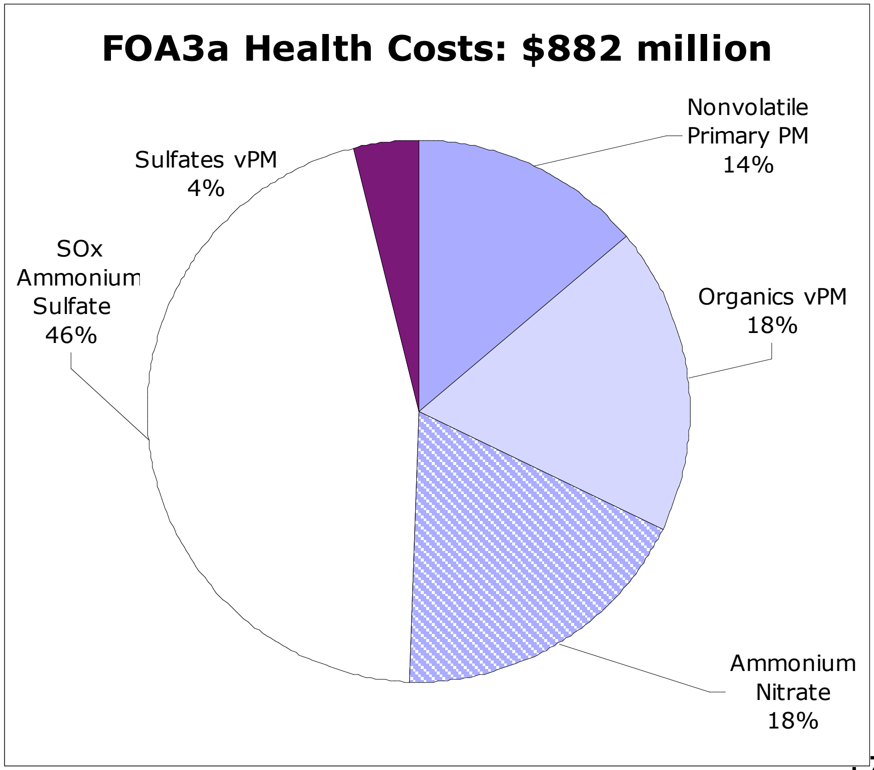
C.I: Confidence Interval

PWD: Population-Weighted Delta

Health costs and apportionment

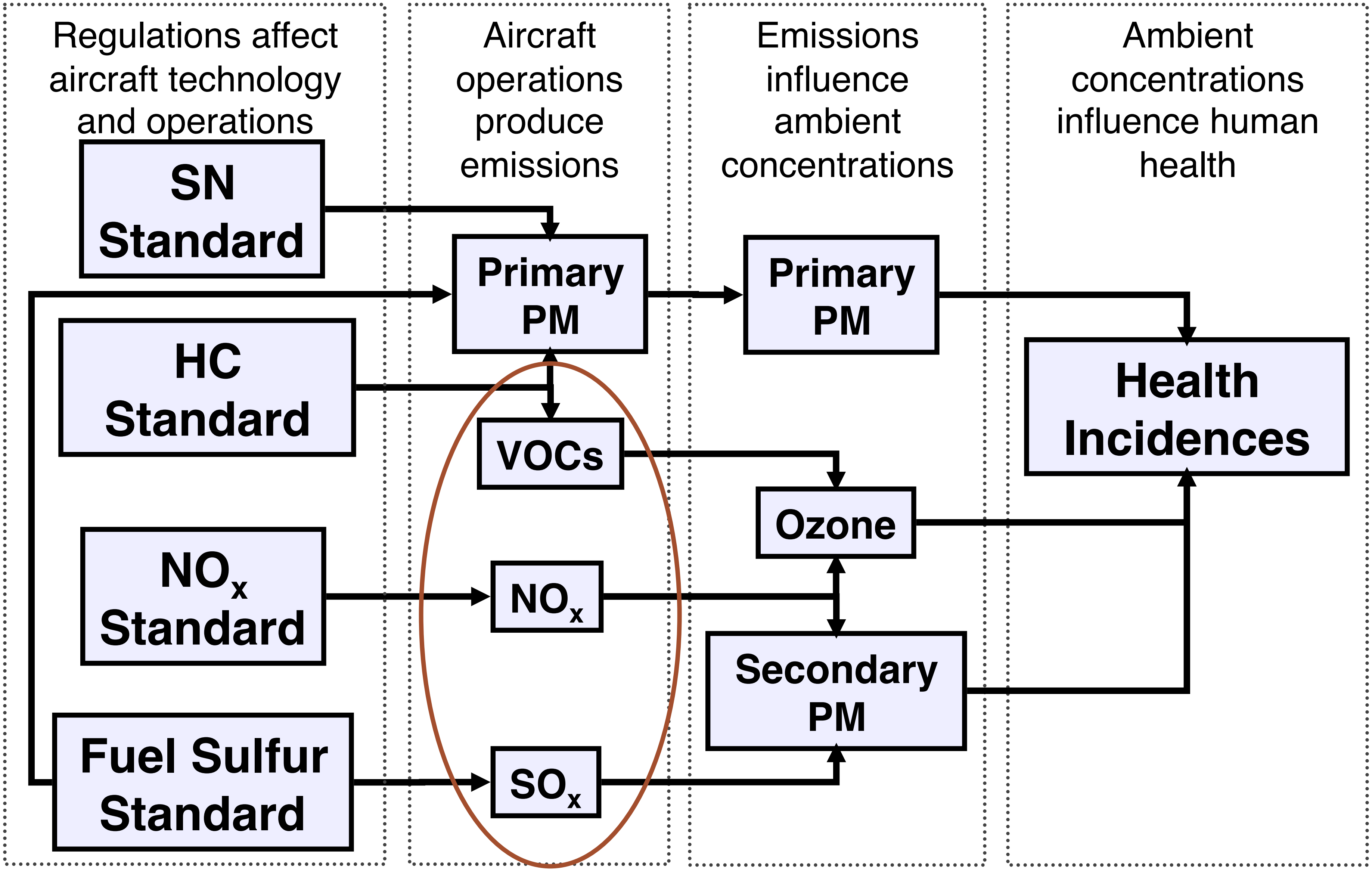
- Not part of EPACT study; estimated by Sequeira (MIT masters thesis)
- Yearly health costs from aviation in the USA: ~ $1 billion, with 93% from premature mortality of adults age 30 and over due to PM exposure
  - Approximately 140 – 160 yearly incidences





Preliminary results, do not cite or quote

Analysis underscores importance of secondary aerosol precursors



Uncertainties

- Modeling resolution (36km) may underestimate near-airport effects by factor of ~2 (largely an issue for primary PM not secondary PM which dominate the health impacts)
- Not including emissions above 3000 ft AGL may underestimate impacts by factor of ~2-10 (Barrett et al., forthcoming)
- Not certain of fuel sulfur content (or regional distribution thereof) -- assumed 600ppm most places (400ppm in some places due to error)
- Uncertainties regarding primary PM emissions
- Contributions of non-aircraft sources
- Impacts of meteorology (e.g. relative to year 2005 met data)
- Baseline health impacts concentration response function (Pope et al., 2002) does not reflect full range of estimates in the literature
- Apportionment of water and ammonia to CMAQ dry ion estimates (in Sequeira analysis)

Summary

- EPAct study provides an assessment of local air quality impacts of commercial aviation emissions below 3000 ft AGL in the U.S.
  - Quantifies aircraft emissions inventory and related health impacts
  - Quantifies effects of several airport congestion and ATM initiatives (not discussed in this presentation)
- EPAct study has identified opportunities for further study
- Report has not yet been finalized

Questions?