Modeling Aviation Emissions on a Local and Global Scale

ICAO Colloquium on Aviation Emissions

Gregg G. Fleming
U.S. DOT/Volpe Center

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Outline

• Contributing organizations and models used
• Modeling methodology
• ICAO/CAEP environmental goals
  - Introduction
  - Observations
  - Example trends
• Summary
Contributing Organizations and their Models

- **AEDT/SAGE (US/FAA)**
  
  [www.faa.gov/about/office_org/headquarters_offices/aep/models/sage/](http://www.faa.gov/about/office_org/headquarters_offices/aep/models/sage/)

- **AEM (EUROCONTROL)**
  

- **AERO2k (UK/QinetiQ)**
  
  [www.cate.mmu.ac.uk/aero2k.asp](http://www.cate.mmu.ac.uk/aero2k.asp)

- **FAST (UK/MMU)**
  
  [www.cate.mmu.ac.uk/documents/projects/mmuallocationsreport2currentdayv1_5.pdf](http://www.cate.mmu.ac.uk/documents/projects/mmuallocationsreport2currentdayv1_5.pdf)
Basic Modeling Principle

Models used for computing local (LAQ) and global (GHG) inventories of aviation emissions and fuel usage.
OUTPUT DATA/RESULTS

Aggregate (Queried) Results:

Results by region, country and/or mode

Regions/countries are defined by the airports within an area

Africa  Asia  Australia and Oceania  Eastern Europe  Middle East  North America & Caribbean  South America  Western Europe & North Atlantic

Within region
Region to other (bunker)

Ground ( =0 ft) >0 ft and <=3000 ft (above field elevation) (LAQ) >3000 ft (GHG) Total

Distance
Fuel Burn
CO
HC
NOx
CO$_2$
H$_2$O
SOx

Fuel Burn (Kg/Year/1 Degree Latitude by 1 Degree Longitude)

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Historical Emissions Inventories

- Fuel Burn (Tg)
- NOx (Tg)
- Fuel Used (Tg)
- NOx Emissions (Tg)

Legend:
- NASA
- DLR
- ANCAT
- AERO2K
- Military
- FESG

- SAGE Version 1.5
- NASA/Boeing Scheduled
- NASA/Boeing Civil
- NASA/Boeing Global
- ANCAT/EC2 Civil
- ANCAT/EC2 Global
- DLR Civil
  - DLR Global
  - AERO-MS
CAEP Environmental Goals

- SG20041-WP/11 presented a recommendation from Appendix A of A35 to report on three environmental goals:
  - limit or reduce the number of people impacted by noise;
  - limit or reduce the impact of aviation emissions on local air quality (LAQ); and
  - limit or reduce the impact of aviation greenhouse gas (GHG) emissions on the global climate.

- There is no accepted metric or modelling system for reporting impact of LAQ and GHG emissions
- Model evaluations currently ongoing
CAEP Environmental Goals

- Use existing GHG models, offered under the model evaluation process by CAEP Member States, to provide initial emissions trends for GHG and LAQ emissions:
  
  - AEDT/SAGE (US/FAA)
  - AEM (EUROCONTROL)
  - AERO2k (UK/QinetiQ)
  - FAST (UK/MMU)
CAEP Environmental Goals (3)

- Assumptions for initial emissions trends:
  - 2002 CAEP forecast
  - No projections of future aircraft technologies
  - No projections of communication navigation surveillance, air traffic management technologies
  - No operational improvements, e.g., continuous descent arrivals (CDA), single engine taxi, etc.

As such, the assessment overestimates future emissions trends as it does not take into account improvements in either aircraft technology or air traffic operations which can be expected.
GHG Observations

- **CO₂ emissions:**
  - 500 million tons in 2002
  - substantially lower than in 2000 (9/11, SARS and economy)
  - since 2002, market recovery resulted in an up to 13% increase by 2005
  - 2025 levels approximately 2.25 times higher than 2005 levels

- **NOₓ emissions:**
  - 2.25 million tons in 2002
  - larger percentage increase in NOₓ emissions Vs CO₂
  - 2025 levels approximately 2.75 times higher than 2005 levels
  - migration of the fleet to higher NOx emissions per unit fuel burn (old Vs new technology)
LAQ Observations

- **NO\textsubscript{x} emissions:**
  - between 7 and 12\% of the total annual NO\textsubscript{x} emissions from aircraft
  - for 2005 to 2025, slightly smaller increases, compared with the increases in total NO\textsubscript{x}
  - fleet mix and/or stage length dependent

- **CO/HC emissions:**
  - large variation between models
  - larger proportion of total flight CO and HC is emitted below 3000 ft
  - levels remain low relative to air quality concerns
  - for 2005 to 2025, increases less than the increase in traffic and fuel
  - engines have lower CO and HC per unit thrust
Trends in Global Fuel Burn

Fuel Burn (Tg) (Tg = Teragrams or 10^12 grams)

Year

AEDT / SAGE *
AEM
AERO2K
FAST
ALL

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Trends in Global NOx (LAQ)

- Trend lines for different emissions models:
  - AEDT / SAGE *
  - AEM
  - AERO2K
  - FAST
  - ALL

- Units: NOx (Tg) or Teragrams (10^12 grams)

- Years: 2000 - 2025

- Key points:
  - Increase in NOx emissions from 2000 to 2025
  - Variations among different models
Trends in Global NOx (GHG)

NOx (Tg)

(Tg = Teragrams or 10^12 grams)

Year


AEDT / SAGE *
AEM
AERO2K
FAST
ALL
Summary

• Four GHG models are currently under evaluation by CAEP
• Generally use consistent methodologies
• Used to compute LAQ and GHG trends for CAEP/7
• Plan to refine process for CAEP/8:
  - Aircraft technology
  - CNS/ATM technology
  - Operational improvements, e.g., CDA, single-engine taxi, etc.
Questions