



Modeling Aviation Emissions on a Local and Global Scale

ICAO Colloquium on
Aviation Emissions

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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)**

http://www.faa.gov/about/office_org/headquarters_offices/aep/models/sage/

- **AEM (EUROCONTROL)**

http://www.eurocontrol.int/eec/public/standard_page/SEE_2004_report_15.html

- **AERO2k (UK/QinetiQ)**

<http://www.cate.mmu.ac.uk/aero2k.asp>

- **FAST (UK/MMU)**

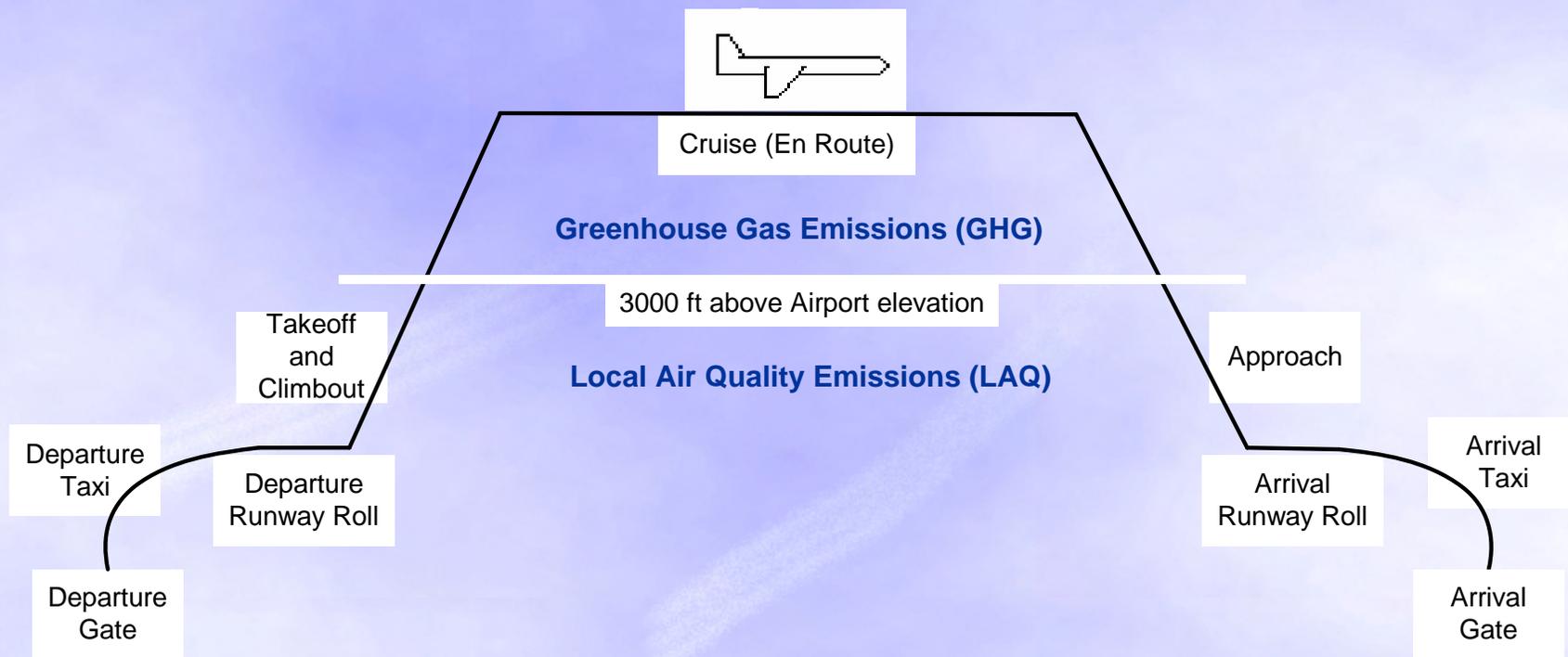
http://www.cate.mmu.ac.uk/documents/projects/mmuallocationsreport2currentdayv1_5.pdf



Basic Modeling Principle



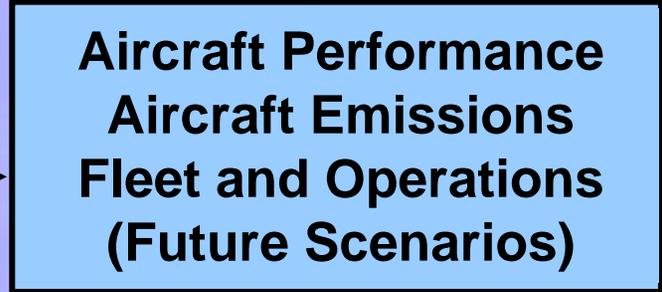
Models used for computing local (LAQ) and global (GHG) inventories of aviation emissions and fuel usage.



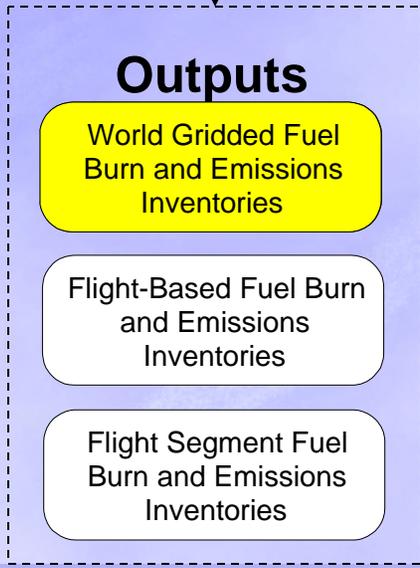
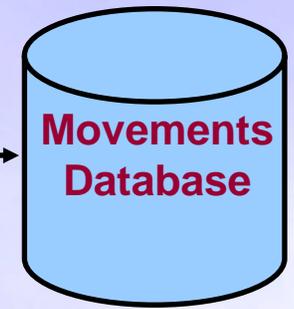


Aircraft/engine model and registration information

Relevant airport information, e.g., lat, lon, rwy, country, etc.

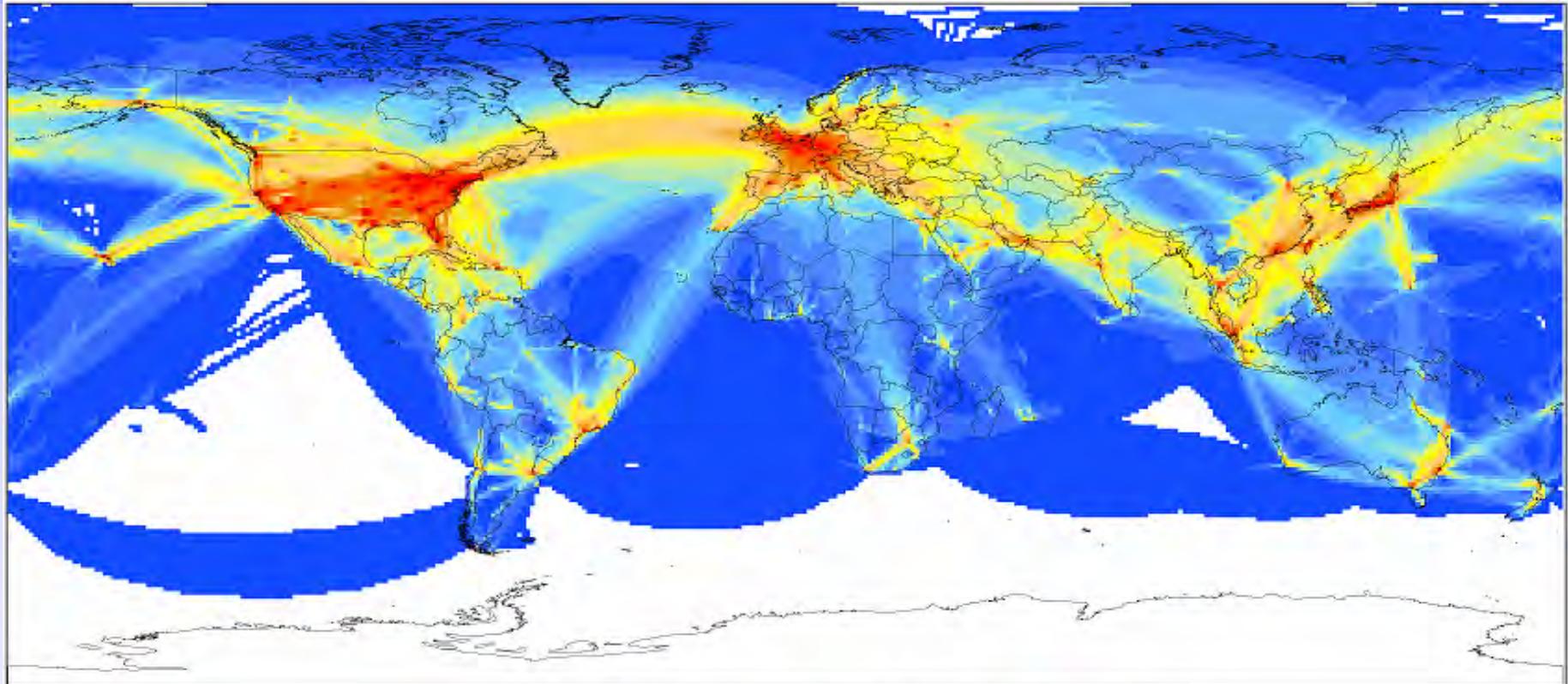


Operations and trajectory information





OUTPUT DATA/RESULTS

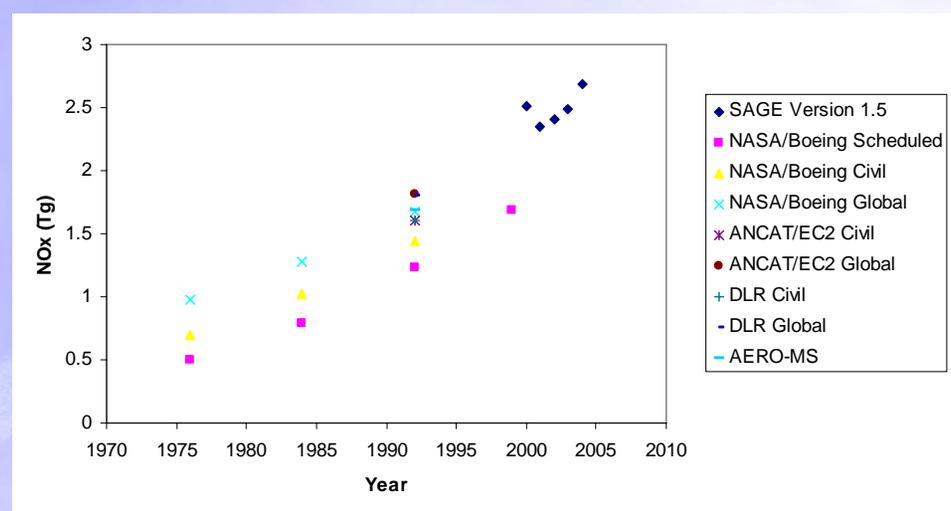
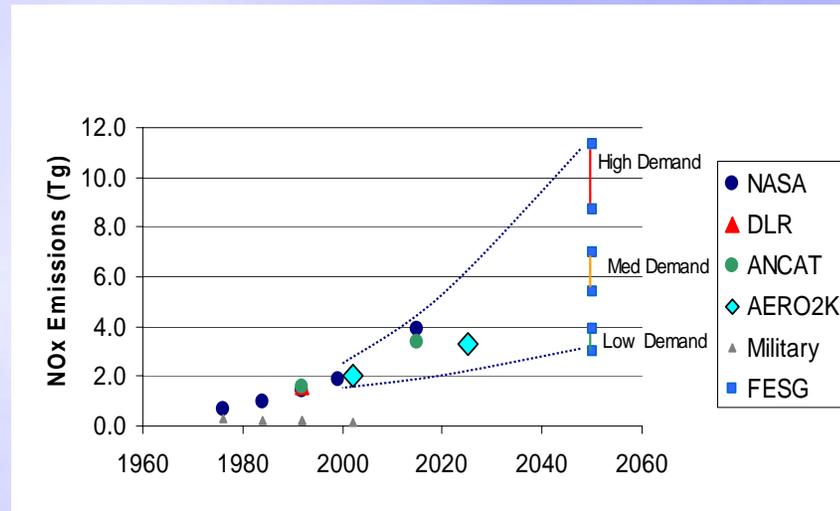
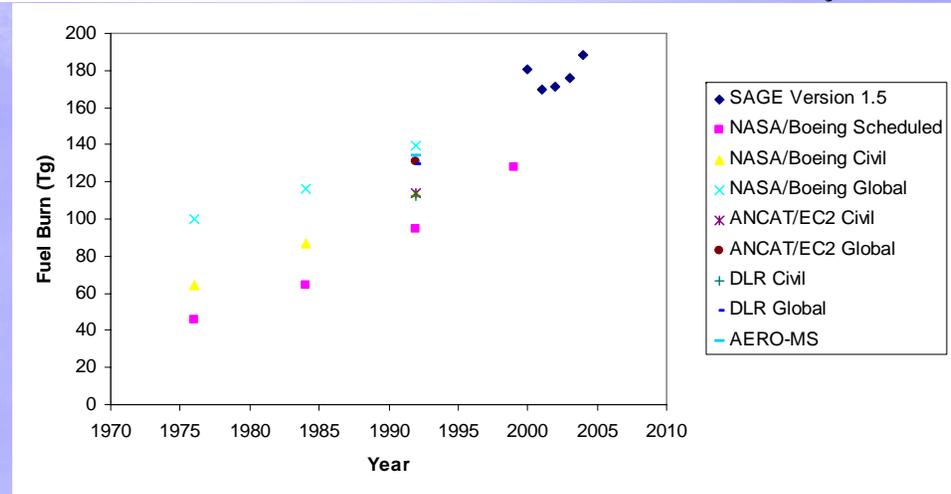
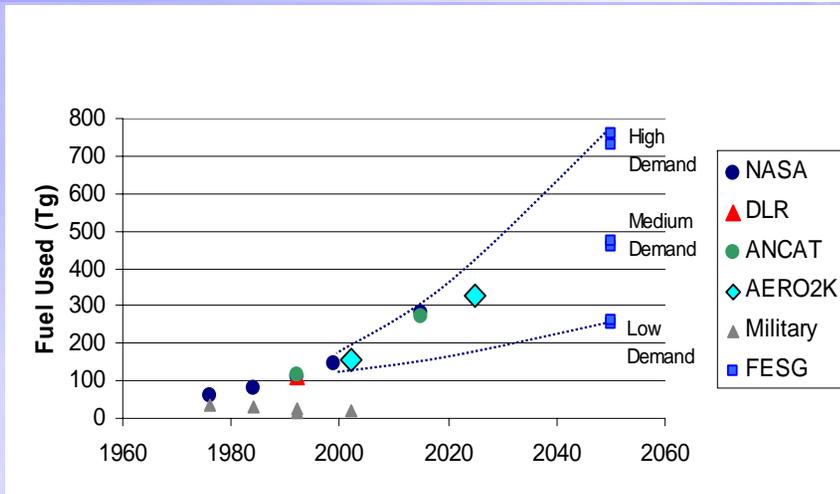


Fuel Burn (Kg/Year/1 Degree Latitude by 1 Degree Longitude)

0.00e+000 - 3.01e+005	5.81e+006 - 7.22e+006	2.49e+007 - 3.01e+007	9.49e+007 - 1.14e+008
3.02e+005 - 7.66e+005	7.23e+006 - 8.79e+006	3.02e+007 - 3.59e+007	1.15e+008 - 1.38e+008
7.67e+005 - 1.31e+006	8.80e+006 - 1.05e+007	3.60e+007 - 4.20e+007	1.39e+008 - 1.69e+008
1.32e+006 - 1.93e+006	1.06e+007 - 1.24e+007	4.21e+007 - 4.89e+007	1.70e+008 - 2.23e+008
1.94e+006 - 2.65e+006	1.25e+007 - 1.48e+007	4.90e+007 - 5.64e+007	2.24e+008 - 2.86e+008
2.66e+006 - 3.51e+006	1.49e+007 - 1.75e+007	5.65e+007 - 6.60e+007	2.87e+008 - 4.02e+008
3.52e+006 - 4.54e+006	1.76e+007 - 2.07e+007	6.61e+007 - 7.88e+007	4.03e+008 - 5.95e+008
4.55e+006 - 5.80e+006	2.08e+007 - 2.48e+007	7.89e+007 - 9.48e+007	5.96e+008 - 1.09e+009



Historical Emissions Inventories





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



LAQ Observations



- **NO_x emissions:**

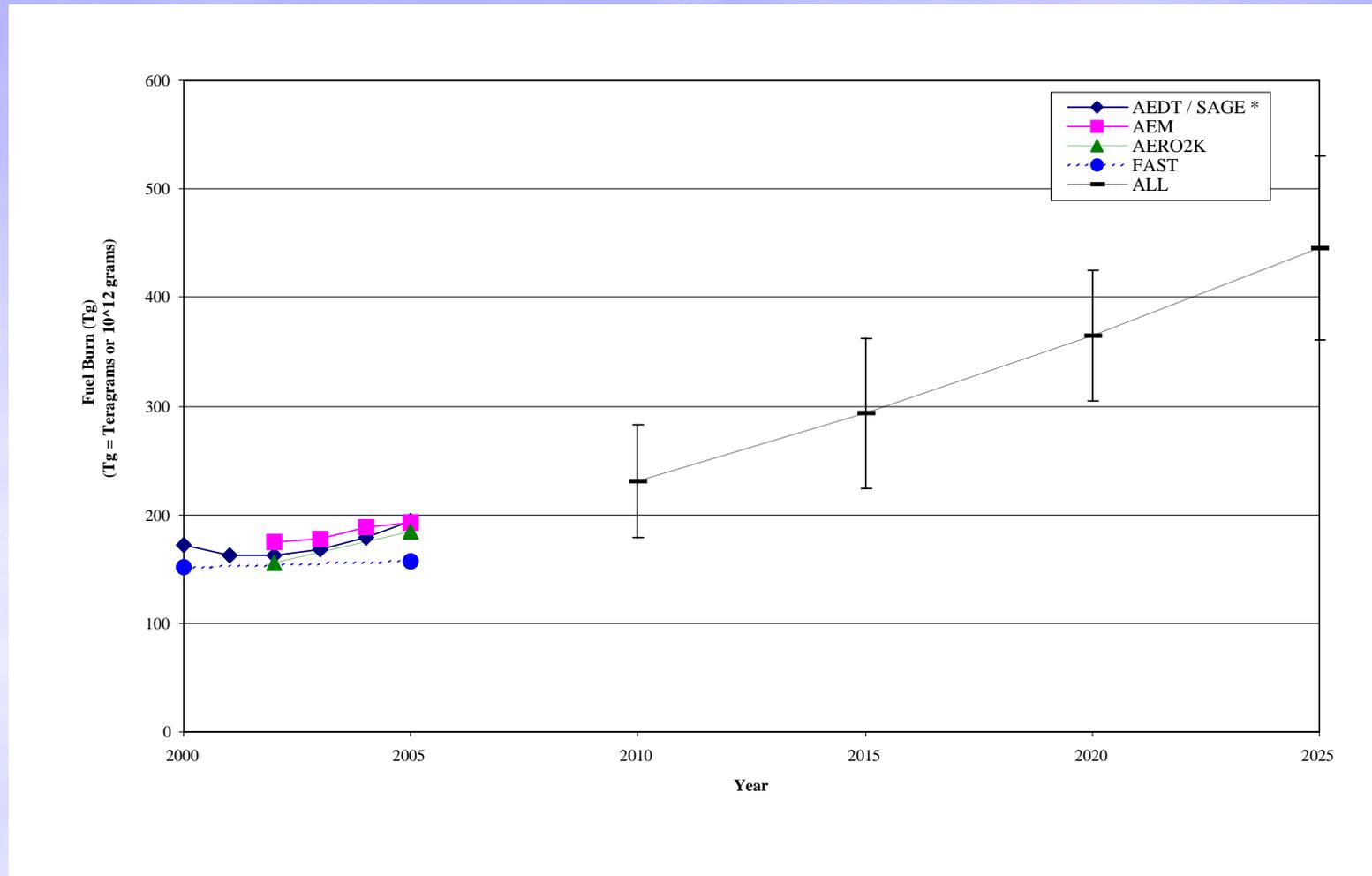
- between 7 and 12% of the total annual NO_x emissions from aircraft
- for 2005 to 2025, slightly smaller increases, compared with the increases in total NO_x
- fleet mix and/or stage length dependent

- **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

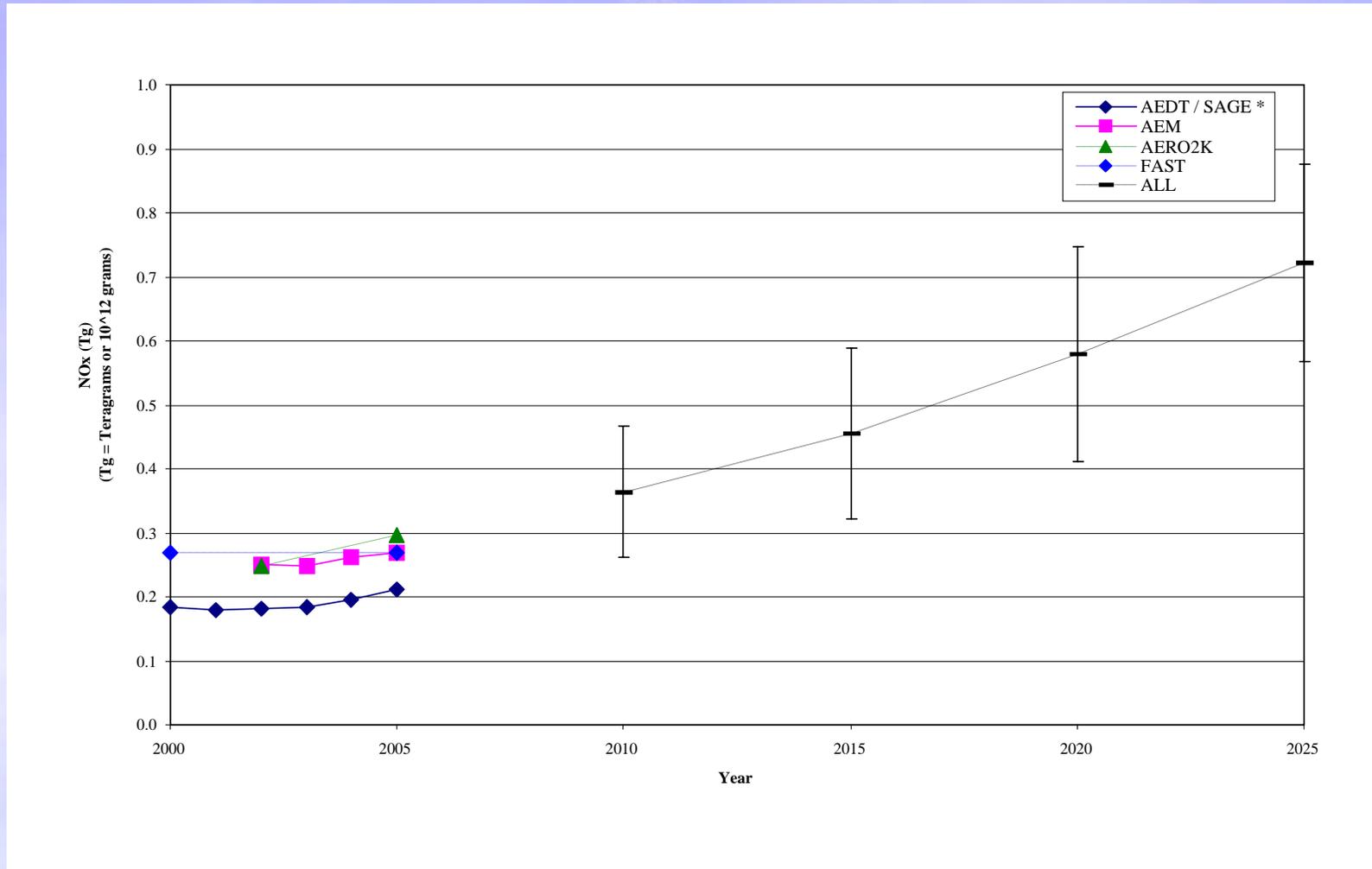


Trends in Global Fuel Burn



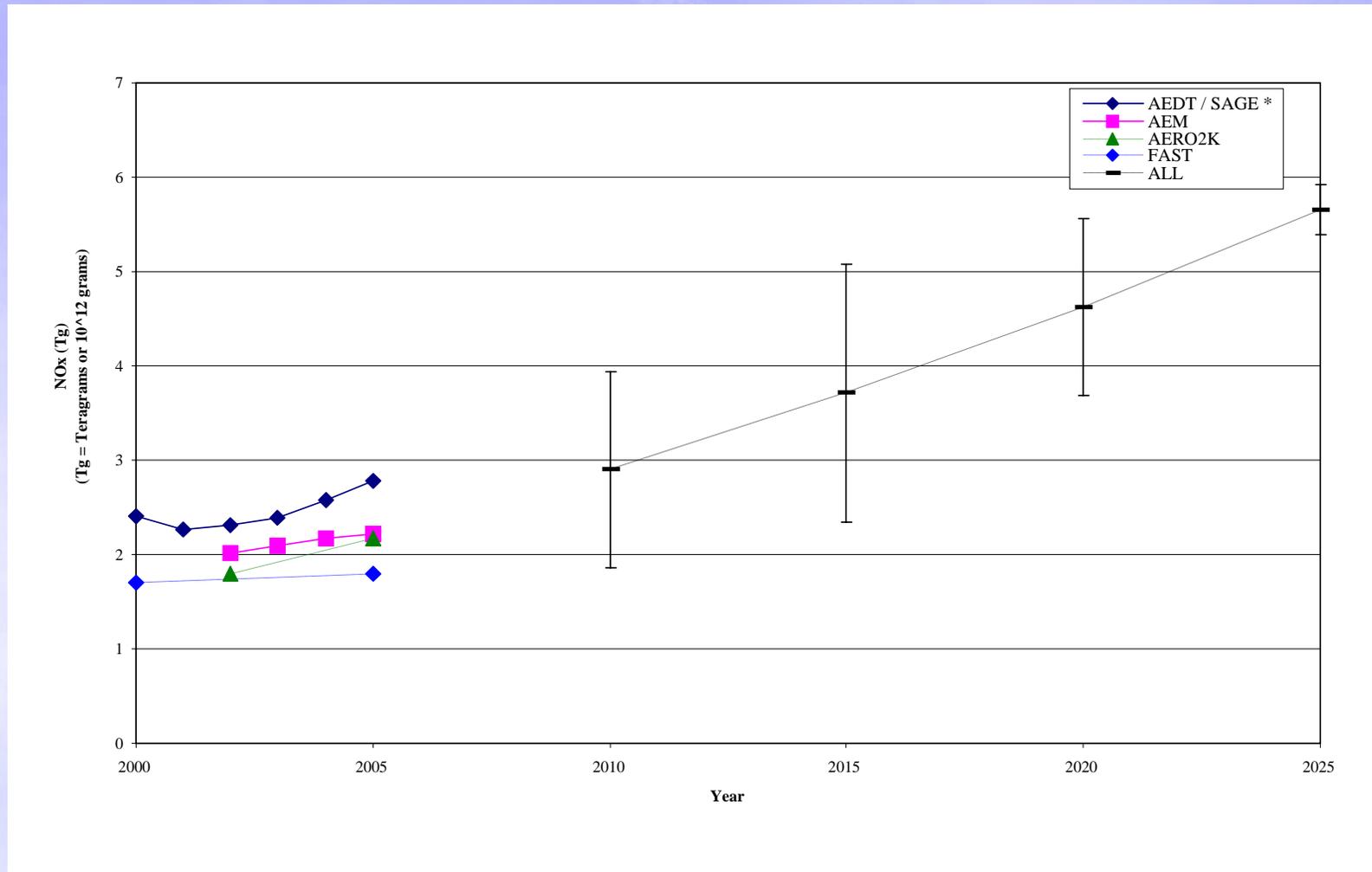


Trends in Global NO_x (LAQ)





Trends in Global NO_x (GHG)





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 ???