FAA/AEE's
Aviation Environmental Design Tool (AEDT)
System for assessing Aviation's Global Emissions (SAGE)

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Research and Innovative Technology Administration

Technical workshop on emission from
aviation and maritime transport
4-5 October 2007

OUTLINE

- Motivation and history of SAGE
- AEDT/SAGE
  - Introduction/Overview
  - Output Data
  - Documentation
  - Results
- Questions

MOTIVATION FOR SAGE

Ability to model global GHG emissions

- International Civil Aviation Organization's Committee on Aviation and Environmental Protection
- United Nations Framework Convention on Climate Change
- U.S. Next Generation Air Transportation System (NextGen)

SAGE Development History

- 2001: Project Initiated
- 2002: Version 1 delivered
- 2003: Version 1.1 & 2000-2003 global inventories delivered
- 2004: SBSTA-20 comparison of UNFCCC aviation inventory data with SAGE-modelled data
- 2005: Version 1.5 & 2000-2004 global inventories delivered
- 2006: IPCC guidelines for national GHG inventories, aviation Tier 3B methodology

Transition to AEDT/SAGE…

MOTIVATION FOR AEDT (1)

- Substantial progress achieved in reducing environmental impacts of aviation
- <u>However</u> – despite interrelationships between noise and emissions and amongst emission pollutants, these environmental impacts are addressed in "stove pipes"

INTRODUCTION TO AEDT/SAGE

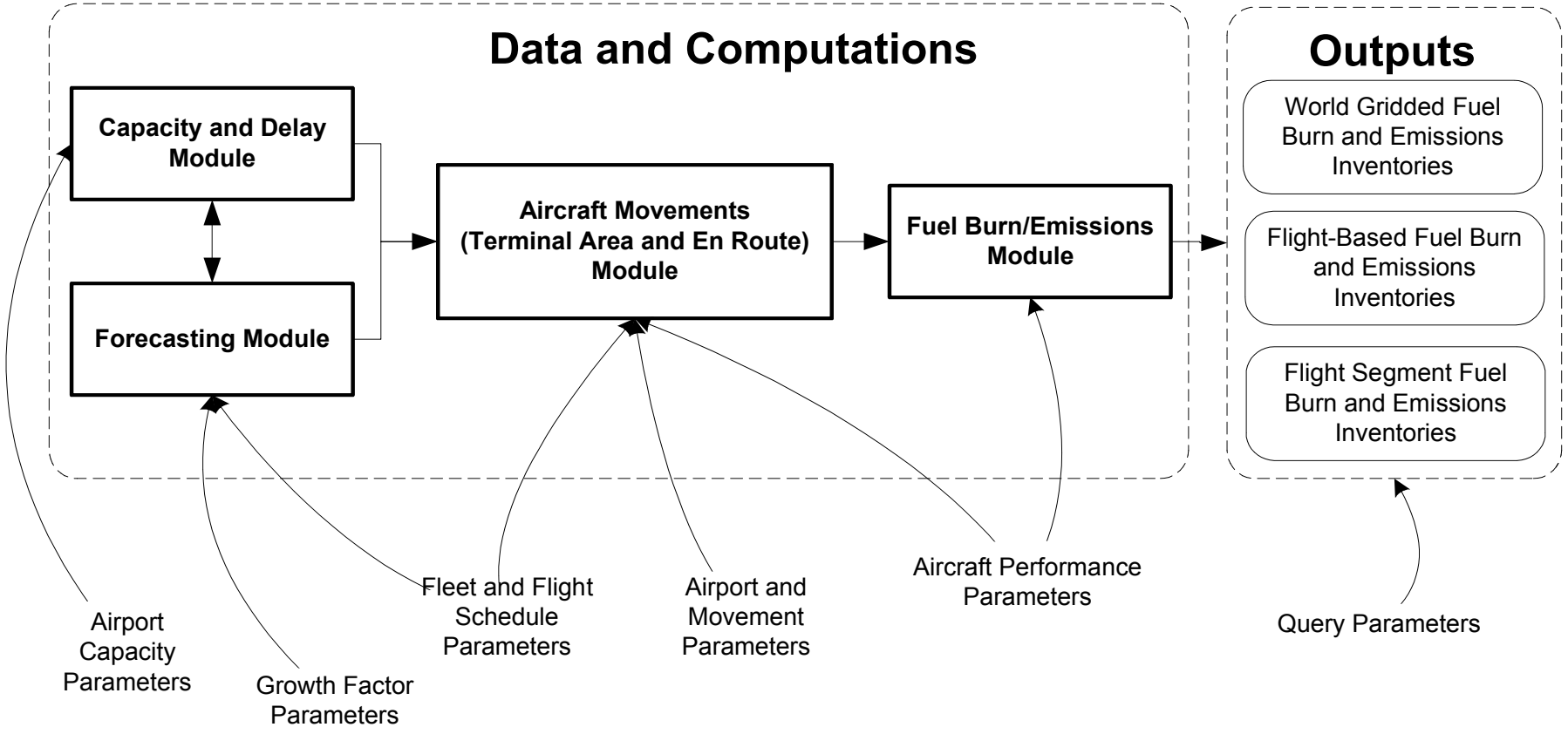
AEDT/SAGE

- estimates aircraft fuel burn and emissions
- for *variable-year* emissions inventories and
- for operational, policy, and technology-related scenarios.

- **Analysis Scale**
  - Single flight
  - Aircraft
  - Engine
  - Airport
  - Country/ Region
  - Global Totals
- **Gridded**
  - latitude
  - longitude
  - altitude
  - time
- **Pollutants**
  - carbon monoxide (CO)
  - hydrocarbons (HC)
  - nitrogen oxides (NOx)
  - carbon dioxide (CO2)
  - water (H2O)
  - sulfur oxides
  - (SOx modeled as SO2)
  - particulate matter (PM)

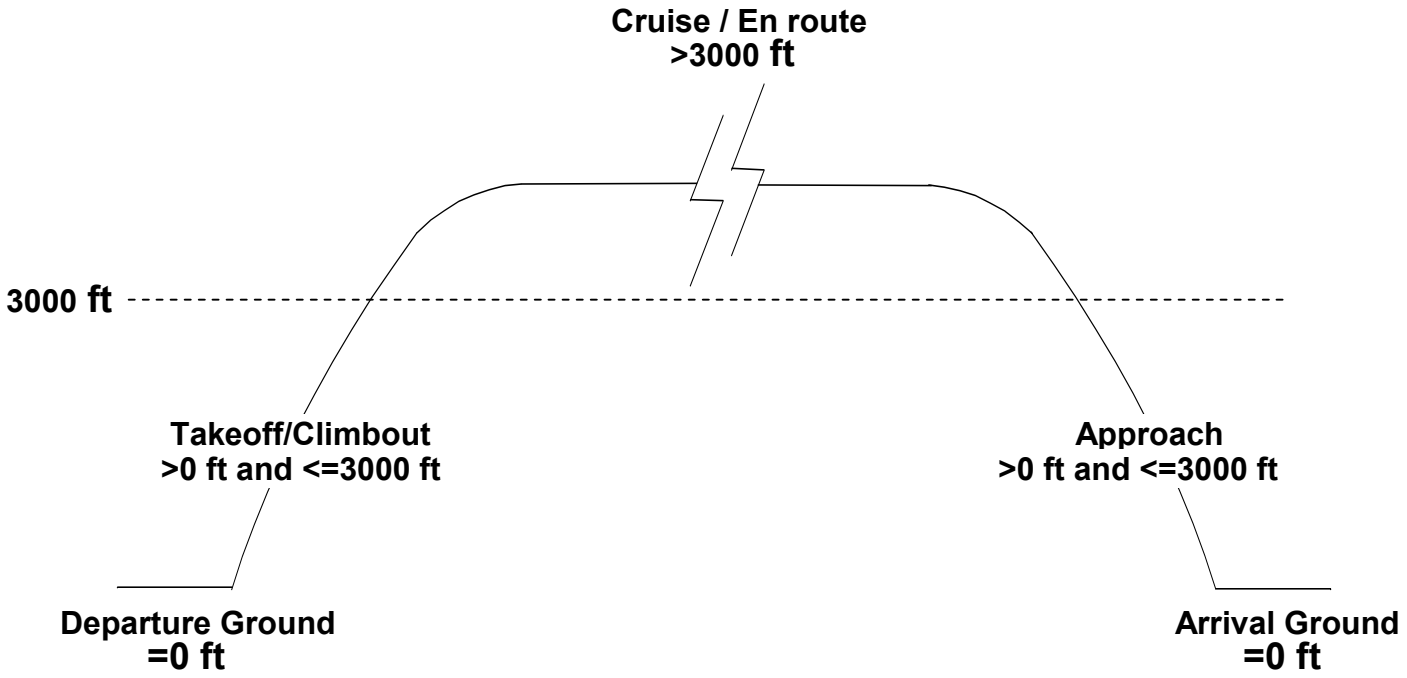
AEDT/SAGE OVERVIEW (1)

- **Model *Structure***



AEDT/SAGE OVERVIEW (3)

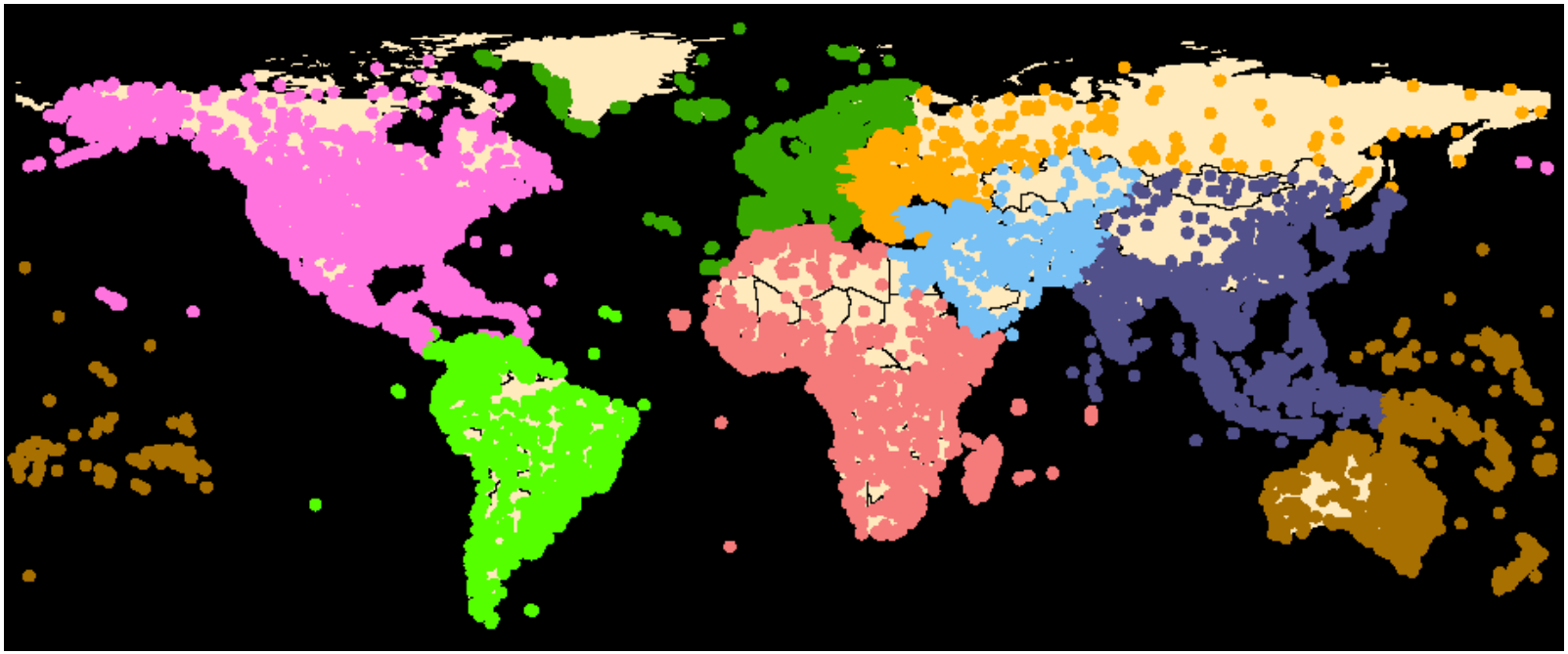
- **Flight regime and modes**



AEDT/SAGE OUTPUT DATA (1)

Country and Region definitions are based on airport locations

- Within region and bunker



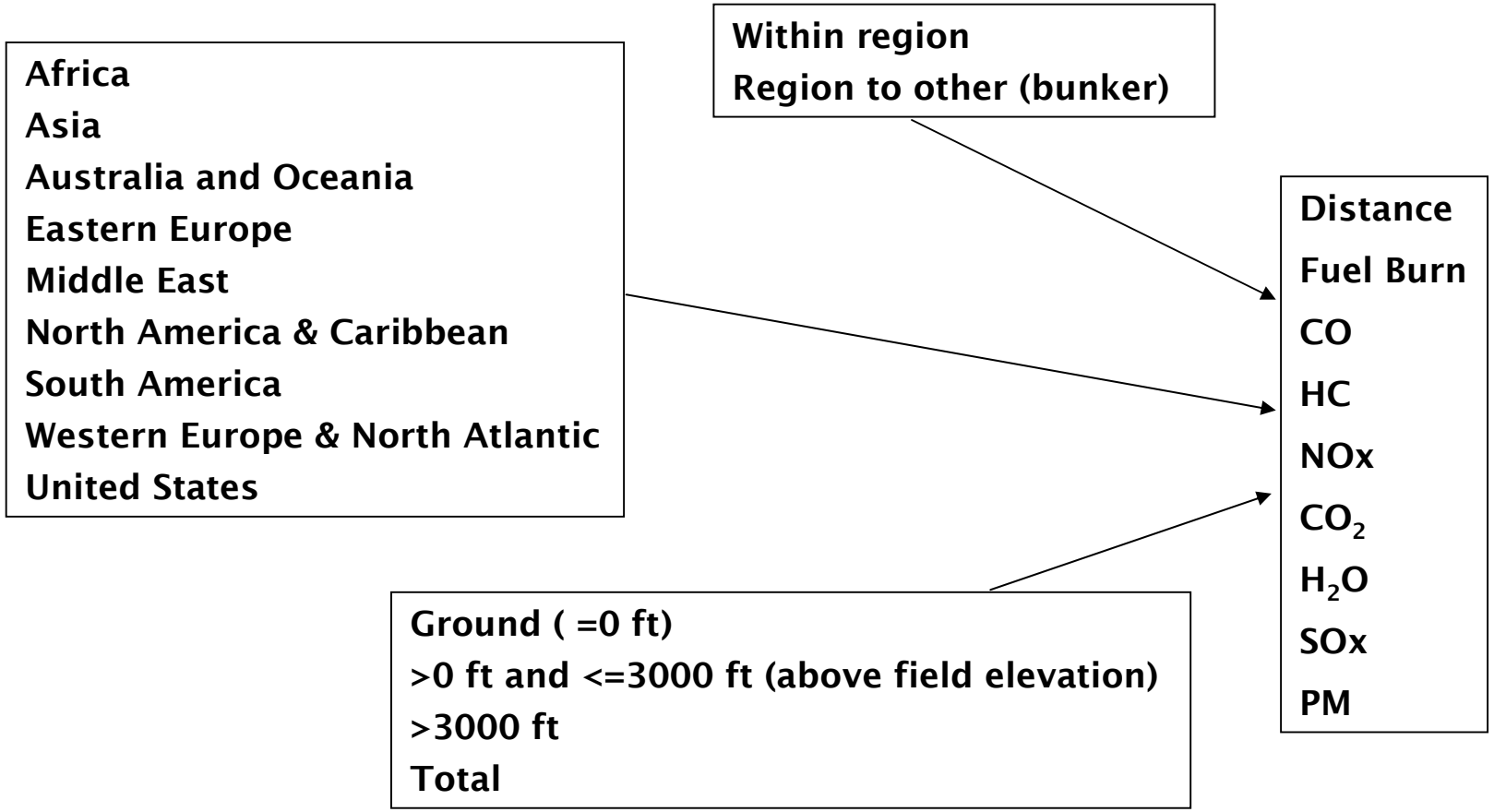
(1) Africa, (2) Asia, (3) Australia and Oceania, (4) Eastern Europe, (5) Middle East, (6) North America & Caribbean, (7) South America, and (8) Western Europe & North Atlantic.

AEDT/SAGE OUTPUT DATA (2)

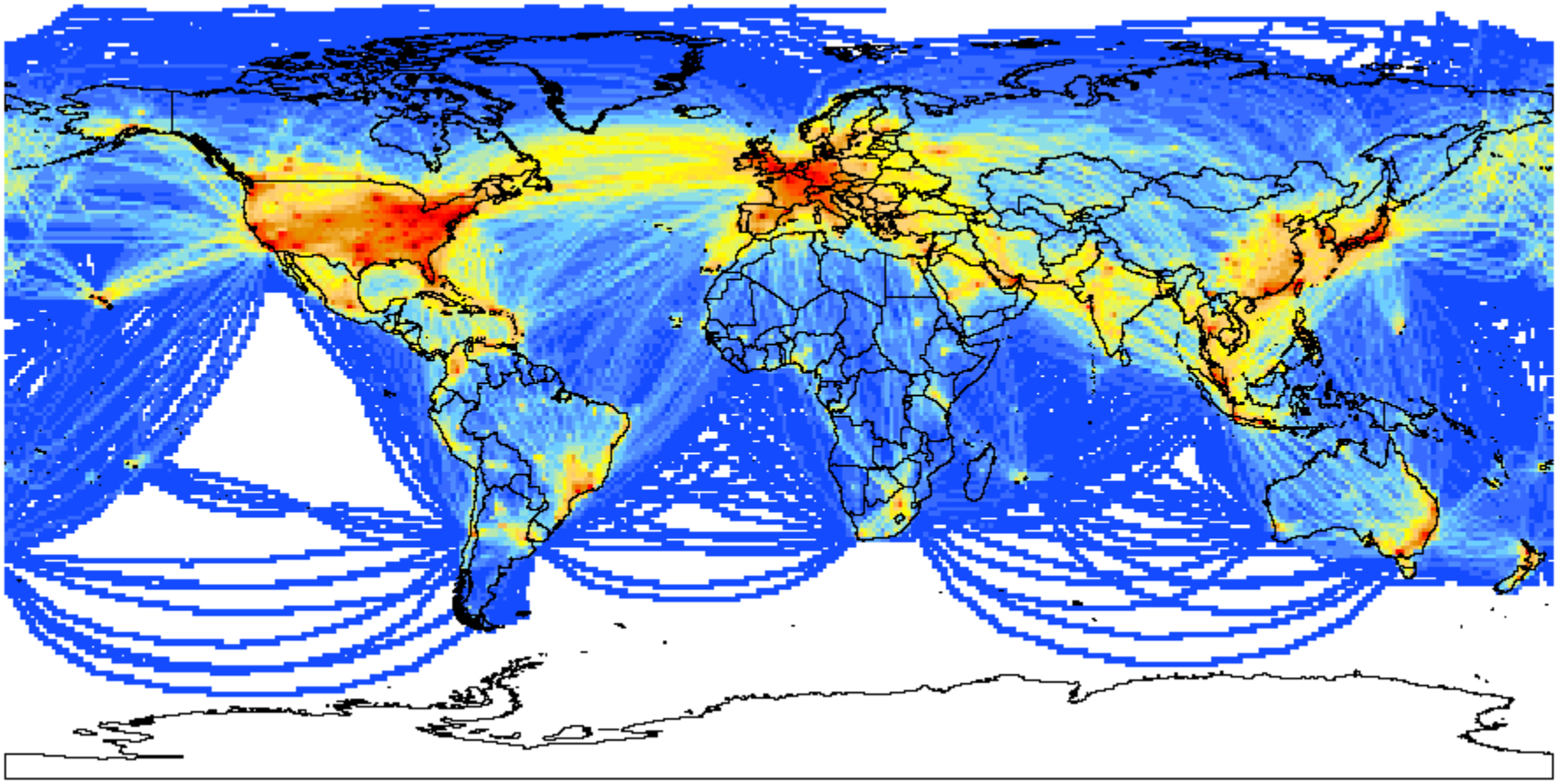
- **Inventory of fuel burn and emissions for individual *flights***
  - Approximately 35 million records per year
- **Inventory of fuel burn and emissions for flight *segments***
  (points along flight path)
  - Approximately 1 billion records per year
- **Inventory of fuel burn and emissions for world *grids*,**
  1 degree by 1 degree by 1 kilometer for each hour of the year
  - Approximately 900 million records per year

AEDT/SAGE OUTPUT DATA (3)

- **Aggregate (Queried) Results**
  - Results by region, country and/or mode
  - Regions/countries are defined by the airports within an area



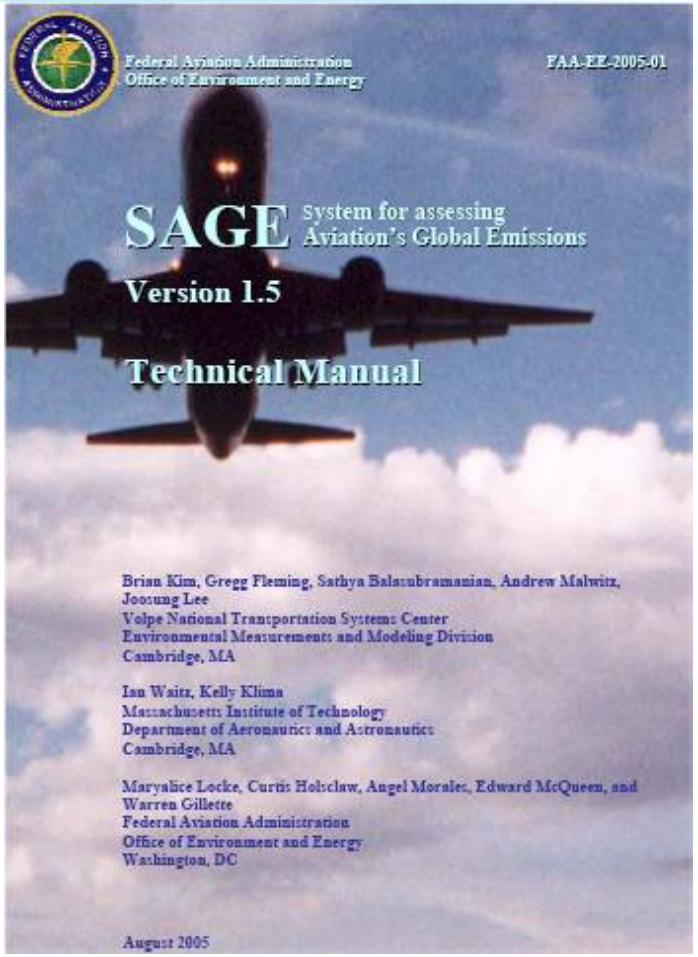
AEDT/SAGE OUTPUT DATA (4)



Example plot of fuel burn on a 1 degree by 1 degree world grid

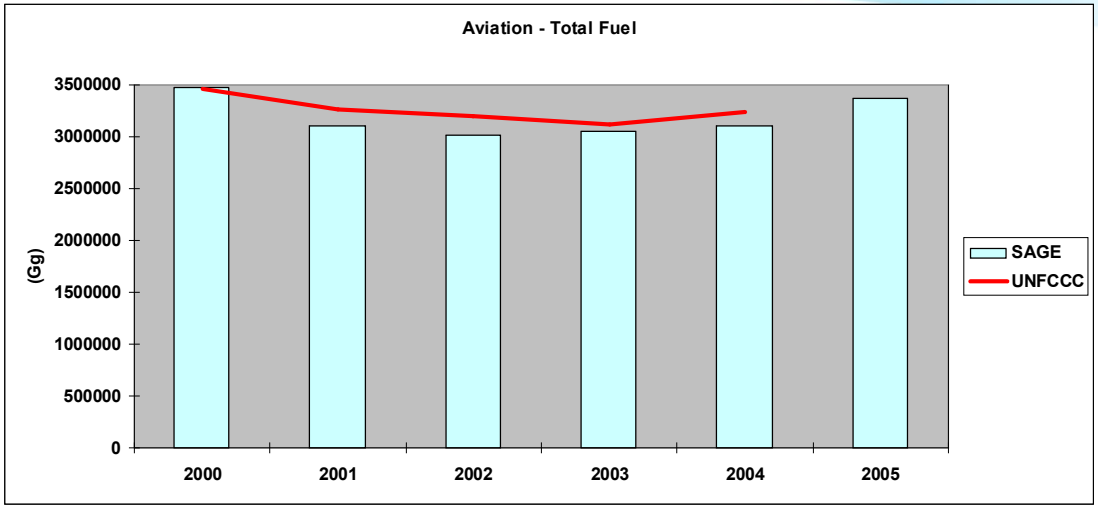
AEDT/SAGE DOCUMENTATION

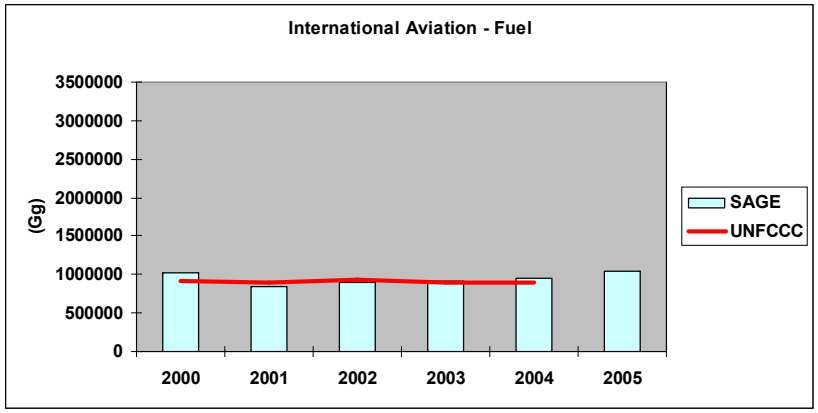
- **SAGE: Technical Manual** (FAA-EE-2005-01)
- **SAGE: Global Aviation Emissions Inventories for 2000 through 2004** (FAA-EE-2005-02)
- **SAGE: Validation Assessment, Model Assumptions and Uncertainties** (FAA-EE-2005-03)
- **SAGE: Version 1.5 System Revision History** (FAA-EE-2005-04)
- **SAGE: Programmer's Maintenance Manual**
- Kim, Brian, et.al., System for assessing Aviation's Global Emissions (SAGE), Part 1: Model description and inventory results, **Transportation Research Part D,** 12 2007, 325-346.
- Lee, J., et.al., System for assessing Aviaion's Global Emissions (SAGE), Part 2: Uncertainty assessment, **Transportation Research Part D,** 12 2007, 325-346.
- Fleming, Gregg G., et.al., 2004. "Flight Movement Inventory: SAGE-AERO2K", **Air Traffic Control Quarterly**, v.12, n.2, 2004, pp. 125-145.

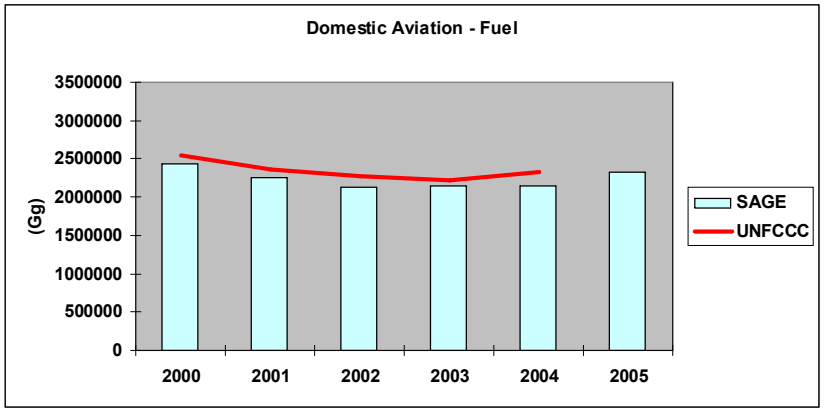


RESULTS (1)

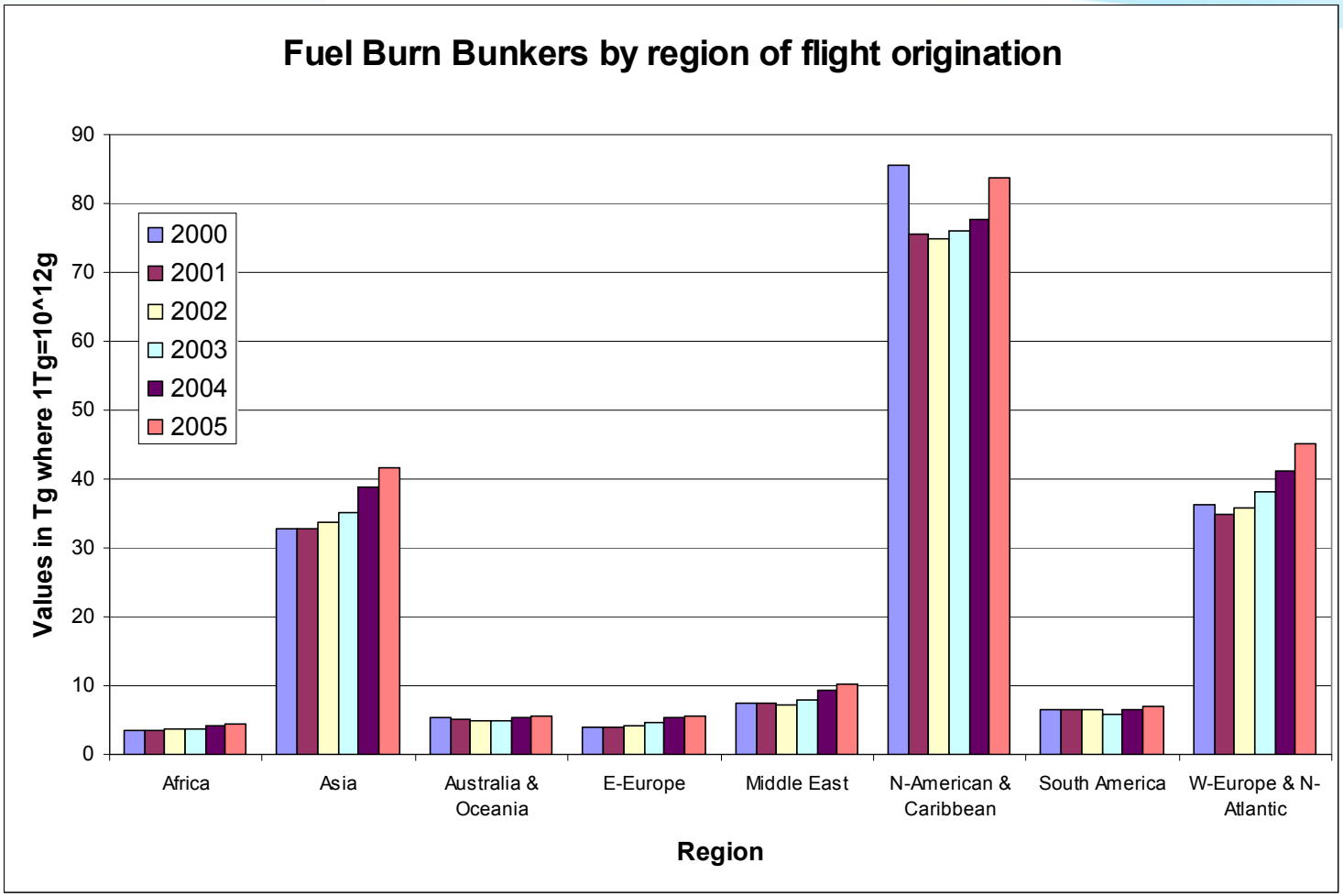
USA – Fuel







RESULTS (2)


Fuel Burn Bunkers by region of flight origination
Values in Tg where 1Tg=10^12g
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003
2004
2005
Africa
Asia
Australia & Oceania
E-Europe
Middle East
N-American & Caribbean
South America
W-Europe & N-Atlantic
Region

?? QUESTIONS ??

FAA Environmental Tools web site:

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