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SUBSIDIARY BODY FOR SCIENTIFIC AND TECHNOLOGICAL ADVICE
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Item 5 (a) of the provisional agenda
Methodological issues
Emissions from fuel used for international aviation and maritime transport

Compilation of data on emissions from international aviation

Submission from the International Civil Aviation Organization

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its nineteenth session, took note of the information contained in document FCCC/TP/2003/3. It also took note of the status of two new models (AERO2K and SAGE) that are being developed. Recalling the invitation made at its eighteenth session, and noting the relevant provisions of the Convention and of the Kyoto Protocol, the SBSTA invited the International Civil Aviation Organization (ICAO) to encourage the developers of these two models to complete them as soon as possible so that the resulting data would be available preferably by 1 March 2004 (FCCC/SBSTA/2003/15, para. 17 (e)).

2. In response to the above request, ICAO provided comparisons of fuel consumption data from three models (AERO, AERO2k and SAGE) with data submitted by Parties included in Annex I to the Convention in 2004 using the common reporting format.

3. In accordance with the procedure for miscellaneous documents, these data are reproduced[*] as received from ICAO and without formal editing.

[*] This submission has been electronically imported in order to make it available on electronic systems, including the World Wide Web. The secretariat has made every effort to ensure the correct reproduction of the text as submitted.

FCCC/SBSTA/2005/MISC.4

GE.05- 61305 (E)

SUBMISSION FROM THE INTERNATIONAL CIVIL AVIATION ORGANIZATION

14/04/05

INFORMATION ON AVIATION EMISSIONS DATA PROVIDED BY ICAO

SUMMARY

This paper presents results of a comparison between data from aviation models made available to ICAO (AERO, AERO2k and SAGE) and the latest available inventory information from UNFCCC addressing fuel consumption data for domestic and international aviation. Although the emissions totals (domestic and international) show similar results, for a number of countries the comparison shows noticeable differences between UNFCCC and modeled data. The suspected reasons for these differences are varied, including how inventory data is assigned to specific countries, the scope of operations included, the availability of data, and methodological differences.

1. INTRODUCTION

1.1 At SBSTA's request, the International Civil Aviation Organization (ICAO) has been providing information on its emissions-related activities on a regular basis[1].

1.2 At its eleventh session, the SBSTA requested assistance from ICAO regarding emissions data, and at its fifteenth session, invited the ICAO and UNFCCC Secretariats to explore opportunities for examining and improving the quality of data reporting and comparability under the relevant provisions of the Convention and the Kyoto Protocol and under ICAO.

1.3 The two secretariats have since been cooperating to achieve this objective. In 2003 and 2004, ICAO organized two expert meetings with the aim of increasing the quality of data for aviation-related emissions with the participation from the UNFCCC and IPCC Secretariats and aviation and inventory experts from states and international organizations. The conclusions of the expert meetings, including the status of the development of aviation models being used in the comparisons, were reported at subsequent sessions of the SBSTA (FCCC/SBSTA/2003/INF.3, FCCC/SBSTA/2004/INF.5 and FCCC/TP/2003/3). The participation of the UNFCCC Secretariat as an observer in ICAO's Committee on Aviation Environmental Protection (CAEP) has also facilitated this work.

1.4 ICAO also participated on the development of the 1996 IPCC Guidelines and IPCC Good Practice Guidance insofar as they relate to aviation emissions, and is actively engaged in the revision that is currently taking place, in particular, ICAO is involved in the revision and update of aviation emissions factors.

1.5 At its eighteenth session, the SBSTA endorsed the elements for future methodological work outlined in paragraph 64 of document FCCC/SBSTA/2003/INF.3, which contained a request to ICAO to provide modeled fuel consumption and emissions data arising from the use of validated aviation models.

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[1] ICAO statements to UNFCCC are available at www.icao.int

1.6 ICAO presented the preliminary results of the comparison of aviation emissions inventory data with the modeled data at a side event to SBSTA 20[2] and has since continued to cooperate with the model developers to respond to the UNFCCC request.

1.7 This paper focuses on the results of a comparison between aviation fuel consumption data from UNFCCC inventories and modeled data from three aviation models made available to ICAO.

2. AVIATION MODELS

2.1 In response to the request by the SBSTA (FCCC/SBSTA2003/INF.3), ICAO decided to use modeled data from three aviation emissions tools made available to ICAO: AERO, AERO2k and SAGE. These data should enable a comparison to be made with national data submitted by Parties under the UNFCCC and may provide insights on how to improve the quality of data reporting. These models provide fuel burn and emissions data for assessment and forecasting of aviation effects, including provision of 4-D data for climatologists and global data for technologists, stakeholders and policymakers.

2.2 The AERO model was already used by ICAO for other analytical purposes. AERO2k and SAGE are more recently developed models and will be subject to CAEP analysis as part of its current work programme.

2.3 There are still improvements on the modeled data results that can be expected from further development of the models, such as the inclusion of more detailed operational procedures and the impact of meteorological issues (i.e. wind effects). However, for the data comparison exercise, the data generated by the models enable the identification of discrepancies between these results and the inventory data and provide for information that would help in the analysis of possible causes of these deviations.

2.4 A brief description of the AERO, AERO2k and SAGE models is provided below.

2.4.1 AERO

2.4.1.1 Introduction

2.4.1.1.1 The AERO model was developed by the Dutch Civil Aviation Authority in the period 1994 to 2000, and is an internationally accepted tool for the computation of aviation emissions.[3] The AERO model is devised to evaluate fiscal, regulatory, operational and technical measures to reduce air traffic impacts on the atmosphere.

2.4.1.2 Description

2.4.1.2.1 The AERO model comprises a series of modules, covering description/generation of aviation demand right through to assessment of the environmental impacts of aviation emissions. The base year in the AERO model is 1992, but an intermediate check of the base case was done in 1998. At the core of the AERO model is the Unified Database, which holds data on civil aircraft movements and

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[2] The SBSTA 20 presentations from the “Emissions from Aviation” side event are available under “schedule of side events and list of exhibits” at http://unfccc.int/meetings/archive/items/1646.php .

[3] A description of the AERO model can be found in *Comparison of UNFCCC Data on Emissions from Domestic and International Aviation with Data from the AERO Model*, SMI-WP/3, ICAO, February 2003, which can be obtained directly from the ICAO secretariat (attention: Secretary of CAEP) and in FCCC/SBSTA/2003/INF.3 . More detailed information is published in *Aviation Emissions and Evaluation of Reduction Options/AERO* published by the Directorate General for Civil Aviation, Ministry of Transport, Public Works and Water Management of the Kingdom of the Netherlands, July 2002, ISBN 90-369-1792-1.

air passenger and cargo demand for the base year 1992. It provides worldwide coverage, although data are stored at the level of individual major city pairs and groups of minor city pairs. The Unified Database merges the content of four other major aviation databases. It covers flights between over 50000 city pairs. After a grouping of minor city pairs, this results in some 19000 city-to-city flight stages being explicitly distinguished in the model schematisation. For each city pair, it can be ascertained whether connecting flights are domestic or international simply by checking whether the cities of departure and destination are in the same country.

2.4.1.2.2 In AERO, aircraft flights are specified by ten generic aircraft types (based on relevant combinations of range and capacity) and two technology levels. The AERO model computes fuel use and emissions by flight stage. The AERO model also computes the following emissions: CO_2, C_xH_y, CO, H_2O, NO_x and SO_2.

2.4.1.2.3 In the AERO model, fuel use and emissions are computed by flight stage. As indicated above, international flight stages (i.e. cities of departure and destination in different countries) can be separated from domestic flight stages (i.e. city of departure and destination in the same country). The assumption also was made that all fuel used on a given flight stage is bunkered in the country of departure of that flight. It should be stressed that this assumption means that the effects of ‘tankering’ (taking on board extra fuel to be used on the next flight) are ignored. Thus, all fuel use and associated emissions for a given flight are allocated to the country of departure of that flight.

2.4.1.3 Validation

2.4.1.3.1 The validation process of AERO is described in detail in the AERO publication (footnote 3 refers).

2.4.2 **AERO2k**

2.4.2.1 Introduction

2.4.2.1.1 The AERO2k project was supported through the European Commission Fifth Framework programme and was developed by a consortium led by QinetiQ (United Kingdom) with DLR (Germany), NLR (Netherlands), Eurocontrol, Airbus (France), Manchester Metropolitan University (United Kingdom) and the Department of Trade and Industry (United Kingdom). AERO2k developed a new four dimensional (4-D: latitude, longitude, height and time) gridded database of global aircraft emissions of priority pollutants using improved methodologies and analytical tools.

2.4.2.2 Structure

2.4.2.2.1 The inventory software package includes an MS Access database which stores data on aircraft flight movements over a specified period and geographical area. The emissions can be displayed in a 4-D grid. Grid sizes are flexible to suit the application and the emissions are calculated from knowledge of flight routing, flight phase, aircraft and engine type, thrust settings, fuel consumption and emissions factors. Although this approach is not in itself novel, the techniques used in generating the input information provide a substantially more reliable data set than has previously been available. Such techniques include use of actual radar tracking data (as opposed to great circle data); increased number of representative aircraft types; calculation of aircraft in-flight weight changes with consequent variations in fuel burn and emissions; characterization of landing and take-off (LTO) times by airport; and use of latest available information and methodology for calculation of LTO and altitude emissions.

2.4.2.3 Outputs

2.4.2.3.1 The main outputs of the current project are a new civil air traffic movements database for 2002 based upon improved routing assumptions and methodologies; emissions inventories for pollutants (CO_2, SO_2, H_2O, CO, NO_x, soot (mass) and hydrocarbons) from aircraft; uncertainty analyses; an inventory of distances flown in and between regions of the world; and a new 2025 emissions forecast. Full reports including gridded global data are available at http://www.cate.mmu.ac.uk/aero2k.asp.

2.4.2.4 Validation

2.4.2.4.1 Validation of the AERO2k method and results has been carried out at overview and module level against available airline data, previous inventories and other models. Further details are available in http://www.cate.mmu.ac.uk/aero2k.asp.

2.4.3 SAGE

2.4.3.1 Introduction

2.4.3.1.1 The United States Federal Aviation Administration (U.S. FAA) has developed the System for assessing Aviation's Global Emissions (SAGE), with support from the Volpe National Transportation Systems Center, the Massachusetts Institute of Technology and the Logistics Management Institute. The SAGE computer model is used for estimating aircraft emissions (CO_2, CO, HC, NO_X, H_2O and SO_X modeled as SO_2) over the whole flight regime, including the landing and take-off cycle, and cruise. With regard to scope, the model is capable of analyses on an aircraft, airport, regional, and global level. Various operational, policy and technology-related scenarios can be evaluated using this model to assess their potential effects on global aircraft emissions. The SAGE model is based on the best available data and methodologies, and undergoes periodic updates to maintain currency. At this time, it is the only model with such scope and flexibility generating annual global aviation inventories based on annually updated aircraft performance and radar tracking data.

2.4.3.2 Structure

2.4.3.2.1 The SAGE model comprises four basic computational modules: aircraft movements, capacity and delay, fuel burn and emissions, and forecasting. These modules encompass both the methods and the input data requirements to run the model. SAGE was developed using the best available data and methods that allow high-resolution and high-fidelity modelling of aircraft fuel burn and emissions during all phases of flight. SAGE can be used to model individual flights with variations in trajectories, aircraft/engine types and performance parameters because SAGE contains a dynamic aircraft performance module, rather than a static lookup table. On an aggregate level, all flights worldwide in a given year are modeled in SAGE with no need for scaling of smaller sets of data. These are the reasons why SAGE can model a single flight at a given time and date as well as larger-scales such as global totals of fuel burn and emissions.

2.4.3.3 Outputs

2.4.3.3.1 SAGE generates annual inventories of aircraft fuel burn and emissions, beginning with year 2000, based upon detailed knowledge of worldwide aircraft movements. The model generates three basic inventories from which further queries and analyses can be conducted. First, the world gridded

inventory contains results in "standardized" 1° latitude x 1° longitude x 1 km grids which are variable depending on analysis requirements. These 4D (including time) gridded results contain information specific to each flight that traversed each grid at a certain date and time. Second, the flight inventory contains listings of each of the approximately 30 million flights worldwide per year. The parameters (fields) in this inventory include: departure/arrival airport, date and time, aircraft/engine types, airport country and region, flight distance, modal fuel burn and emissions. The modes include ground movements (e.g., delay and taxi), takeoff and climbout, cruise, and approach. Third, the chorded (or segment) inventory contains listings of each of the flight chords (flight segments) of each of the flights worldwide per year. The parameters in this inventory include aircraft performance information such as time, speed, weight, distance, etc. for each chord. For each flight, there are approximately 30-40 chords that define the trajectory. Queries and analyses of these inventories and those for subsequent years will help to determine trends in aircraft emissions on a regional and global level, allow for more accurate comparisons to emissions from other industries, and provide a basis for forecasts of future aircraft greenhouse gas emissions. Detailed knowledge of aircraft movements allows for analysis of fuel burn and emissions within regions and between regions using SAGE.

2.4.3.4 Validation

2.4.3.4.1 Preliminary validation work has shown good agreement on both modular and system levels within +/-5% agreement on fuel burn when compared to measured data from various sources including major airlines. This agreement provides a strong level of comfort in the flight and flight chord level results that, when aggregated in a bottom-up method, provides the larger-scale inventories. The U.S. FAA is preparing for additional validation work to determine areas for model improvement and to better understand areas of uncertainty. This uncertainty work and the ensuing model improvements will allow for SAGE to provide higher-fidelity results. Emission reduction options relating to new emissions reduction technologies and new operational procedures and strategies could also be analyzed within SAGE once the appropriate input data are made available. The U.S. FAA has made a long-term resource commitment to continue validation and development of SAGE to provide the international community with a useful and accurate model for predicting aircraft fuel burn and emissions.

3. COMPARISON BETWEEN UNFCCC AND MODELED DATA METHODS

3.1 The data generated by the three models described above have been compared with the inventory data from UNFCCC for the years 1999 (for AERO data) and 2002 (for SAGE and AERO2k data). The modeled aviation data provided in this paper have not yet been used in the ICAO/CAEP process and should be regarded as data provided by the model developers. ICAO presented preliminary results of this comparison at a side event to SBSTA20 (footnote 5 refers). Since then the AERO2k project was finalized (December 2004) and the SAGE model was updated (Version 1.5 January 2005) with inventories through 2004 (April 2005).

3.2 The following assumptions and definitions were used by the modelers to enable this comparison exercise to be carried out:

3.2.1 ***Baseline*** – AERO uses the year 1992 as a baseline, which was recalibrated in 1998; it has a forecasting model as part of its programme to generate the data for the other years, including the 1999 data shown herein. AERO2k has an inventory of operational data for the year 2002 and forecasts data for a 2025 scenario. The SAGE model generates annual inventories of aircraft fuel burn and emissions, beginning with the year 2000, and based on annually updated aircraft performance and worldwide aircraft movements data. Using the definitions for domestic and international flights described below, the three aviation inventory tools were queried to obtain data for individual countries in individual years.

3.2.2 ***Fuel conversion*** – All the modeled data computed the fuel consumption in mass units (Gg); but, as the UNFCCC inventories report fuel consumption in energy units (TJ), to facilitate the comparison the modeled data presented in the tables were converted from Gg to TJ using default conversion factors (gross caloric value 46.82TJ/Gg for Australia, Canada, New Zealand and the United States, and net caloric value 44.59 TJ/Gg for all other countries).

3.2.3 ***Domestic/International*** – Fuel consumption is split into domestic and international traffic components and is presented by country. A flight is defined as a single take-off to the next landing. A domestic flight is a flight taking off and landing in the same country. International flights are flights taking off in one country and landing in a different country. All fuel consumption on domestic and international flights departing from a particular country is allocated to that departure country. The data were generated by modeling worldwide flights and aggregating the data into each country's domestic and international flight categories. Flights were attributed to countries based on airport locations using various publicly available airport databases. Territories and other political entities, that may be included in UNFCCC inventories for a reporting party, were considered as separate entities in developing the data for this exercise.

3.2.4 ***Emissions Coverage*** – The aviation tools discussed in this paper compute fuel burn and emissions of CO_2, H_2O, CO, HC, NO_x, and SO_x (modeled as SO_2). For the purpose of this exercise, the results of the comparison between the modeled data and the latest available UNFCCC data are presented only for fuel consumption for domestic and international aviation. CO_2 and H_2O emissions can be directly computed from this fuel consumption data, if required.

3.2.5 ***Methods Comparison*** – Aspects of the methods used in generating the modeled data presented here may tend to result in fuel and emissions estimates that may be slightly lower (or higher) than the probable actual value. These small effects include, for example, the omission of the effect of winds on aircraft fuel consumption. Modeling methods, however, are continuously improving, including the reduction of these effects. Similarly, systematic effects in fuel-sold inventory methods may tend to overestimate fuel actually burned in commercial aircraft as they do not account for leakage, evaporation, fuel not used (i.e. disposed of) and fuel ultimately used for other purposes. When comparing data from the different methods, consideration must also be given to variations in the scope of data covered; for example, military, piston-engine aircraft and general aviation operations are not included in the modeled data presented in this paper. There may be other factors which cause effects; but, in general, the actual fuel and emissions are most likely to fall between the values obtained from the flight-based modeled inventory and fuel-used methods.

3.2.6 ***Geographic coverage*** –The modeling of aircraft fuel burn and emissions for strictly ICAO analytical purposes does not consider data in terms of Annex I and non-Annex I parties. As such, the countries selected for inclusion in the data provided by the model developers for this comparison were determined based in part on the list of countries for which there was relatively complete aviation data provided in the UNFCCC inventories. Also of note, how a country is defined may vary between the various data. Modelers assign airports to countries to generate country-specific inventories. However, whether a particular airport on an island or territory is part of a country for inventory purposes can be uncertain; and, thus, there can be geographic variations between the data sets for a given country.

3.3 Tables presenting the overall data results from the comparison of modeled data (AERO, AERO2k and SAGE) and UNFCCC inventory data are included in the Appendix to this paper. The data from the Appendix are presented in graphical form in the following sections.

4. COMPARISON BETWEEN UNFCCC AND AERO MODEL DATA

4.1 The AERO model has been accepted by CAEP for its use in analytical work on emissions options. The results of the aviation emissions per country generated by the AERO model for the year of 1999 were compared with the UNFCCC inventory data for the same year; the data were previously presented, in a tabular format, to SBSTA 19 (FCCC/TP/2003/3).

4.2 Figure 1 compares AERO and UNFCCC total fuel consumption data giving the overall perspective between the data for various countries. Figures 2 and 3 show a magnified view for selected countries to allow closer examination.

Figure 1

Comparison of 1999 AERO-UNFCCC Total Fuel Consumption (TJ)

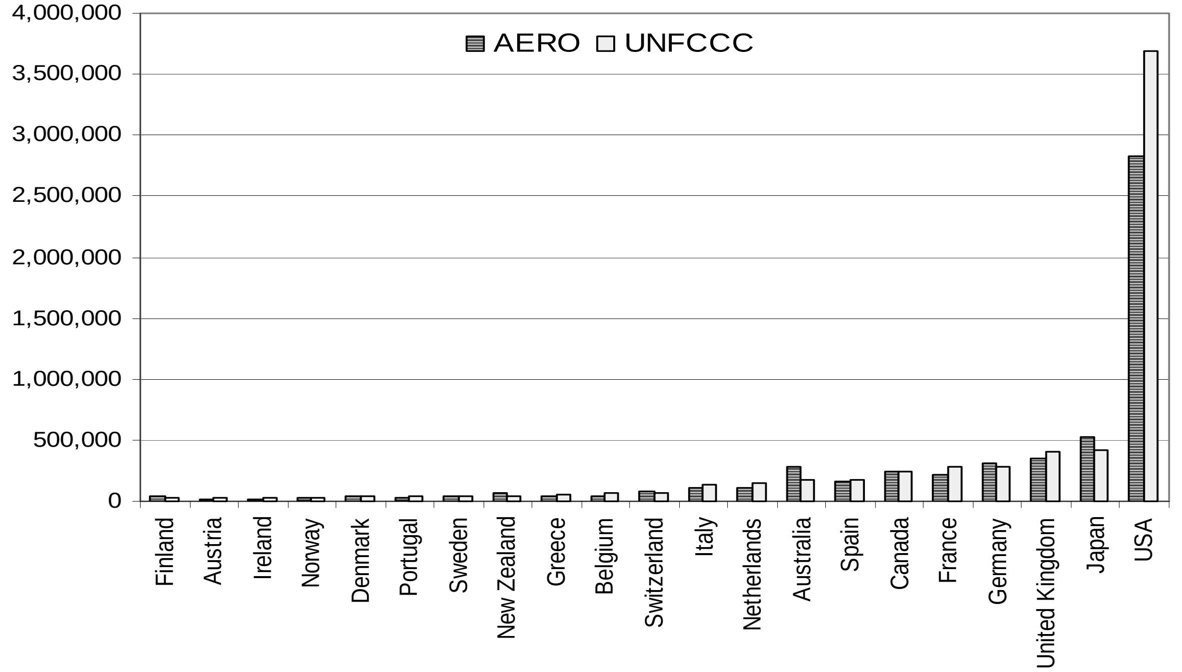
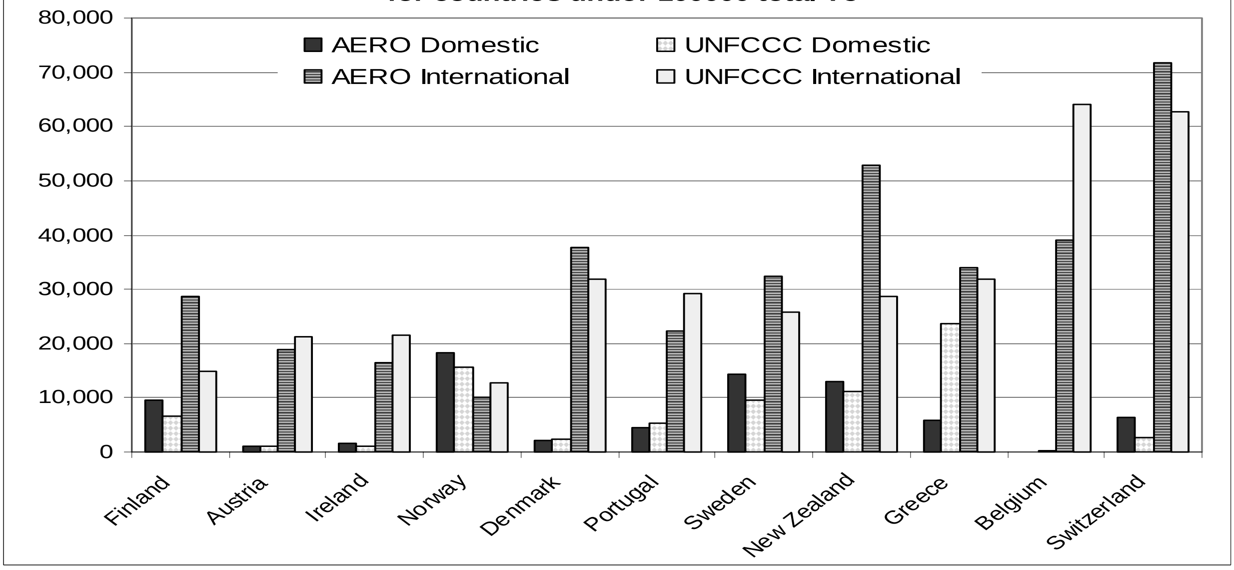
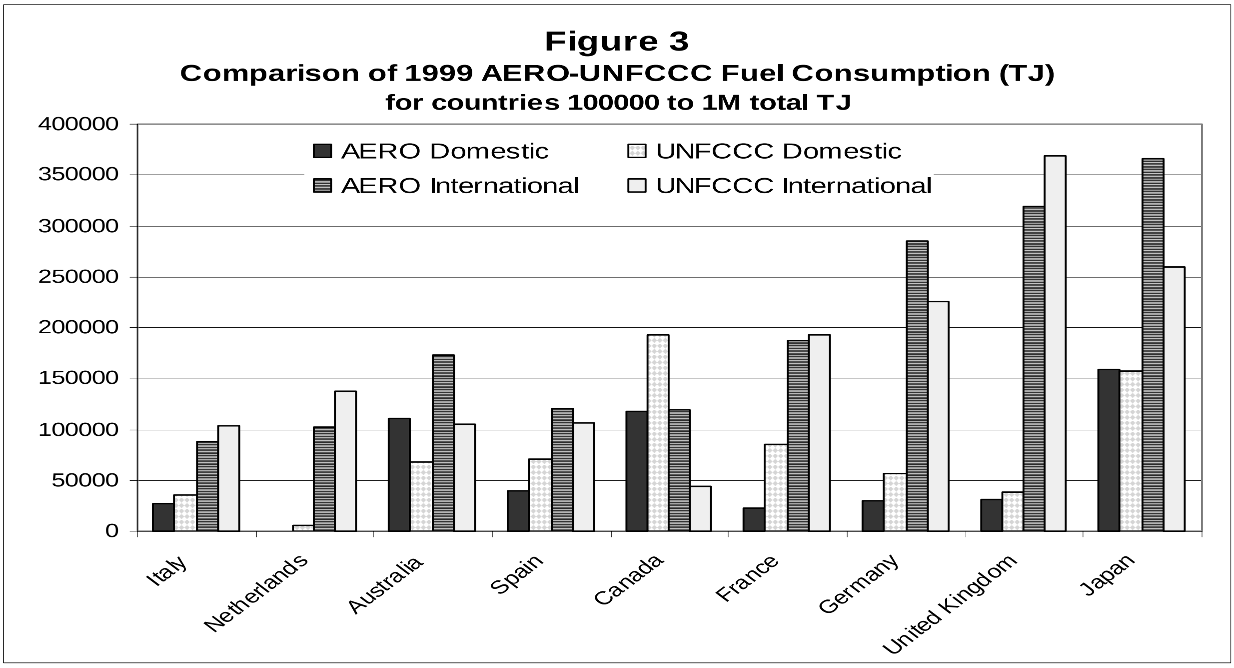


Figure 2

Comparison of 1999 AERO-UNFCCC Fuel Consumption (TJ) for countries under 100000 total TJ





4.3 From the comparison between 1999 UNFCCC and AERO data, it is observed that:

a) for some countries (for example, Australia, Finland and New Zealand), the differences are rather large, with the AERO model usually computing the fuel consumption (both domestic and international) at a higher level compared to the data reported to the UNFCCC;

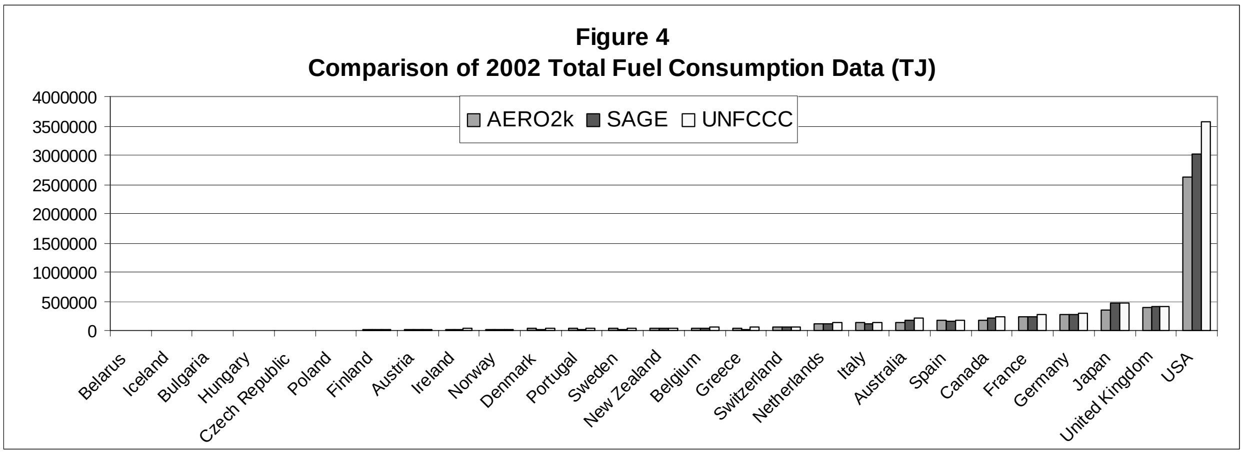
b) the data for Japan practically agree for domestic emissions but present higher values for the AERO-modeled international emissions; and

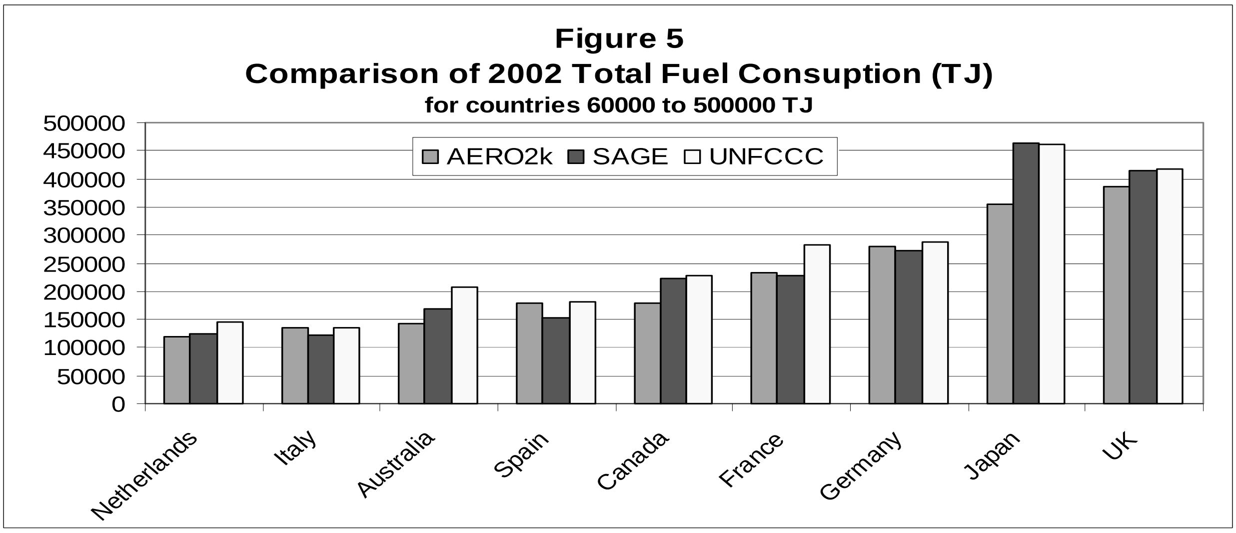
c) the split between domestic and international data for Canada appears to be a problem, although the total fuel consumption values agree well.

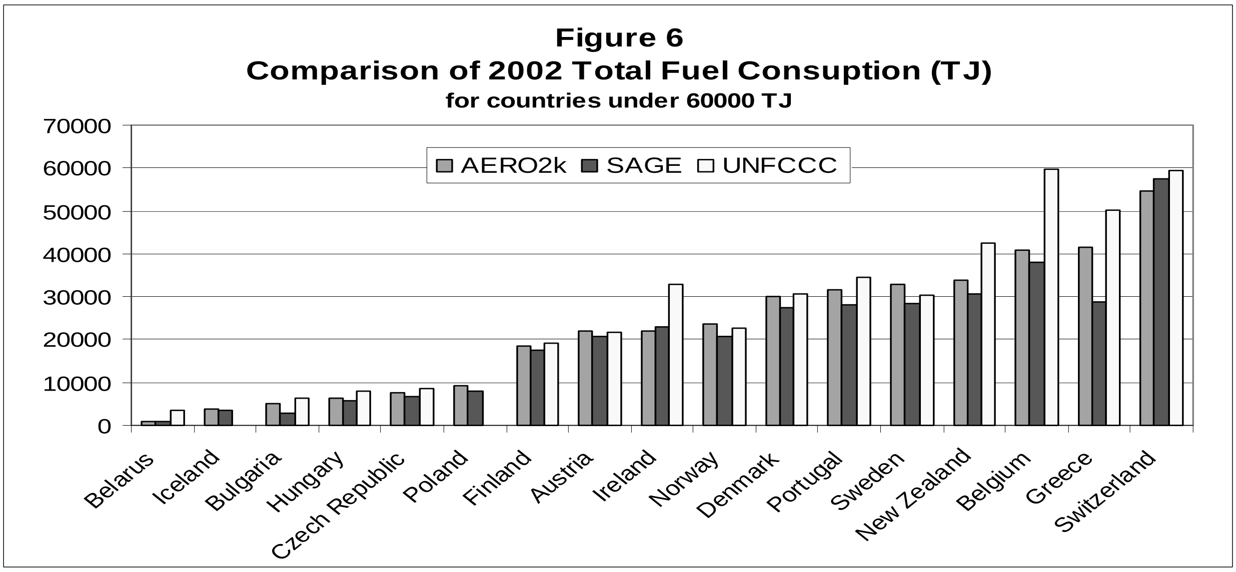
5. COMPARISON WITH AERO2k AND SAGE

5.1 For year 2002, UNFCCC inventory data were compared to data modeled by AERO2k and SAGE. A preliminary version of this data was presented to SBSTA 20 at the "Emissions from Aviation" side event (footnote 2 refers).

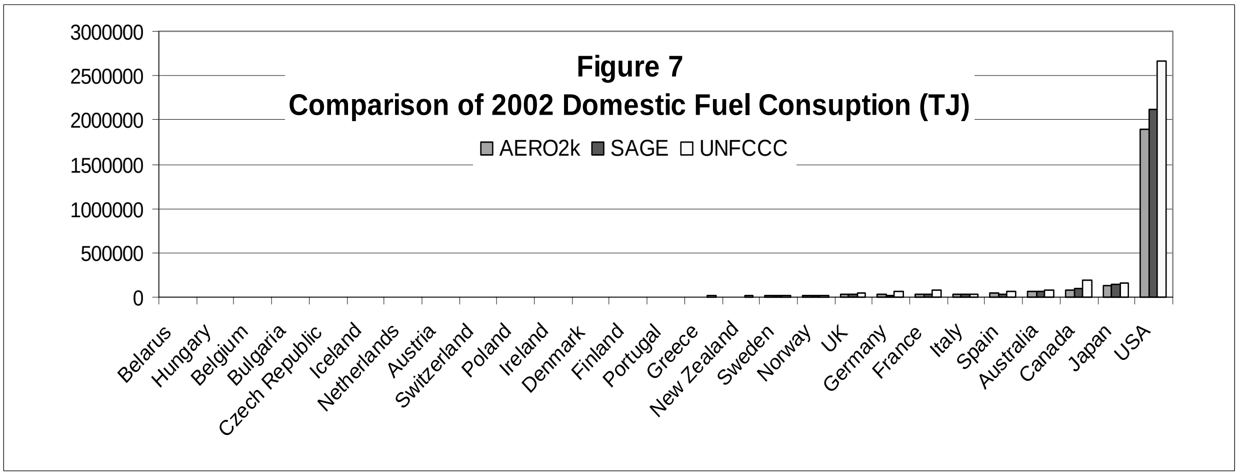
5.2 ***Total fuel consumption*** – Figure 4 compares AERO2k, SAGE and UNFCCC total fuel consumption data giving the overall perspective between the data for various countries. Figures 5 and 6 show the same data in magnified views for closer examination.

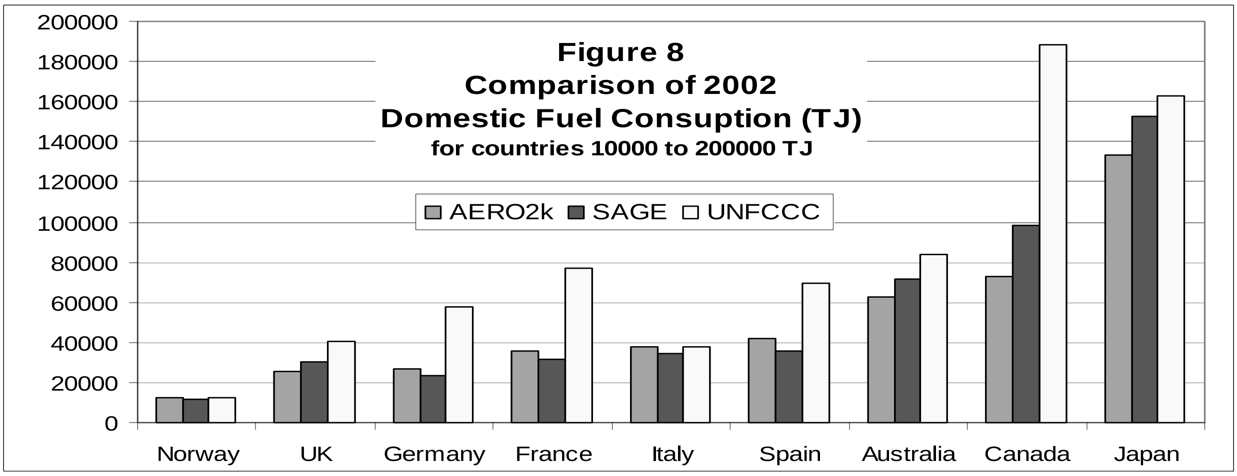


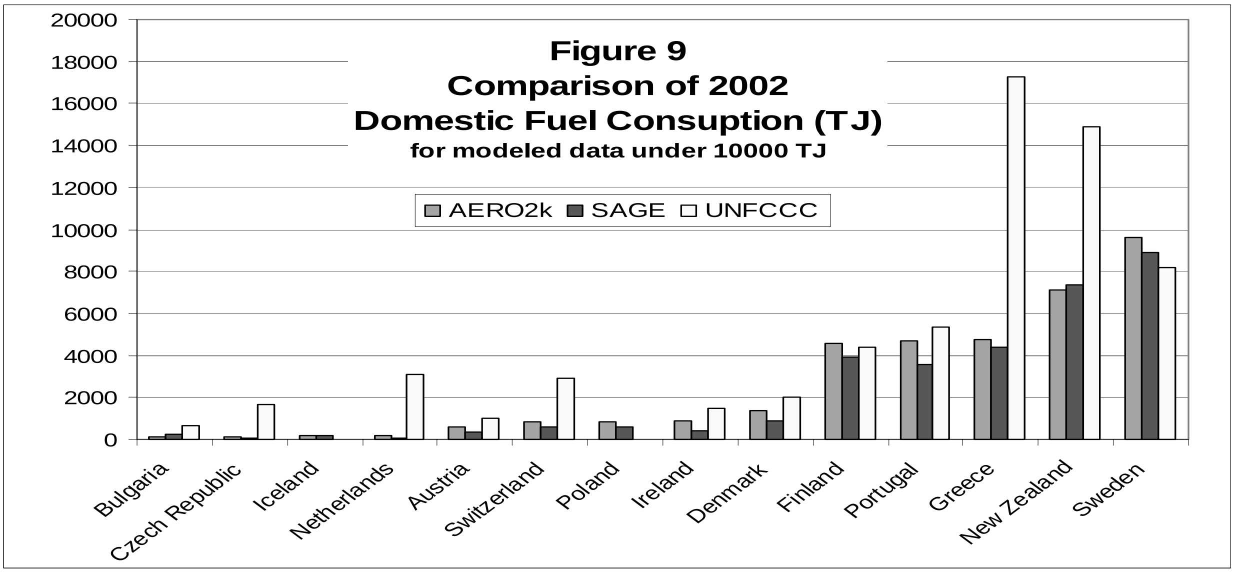




5.3 ***Domestic fuel consumption*** – Figure 7 compares AERO2k, SAGE and UNFCCC domestic fuel consumption data giving the overall perspective between the data for various countries. Figures 8 and 9 show the same data in magnified views for closer examination.







5.4 ***International fuel consumption***– Figure 10 compares AERO2k, SAGE and UNFCCC international fuel consumption data giving the overall perspective between the data for various countries. Figures 11 and 12 show the same data in magnified views for closer examination.

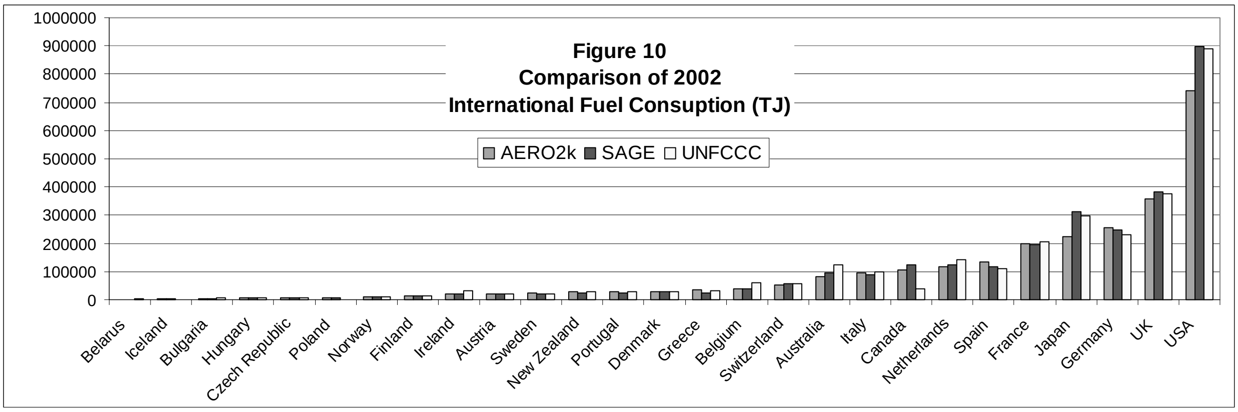


Figure 10
Comparison of 2002
International Fuel Consuption (TJ)
AERO2k SAGE UNFCCC
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Belarus
Iceland
Bulgaria
Hungary
Czech Republic
Poland
Norway
Finland
Ireland
Austria
Sweden
New Zealand
Portugal
Denmark
Greece
Belgium
Switzerland
Australia
Italy
Canada
Netherlands
Spain
France
Japan
Germany
UK
USA

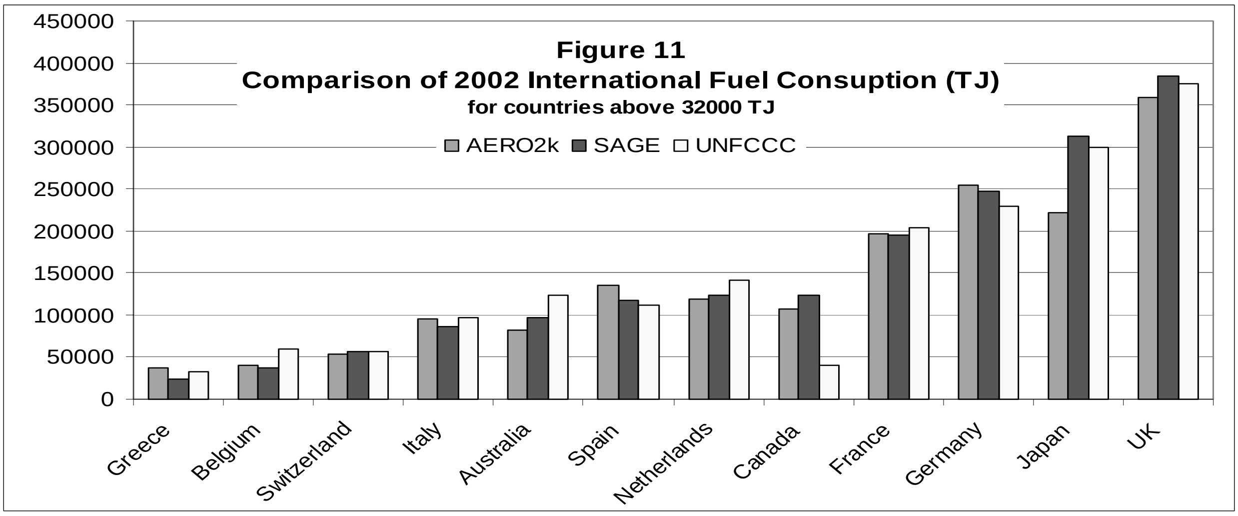


Figure 11
Comparison of 2002 International Fuel Consuption (TJ)
for countries above 32000 TJ
AERO2k SAGE UNFCCC
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Greece
Belgium
Switzerland
Italy
Australia
Spain
Netherlands
Canada
France
Germany
Japan
UK

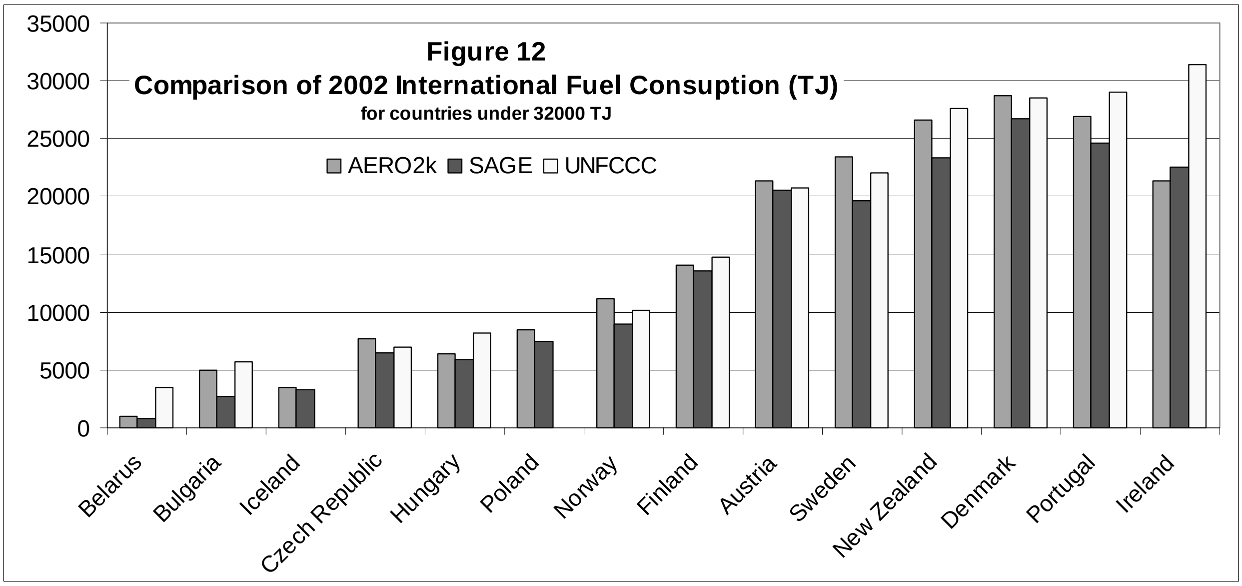


Figure 12
Comparison of 2002 International Fuel Consuption (TJ)
for countries under 32000 TJ
AERO2k SAGE UNFCCC
35000
30000
25000
20000
15000
10000
5000
0
Belarus
Bulgaria
Iceland
Czech Republic
Hungary
Poland
Norway
Finland
Austria
Sweden
New Zealand
Denmark
Portugal
Ireland

6. OBSERVATIONS ON AERO2K/SAGE/UNFCCC COMPARISON FOR 2002

6.1 The following observations were taken from the data comparison:

a) The comparison has verified similar values for the total fuel consumption figures (domestic plus international) for modeled and inventory data. However, UNFCCC total and domestic fuel consumption data are generally slightly higher than modeled data, perhaps due to the issues described in paragraph 3.2.5. International fuel consumption figures appear to show closer agreement than domestic fuel consumption.

b) Beyond this, there are few systematic differences to be observed. Most UNFCCC data are based on fuel sold data. A review of the methodologies applied by Annex I Parties for disaggregating fuel use data into domestic and international components shows that there is no uniform approach to the issue. To a large extent, this may be due to the different definitions and guidelines among different institutions (including ICAO, IEA and IPCC) and to a diversity of sources for obtaining data to split domestic and international.[4] For example, the UNFCCC guidelines require that fuel consumed by military aircraft be separated from fuel consumed by civil aircraft and be reported separately and IEA reporting guidelines include a country's military aircraft emissions under domestic aviation. In addition, statistical data are often formatted and aggregated for specific purposes and may require adaptation before they are suitable for preparing national inventories; further, some of the sources of data are restricted to commercial use. These methodological differences between the different countries are considered to cause greater variation than the differences between modeled data. Hence systematic differences between modeled and inventory data are not observed. Perhaps as a result of these discrepancies, it is worth considering basing the split of domestic and international aviation emissions on traffic, using fuel sold as verification.

c) Another source of discrepancy between the modeled data and the inventories comes from the accounting for the emissions from overseas territories. IPCC/UNFCCC reporting guidelines recommend that emissions from flights to and from overseas territories should be included in national inventories as domestic, but this is not fully applied in practice. As mentioned in paragraph 3.2.3, modelers do not always know which territories to include within a country's domestic inventory. For example, the preliminary analysis for this paper pointed out that the SAGE modeled data for Portugal was noticeably lower than UNFCCC and other modeled data; further examination showed that Madeira Island had not been included with Portugal. This incongruity was corrected for the information presented herein; and, the ICAO modelers are working toward creating common reference data sets to avoid future discrepancies.

d) Regarding individual countries, there are a number of significant differences between modeled and inventory data. The data for the U.S. is one point for further investigation; though the percent difference between modeled and UNFCCC data is within the range of those for other countries, the magnitude of emissions is such that we would hope for the greatest possible accuracy for this data. Concern also remains regarding the domestic/international split for Canada, previously noted with the 1999 AERO/UNFCCC comparison. The large differences noted in 1999 for some other countries, however, are not repeated in the 2002 analysis. Unfortunately, new large differences have appeared; for example:

i. for total fuel consumption: Belgium, Ireland and New Zealand;

[4] According to the IPCC guidelines, fuel use data distinguished between domestic and international aviation may be obtained in different ways. Both bottom-up and top-down approaches should be evaluated. Examples of bottom-up approach data sources are surveys of airline companies for fuel used and aircraft movement data. Examples of sources for top-down data are national energy statistics and airport surveys.

ii. for international fuel consumption: Ireland and Belarus; and

iii. for domestic fuel consumption: France, Germany, Greece, the Netherlands, New Zealand, Spain, and Switzerland .

Understanding these would require further assessment of the circumstances and methods used for each individual country.

7 NEXT STEPS

7.1 The comparison of the emissions data from inventories and modelled data was a valid and positive exercise and has helped identify many areas where further development is necessary to improve the quality of data reporting and the comparability of aviation emissions data. ICAO considers that a point has now been reached where further comparisons of modeled results with the UNFCCC data in the short term is unlikely to provide significant additional information on areas where improvement of data quality could be explored.

7.2 ICAO believes that the comparison of the modeled and inventory data has offered many observations that will help the UNFCCC Secretariat to continue to work with Parties towards the improvement of the quality of aviation emissions data in their inventories.

7.3 Under the guidance of ICAO, these modeling tools will be further refined. CAEP will continue to evaluate the aviation models and to identify possible areas of improvement of their computational process and output data. ICAO will also continue to work on the assessment of the evolution of emissions from air transport and towards improving the availability of information related to the present and future impact of aircraft engine emissions as requested by the ICAO Assembly[5].

7.4 During the data comparison exercise, ICAO noted that air traffic data is not always easily available or provided in a format suitable for UNFCCC inventory activities. ICAO is therefore exploring the feasibility and cost implications of making available an ICAO database of worldwide air services in a format that individual UNFCCC Parties could use.

7.5 ICAO will continue to study policy options to limit or reduce the environmental impact of aircraft engine emissions, to cooperate with the UNFCCC Secretariat and to assist SBSTA with regard to methodological issues, as needed.

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[5] ICAO Assembly Resolution A35-5: “Consolidated statement of continuing ICAO policies and practices related to environmental protection”, Appendix A, Resolving Clauses 3 and 4 .

APPENDIX
AVIATION FUEL CONSUMPTION DATA[6]

TABLE 1 – Comparison of 1999 Aviation Fuel Consumption (TJ) Data: AERO[7] and UNFCCC

	DOMESTIC 1999		INTERNATIONAL 1999		TOTAL 1999		
Country	AERO	UNFCCC	AERO	UNFCCC	AERO	UNFCCC	AERO total as % of UNFCCC total
Australia	109,933	68,062	172,813	105,330	282,746	173,392	*163*
Austria	981	1,113	18,772	21,196	19,753	22,309	*89*
Belgium	89	170	39,016	63,977	39,105	64,147	*61*
Bulgaria	223		4,504		4,727		
Canada	118,127	193,062	119,110	44,471	237,237	237,533	*100*
Czech Republic	1,516		12,084		13,600		
Denmark	2,140	2,410	37,768	31,812	39,908	34,222	*117*
Finland	9,631	6,561	28,627	14,946	38,258	21,507	*178*
France	23,053	84,548	187,144	192,219	210,197	276,768	*76*
Germany	29,652	56,271	284,752	225,083	314,404	281,354	*112*
Greece	5797	23,722	33,933	32,016	39,730	55,738	*71*
Hungary	0		4,727		4,727		
Iceland	0		4,727		4,727		
Ireland	1,694	1,183	16,498	21,593	18,192	22,776	*80*
Italy	26,531	34,923	87,842	104,147	114,373	139,070	*82*
Japan	159,543	156,869	366,084	260,027	525,627	416,897	*126*
Netherlands	669	5,747	102,780	137,949	103,449	143,696	*72*
New Zealand	13,063	11,124	52,766	28,806	65,829	39,930	*165*
Norway	18,326	15,810	9,988	12,884	28,314	28,695	*99*
Poland	401		6,198		6,599		
Portugal	4,414	5,261	22,250	29,248	26,664	34,509	*77*
Spain	39,105	71,154	120,036	106,492	159,141	177,646	*90*
Sweden	14,269	9,563	32,417	25,710	46,686	35,273	*132*
Switzerland	6,287	2,543	71,701	62,688	77,988	65,231	*120*
United States	1,992,566	2,808,602	836,627	885,098	2,829,193	3,693,700	*77*
United Kingdom	30,812	38,394	319,532	369,184	350,344	407,578	*86*

[6] Data presented in Tables 1 and 2 do not cover piston aircraft. Current emission indices for piston aircraft are not based on certificated data and there is some question as to the accuracy of these indices. There are also questions about the applicability of current fuel burn and emissions predictions methodologies to piston-driven aircraft. Analyses of piston-driven aircraft showed that their contribution to country totals were insignificant (less than one percent).

[7] AERO data same as provided in FCCC/TP/2003/3, *Compilation of Data on Emissions from International Aviation*

TABLE 2 – Comparison of 2002 Aviation Fuel Consumption (TJ) Data: AERO2k, SAGE and UNFCCC

	DOMESTIC 2002 Fuel Consumption (TJ)			INTERNATIONAL 2002 Fuel Consumption (TJ)			TOTAL 2002 Fuel Consumption (TJ)			% Difference for Fuel Consumption Totals		
Country	AERO2k	SAGE	UNFCCC	AERO2k	SAGE	UNFCCC	AERO2k	SAGE	UNFCCC	AERO2k as % of SAGE	AERO2k % of UNFCCC	SAGE as % of UNFCCC
Australia	62427	71317	83853	81256	96475	124158	143684	167792	208011	*86*	*69*	*81*
Austria	580	332	1026	21346	20513	20789	21926	20845	21815	*105*	*101*	*96*
Belarus	0	7	56	972	843	3448	972	850	3504	*114*	*28*	*24*
Belgium	13	0	175	40760	37976	59464	40773	37976	59639	*107*	*68*	*64*
Bulgaria	103	227	677	5025	2681	5654	5128	2908	6331	*176*	*81*	*46*
Canada	72734	98540	188147	106791	123957	39917	179525	222497	228063	*81*	*79*	*98*
Czech Republic	114	46	1634	7683	6512	7017	7797	6558	8651	*119*	*90*	*76*
Denmark	1349	888	2025	28724	26686	28519	30072	27573	30544	*109*	*98*	*90*
Finland	4550	3912	4414	14062	13567	14721	18612	17479	19135	*106*	*97*	*91*
France	35915	31469	77138	197118	195783	204876	233033	227252	282014	*103*	*83*	*81*
Germany	26825	23226	57400	254092	247938	229600	280917	271164	287000	*104*	*98*	*94*
Greece	4732	4380	17260	36938	24408	32863	41671	28787	50123	*145*	*83*	*57*
Hungary	1	0	0	6345	5864	8150	6346	5864	8150	*108*	*78*	*72*
Iceland	178	194		3523	3329		3701	3524		*105*		
Ireland	868	443	1469	21328	22493	31455	22195	22936	32923	*97*	*67*	*70*
Italy	37896	34574	37845	95868	86905	97570	133764	121480	135415	*110*	*99*	*90*
Japan	133562	152332	162860	221786	312504	299268	355348	464836	462128	*76*	*77*	*101*
Netherlands	192	72	3089	118650	123312	140827	118842	123384	143916	*96*	*83*	*86*
New Zealand	7147	7330	14882	26658	23337	27617	33805	30667	42499	*110*	*80*	*72*
Norway	12358	11753	12497	11212	9008	10122	23570	20761	22619	*114*	*104*	*92*
Poland	830	593		8461	7492		9291	8085		*115*		
Portugal	4663	3543	5358	26921	24628	29032	31583	28171	34389	*113*	*92*	*82*
Spain	41700	35426	69723	136127	117273	111326	177826	152699	181049	*116*	*98*	*84*
Sweden	9601	8923	8218	23471	19612	22045	33072	28535	30263	*116*	*109*	*94*
Switzerland	818	598	2898	53991	56803	56442	54809	57401	59340	*95*	*92*	*97*
United States	1891300	2120785	2670576	742671	898373	889234	2633971	3019158	3559810	*87*	*74*	*85*
United Kingdom	25598	30079	40745	359848	384506	375216	385446	414585	415960	*93*	*93*	*100*

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