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METHODOLOGICAL ISSUES

EMISSIONS RESULTING FROM FUEL USED IN INTERNATIONAL AVIATION AND MARITIME TRANSPORTATION

Note by the secretariat

Summary

This note provides information on methodological issues relating to accounting of greenhouse gas (GHG) emissions from international aviation and maritime transportation. It draws on emissions data submitted in 2002 by 29 Parties included in Annex I to the Convention (Annex I Parties) for international aviation and by 25 Annex I Parties for international maritime transportation, and information from two expert meetings organized by the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) in consultation with the secretariat. Total GHG emissions for these Parties from international aviation in 2000 were 48 per cent higher compared to 1990 levels, whereas total GHG emissions from international maritime transportation remained relatively constant during that period.

The systems for collection of statistical information by ICAO and IMO are at different stages of development. ICAO regularly estimates the amount of fuel used by each airline in the world for scheduled airline operations, but the data do have some shortcomings. The aviation community has developed models that could provide information on fuel consumption and emissions on a national basis that would enable direct comparison with data from the secretariat GHG database. The IMO does not yet have a similar system to collect or estimate fuel used by its member States.

This document contains proposed elements for future work to improve the estimation and reporting of GHG emissions from international aviation and maritime transportation.

CONTENTS

I. INTRODUCTION

A. Mandate

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its fifteenth session, invited the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), in consultation with the secretariat, to explore opportunities for examining and improving the quality of data reporting and comparability relating to fuel used in international aviation and maritime transportation.[1]

2. The SBSTA, at its sixteenth session, decided to consider the methodological aspects relating to the reporting of emissions based upon fuel sold to ships and aircraft engaged in international transportation at its eighteenth session. It invited ICAO and IMO to report on their activities in this regard at that session.[2]

B. Scope of the note

3. This document has been prepared to facilitate consideration by the SBSTA, at its eighteenth session, of methodological issues relating to accounting of greenhouse gas (GHG) emissions from international aviation and maritime transportation. It contains:

(a) Summarized GHG inventory information submitted by Parties included in Annex I to the Convention (Annex I Parties) in 2002;

(b) A discussion on definitions for domestic and international emissions;

(c) A description of the methodologies for estimating emissions from international and domestic aviation and maritime transportation included in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC Guidelines) as elaborated by the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC good practice guidance);

(d) A description of sources of activity data and other related information available under the ICAO and IMO process;

(e) A proposal for possible future work.

4. This note also draws on information from two expert meetings organized by ICAO and IMO in consultation with the secretariat. The participants in these two meetings were experts involved in the preparation of GHG inventories, experts in the aviation and marine sectors and representatives of intergovernmental organizations (the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA)). The ICAO meeting took place from 27 to 28 February 2003 in Montreal, Canada, and the IMO meeting took place on 6 March 2003 in London, United Kingdom. The purpose of these meetings was to discuss:

(a) Difficulties that Annex I Parties face in compiling and reporting GHG inventory data relating to international and domestic aviation and shipping, including methodological problems and problems with definitions of domestic and international fuel use;

(b) Links between data on emissions and other data contained in the secretariat GHG database and relevant ICAO and IMO databases and how these data can be used under the ICAO, IMO and UNFCCC processes, with a view to improving the quality of data reporting and comparability.

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[1] FCCC/SBSTA/2001/8, paragraph 19 (f).
[2] FCCC/SBSTA/2002/6, paragraph 52 (c).

C. Action by the SBSTA

5. The SBSTA may wish to consider the information contained in this document, including the future work elements proposed in chapter VI. It may also wish to invite ICAO and IMO to continue to cooperate with the secretariat on methodological issues relating to emissions from international aviation and maritime transportation and, in particular, on the work elements outlined in chapter VI.

II. BACKGROUND

6. According to the IPCC Guidelines "emissions from the use of fuels for international marine and air transport are excluded from national emissions totals".[3] This provision has been reflected in the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, part I: UNFCCC reporting guidelines on annual inventories" (UNFCCC reporting guidelines) that have been adopted under the Convention process.[4]

7. The UNFCCC reporting guidelines stipulate that "Parties should also report emissions from international aviation and marine bunker fuels as two separate entries in their inventories". This information should be reported in a table of the common reporting format (CRF) which is specifically designed for this purpose (table 1.C). In addition, Parties are required to provide an explanation on "how they distinguish between domestic marine and aviation emissions … and international bunker emissions" in their national inventory reports (NIRs), and an explanation on "how the consumption of international marine and aviation bunker fuels was estimated and separated from the domestic consumption" in the CRF table 1.C.

A. Status of reporting

8. In 2002, estimates of emissions from international aviation were provided by 29 Annex I Parties, and estimates of emissions from international maritime transportation by 25 Annex I Parties. A summary of the information provided by these Parties is provided in annex I to this report.

9. Generally, Annex I Parties have been complying with the provisions of the IPCC and UNFCCC guidelines by distinguishing between domestic and international emissions from the aviation and marine sectors and by excluding emissions from international aviation and maritime transportation from their national totals. As shown in annex I, in 2002, more than half of the Annex I Parties provided the required numerical data in the CRF (fuel consumption, emissions data).

B. Trends in emissions

10. Total aggregate GHG emissions trends for domestic and international aviation and maritime transportation reported by Annex I Parties in their 2002 GHG inventory submissions, covering the period 1990–2000,[5] are presented in figure 1. In 2000, total GHG emissions from international aviation and international maritime transportation were about 202,000 and 204,000 Gg CO_2 equivalent, respectively. Carbon dioxide is the most important GHG for this sector, accounting for about 99 per cent of the total GHG emissions in 2000; N_2O emissions accounted for 0.8 per cent and CH_4 emissions for the remaining 0.2 per cent. Total emissions from international aviation and maritime transportation together are equivalent to about 2.4 per cent of the total national GHG emissions (excluding emissions from international aviation and maritime transportation) of Annex I Parties in 2000.

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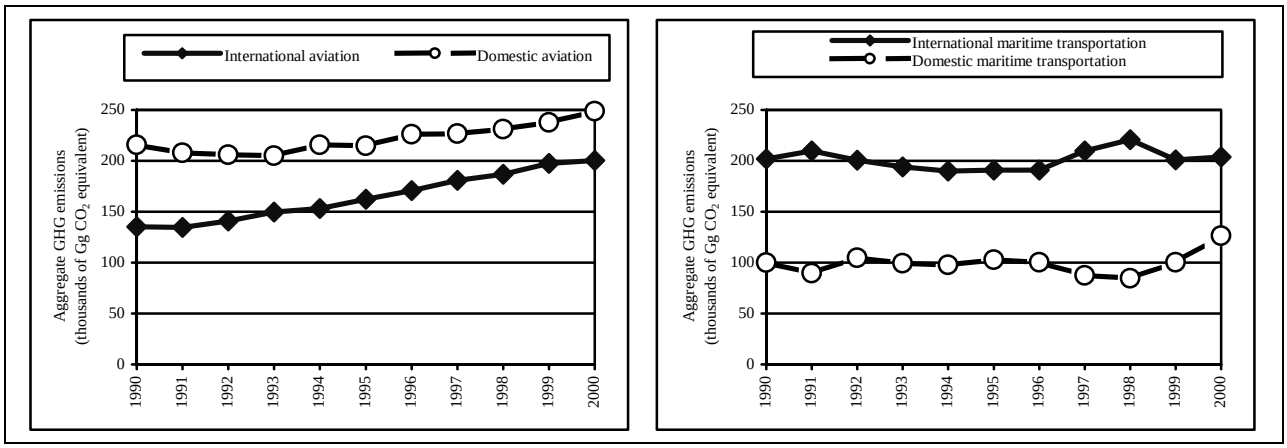
[3] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, volume 2, page 1.3

[4] Adopted under decision 3/CP.5. The full text of these guidelines is contained in document FCCC/CP/1999/7.

[5] For aviation, data from 25 Annex I Parties (excluding the European Community) that submitted emission estimates for the complete time series (1990–2000) have been considered (see annex I). For maritime transportation, data from 22 Annex I Parties (excluding the European Community) that submitted emission estimates for the complete time series (1990–2000) have been considered (see annex I).

Figure 1. Trends in emissions from domestic and international aviation and maritime transportation for Annex I Parties



11. During the period 1990–2000, international aviation emissions from Annex I Parties increased at an average annual rate of 4 per cent. This growth rate resulted in 2000 emissions being about 48 per cent higher than those in 1990. This is by far the largest increase observed for any sector for this period.[6] Domestic emissions also increased during the same period, but their growth pattern appears to have been affected by the global economic developments during this decade – a decline (slow-down) during the period 1991–1994 and a recovery after 1995. In 2000, emissions from domestic aviation were about 15 per cent higher than the 1990 levels. Comparable data are not currently available for 2001 and 2002, but ICAO reports a slowing of traffic growth in 2001 and 2002[7] and changes in fleet composition since the events of 11 September 2001, which may affect emissions.

12. In contrast, domestic and international maritime transportation emissions from Annex I Parties have remained relatively constant during the period 1990–2000. The main characteristic of the domestic and international maritime emissions is the opposite trends for the years 1990–1992 and 1996–1999. The reason for this is not obvious, although it is noted that the overall trends for domestic maritime transportation are dominated by the emissions of the United States which, on average, accounted for more than 60 per cent of the total emissions during the period 1990–2000. The second largest contributor is Japan which, on average, accounted for about 15 per cent of total emissions during the same period.

13. Emissions estimates from Annex I Parties for other gases (NO_X, CO, NMVOC, SO_2) for 2000 are presented in table 1 together with the total national emissions (excluding emissions from international aviation and maritime transportation). Generally, the emissions of these gases are relatively small (equivalent to less than 0.5 per cent of the total other emissions). The only notable exceptions are NO_X emissions from both activities and SO_2 emissions from international maritime transportation.

Table 1. Emissions of NO_X, CO, NMVOC and SO_2 (Gg) for the year 2000

	NO_X	CO	NMVOC	SO_2
International aviation	705.5 *(1.7%)*	374.1 *(0.2%)*	118.6 *(0.3%)*	23.1 *(0.1%)*
International maritime transportation	2,795.8 *(6.6%)*	152.4 *(0.1%)*	176.2 *(0.5%)*	1,163.9 *(3.8%)*
Total national emissions[a]	42,485.1	167,419.0	36,531.6	30,766.3

[a] Excluding emissions from international aviation and maritime transportation.

[6] See document FCCC/SBI/2003/7/Add.1.

[7] ICAO news releases 06/2002 and 16/2002 available at http://www.icao.int

III. DEFINITIONS OF DOMESTIC AND INTERNATIONAL EMISSIONS

14. Under the Convention and the Kyoto Protocol, emissions from domestic aviation and maritime transportation form part of the national totals and, hence, are subject to the limitation or reduction commitments of Annex I Parties. It is therefore imperative that fuel use for domestic and international transportation is disaggregated in a systematic, consistent and transparent manner.

A. IPCC definitions

15. The IPCC Guidelines provide the following definitions relating to domestic and international aviation and maritime transportation:

(a) **Aviation**: "If an aircraft goes from one airport in one country to another in the same country and then leaves for a third airport in another country, the first flight stage is considered a domestic trip while the second is considered an international trip. It is not important whether the airport is a domestic or an international airport. In addition, the type of activity (landing/take off (LTO) cycles, cruise, domestic, international) is independent of the nationality of the carrier".[8]

(b) **Marine**: Emissions from international marine bunkers: "emissions from fuels burned by seagoing ships of all flags that are engaged in international transport". National emissions: "emissions from fuel used for navigation of all vessels not engaged in international transport, except fishing".[9] This definition implies that journeys of considerable length between two ports in one country are "national" (for example San Francisco to Honolulu).

16. The IPCC good practice guidance provides elaborations on the above definitions for domestic and international operations (see table 2), which apply to both aviation and maritime transportation and should be applied irrespective of the nationality (or flag for the case of maritime transportation) of the carrier.

Table 2. Definitions for domestic and international operations, according to the IPCC good practice guidance

Type of operation		Domestic	International
A.	Originates and terminates in same country	Yes	No
B.	Departs from one country and arrives in another	No	Yes
C.	Departs from one country, makes a stop in the same country without dropping or picking up any passengers or freight, then departs again to arrive in another country	No	Yes
E.	Departs from one country, stops in the same country and drops and picks up passengers or freight, then departs again, finally arriving in another country	Domestic segment	International segment
F.	Departs from one country, stops in the same country and only picks up more passengers or freight and then departs again, finally arriving in another country	No	Yes
G.	Departs from one country with a destination in another country, and makes an intermediate stop in the destination country where no passengers or cargo are loaded	No	Both segments international

[8] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, volume 1, footnote 3, page 1.20, and volume 3, footnote 24, pages 1.92 and 1.93.

[9] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, volume 1, page 1.5.

B. ICAO definitions

17. Under the ICAO process, the following definitions have been agreed for the purposes of classifying flight stages when reporting air carrier statistical data to ICAO:

(a) Domestic flight stage: a flight stage flown between points within the domestic boundaries of a State by an air carrier whose principal place of business is in that State. Flight stages between a State and territories belonging to it, as well as any flight stages between two such territories, should be classified as domestic. This applies even though a stage may cross international waters or the territory of another State;

(b) International flight stage: a flight stage with one or both terminals in the territory of a State other than the State in which the air carrier has its principal place of business should be classified as international;

(c) In the case of multinational airlines owned by partner States, traffic within each partner State should be reported separately as domestic and all other traffic as international.

18. Comparing the IPCC and the ICAO definitions, it is clear the IPCC definition of international operations is narrower than the ICAO one in that the latter omits domestic stages flown by foreign carriers – an observation also noted in the IPCC Guidelines. In practice, the difference between the two definitions relates to cabotage traffic,[10] which constitutes a very small proportion of total traffic. However, this proportion may grow as air transport agreements between States become more flexible with increased liberalization.

C. IEA definitions

19. One source of information on fuel consumption that is often used and quoted by Parties is the energy statistics of the IEA. These statistics cover domestic and international aviation and shipping and are based on national reporting in the Joint IEA/Eurostat/UNECE (United Nations Economic Commission for Europe) annual questionnaires submitted to IEA by its member Countries. IEA has developed the following definitions for fuel consumption in air and sea transportation; these definitions form part of the questionnaires that IEA member Countries complete and submit to IEA annually:[11]

(a) Domestic air transport: consumption of aviation fuels by domestic aircraft (commercial, private, agricultural, etc.); includes oil used for purposes other than flying (e.g. bench testing of engines) and military use of aviation fuels; excludes use by airlines of motor-spirit for their road vehicles;

(b) International civil aviation: consumption of aviation fuels other than for domestic aircraft activities;

(c) Inland waterways, coastal shipping:[12] quantities of oil consumed on inland waterways and by coastal shipping (for example, small craft, barges, and those coastal ships which are not included in international marine bunkers);

(d) International marine bunkers: quantities of fuels delivered to sea-going ships of all flags, including warships.

20. Although, the IEA definitions appear to be generally consistent with the IPCC Guidelines, they could introduce ambiguities because, for example, the IEA definition of domestic air transport uses the

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[10] Airline cabotage is the carriage of air traffic that originates and terminates within the boundaries of a given country by an air carrier of another country.

[11] The oil questionnaire of IEA can be found at http://www.iea.org/statist/centre/quest.htm

[12] According to IEA oil consumption, and the corresponding emissions, by users classified as fishing (ocean, coastal and inland fishing) should be reported under the IEA subcategory Agriculture.

term "domestic aircraft" rather than defining what constitutes the domestic segment of a flight. This could lead to accounting for part of the fuel used for operations such as C, E and G of the IPCC (see table 2) as domestic consumption.

21. Because the IEA does not have direct access to the underlying disaggregated national statistical information used to produce the aggregate figures that it publishes annually, it is difficult to assess how countries interpret these definitions and whether they use them in a systematic and consistent way. Every five or six years IEA, together with Eurostat and UNECE, organizes Energy Statistics Working Group meetings to discuss possible changes to its annual questionnaires. In the next meeting, definitions for domestic and international aviation and maritime transportation could be discussed with the aim of reducing ambiguities and better harmonizing them, if possible, with those used by other international organizations.

D. Other definitions

22. The *Joint EMEP/CORINAIR*[13] *Atmospheric Emission Inventory Guidebook* (Third Edition, Copenhagen: European Environment Agency) explains that national sea traffic includes "all national ship transport including ferries, irrespective of flags, between ports in the same country, localised within the EMEP area." This definition implies that, for example, Danish traffic to the Faeroe Islands and Norwegian traffic to Svalbard is included as "national" whereas Danish traffic to west Greenland is excluded. French traffic between Atlantic and Mediterranean ports is also national.

23. Although IMO does not have an official definition for international bunker fuels, Regulation 6 of Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) specifies that an international air pollution prevention certificate shall be issued to "any ship of 400 gross tonnage or above engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties".[14]

E. Reporting by Parties

24. Annex II presents explanatory information reported by some Annex I Parties on how the quantity of fuel used for international aviation and maritime transportation was estimated and separated from domestic consumption. These descriptions are not always clear and some of them refer to inherent difficulties associated with separating international and domestic fuel consumption through the use of existing national statistical procedures.

25. From the information in annex II, it is apparent that there is no uniform approach among Annex I Parties for disaggregating fuel use data into domestic and international components. Fuel use for domestic and international purposes is estimated in various ways by national statistical agencies using, for example, information on fuel taxation (Australia), information on the flag or country of registration of carriers (Canada, Portugal), information direct from oil companies (Iceland, New Zealand), or information from airlines (Norway). In other cases, the national statistical agencies provide total amounts of fuel and the domestic and international amounts are estimated by using surrogate data. For example, for aviation fuels, Austria, France, Sweden and the United Kingdom use LTO cycles and "default" fuel consumption factors, whereas the United States uses jet fuel expenditures and information on the flag of the carriers.

26. Some Parties reported problems with distinguishing between domestic and international fuel use. Belgium allocated all fuel used for maritime transportation as international bunkers because data on fuel use were not available; Estonia allocated all fuel consumption for aviation as domestic aviation; in

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[13] EMEP: Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe. CORINAIR: a project to gather and organize information on emissions into the air relevant to acid deposition in the context of the work programme CORINE (CO-oRdination d'INformation Environnementale).

[14] Annex VI of MARPOL 73/78, *Regulations for the Prevention of Air Pollution from Ships*, IMO, London, 1998.

Finland there are differences in the definitions of international transportation used by two national agencies; in Sweden the division into domestic and international maritime operations (for the period 1990–1999) was approximate and not well documented.

27. The United States identified two problems that affect the level of emissions from international aviation and are related to specific definitions used by national agencies. In particular, international flight segment fuel data used for United States flagged carriers do not cover smaller air carriers, and flights departing to Canada and some flights to Mexico are defined as domestic instead of international.

28. The problem of characterization of domestic and international flights may also apply to the GHG inventory submission of the European Community (EC). For the sectoral approach, emissions from international aviation and maritime transportation of the EC inventory are estimated by summing the individual emissions of the 15 member States. This approach may not appropriately reflect the emissions of the EC as an individual Annex I Party because, for example, a flight from Madrid to Berlin may be allocated as international by either Spain or Germany but, in practice, it would be a domestic flight for the EC inventory. The EC mentioned in its NIR that a project has been initiated to improve the quality of the estimates of emissions from international aviation.

29. For both the United States and the EC, it is not possible to assess the actual impact of these problems on the emissions levels because relevant information (for example, amounts of fuel used by small carriers in the United States or amounts of fuel use for flights between member States of the EC) is not available in the national inventory reports.

IV. METHODOLOGIES USED FOR ESTIMATING GHG EMISSIONS

A. Aviation

30. One Tier 1 and two Tier 2 methods (designated Tier 2a and 2b) are outlined in the IPCC Guidelines. All methods are based on distinguishing between domestic fuel use and international fuel use. The Tier 1 method is purely fuel based, whereas the Tier 2 methods are based on the number of LTO cycles and fuel use. National approaches can also be used if they are well documented and have been peer reviewed. Clearly, the choice of method depends on national circumstances, particularly the availability of data.

Tier 1 method

31. The simple Tier 1 method is based on an aggregate figure of fuel consumption for civil aviation multiplied by average emissions factors. The emissions factors have been averaged over all flying phases based on the assumption that 10 per cent of the fuel is used in the LTO phase of the flight.

Tier 2 method

32. The Tier 2 method is only applicable for jet fuel use in jet engines. In the Tier 2 method a distinction is made between emissions below and above 914 m (3,000 ft) in order to increase the accuracy of the estimates, because emission factors and fuel use factors vary between phases of the flight. The emissions in these two flying phases are estimated separately. Emissions and fuel used in the LTO phase are estimated from statistics on the number of LTOs (aggregate or per aircraft type) and default emission factors or fuel use factors per LTO cycle (average or per aircraft type).

33. This method can be applied at either the aggregated level of all aircraft (Tier 2a) or at the level of individual aircraft types (Tier 2b). For the Tier 2b approach, the estimate should include all aircraft types frequently used for domestic and international aviation. For the Tier 2a approach, all aircraft are included and the IPCC Guidelines provide aggregate emission factors per LTO.

34. Cruise emissions depend on the length of the flight, among other variables. In the Tier 2 method the fuel used in the cruise phase is estimated as total fuel use minus fuel used in the LTO phase of the

flight. Fuel use is estimated for domestic and international aviation separately. The estimated fuel use is multiplied by aggregate emission factors (average or per aircraft type) in order to estimate the emissions. The resource demand for the various tiers depends on the number of air traffic movements and the availability of the data in the country. Tier 1 and Tier 2a, based on aggregate LTO data, should not require considerable resources, but Tier 2b, based on individual aircraft, may be very time–consuming.

Reporting by Parties

35. In 2002, a total of 10 Annex I Parties (Australia, Belgium, Canada, Denmark, Finland, France, Netherlands, Sweden, United Kingdom and United States) provided information on the methodologies used for estimating emissions from international aviation in their NIRs. Five Parties reported that they used the Tier 1 method, three Parties reported that they used a Tier 2 method and two Parties reported that they used a hybrid method (Tier 1 for CO_2 and Tier 2 for other gases).

B. Maritime transportation

36. The IPCC Guidelines present two tiers of methods for estimating emissions of CO_2, CH_4 and N_2O from water-borne navigation. Both tiers rely on essentially the same analytical approach, which is to apply emission factors to fuel consumption activity data. The IPCC good practice guidance suggests that Parties should use Tier 1 for CO_2 and Tier 2 for CH_4 and N_2O. National approaches may also be used if they are well documented and have been peer reviewed.

Tier 1 method

37. Use of Tier 1 to estimate CO_2 emissions is based on fuel consumption by fuel type, the carbon content of the fuel, and the fraction of the fuel left unoxidized. The fuel consumption data and emission factors in the Tier 1 method are fuel-type- and mode-specific.

Tier 2 method

38. Use of Tier 2 to estimate non-CO_2 emissions is also based on fuel consumption by fuel type, but there is a variety of generic and country-specific emission factors for selected fuel, engine and vehicle types. The Tier 2 method presents a variety of emission factors requiring varying degrees of specificity in the classification of modes, fuel type, and even engine type.

Reporting by Parties

39. In 2002, nine Annex I Parties (Australia, Belgium, Canada, Finland, France, Netherlands, Sweden, United Kingdom and United States) provided information on the methodologies used for estimating emissions from international maritime transportation in their NIRs. All nine Parties reported that they used the Tier 1 method.

V. ICAO AND IMO EXPERT MEETINGS

40. The main items on the agendas of the two expert meetings were the definitions of domestic and international fuel use, and methodological issues (availability of information relating to activity data (fuel consumption, types of engines, routing), emission factors, etc.). The main findings and conclusions are summarized below. Prior to both meetings, the secretariat provided information on fuel consumption and emissions data from Annex I Parties for the consideration of the ICAO Committee on Aviation Environmental Protection (CAEP) and the IMO Marine Environment Protection Committee (MEPC). No equivalent statistical information was made available from ICAO or IMO.

A. Definitions of domestic and international fuel use

41. At both meetings experts emphasized that the application of the definitions of domestic and international fuel use is closely related to the availability of statistical information, and agreed that the existing definitions may need to be revisited. The IPCC definitions could be revisited as part of the

revision of the IPCC Guidelines (see section V.C), taking into consideration the existing sources of information, any outcome of projects currently under development, and any other relevant methodological work on aviation and maritime transportation.

42. During the ICAO meeting it was emphasized that, in 2002, the steering group of the CAEP concluded that it would be appropriate for the CAEP to take the IPCC definitions into account in its work on market-based measures to address emissions.[15] It was also noted that Annex I Parties have used the IPCC Guidelines since 1997, that detailed information on the methodologies used has been provided in NIRs only since 2000, and that the IPCC good practice guidance is to be applied by all Annex I Parties from 2003 onwards. The technical review process for GHG inventories may provide useful information to assess whether the more detailed definitions of the IPCC can be applied in practice.

B. Methodological issues

1. International aviation

43. The experts participating in the ICAO meeting emphasized that aviation emissions are unique in that they are injected into the atmosphere at altitude. They agreed that the uncertainty in the emissions estimates was primarily related to definitions, data sources and the methodologies used. They also noted that although the detailed methodologies in the IPCC Guidelines (Tiers 2a and 2b) are demanding in terms of activity data and relevant parameters, they are still not as detailed as some emissions modelling methods developed under the ICAO process.

Activity data

44. For some years, ICAO has collected data from States for the purpose of estimating and comparing airline costs in different regions of the world, for a study entitled *Regional Differences in International Airline Operating Economics*, (formerly *Regional Differences in Fares, Rates and Costs for International Air Transport*). In order to determine fuel costs, estimates are made of the amount of fuel used by each airline, based on information from the schedules of operations (not on actual operations performed), the aircraft used and the fuel consumption characteristics of each aircraft type. Based on this information it has been possible to obtain an approximate figure for how much fuel each airline has used, and since 1991 it has been possible to distinguish between national and international services. From these fuel consumption figures, it is possible to estimate emissions for each airline. However, the fuel data do have some shortcomings, notably that non-scheduled operations are not included (particularly significant in Europe), the reliability of the information is not uniform for all regions, and there is some inaccuracy in fuel consumption estimates (because aircraft are assumed to fly from A to B using great circle mileage and because detailed information on some aircraft types is unavailable and the characteristics of some of the latest types may not be adequately reflected).

45. Each of ICAO's Contracting States (188 in total) has undertaken that its international airlines shall file the statistics requested by the Council of ICAO in accordance with Article 67 of the Convention on International Civil Aviation. As a result, ICAO has a long-established Statistics Programme that collects comprehensive statistical data from States on a regular systematic basis. For each State, ICAO has a number of different measures of aviation activity such as tonne-kilometres available (measure of capacity offered), tonnes-kilometres performed (measure of traffic carried) and operational parameters such as departures, aircraft-kilometres and aircraft hours flown. This information, however, has limited use for estimating GHG emissions from aircraft.

46. The International Air Transport Association has initiated a data collection project in the context of its Fuel Efficiency Goal that relates to improving environmental performance of airlines by introducing quantifiable efficiency improvements, the objective being an overall fuel efficiency

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[15] CAEP-SG-WP/3, paragraph 5.1 and 5.2, May 2002; and CAEP-SG2002-SD/2.

improvement of 26 per cent over the period 1990–2012. The information that is currently collected under this project includes total fuel consumption for international, domestic and system-wide operations on an annual basis for all services, including cargo and charter services. The information that has been collected so far is for only some of the world's airlines and relates only to the years 1999–2001. It should be noted that the definitions used for the above-mentioned categories are the ICAO definitions. This means that additional work would be necessary to convert the stored data to correspond to the IPCC definitions.

47. Other aviation-related information (although some of it may be confidential) includes detailed data for each segment of any flight, including longitude, latitude, altitude and time. Such information is collected by aviation institutions, such as EUROCONTROL, but is not made publicly accessible. Storing these data from all flights around the world requires considerable storage capacity (more than 3 TB for a year's worth of data), and processing these data, for the purpose of estimating GHG emissions, requires sufficient expertise, specialized software packages and extensive computing power.

Emission factors

48. The ICAO Engine Exhaust Emission Data Bank is one of the projects of the ICAO/CAEP Emissions Working Group and is maintained and updated by QinetiQ (United Kingdom). This data bank is referenced in the IPCC Guidelines as a source of information for GHG inventories. It includes data on all engines that have been certified for emissions compliance and any engines before the requirement for certification was established (1 January 1983 for smoke and 1 January 1986 for gases). The data bank holds information for four specific power conditions during an LTO cycle (take-off, climb out, approach, idle) including fuel flow (kg/s) and emissions indices (kg/kg fuel) for hydrocarbons, CO and NO_X.

49. The fuel data stored in the data bank cannot, however, be used to determine cruise fuel consumption or cruise emission factors. This information could be obtained either from manufacturers' proprietary performance codes or from non-proprietary performance codes, at an accuracy adequate for inventory generation purposes.

Estimating emissions using models

50. The software tools developed within the aviation community are primarily aimed at modelling the volume of emissions from aircraft and the location where they are injected (longitude, latitude and altitude). The output of these tools forms the basis of databases which are relatively sophisticated and have been designed, in consultation with the scientific community, to provide a better understanding of the impact of emissions (for example for the IPCC Special Report in 1999) and ultimately as a basis for policy-making within ICAO and its CAEP. They are constructed on a route or airport-to-airport basis, rather than on a national basis.

51. One such model is the AERO model,[16] which can provide estimates for fuel consumption and emissions for both domestic and international aviation on a national basis, although it was originally designed to yield data on a route or airport-to-airport basis. A preliminary comparison of common reporting format data with data from the AERO model, prepared for the ICAO meeting, shows relatively good agreement for fuel consumption and emissions of CO_2 and NO_X.[17]

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[16] 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, within the context of emissions from other (ground) sources. By defining future scenarios, model users can analyse the environmental effects of a wide range of autonomous trends (economic, technical and political) and abatement measures (regulatory, fiscal, operational and technical) at both the global and the regional level.

[17] *Comparison of UNFCCC Data on Emissions from Domestic and International Aviation with Data from the AERO Model*, SMI-WP/3, ICAO, February 2003. This report can be obtained directly from the ICAO secretariat (attention: Secretary of CAEP).

2. International maritime transportation

Activity data

52. In 2000, the IMO prepared a study on GHG emissions from ships, which was supported by national studies. However, the IMO does not compile fuel consumption or emissions data on a regular basis. Recently, several special studies on the regional impact of GHG emissions have been carried out by some IMO States, but the results of these studies have not yet been published. In addition, sections of the international oil industry and the bunker suppliers have also developed statistics on oil deliveries to the maritime sector, but this information is not directly applicable for the purpose of UNFCCC GHG inventories.

Emission factors

53. During the IMO meeting, it was agreed that a reasonable estimate of GHG emissions, especially CO_2 emissions, can be obtained from data on the quantity of bunker oils delivered to ships. It was proposed that a more relevant factor to use in the calculation of CO_2 emissions may be g/kWh and that emission factors are more relevant to the calculation of SO_X and NO_X emissions. In relation to N_2O or CH_4, it was noted that the contribution of these gases to total emissions is only a fraction of that of CO_2. For these two gases, specific emission factors are not available.

54. Some experts were of the view that it is possible to develop precise emission profiles for each ship (similar to the ICAO work). However, it was acknowledged that the research necessary to develop such profiles and emission factors would be very expensive and complicated because there are many operations and parameters that may influence the GHG emissions in the course of a voyage (for example, boilers usage, ship board operations carried out an route, refrigeration plant on board reefer ships or the operation of refrigerated containers on board a container ship, speed of a ship or power output). In addition, the movement of international (and domestic shipping) is more difficult to track than is air traffic where almost all traffic is monitored by air traffic control systems. If the GHG emission for a voyage were to be calculated in segments of the voyage, estimation of GHG emissions per voyage would be extremely difficult. Moreover, the world's ships make a vast number of voyages each year, making the estimation of total GHG emissions from shipping an almost impossible task.

C. IPCC work relating to greenhouse gases

55. The IPCC is in the process of developing an Emission Factor Database based on information provided in the IPCC methodology reports and by other data providers (for example, researchers, scientists, industry, inventory compilers) on a voluntary basis. In response to an invitation by the SBSTA, at its seventeenth session,[18] the IPCC has initiated the process for the revision of the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. The revised guidelines are expected to be finalized by early 2006. Even after the publication of the new revised guidelines, the current IPCC Guidelines will be used by Annex I Parties to estimate GHG emissions for the period 2008–2012, in accordance with decision 2/CP.3.

56. ICAO and IMO experts expressed their willingness to assist in both projects. In particular, for the revision of the IPCC Guidelines they expressed their desire to be involved in any revision of the methodologies for aviation and maritime transportation at as an early stage as possible.

57. In relation to emissions from maritime transportation, the Correspondence Group on Air Pollution of the MEPC has been instructed to collect information and references on the work undertaken on GHG emissions from international shipping and comment on the associated methodology for calculating and reporting GHG emissions according to the IPCC Guidelines and good practice guidance. An additional task, which may also provide useful information on CO_2 emissions, is the review of

[18] FCCC/SBSTA/2002/13, paragraph 14 (f).

options for quantifying CO_2 emissions and the applicability of these emissions for use in an indexing system for ships.

D. Future developments

1. ICAO modeling activities

58. During the ICAO meeting, it was noted that, in addition to the AERO model (see para. 51), specific tools are being developed that could be endorsed by ICAO to provide estimates of emissions for each Annex I Party (including the domestic/international split). This information could be used by the UNFCCC process to further improve the quality of data reported. Further discussions need to take place within the CAEP process on when these tools could be made available.

Global aircraft emissions data project for climate impacts evaluation (AERO2K)

59. AERO2K is a European Union 5th Framework Programme project aiming to produce a new global 4D inventory of fuel usage and emissions of pollutants (NO_X, CO, hydrocarbons, CO_2, particles) for the year 2001–2002 and a forecast for the year 2025, which will be used for assessing aircraft impacts on the upper atmosphere. This information will be derived from movements of civil (all categories) and military aviation with a spatial resolution of 1 degree latitude x 1 degree longitude x 0.5 km in height, by month and include high time resolution (hours) for representative days. The project is due to be completed by March 2004.

System for assessing aviation's global emissions (SAGE)

60. SAGE is a modelling system to forecast aircraft operations and estimate aircraft emissions (CO_2, CO, NO_X, hydrocarbons) as a function of altitude and geographic location, with potential functionality to compute the costs and benefits of aviation emission-mitigation options. This model will be used to estimate and evaluate the global environmental impact of aircraft emissions for all phases of flight (LTO cycle and cruise). SAGE should be capable of simulating activity level, fleet mix and operational routes in order to quantify emissions for geographic regions. The evaluation will be done in a grid of spatial resolution of 1 degree latitude x 1 degree longitude x 1 km in height. As part of the ongoing programme beyond model development, it is anticipated that SAGE will be used to conduct periodic forecasts of national and global emissions.

2. Entry into force of Annex VI of MARPOL 73/78

61. Annex VI of MARPOL 73/78 is expected to enter into force during 2004. Regulation 18 of Annex VI stipulates that for each ship greater than 400 gross tonnage (GT) "details of fuel oil for combustion purposes delivered to and used on board shall be recorded by means of a bunker delivery note" (BDN).[19] The BDN will be provided by fuel suppliers and will include information on ship IMO number, ship size/type, date and place of bunker operation and quantity of all delivered bunkers (diesel oil through to heavy fuel oils). Although not explicitly specified in Annex VI, a bunker receipt of some type will also be supplied to ships of less than 400 GT. The existence of a BDN avoids double counting, as each delivery will generate only one bunker receipt.

62. A register is to be maintained of local bunker suppliers by port (or other) authorities, and bunker suppliers shall retain the bunker receipts for three years from the date of supply. Consequently, after the entry into force of Annex VI, data will be available from all port authorities on all bunker loading. Governments should be able to collate this information and establish how much fuel is supplied to shipping by year. A national/international split could be estimated by the selection of a lower limit of ship gross tonnage (at present 400 GT).

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[19] Annex VI of MARPOL 73/78, *Regulations for the Prevention of Air Pollution from Ships*, IMO, London, 1998.

63. However, not all fuel supplies will be covered under Annex VI. Fuel delivered for intra-national non-commercial use and for recreational–national only use would not be counted, but these amounts may not be substantial. Military and non-commercial state-owned ships will also not be counted, because governments in most countries buy, store and deliver fuel for such usage. However, such data may be available from other national sources (e.g. Ministries of Defence).

VI. POSSIBLE FUTURE WORK

64. At the end of both expert meetings, ICAO and IMO experts welcomed the convening of these meetings and the exchange of ideas and information that had taken place. They also expressed their support for further, similar meetings that may need to be initiated to ensure the necessary cooperation between the ICAO, IMO and UNFCCC process regarding emissions from aviation and maritime transportation.[20] Meanwhile, the conclusions of the ICAO and the IMO meetings will soon be reviewed by the CAEP and the MEPC, respectively. Based on the discussions during the two expert meetings, the following possible further work elements are proposed:

(a) Comparison of UNFCCC data and data provided by ICAO. ICAO should be requested to provide modelled fuel consumption and emissions data arising from the use of validated aviation models for at least 2000 and 2001, before SBSTA 19. This would include data by country, airline and aircraft/engine combination. These data should enable a further comparison to be made of national CRF data and data provided by ICAO and may provide insights on how to improve the quality of data reporting, including revised and updated emissions factors. The secretariat proposes to provide a document comparing the data, including trends, for SBSTA 19;

(b) Assessment of options for improving the methodologies for estimating and reporting GHG emissions from international aviation. Based on the above data comparison, the secretariat, in cooperation with ICAO, would identify options to improve the methodologies for estimating and reporting GHG emissions from international aviation for SBSTA 20. The SBSTA may also wish to consider whether an expert meeting or workshop on this topic would be warranted;

(c) Assessment of options for improving the methodologies for estimating and reporting GHG emissions from international maritime transportation. Following the work of the Correspondence Group on Air Pollution of the MEPC (see paragraph 57), the secretariat, in cooperation with IMO, would identify options to improve the methodologies for estimating and reporting GHG emissions from international maritime transportation for SBSTA 20. The SBSTA may also wish to consider whether an expert meeting or workshop on this topic would be warranted;

(d) Regular exchange of information on GHG emission. Updated GHG emissions data and other relevant information, including emissions forecasts, on the aviation and maritime transportation sectors would be exchanged, as they become available, between ICAO, IMO and the secretariat. The secretariat will forward data provided by ICAO and IMO to expert review teams to support their work.

(e) Regular exchange of information on GHG emission. Updated GHG emissions data and other relevant information, including emissions forecasts, on the aviation and maritime transportation sectors would be exchanged, as they become available, between ICAO, IMO and the secretariat. The secretariat will forward data provided by ICAO and IMO to expert review teams to support their work.

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[20] The convening of any future meetings will be considered in the light of the outcome of the forthcoming meetings of the CAEP, MEPC and SBSTA. In addition, any budgetary implications for ICAO, IMO and the UNFCCC secretariat would need consideration.

Annex I

Emissions data reported by Annex I Parties in their 2002 GHG inventory submissions (CRF table 1.C)

Party	Years	International aviation								International maritime transportation							
		Fuel amount	Emissions data for:							Fuel amount	Emissions data for:						
			CO_2	CH_4	N_2O	CO	NO_X	NMVOC	SO_2		CO_2	CH_4	N_2O	CO	NO_X	NMVOC	SO_2
Australia	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Austria	1990–2000	√	√	√	√	√	√	√	√								
Belgium	1990–2000		√	√	√	√	√	√	√		√						
Bulgaria[a]	1999	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√
Canada	1990–2000	√	√	√	√					√	√	√	√				
Czech Republic	1990, 2000	√	√	√	√	√	√	√	√								
Denmark	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Estonia	2000					√	√	√		√	√						√
European Community[a]	1990–2000		√	√	√	√	√	√	√		√	√	√	√	√	√	√
Finland	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
France	1990–2000	√	√			√	√	√	√	√	√		√	√	√	√	√
Germany	1990–2000		√	√	√	√	√	√	√		√	√	√	√	√	√	√
Greece	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Hungary[a]	2000	√	√			√											
Iceland[a]	2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Ireland	1990–2000	√	√			√	√	√	√	√	√			√	√	√	√
Italy[a]	2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Japan	1990–1999	√	√	√	√	√	√	√		√	√	√	√	√	√	√	
Luxembourg	2000		√			√	√	√	√								
Netherlands	1990–2000	√	√							√	√						
New Zealand[a]	2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Norway[a]	1990, 1998–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Poland[a]	2000	√	√	√	√					√	√	√	√				
Portugal	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Romania	1992, 1994–1997, 1999					√	√	√	√								
Russian Federation	1997–1999										√	√	√				
Spain	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Sweden	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Switzerland[a]	2000	√	√	√	√	√	√	√	√								
United Kingdom	1990–2000	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
United States	1990–2000	√	√	√	√	√	√	√		√	√	√	√	√	√	√	

Note: Grey cells indicate that the activity is not occuring in the Party

[a] The Party provided emissions data for the period 1990–2000 in the CRF trends table (table 10).

Annex II

Information provided by Annex I Parties in their 2002 GHG inventory submissions on the distinction between domestic and international emissions[a]

Party	Aviation	Maritime
Australia	No special methodology is required to disaggregate international and domestic aviation and navigation fuel consumption. In Australia, data on international and domestic fuel consumption are collected separately due to the differential excise tax placed on the fuel. Petroleum companies collect and report these data to the Department of Industry, Science and Resources.	
Austria	Kerosene consumption in Austria is divided into national and international traffic by using national LTO-statistics.	
Belgium	Concerning air transport, only domestic air traffic is considered for calculating the CO_2-emissions. All kerosene used in air transport is assigned to the bunker fuels, all gasoline for air transport is allocated to domestic air transport. This approach was chosen because it is impossible to split these fuels otherwise and because, due to the small size of Belgium (and Flanders), most kerosene is used for international transport. Emissions are calculated for 3 airports for civil aviation (inclusive the international airport of Brussels-National) and for 3 airports for military aviation. Emissions from military flights are estimated by the Flemish region for Belgium.	The fuel consumption by inland navigation is extracted from the energy fuel balance in the Walloon region. The available data do not permit to separate national and international emissions.
Canada	In the Canadian inventory, any fuel recorded by Statistics Canada as having been sold to foreign registered marine or aviation carriers is excluded from national inventory emission totals. Unfortunately, it is not clear whether or not all of the fuel sold to foreign registered carriers in Canada is used for international transport. Conversely, it has become apparent that not all of the fuels sold to domestically registered carriers are consumed within the country. In Canada, modified statistical procedures may be required to more accurately track bunker fuels.	
Denmark	In the Danish emission inventories presented in the CRF the distinction between domestic marine and aviation emissions, which are to be included in the national totals, and international bunker emissions, is made in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. This means that domestic marine and aviation emissions are emissions that are coming from the transportation between two national harbours or airports. However, a minor part of the present international bunker emissions is actually emissions coming from transportation between Denmark and Greenland and between Denmark and the Faroe Islands. These emissions should be included in the national totals due to national circumstances. This issue will be further elaborated in the near future.	
Estonia	Fuel consumption for aviation (919TJ) is not split into domestic and international consumption and is included in the air transport sector (for domestic use).	In Energy Balance (the data source) is data on fuel consumption by international navigation separately given (under "Marine Bunkering").
European Community	Reference approach: For international bunkers, only fuel consumption for international navigation is available separately; data on international aviation is not estimated separately. Therefore, total CO_2 emissions as estimated with the IPCC reference approach on basis of Eurostat data include CO_2 emissions from international aviation. Sectoral approach: International bunker emissions of the EC inventory are the sum of the international bunker emissions of the Member States.	

[a] These texts are reproduced verbatim from Parties' submissions, without editing.

Party	Aviation	Maritime
Finland	Fuel consumption by transport mode from the Energy statistics; fuel sales to ships and planes going abroad. The case of Åland could be seen as an exception to the IPCC definitions. In the present inventory all trips going to Sweden via Åland are treated as international, because hardly any passengers (or cargo) leave or enter the ships in Åland. According to the IPCC methodology, the trip should be divided into domestic and international parts. There are differences in the definitions of international transportation (international bunker emissions) in the Technical Research Centre of Finland's LIPASTO model and in the ILMARI system. Harmonisation of emission factors in the ILMARI and LIPASTO calculation models is underway. The results will be updated to the CRF tables as soon as possible.	
France[b]	Aviation bunker : the fuel consumption for international aviation is deduced from the balance between the total aviation fuel sale and the estimation of the domestic traffic consumption which is calculated with a detailed approach (based on the individual aircraft movements and using ICAO, MEET and CORINAIR sources of information).	The UN-ECE definition for international marine traffic is considered. Thus a part from the French bunker fuel is counted within the international marine bunkers. The share of the national traffic is defined as the traffic between two ports located in the same country inside zone EMEP (roughly Europe). Thus the connection Le Havre – Ajaccio is entered in the French emissions, even if the emissions occur partly far from France. Conversely, the emissions of a ferry connecting Dover and Calais are not included in the national total. Emissions from Fishing are included in domestic totals (taken into account the consumption of energy in this sector) irrespective of where fishing takes place.
Iceland	Emissions are calculated on the basis of sold fuel. The oil companies in Iceland report every year sold fuels, categorized in a way that separates consumption of international bunkers from domestic consumption.	
Netherlands	For calculating CO_2 emissions from domestic air transport domestic fuel sales figures for aircraft from the Netherlands' Energy Statistics were used. International air transport includes only CO_2 emissions from aircraft estimated in accordance with bunker fuel sales in the Netherlands.	Inland shipping emissions are based on fuel sold within the Netherlands corrected for a small part of 'Dutch' fuel consumed in other countries, e.g. when moving along international waterways. International shipping includes only CO_2 emissions estimated according to bunker fuel sales in the Netherlands
New Zealand	The data on fuel use by international transportation come from the Energy Data File (a Ministry of Economic Development Publication). This sources information from oil company returns to the Ministry of Economic Development. Data on fuel use by domestic transport are sourced from the Deliveries of Petroleum Fuels by Industry survey undertaken by Statistics New Zealand. The distinction between domestic and international transport is made easier because New Zealand is an island nation.	

[b] Unofficial translation.

Party	Aviation	Maritime
Norway	Total sales to air transport (from the sales statistics) exclusive of use in domestic air transport (figure based upon reports from the airlines).	The Norwegian sales statistics for liquid commercial fluids give figures for sales to marine bunkers.
Poland	The consumption of international marine and aviation bunkers fuels is based on Polish Central Statistical Office figures	
Portugal	Allocation of domestic and international emissions are based on fuel consumption by company flag, and not on the real traffic inside and outside the country.	
Spain	For the emissions corresponding to international sea and air traffic, the activity variable have been taken to be the fuel consumption figures appearing in the energy balance sheets as allocated to the respective international traffic flows: a) international marine bunkers; and b) international aviation, respectively.	
Sweden	The consumption of aviation fuel reported in the Swedish Energy Statistics is split into international and domestic use by information from the Swedish Aviation Board. The division between domestic and international flights is made according to the calculations for CORINAIR made by the Swedish EPA. These calculations are in turn based on calculations from the Swedish Civil Aviation Administration. LTO-cycles are considered according to the Good Practice Guidance.	The consumption of marine international bunkers is separately reported in the Swedish Energy Statistics. For 2000, emissions from domestic and international Navigation are calculated on the basis of fuel consumption according to a survey to wholesale dealers. For the year 2000, Military use is separated and reported under 1A5b. Information on emissions from navigation, and division between domestic and international marine operations, has been collected from the Swedish Maritime Administration for the years 1990–1999. The quality of the calculated emissions is considered to be representative, but the division into national and international operations is approximate and not well documented.
Switzerland	International aviation bunker consumption is the difference between apparent and domestic consumption. Consumption of aviation gasoline in international aviation is negligible (< 0.5% of the total aviation consumption) and is treated as jet kerosene.	
United Kingdom	Aviation: Domestic consumption is estimated from LTO data and total domestic air km using IPCC default fuel consumption factors. Aviation bunkers are estimated from total sales of aviation fuel in the UK less domestic and military consumption. (A more detailed explanation is provided in the NIR)	Marine: Fuel consumption by marine bunkers is reported in the UK Energy Statistics. A correction is applied for naval consumption. (A more detailed explanation is provided in the NIR)

Party	Aviation	Maritime
United States	Activity data from three sources was aggregated. First, it was assumed that 50 per cent of the fuel used by United States flagged carriers for international flights was purchased in the United States and used for departures. Second, fuel consumption by foreign flagged carriers departing the United States was estimated using data on jet fuel expenditures by carriers departing United States airports and approximate average fuel prices paid by air carriers for aircraft on international flights. Third, data on jet fuel expenditures by the United States military and estimates of the percentage of each services' total operations that are international operations were obtained from the Department of Defence (DoD). Military aviation bunkers include international operations, operations conducted from naval vessels at sea, and operations conducted from United States installations principally over international water in direct support of military operations at sea. Data on fuel delivered to the military within the United States was also provided by the DoD. Together, the data allow the quantity of fuel used in military international operations to be estimated. (A more detailed explanation is provided in the NIR).	Total fuel consumption by cargo or passenger carrying marine vessels and military marine vessels departing United States ports was estimated, and then subtracted from United States totals. (A more detailed explanation is provided in the NIR).

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