NASA Contractor Report 4700

Scheduled Civil Aircraft Emission Inventories for 1992: Database Development and Analysis

Steven L. Baughcum, Terrance G. Tritz, Stephen C. Henderson, and David C. Pickett

Contract NAS1-19360
Prepared for Langley Research Center

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Executive Summary

This report describes the development of a database of aircraft fuel burned and emissions from scheduled air traffic for each month of 1992. In addition, the earlier results (NASA CR-4592) for May 1990 scheduled air traffic have been updated using improved algorithms. These emissions inventories were developed under the NASA High Speed Research Systems Studies (HSRSS) contract NAS1-19360, Task Assignment 53. They will be available for use by atmospheric scientists conducting the Atmospheric Effects of Aviation Project (AEAP) modeling studies.

A detailed database of fuel burned and emissions [NOx, carbon monoxide(CO), and hydrocarbons (HC)] for scheduled air traffic has been calculated for each month of 1992. In addition, the emissions for May 1990 have been recalculated using the same methodology. The data are on a 1° latitude x 1° longitude x 1 km altitude grid. The datafiles were delivered to NASA Langley Research Center electronically.

Global fuel use for 1992 by scheduled air traffic was calculated to be 9.5×10^{10} kilograms/year. Global NOx emissions by scheduled air traffic in 1992 were calculated to be 1.2×10^9 kilograms(as NO_2)/year. The calculated emissions show a clear seasonal variation, peaking in the summer with a minimum in the winter. The North Atlantic region showed the most marked seasonal variation with a peak of about 18% above the annual average. In North America and Europe the amplitude of the seasonal variation was about 6% above the annual average, considering all altitudes. Emissions for May 1992 were close to the average for the year, confirming that using May as an "average" month (as was done in the earlier work) is reasonable.

This report describes the assumptions and methodology for the calculations and summarizes the results of those calculations. Results of parametric studies are presented in order to evaluate the possible errors introduced by making simplifying approximations necessary to calculate a global inventory.

The methods used to extract departures from the Official Airline Guide have been improved from those reported earlier (NASA CR-4592) to eliminate flight duplications. In addition, the emission calculations have been upgraded to use Boeing fuel flow method 2, which corrects for ambient temperature, pressure, humidity, and aircraft speed.

Using the revised methodology, the fuel predicted for May 1990 scheduled air traffic decreased by 3.5% compared to the value reported in NASA CR-4592. This appears to be due primarily to the elimination of duplicate flights from the OAG data. In the revised database, global NOx emissions were calculated to be about 1% lower than reported previously. The global average EI(NOx) increased by about 2% compared to that calculated earlier. Hydrocarbon emissions for May 1990 were calculated to be about 50% greater

than the values reported earlier in NASA CR-4592, because of the inclusion of many more older aircraft/engine combinations in this work and the use of a newly published engine emission database.

A series of parametric studies were conducted to evaluate the effects of wind, temperature, payload, tankering, and cargo on the calculated fuel use. Altitude effects, due to whether a flight is an East bound or West bound flight, have approximately a 0.1% effect on fuel burn and are negligible. Wind and temperature have a combined effect of 1.4 - 2.3% on round trip fuel burn (annual average) for East-West flights and about 1% for North-South flights, based on analyses for a Boeing 747-400. The effect is largest in the North Pacific. Since the airlines will try to fly routes which take advantage of the wind (rather than great circle routes), this may overestimate the effects of winds in the real world. Typically, an airline, given its choice of flight corridors, would try to maximize its tail wind and minimize the head wind on the return flight.

The parametric studies show that increasing the payload from 70 to 75% can increase the fuel burn by 2.5% for a 737 flying between San Francisco and Los Angeles. Similarly, the use of tankering fuel on the same flight could increase the average fuel burn on the route by up to 4%. For a 747-400 on a longer route, increasing the load factor from 70 to 75% increased the fuel consumption by 0.8%. The 747-400 can carry a significant amount of cargo, and, if the aircraft was loaded to its maximum weight limit, it would use 13% more fuel. More reasonably, if the cargo was volume limited, the fuel burn would increase by 7.7%. The effect of both fuel tankering and cargo loads on the global inventory has not been evaluated. Fuel tankering will primarily be an issue for small aircraft, while cargo load will be important for large aircraft, particularly the 747 and the DC-10.

None of the parametric studies have yet looked at combined fuel burn/emissions effects. Increased fuel burn will have an obvious effect on total emissions but will change the emission indices if the increased fuel use is due to higher fuel burn rates. These combined effects should be examined to see if they would cause a significant change in the database as calculated.

Based on available fuel data from the US Department of Energy, it appears that an earlier NASA study (NASA RP-1313) underestimated the jet fuel used by aircraft within the former Soviet Union. The reason for this has not been identified although it appears that the number of flights may have been underestimated. The difference between the calculated fuel use in the former Soviet Union and the apparent jet fuel use reported by DOE is 4.8% of the global jet fuel production.

Table of Contents

Table of Contents (cont)

List of Figures

List of Figures (cont)

List of Tables

List of Tables (cont)

List of Tables (cont)

GLOSSARY

AEAP	Atmospheric Effects of Aviation Project
AESA	Atmospheric Effects of Stratospheric Aircraft
APU	Auxiliary power unit
ASM	Available seat mile (the number of seats an airline provides times the number of miles they are flown)
ATC	Air traffic control
ATM	Available ton-miles (the number of tons capable of being carried times the number of miles flown)
BCAG	Boeing Commercial Airplane Group
BMAP	Boeing Mission Analysis Process
CAEP	ICAO Committee on Aviation Environmental Protection
CIAP	Climatic Impact Assessment Program (US Dept. of Transportation program in the early 1970s)
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EI(CO)	Emission Index (grams CO/kg fuel burn)
EI(HC)	Emission Index [grams hydrocarbon (as CH_4)/kg fuel burn]
EI(NOx)	Emission Index (grams NOx (as NO_2)/kg fuel burn)
ESAD	Equivalent Still Air Distance
F	Fahrenheit
FAA	Federal Aviation Administration
GAEC	Global Atmospheric Emissions Code
GCD	Great circle distance
GE	General Electric
gm	gram
HC	Unburned hydrocarbon
H_2O	Water
HSCT	High Speed Civil Transport
HSRP	High Speed Research Program (NASA)
ICAO	International Civil Aviation Organization
ISA	International standard atmosphere
kg	kilogram
kts	knots
lb	pound
Load Factor	Percentage of an airplane's seat capacity occupied by passengers on a given flight
LTO cycle	Landing takeoff cycle
M	Mach number
MDC	McDonnell Douglas Corporation
MTOW	Maximum takeoff weight
NASA	National Aeronautics and Space Administration
NMC	National Meteorological Center
nmi	Nautical mile
NOx	Oxides of nitrogen (NO + NO_2) in units of gram equivalent NO_2
OAG	Official Airline Guide

GLOSSARY (cont)

OECD	The Organization for Economic Cooperation and Development
OEW	Operating Empty Weight
P&W	Pratt & Whitney
PAX	passengers
RAM	Revenue air mile
RPM	Revenue passenger miles (the number of paying passengers times the number of miles they fly)
RTM	Revenue ton-miles (number of tons carried times the number of miles flown)
SO_2	Sulfur dioxide
TBE	Turbine bypass engine
TOGW	Takeoff gross weight
ton	2000 pounds
US	United States
3D	Three dimensional

1. Introduction

The NASA Atmospheric Effects of Aviation Project (AEAP) has been initiated to evaluate the effects of aircraft emissions on the atmosphere. For this assessment, inventories of aircraft emissions as a function of altitude and geographical position are required. These inventories are used as the input to chemical transport models to evaluate the effect of aircraft emissions: how long they persist in the atmosphere, how much they perturb the chemistry or microphysics of the upper troposphere, and how they compare with other sources of NOx, water, soot, and condensation nuclei in the upper troposphere.

Three-dimensional inventories of aircraft emissions for May 1990 were previously developed as part of the NASA program, and projections were made to the year 2015 for both subsonic and high speed civil transport fleets (Wuebbles, *et. al.*, 1993; Baughcum, *et. al.*, 1994, Landau, *et. al.*, 1994; Baughcum and Henderson, 1995). The NASA-funded work has used a "bottoms-up" approach in which aircraft schedules are obtained or estimated and the aircraft/engine combinations identified. Then, detailed calculations of fuel burned and emissions are made along each flight path. Other studies have used a mixture of a "bottoms-up" approach to account for scheduled air traffic and a "top-down" approach to account for military and non-scheduled traffic (McInnes and Walker, 1992; Schumann, 1995).

Since seasonal variations in air traffic departures are significant for some geographical regions, the previous work has been extended to explicitly calculate the aircraft emissions as a function of each month of 1992. In this report, we present the results and methodology used for the calculation of emissions from scheduled air traffic, including turboprops, passenger jets, and jet cargo aircraft. These inventories are calculated using the Official Airline Guide (OAG) as the source of scheduled flight data. In a parallel study, McDonnell Douglas Aerospace has calculated emission inventories for military aircraft, charter airlines, and flights in the former Soviet Union and China that were not listed in the OAG (Metwally, 1995). In a separate study, aircraft emission inventories for scheduled air traffic for selected months of 1976 and 1984 have been calculated (Baughcum, *et. al.*, 1996).

To calculate these inventories, flight schedule data (number of departures for each city pair along with airplane and engine type) have been combined with performance and emissions data to calculate the fuel burned, emissions, and altitude along each route. Fuel burned, oxides of nitrogen (NOx), carbon monoxide (CO), and total hydrocarbons (HC) have been calculated on a 1° longitude x 1° latitude x 1 kilometer altitude grid. The results for all the different routes and airplane/engine combinations were summed to produce the total inventory. The details of this process are described in Section 2 of this report.

The results and the seasonal variability of the emissions were analyzed, and the results are discussed in Section 3 of this report. During the development of the 1992 emission inventory, several improvements in the Boeing methodology were made and are discussed in Section 2. For self consistency, the previously published emission inventory for May 1990 was recalculated. An analysis is presented in Section 3.4 of the differences between this updated calculation and that reported earlier (Baughcum, *et. al.*, 1994).

To calculate global aircraft emission inventories, it is necessary to make some simplifying approximations about how each route will be flown. In these emission inventory calculations, we have assumed that the airplane will be flown according to design (flight manual performance) and that the effects of any prevailing winds enroute would be canceled by having flights in both directions. All flights were assumed to follow great circle paths between airports, and no account was taken of circuitous routing at takeoff or landing approach. In Section 4, the results of parametric studies are presented which have attempted to quantify the effects of some of these simplifying assumptions.

In Section 5, available jet fuel data for 1990 is summarized and discussed briefly. Such data is useful for comparison with jet fuel use calculated in the earlier NASA-funded emission inventory work. (Wuebbles, *et. al.*, 1993; Baughcum, *et. al.*, 1994; Landau, *et. al.*, 1994). The conclusions of the study are summarized in Section 6.

The work described in this report was conducted under NASA Langley Contract NAS1-19360, Task 53. The NASA Langley Task Manager was Donald L. Maiden.

The program managers for the work described in this task were John D. Vachal and Phillip F. Sweetland. The principal investigator was Steven L. Baughcum. Wes Banning and Stephen C. Henderson extracted and validated aircraft departure data from the Official Airline Guide. Terrance G. Tritz collected the data set and calculated the 3-dimensional aircraft emission inventories using the Boeing proprietary Global Aircraft Emissions Code (GAEC). David C. Pickett performed the performance and parametric studies described in Section 4 . Oren J. Hadaller and Albert M. Momenthy provided information on available jet fuel data. The GAEC code used to calculate the aircraft emission inventories was written by Peter S. Hertel. The analysis of the results was completed by Steven L. Baughcum.

2. Database Development Methodology

The calculation of the emission inventories has been described previously (Baughcum, et. al., 1994) and will be briefly summarized here. The overall process is shown schematically in Figure 2-1.

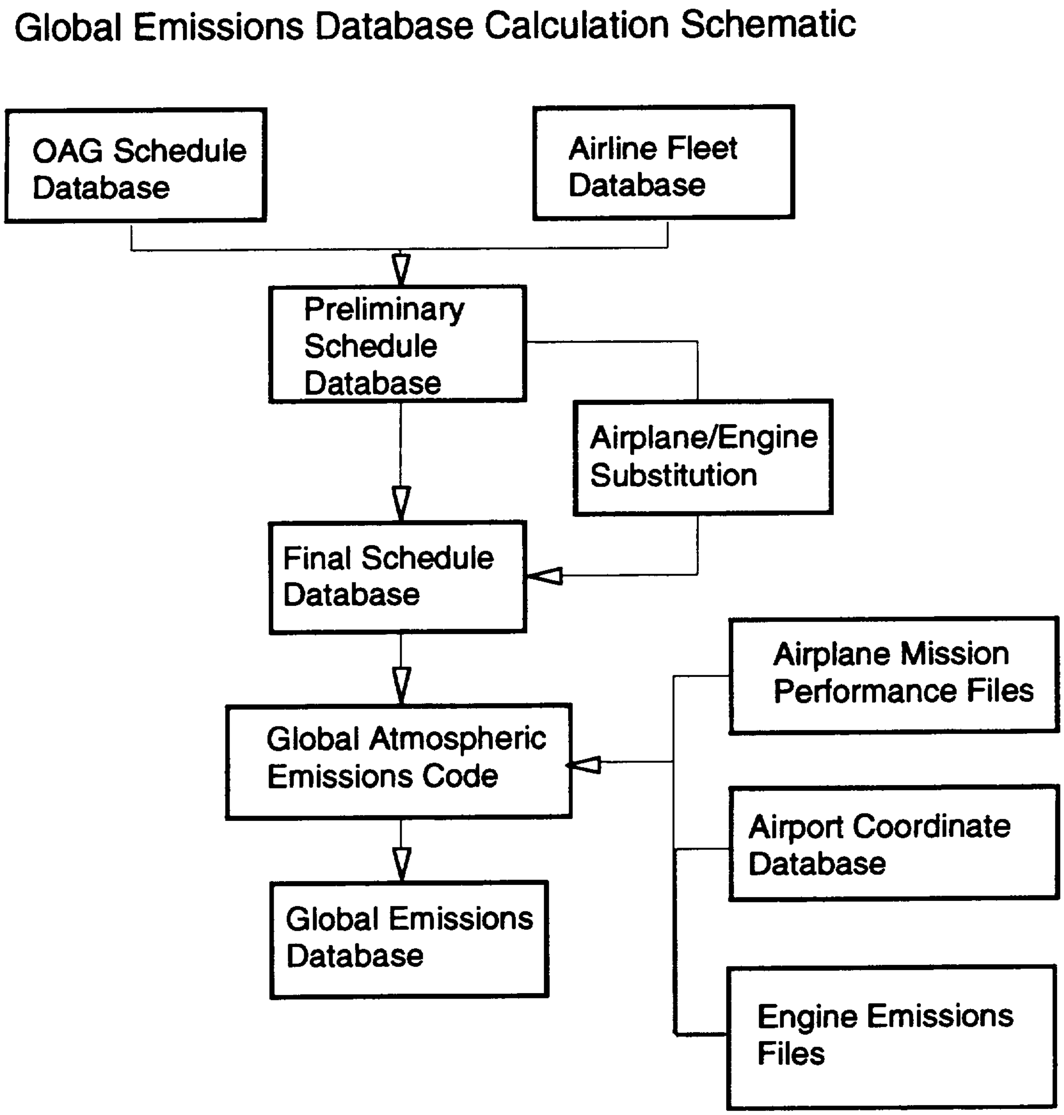

Figure 2-1. Schematic of emission inventory calculation.

2.1 Database Acquisition and Description

The database used in calculating monthly emissions from scheduled jet aircraft was that prepared by Official Airline Guide (OAG) (Oakbrook, IL), a subsidiary of the Reed Travel Group. The database contains listings of every scheduled jet and turboprop flight listed by city-pair and airline, and includes departure and arrival times, airplane code, and trip frequency. This database is published monthly and can be obtained in printed form or on magnetic tape.

The coverage of the OAG database depends on schedule data submitted by the individual airlines, and is based on the airlines' forecast of their operations for the next month. While it is quite accurate overall, changes in airline planned operations during any month or operations not reported by the airline as part of their schedule are not included. The OAG offers some coverage of flights within the former Soviet Union or the Peoples Republic of China, and fairly complete coverage of flights between these regions and the rest of the world. The extent of the coverage of internal flights within the former Soviet Union and China has been rapidly increasing with time.

Boeing normally purchases tapes containing the schedule data for five months of any year: February, May, August, September and November. These tapes are then processed and the data considerably "enriched" to create standard databases that are used in a variety of airline and airplane studies within Boeing. To obtain a complete set of all months of 1992, Boeing was required to purchase the data tapes from OAG to complete the missing months. Unfortunately, by the time the task was assigned, OAG had purged the January, 1992 data from their archives (they keep only two years of data). January 1992 schedule data was therefore purchased from another database vendor, BACK Information Services (Stamford, CT).

For data generated in any given year, an airport listing is needed for that year. These listings consist of a match of the three-letter OAG airport code with the city and coordinates (latitude, longitude, and altitude) of the airport. Airport listings were generated from data at Boeing for 1990 and 1992. Separate listings are needed for each year due to the addition and subtraction of airports around the world and to changes in the three-letter airport codes used in the OAG. The three-letter codes for airports are re-used by the OAG in later years, which is the main reason for using the appropriate year's airport listing. This is of particular concern when historical databases, such as those for 1976 and 1984, are generated. Thus, for each year for which aircraft emission inventories are to be calculated, data files of the correct OAG airport codes for that year must be located and used.

2.2 Data Extract Challenges

The OAG database is designed for the purpose of flight itinerary planning by airline passengers and travel agents. As a result, certain duplicate listings of the same actual flight segment may occur in the schedule data. These duplications are not noted in the database, and logic must be built into the extract code to eliminate these duplications as much as possible. Much of the time on this task was spent in the process of discovering and eliminating these duplications. The processing of OAG data normally done within Boeing was inadequate for the purposes of this work.

The flight duplications which had to be eliminated fell into three main categories, which we termed "Codeshare Duplication", "Starburst Duplication" and "Effectivity Duplication".

"Codeshare Duplication"

This form of schedule duplication occurs when airlines which are involved in cooperative flight sharing arrangements (codesharing) will both list the same flight segment under their own airline code and flight number. The same flight from Detroit to Amsterdam (for instance) may be listed under both Northwest Airlines and KLM, which have many codesharing agreements. The duplications are removed by checking for flights that are listed under two different airlines, but with the same airport-pair, time of day departure and arrival, same day and same equipment. (See Figure 2-2)

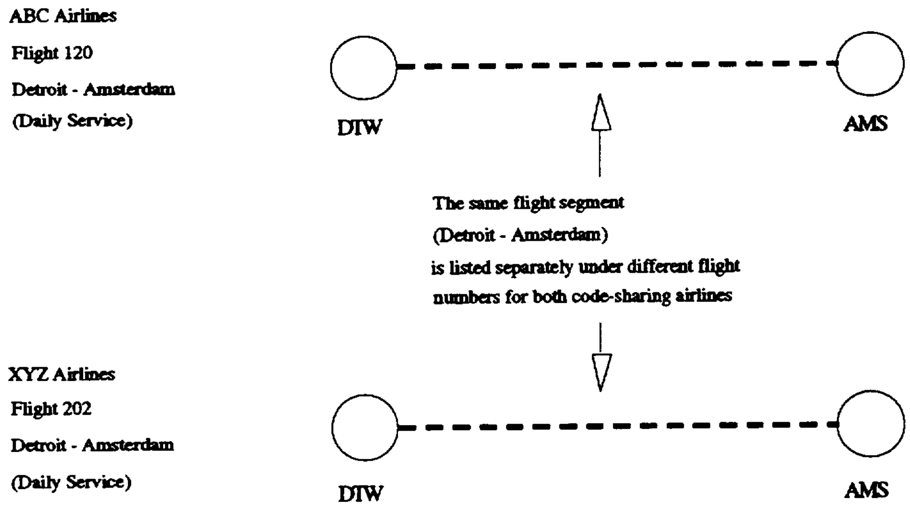

Figure 2-2. "Codeshare" flight duplication.

"Starburst Duplication"

This form of duplication arises from the practice of airlines listing under separate flight numbers one-stop or multi-stop itineraries which contain the same flight segment. As a simple example of this practice, an airline listing a one-stop flight from Cleveland to London through New York and another one-stop flight from Washington to London through New York will combine the passengers from both flight numbers on the same New York - London flight segment. The published schedule, however, would lead one to believe that there are two separate flights from New York to London. This duplication is removed by checking flight itineraries for segments listed under the same airline, airport-pair, time of day departure and arrival, same day and equipment. (See Figure 2-3)

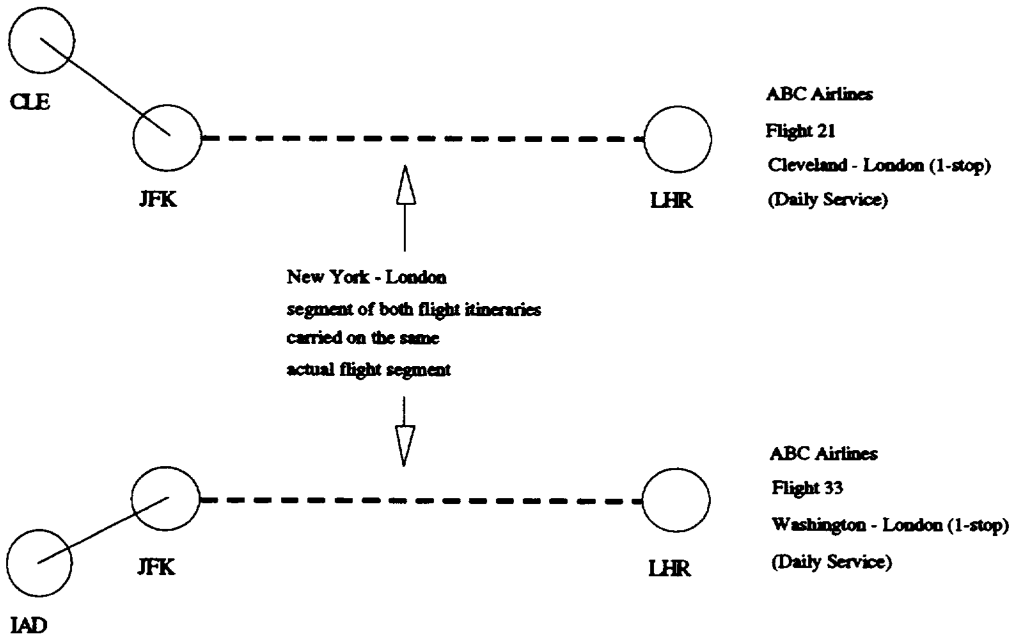

Figure 2-3. "Starburst" flight duplication.

"Effectivity Duplication"

Although the OAG schedule data is supplied as representing the airline schedules for a certain month, data within the schedules show the dates at which flights cease operation or begin operation within the month. The flight data itself shows which days of the week the flight operates. If every flight that operates in a given week is counted, then the same flight segment may be counted twice as airlines change schedules (and flight numbers) within the week to account for holidays, daylight time, change of airplane type, etc. This duplication can be removed by choosing a single date for flight effectivity, rather than a whole week. All flights effective on the 18th day of the month are included in the analyses presented here. (See Figure 2-4)

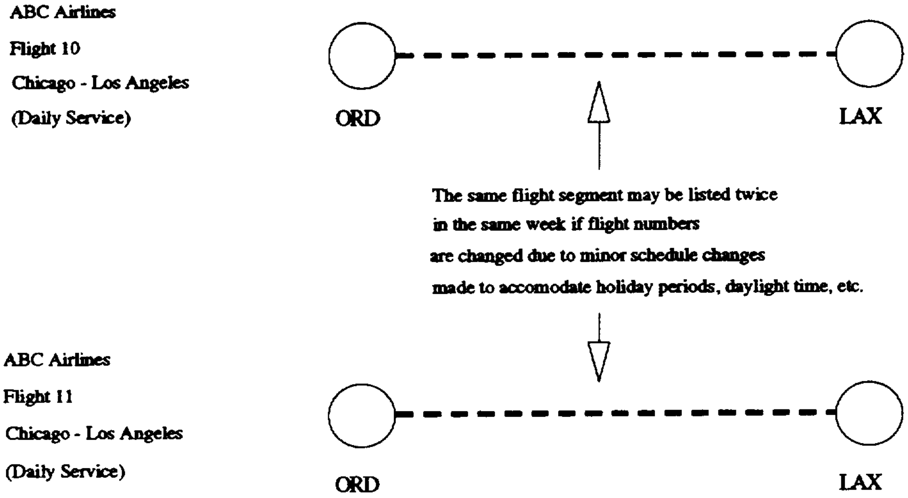

Figure 2-4. "Effectivity" flight duplication.

Once the logic required to remove these duplicate flights was in place and tested, a complete set of schedules was extracted for each month of 1992. The flight schedule data for January 1992 were purchased from BACK Information Services, since OAG had purged that month from their datafiles. The data from BACK had been processed using their own proprietary algorithms. As a result, the January 1992 data shows consistently low values of departures, total flight distances, fuel and emissions compared to the rest of the months of 1992, which were calculated using "raw" data from OAG and processed using Boeing-developed algorithms. Also, the number of aircraft types used by BACK in the January data set is significantly lower (173 compared to 228-235 for the other months) than for the other months of schedule data.

2.3 Creation of Emissions Database:

2.3.1. Schedule Data Translation

The monthly airline schedules extracted from the OAG database do not contain enough information to allow calculation of emissions for a given flight. The schedule data emerges looking like the following example:

Airline	Airplane	Origin	Destination	Weekly Freq.
JL	747PAX	LAX	TYO	14

Since there is no airplane called a "747PAX", and since engine type is not listed, a fleet information database is used to add more information to the data. Appendix A summarizes such a database for Boeing 747's owned by Japan Airlines (JL). The fleet database reveals that the JL "747PAX" is most likely a 747-200B with Pratt & Whitney JT9D-7A engines. It is "most likely" because although JL has 747-100's, -200's, -300's and -400's in their fleet, the "747PAX" designator is usually reserved for 747-100 and -200 models. JL has more 747-200's than -100's, and has more JT9D-7A powered -200's than other engine types, so we make the simplifying assumption that the schedule data can be revised to appear as follows:

Airline	Airplane	Engine	Origin	Destination	Weekly Freq.
JL	747-200B	JT9D-7A	LAX	TYO	14

This translation of the schedule data now allows emissions calculations for the flight.

2.3.2. Airplane/Engine Performance Data Substitution

Another type of data translation necessary to create an emissions database is the substitution of one type of aircraft/engine combination for another. While Boeing has performance information needed to calculate fuel burned and emissions for a large number of turbojet-powered airplane types, including all Boeing models and many non-Boeing models, we do not have such information for all airplane types in airline service. As an example, a flight listed as:

Airline	Airplane	Origin	Destination	Weekly Freq.
IT	MRC-100	PAR	LYS	21

can be translated into:

Airline	Airplane	Engine	Origin	Destination	Weekly Freq.
IT	Mercure	JT8D-9	PAR	LYS	21

Boeing does not have enough information on the Dassault Mercure to calculate fuel burned or emissions on this flight. The Mercure is a twin-engined aircraft of similar size to the 737-200, and is powered by the same engines as some of the 737-200 models. The data for this flight can therefore be revised to:

Airline	Airplane	Engine	Origin	Destination	Weekly Freq.
IT	737-200	JT8D-9	PAR	LYS	21

In addition to the data changes made substituting one turbojet-powered airplane for another, all of the myriad turboprop models were grouped into three categories, small, medium and large. The "small" category includes airplanes such as the DeHaviland Twin Otter, the "medium" category includes airplanes such as the DeHaviland Dash-8, the "large" category includes airplanes such as the Fokker F-27 and F-50.

Appendix B contains a listing of all the airplane types obtained from the schedule data translation and the airplanes actually used in the emissions calculations, showing the matchup. For 1992, the number of different airplane types listed in the OAG data files was between 228-235, varying between months. For the January data file purchased from a database vendor, the data had been partially processed and 173 airplane types were identified. These data files were then matched to 76 aircraft/engine combinations for which detailed performance and emissions data were available.

A file was created for each of the months of 1992 containing all the flight segments operated by each airplane type (as substituted if required), on a departures per week basis. This final schedule database formed part of the data input required for the emissions inventory calculations.

The aircraft and engines used in the performance calculations are shown in Table 2-1.

Table 2-1. List of aircraft and engines used in the performance and emissions calculations for the 1992 emission inventory calculations.

Airplane	Engine	Airplane	Engine
707-320B-C	JT3D-3B	767-300ER	CF6-80C2B6F
720	JT3C-7	A300-600R	CF6-80C2
727-100	JT8D-7	A300-621R-ER	JT9D-7R4H1
727-100	JT8D-9	A300-622R-ER	PW4056
727-200	JT8D-15-15A	A300-B2-B4	CF6-50C2
727-200	JT8D-9	A310-300	CF6-80A3
737-100	JT8D-9	A310-300	CF6-80C2A2
737-200	JT8D-15	A310-300	JT9D-7R4E1
737-200	JT8D-7	A320-200	CFM56-5-A1
737-200ADV	JT8D-15A	A320-200	V2525-A5
737-200ADV	JT8D-9-9A	A330-300	PW4164
737-300	CFM56-3-B1	A340-300	CFM56-5C-2
737-500	CFM56-3-B1-18.5	BAC111-500	MK512-14
747-100	JT9D-3A1	BAE146-300	ALF502R-5
747-100-100SR	CF6-45A2	Caravelle-10B	JT8D-1
747-100-200	CF6-50E2	Concorde	Olympus 593
747-100-200	JT9D-7A	DC-10-30	CF6-50C2
747-200	JT9D-7J	DC-8-21-31-33	JT4A-9
747-200	JT9D-7R4G2	DC-8-63-63CF	JT3D-7
747-200	RB211-524C	DC-8-71-71CF	CFM56-1B
747-200	RB211-524D4U	DC10-10	CF6-6D
747-200B-C-F	JT9D-7Q	DC10-40	JT9D-20
747-300	CF6-50E2	DC9-30	JT8D-7
747-300	CF6-80C2B1	DC9-31	JT8D-15
747-300	JT9D-7R4G2	DC9-50	JT8D-15
747-300	RB211-524D4UP	F-28-4000	MK555-15H
747-400	CF6-80C2-B1F	Fokker-100	TAY-650
747-400	PW4056	L-1011-1-100	RB211-22B
747-400	RB211-524G	L1011-500AC	RB211-524B4
747SP	JT9D-7A	MD-11	CF6-80C2D1F
747SP	RB211-524C2	MD-81	JT8D-209
757-200	PW2037	MD-82	JT8D-217A
757-200	PW2040	MD-83	JT8D-219
757-200	RB211-535C	MD-87	JT8D-217C
757-200	RB211-535E4	MD-88	JT8D-217C
767-200	CF6-80A	Large Turboprop	PW125
767-200	JT9D-7R4D	Small Turboprop	PT6A
767-300	CF6-80A2	Medium Turboprop	PW120

2.3.3. Airplane Mission Performance Calculation

Airplane performance data files were generated for all the airplane/engine combinations shown in Table 2-1 and in Appendix B. These data files provide time, fuel burned and distance flown as a function of aircraft gross weight and altitude for climbout, climb, and descent conditions. They also provide tables of fuel mileage (nautical miles per pound of fuel burned) as a function of gross weight, cruise Mach number and altitude for cruise conditions. These performance data files were generated using the proprietary Boeing Mission Analysis Program (BMAP), and each file covered the whole operating envelope of the airplane. This allowed simple interpolation routines to be used by the Global Atmospheric Emissions Code (GAEC), a proprietary program created for these calculation tasks. Aircraft performance calculations were done assuming 70% load factors.

For purposes of the emissions calculations, the Earth's atmosphere was divided into a grid of three dimensional cells with dimensions of 1 degree of latitude by 1 degree of longitude by 1 kilometer in altitude, up to 22 kilometers.

2.3.4. Calculation of Global Emissions

The primary emissions are water vapor (H_2O) and carbon dioxide (CO_2) produced by the combustion of jet fuel. The emission levels are determined by the fuel consumption and the fraction of hydrogen and carbon contained in the fuel. Results from a Boeing study of jet fuel properties measured from samples taken from airports around the world yielded an average hydrogen content of 13.8% (Hadaller and Momenthy, 1989). Similarly, emissions of sulfur dioxide (SO_2) from aircraft engines are determined by the levels of sulfur compounds in the jet fuel. Although jet fuel specifications require sulfur levels below 0.3%, levels are typically much lower than this. The Boeing measurements obtained an average sulfur content of 0.042% with 90% of the samples below 0.1% (Hadaller and Momenthy, 1989). Future sulfur levels are projected to drop to about 0.02% (Hadaller and Momenthy, 1993).

Current and projected emission indices (in units of grams of emissions per kilogram of fuel burned) are summarized in Table 2-2, based on the analyses of Hadaller and Momenthy for commercial Jet A fuel.

Table 2-2. Recommended emission indices (in units of grams emission/kilogram fuel for 1992).

Emission	Emission Index
Carbon Dioxide (CO_2)	3155
Water (H_2O)	1237
Sulfur oxides (as SO_2)	0.8

Nitrogen oxides (NO_X), carbon monoxide (CO) and hydrocarbons are produced within the combustors and vary in quantity according to the combustor conditions. Nitrogen oxides are produced in the high temperature regions of the combustor primarily through the oxidation of atmospheric nitrogen. Thus, the NO_X produced by an aircraft engine is sensitive to the pressure, temperature, flow rate, and geometry of the combustor. The emissions vary with the power setting of the engine, being highest at high thrust conditions. By contrast, carbon monoxide and hydrocarbon emissions are highest at low power settings where the temperature of the engine is low and combustion is less efficient.

The emissions are characterized in terms of an emission index in units of grams of emission per kilogram of fuel burned. Nitrogen oxides consist of both nitric oxide (NO) and nitrogen dioxide (NO_2). For NO_X, the emission index [EI(NO_X)] is given as gram equivalent NO_2 to avoid ambiguity. Although hydrocarbon measurements of aircraft emissions by species have been made (Spicer *et al.*, 1992), only total hydrocarbon emissions are considered in this work, with the hydrocarbon emission index [EI(HC)] given as equivalent methane (CH_4).

For the majority of the engines considered in this study, emissions data from the engine certification measurements were used. (ICAO, 1995) In these measurements, emissions of nitrogen oxides (NOx), carbon monoxide (CO) and total hydrocarbons (HC) are measured at standard day sea level conditions at four power settings [7% (idle), 30% (approach), 85% (climbout) and 100% (takeoff)]. If the ICAO database did not contain a particular engine, the data for that engine were obtained from the engine manufacturer. This was done for the three sizes of turboprops considered. If a source could not be found (e.g., JT3C and JT4A), engines with a similar core were used with an adjustment for different fuel flow rates.

Emissions data is available from the certification measurements for a larger number of engines than we include in the performance calculations. In the calculations, the OAG airplane/engine combination is matched to both a performance engine and an emissions engine. (see Appendix B for the matchup table) Fuel flow is calculated using the performance data. Then the emissions are calculated using a fuel flow technique described below. In most cases, the emissions engine is the same as that used to calculate the performance. If the OAG engine was similar to the performance engine, the emissions engine was matched to the OAG engine. If the OAG engine is significantly different from the performance engine, the emissions engine was matched to the performance engine.

Boeing has developed two empirical methods which allow the calculation of emissions for a wide variety of aircraft and a large number of missions. These methods are described in detail in Appendix C and in Appendix D. In both cases, emission indices measured during engine certification tests are correlated with the fuel flow and then scaled for ambient temperature, pressure, and humidity.

All global emissions calculations were done using GAEC (Global Atmospheric Emissions Code) as described previously. (Baughcum, *et. al.*, 1994) Modifications have been made to the code since the release of that report. The two main modifications were to the user interface and to the emissions calculations portion of the code. The user interface was made more user friendly and allows a user to match an OAG fleet more automatically, especially if a similar OAG fleet has been previously generated. This interface allows for more rapid processing of multiple months of schedule data.

The second modification allows the use of Boeing Fuel Flow Method #2 in the emissions calculations. The original method used in GAEC was Boeing Fuel Flow Method #1. Method 1 is an empirical method described in detail in Appendix C which takes ambient temperature, pressure, and humidity into account. Method #2 is a more complicated empirical method which takes into account ambient temperature, pressure, humidity and Mach number. Analyses have shown that Method 2 is more accurate for higher altitudes and can be used for non-Standard Day conditions. Method #2 is summarized below and described in detail in Appendix D. Both methods are available for emissions calculations in GAEC. All data generated for this report were generated using Fuel Flow Method #2.

The CAEP Working Group 3 has recommended the adoption of Boeing Method 2 as a standard method for environmental assessments. [Combined Report of the Certification and Technology Subgroups, Paper WG3/WP2, presented by the Chairman of TSG at the third Meeting of ICAO/CAEP Working Group 3, Bonn Germany, June 1995.]

2.4 Emissions Methodology (Boeing Method 2)

The emissions methodology used is described in detail in Appendix D. The method is similar to Method 1 (Appendix C). The only difference is in the correction equations used for the fuel flow and emission indices, which explicitly take into account ambient temperature, pressure, humidity, and aircraft Mach number.

The fuel flow correction is :

$$W_{ff} = W_f \,/\, \delta_{amb} * \Theta_{amb}^{3.8} * \exp(0.2 * M^2)$$

The carbon monoxide correction is :

$$EICO = REICO * \Theta_{amb}^{3.3} \,/\, \delta_{amb}^{1.02}$$

The hydrocarbon correction is :

$$EIHC = REIHC * \Theta_{amb}^{3.3} \,/\, \delta_{amb}^{1.02}$$

The nitrogen oxide correction is:

$$EINOx = REINOx \exp(-19 * (SH-0.0063) * \mathrm{sqrt}\,(\delta_{amb}^{1.02} / \Theta_{amb}^{3.3})$$

where

EICO	carbon monoxide (CO) emission index at altitude
EIHC	hydrocarbon (HC) emission index at altitude
EINOx	NOx emission index at altitude
REICO	referenced CO emission index at sea level conditions
REIHC	referenced HC emission index at sea level conditions
REINOx	referenced NOx emission index at sea level conditions
Θ_{amb}	T_{amb} / 518.67 R
δ_{amb}	P_{amb} / 14.696 psia
T_{amb}	ambient temperature in degrees Rankine (R)
P_{amb}	ambient pressure in pounds per square inch absolute
SH	specific humidity in pounds of water per pound of air at altitude
W_f	fuel flow (kg/hr) at altitude
W_{ff}	fuel flow at sea level conditions
M	Mach Number

As was done with Fuel Flow Method #1, all constants were chosen solely for their ability to collapse the data.

2.5 Changes from previous Boeing inventory calculations

As described above, one of the biggest differences between this analysis and that described previously is the use of the fuel flow method #2, rather than method #1, for the calculation of emission indices. There were several other differences as well. These include the following:

1.) The analysis routine to eliminate multiple counts of flights was made more stringent. This resulted in dropping some flights that had been included in the earlier study for May 1990 but were found to be double counts.

2.) More aircraft/engine combinations were included in the performance and emissions aircraft used in this new study. For the calculation of 1992 inventories 76 aircraft/engine combinations are now used for performance calculations, while 71 are used for the recalculation of May 1990 emissions. By contrast, performance data for 57 aircraft were used in the earlier study.

3.) The emissions file for the Concorde was refined using the values for supersonic cruise recommended by the CIAP study (CIAP, 1975) for NOx, CO, and HC. Our earlier study had only used the NOx recommendation resulting in EI(CO) and EI(HC) that were much too large. The earlier study had used the certification measurements for CO and HC which were done using an afterburner. Since the Concorde does not cruise supersonically using its afterburner, the analysis has been revised.

4.) The small number of business jet-sized scheduled flights were represented as Fokker 28's rather than as turboprops as was done in the earlier study.

5.) The emission engine database was standardized on the ICAO database. Previously, fuel flows were determined from engine data decks for the four power settings.

To better quantify these changes in methodology from that reported earlier, the emission inventory for May 1990 scheduled aircraft was recalculated using the same methodology as that for 1992 for self consistency. The results are compared in Section 3 with those reported earlier in NASA CR-4592.

3. Results and Analysis - Scheduled Aircraft Emissions

3.1 Overview of Results

The daily fuel burned and emissions for each month of 1992 are summarized in Table 3-1. The fuel burned, emissions, and effective emission indices as a function of altitude for each month of data are provided as tables in Appendix E. For each OAG airplane/engine type, Appendices F-K summarize the fuel burned (Appendix F), NOx (Appendix G), hydrocarbons (Appendix H), carbon monoxide (Appendix I), distance flown (Appendix J), and number of departures (Appendix K).

Table 3-1. Fuel burned and emissions for scheduled air traffic for each month of 1992.

Month	Fuel (kg/day)	NOx (kg/day)	HC (kg/day)	CO (kg/day)
January	2.35E+08	3.05E+06	4.27E+05	1.18E+06
February	2.49E+08	3.22E+06	5.38E+05	1.33E+06
March	2.51E+08	3.26E+06	5.41E+05	1.34E+06
April	2.54E+08	3.30E+06	5.42E+05	1.35E+06
May	2.59E+08	3.36E+06	5.45E+05	1.37E+06
June	2.68E+08	3.49E+06	5.51E+05	1.40E+06
July	2.74E+08	3.57E+06	5.62E+05	1.43E+06
August	2.74E+08	3.58E+06	5.61E+05	1.43E+06
September	2.66E+08	3.47E+06	5.52E+05	1.40E+06
October	2.60E+08	3.38E+06	5.34E+05	1.37E+06
November	2.61E+08	3.40E+06	5.28E+05	1.38E+06
December	2.59E+08	3.37E+06	5.22E+05	1.36E+06
Total	9.48E+10 kg/year	1.23E+09 kg/year	1.95E+08 kg/year	4.98E+08 kg/year

The geographical distribution of the NOx emissions for April 1992 scheduled air traffic is shown in Figure 3-1. The top panel shows the emissions as a function of altitude and latitude, while the bottom panel shows them as a function of latitude and longitude. Peak emissions occur over the United States, Europe, the North Atlantic flight corridor, and Japan.

The distribution of the emissions as a function of altitude are shown in Figure 3-2. Peak fuel burned and NOx emissions occur at cruise altitudes, while peak CO and hydrocarbons occur during the landing/takeoff cycle. Approximately 40% of the fuel burned and NOx emissions occur below 10 km altitude, while approximately 78% of the hydrocarbon and carbon monoxide emissions are emitted below 10 km.

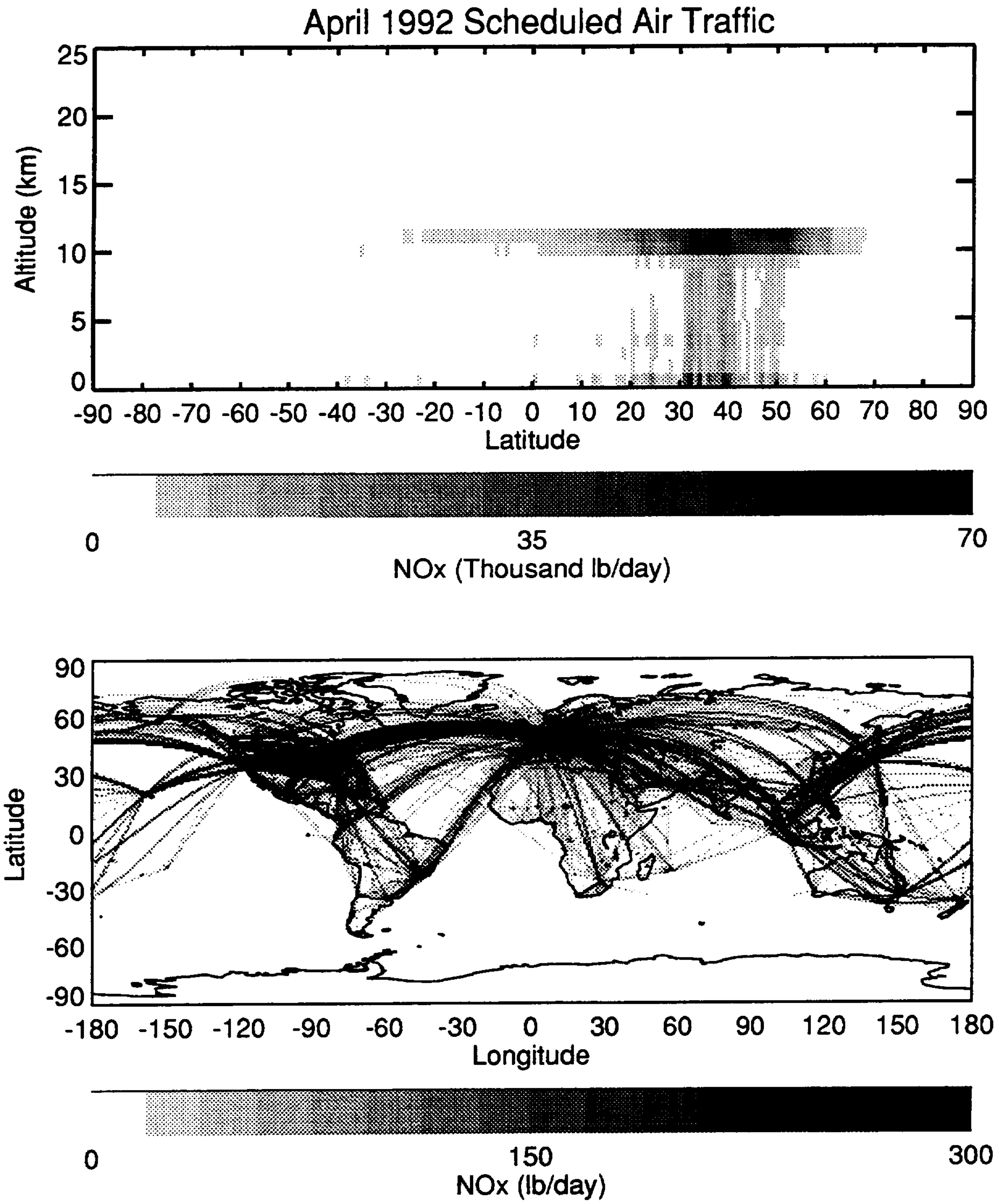

Figure 3-1. NOx emissions for scheduled aircraft, April 1992, as a function of altitude and latitude (summed over longitude, top panel) and as a function of latitude and longitude (summed over the 0-22 km altitude band, bottom panel). (Values greater than maximum are plotted as black.)

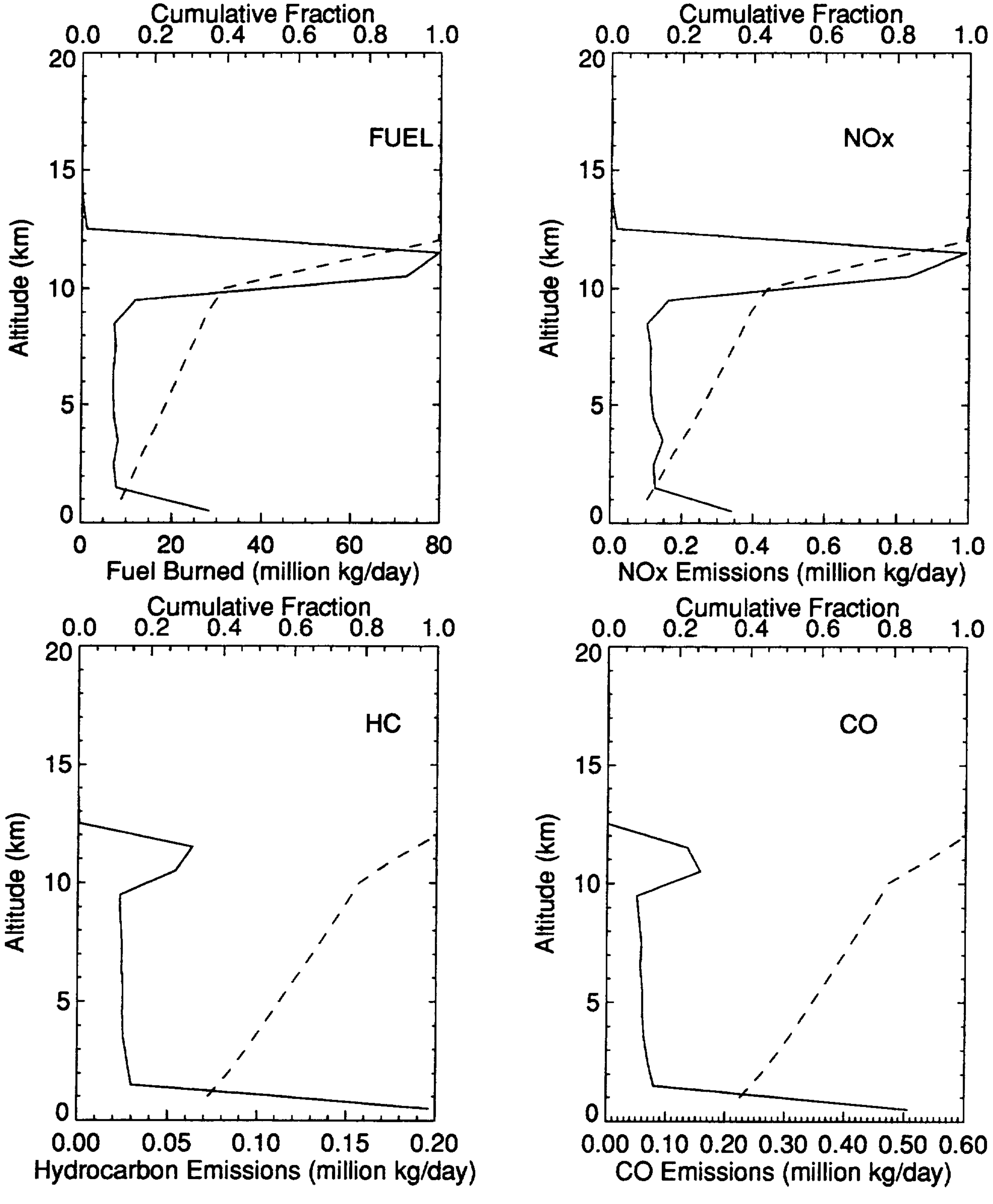

Figure 3-2. Fuel burned and emissions (solid lines) as a function of altitude for scheduled air traffic for April 1992. (summed over latitude and longitude). Dashed lines show the cumulative fraction of emissions. (Note that the emissions shown above 14 km altitude are due to the Concorde.)

The effective emission indices as a function of altitude are shown in Figure 3-3. The NOx emission index is greatest during climb with a range of 11.5-13.8 at cruise altitudes. (see Appendix E for tables of the emissions as a function of altitude for each month). By contrast, the effective emission indices for CO and hydrocarbon are highest during landing/takeoff, dropping significantly at cruise altitudes.

The plots of emissions as a function of latitude in Figure 3-4 emphasize that the largest amount of emissions occur at northern mid-latitudes, with the majority of aircraft emissions occurring between 30° North and 60° North latitude.

Departure statistics for different aircraft are summarized in Table 3-2, which shows the total daily distance flown, the daily departures, and the average route distances for generic classes of aircraft.* A more detailed summary identifying similar results for each OAG airplane/engine combination is provided in Appendix N, which also identifies how each of the generic types in Table 3-2 is defined. Tables of departures and total distance flown for each airplane type for all months are summarized in Appendices J and K.

As Table 3-2 shows, smaller aircraft account for a large fraction of the total daily departures and total mileage flown by the scheduled fleet.

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* Table 3-2 has been truncated to only show generic types which flew more than 8,000 nautical miles per day. Appendix N includes the complete summary of all OAG airplane/engine combinations and all generic groupings.

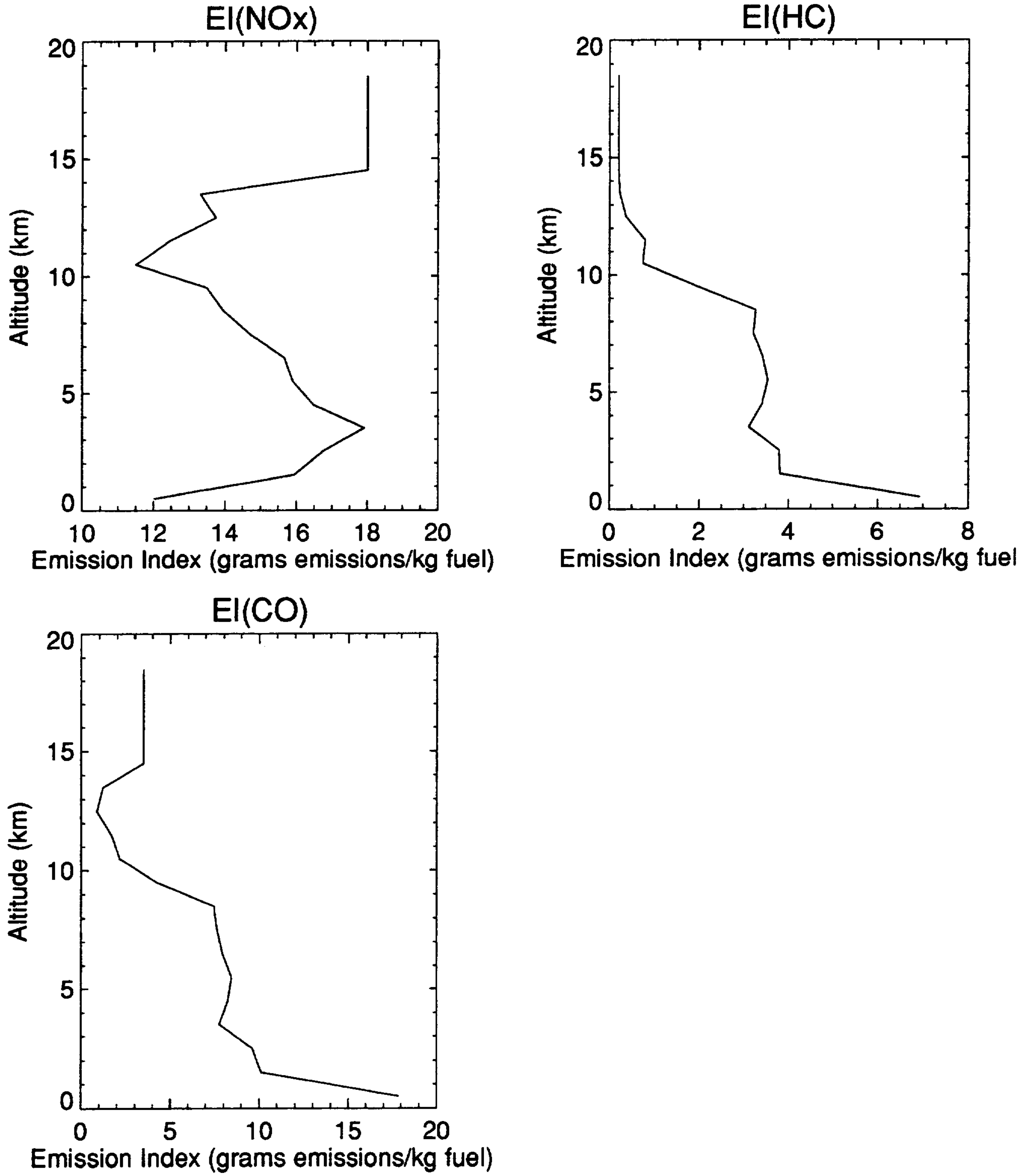

Figure 3-3. Emission indices as a function of altitude for April 1992 scheduled air traffic. (summed over latitude and longitude). (Note that the emission indices shown above 14 km altitude are due to the Concorde.)

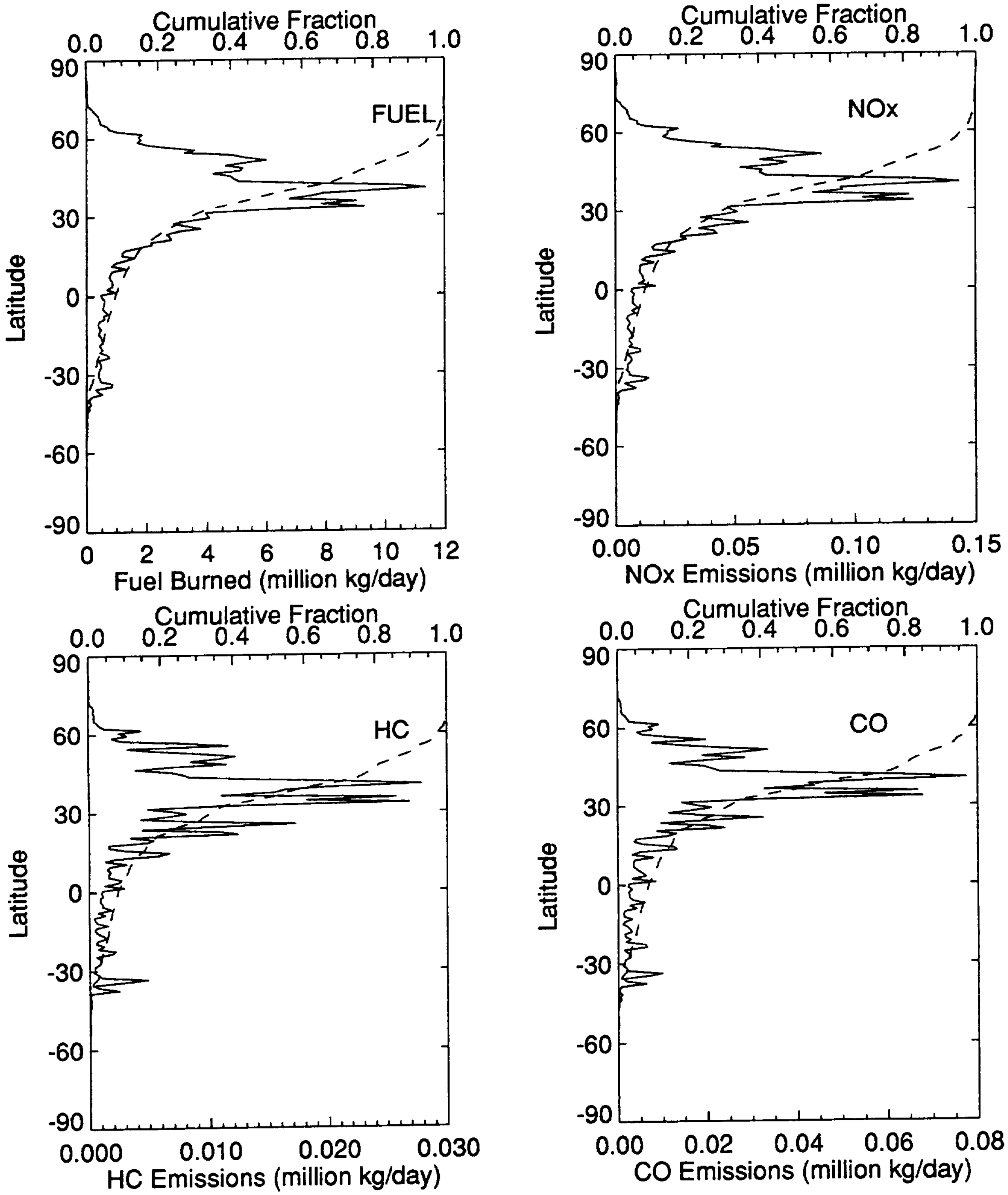

Figure 3-4. Fuel burned and emissions (solid line) as a function of latitude for scheduled April 1992 air traffic. Dashed lines show the cumulative fraction of emissions.

Table 3-2. Summary of departure statistics by aircraft type for April 1992.

Generic Type	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
McDonnell Douglas MD-80	2,131,002	8.46%	4,249	7.94%	502
Boeing 737-200	2,114,891	8.39%	5,646	10.55%	375
Boeing 727-200	2,045,949	8.12%	3,501	6.54%	584
Boeing 737-300	1,596,368	6.33%	3,036	5.67%	526
Small Turboprops	1,357,333	5.39%	9,966	18.62%	136
DC-10	1,287,511	5.11%	812	1.52%	1,586
DC-9	1,252,254	4.97%	3,613	6.75%	347
Boeing 747-200	1,239,289	4.92%	545	1.02%	2,274
Boeing 747-100	1,073,923	4.26%	435	0.81%	2,469
Boeing 757-200	1,064,923	4.23%	1,223	2.29%	871
Boeing 767-200	1,048,039	4.16%	819	1.53%	1,280
Large Turboprops	768,648	3.05%	4,649	8.69%	165
Medium Turboprops	748,067	2.97%	4,673	8.73%	160
Boeing 747-400	746,632	2.96%	259	0.48%	2,883
Airbus A300	725,512	2.88%	1,036	1.94%	700
Airbus A320	611,093	2.42%	1,082	2.02%	565
Lockheed 1011	585,020	2.32%	481	0.90%	1,216
Tupolev 154	574,728	2.28%	636	1.19%	904
Airbus A310	469,968	1.86%	424	0.79%	1,108
Boeing 767-300	435,695	1.73%	342	0.64%	1,274
Boeing 727-100	309,411	1.23%	778	1.45%	398
DC-8	296,601	1.18%	303	0.57%	979
Boeing 747-300	276,191	1.10%	119	0.22%	2,321
Boeing 737-400	274,018	1.09%	665	1.24%	412
Fokker 28	255,767	1.01%	952	1.78%	269
Boeing 737-500	223,671	0.89%	641	1.20%	349
BAE-146	216,262	0.86%	744	1.39%	291
McDonnell Douglas MD-11	198,364	0.79%	74	0.14%	2,681
Boeing 707	181,283	0.72%	172	0.32%	1,054
Ilyushin 62	178,400	0.71%	70	0.13%	2,549
Fokker 100	167,667	0.67%	505	0.94%	332
Boeing 747-SP	138,519	0.55%	54	0.10%	2,565
Airbus A300-600	132,201	0.52%	163	0.30%	811
Tupolev 134	130,207	0.52%	265	0.50%	491
Ilyushin 86	113,764	0.45%	94	0.18%	1,210
BAC111	79,896	0.32%	217	0.41%	368
YAK 42	49,147	0.20%	97	0.18%	507
Boeing 747-SR	27,645	0.11%	54	0.10%	512
Ilyushin 72	22,458	0.09%	18	0.03%	1,248
Concorde	21,024	0.08%	7	0.01%	3,003
Mercure	8,411	0.03%	30	0.06%	280
Boeing 737-100	8,200	0.03%	20	0.04%	410
Total	**25,202,280**		**53,510**		

3.2 Effective Emission Indices

Table 3-3 shows a summary of daily fuel usage for each generic aircraft in April 1992. It also shows the fraction of total scheduled fuel use by that aircraft type.

There has been some confusion in the scientific literature and with various emission inventory calculations with regard to emission indices at flight altitudes. Most of the available data is from certification measurements at sea level conditions. (ICAO, 1995). In some cases, these have been used incorrectly as representative of the emission levels at cruise conditions, without corrections used for ambient conditions of pressure and temperature.

In order to help reduce the confusion about the average emission indices for commercial aircraft, Table 3-3 shows the effective emission indices for NOx, CO, and hydrocarbons for each generic aircraft type for two altitude bands: 0-9 km (taxi, takeoff, climb, descent, and landing) and 9-13 kilometers (primarily cruise but some initial climb and initial descent).* A more detailed summary showing the results for each OAG airplane/combination is included as Appendix M. In that Appendix, Table M-1 clearly identifies how we define the generic airplane types. These tables were calculated by summing the individual inventories calculated for each aircraft type and some variation between similar types may occur because of the different mission distances, as well as different engines.

Since these emission indices represent our best estimate of effective fleet averages (averaged over all missions), they should not be compared directly with an emission index measured behind an individual aircraft in flight. For that comparison, the methodology used to calculate these emission inventories (see Appendix D) can be used if the actual fuel flow, ambient temperature, ambient pressure, humidity, and Mach number are known. Such measurements, if accurate and precise, should provide a way to evaluate the accuracy of the emission methodology used to calculate these inventories.

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* Note that Table 3-3 has been truncated to only include aircraft types with more than 100,000 kg/day of fuel use. The complete summary is provided in Appendix M.

Table 3-3. Summary of fuel burned and effective emission indices for commercial aircraft types (based on April 1992 scheduled air traffic).

			0-9 km Altitude Band			9-13 km Altitude Band		
Airplane Type	Fuel (1000 kg/day)	% of Global Fuel Burned by Scheduled Traffic	EI (NO_x)	EI (CO)	EI (HC)	EI (NO_x)	EI (CO)	EI (HC)
Boeing 747-200	26,359	10.40%	22.8	22.8	12.8	14.2	1.4	0.8
Boeing 747-100	22,519	8.88%	23.4	22.2	12.1	13.9	0.4	0.6
Boeing 727-200	21,478	8.47%	11.6	5.0	0.8	8.7	2.4	0.5
DC-10	19,140	7.55%	21.0	17.6	6.5	13.2	2.0	1.3
MD-80	16,122	6.36%	14.3	5.3	1.5	10.6	3.3	1.2
Boeing 737-200	15,563	6.14%	10.2	6.5	1.4	7.7	2.9	0.6
Boeing 747-400	14,779	5.83%	25.8	8.9	1.6	13.9	1.0	0.4
Boeing 767-200	10,084	3.98%	19.6	6.1	1.3	12.2	2.6	0.6
Boeing 737-300	9,827	3.88%	12.2	15.6	1.3	9.6	2.9	0.2
Airbus A300	9,745	3.84%	20.6	18.9	7.0	14.4	1.2	0.9
DC-9	9,035	3.56%	9.5	9.6	2.7	8.1	2.3	0.5
Lockheed 1011	8,843	3.49%	20.1	19.2	13.5	15.0	1.9	0.7
Boeing 757-200	8,052	3.18%	17.3	10.4	0.9	12.6	2.0	0.2
Boeing 747-300	5,772	2.28%	24.4	15.5	9.6	14.5	1.9	0.5
Tupolev 154	5,610	2.21%	11.8	4.7	0.7	8.7	2.2	0.5
Airbus A310	4,682	1.85%	19.6	6.7	1.4	13.6	2.0	0.5
Boeing 767-300	4,536	1.79%	18.0	11.7	3.0	13.4	2.3	0.6
DC-8	4,397	1.73%	7.5	43.5	37.2	5.6	7.0	2.0
Airbus A320	3,653	1.44%	16.1	6.8	0.5	12.1	2.0	0.4
Boeing 727-100	3,107	1.23%	10.9	7.4	2.2	7.7	3.7	1.1
Small Turboprops	2,975	1.17%	8.1	4.0	0.2			
MD-11	2,841	1.12%	19.6	9.7	1.5	12.4	1.6	0.2
Boeing 747-SP	2,573	1.01%	23.2	30.6	19.9	14.4	1.1	0.8
Large Turboprops	2,126	0.84%	13.0	4.3	0.0			
Boeing 707	2,101	0.83%	15.1	39.1	44.7	5.9	8.0	7.9
Ilyushin 62	1,974	0.78%	14.6	34.2	39.5	5.9	5.9	6.0
Medium Turboprops	1,944	0.77%	11.8	5.1	0.6			
Boeing 737-400	1,787	0.70%	12.2	15.0	1.1	9.6	3.5	0.2
Fokker 28	1,680	0.66%	10.5	6.0	0.5	8.5	1.5	0.4
BAE-146	1,548	0.61%	8.8	8.1	0.8	7.7	0.2	0.0
Airbus A300-600	1,539	0.61%	18.9	10.9	2.0	13.2	2.0	0.4
Boeing 737-500	1,497	0.59%	11.4	12.9	0.8	9.4	3.8	0.2
Ilyushin 86	1,264	0.50%	15.1	38.8	44.7	5.8	8.1	8.0
Fokker 100	1,003	0.40%	9.5	25.9	2.5	6.4	11.5	1.6
Tupolev 134	846	0.33%	9.4	9.3	2.9	8.0	2.1	0.5
Boeing 747-SR	673	0.27%	18.6	19.3	11.1	14.0	2.7	2.7
BAC111	544	0.21%	11.4	13.4	2.3	9.3	2.7	0.6
YAK 42	460	0.18%	10.8	7.4	2.2	7.6	3.8	1.1
Concorde	404	0.16%	10.4	27.9	5.4	10.0	26.0	1.8
Ilyushin 72	248	0.10%	15.1	38.7	44.5	5.8	8.0	7.9

3.3 Seasonal Variability

There is a strong seasonal variation in air traffic departures as airlines shift schedules and aircraft to accommodate passenger demand. For example, increased air traffic may mean that airlines will utilize their aircraft more frequently and that some airplanes will be used more than others. Older, less-efficient aircraft might be used more in the summer than at other times and larger aircraft may be used more frequently. Thus, there may be seasonal variations in emissions which reflect both changes in passenger flow and in the equipment being used. This study was undertaken to quantify those seasonal variations.

In the analyses that follow, the fuel burned and emissions for selected geographical regions have been analyzed and plotted as a function of month. For simplification, the annual average for each region has been calculated and the percent difference from the average calculated and displayed. In addition to the seasonal variation, growth in air traffic occurred during 1992 so that the data contains that increase along with the seasonal variation. For purposes of this analysis, emissions in two altitude bands are considered: 0-19 kilometers (all emissions) and 9-13 kilometers (the typical cruise altitude range). Geographical regions have been defined as simple rectangular boxes as shown in Table 3-4.

Table 3-4. Definitions of geographical regions used in the seasonal analysis.

Geographical Region	Latitude Range	Longitude Range
Global	90S-90N	180W-180E
Northern Hemisphere	0-90N	180W-180E
Southern Hemisphere	90S-0	180W-180E
Continental United States	25N-49N	125W-70W
Europe	37N-70N	10W-25E
North America	25N-70N	125W-70W
North Atlantic	30N-70N	70W-10W
North Pacific	30N-65N	120E-125W

These geographical regions are illustrated in Figure 3-5. Approximately 92% of the calculated global fuel burned was in the Northern Hemisphere with only about 8% in the Southern Hemisphere. Approximately 36% of the fuel use occurred in the region defined as North America with the continental United States accounting for most of that. (34% of the global total) The calculations indicate that 13% of the fuel use was over Europe, 8% over the North Atlantic, and 10% over the North Pacific.*

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* These calculations are based on May 1992 as representative of the annual average.

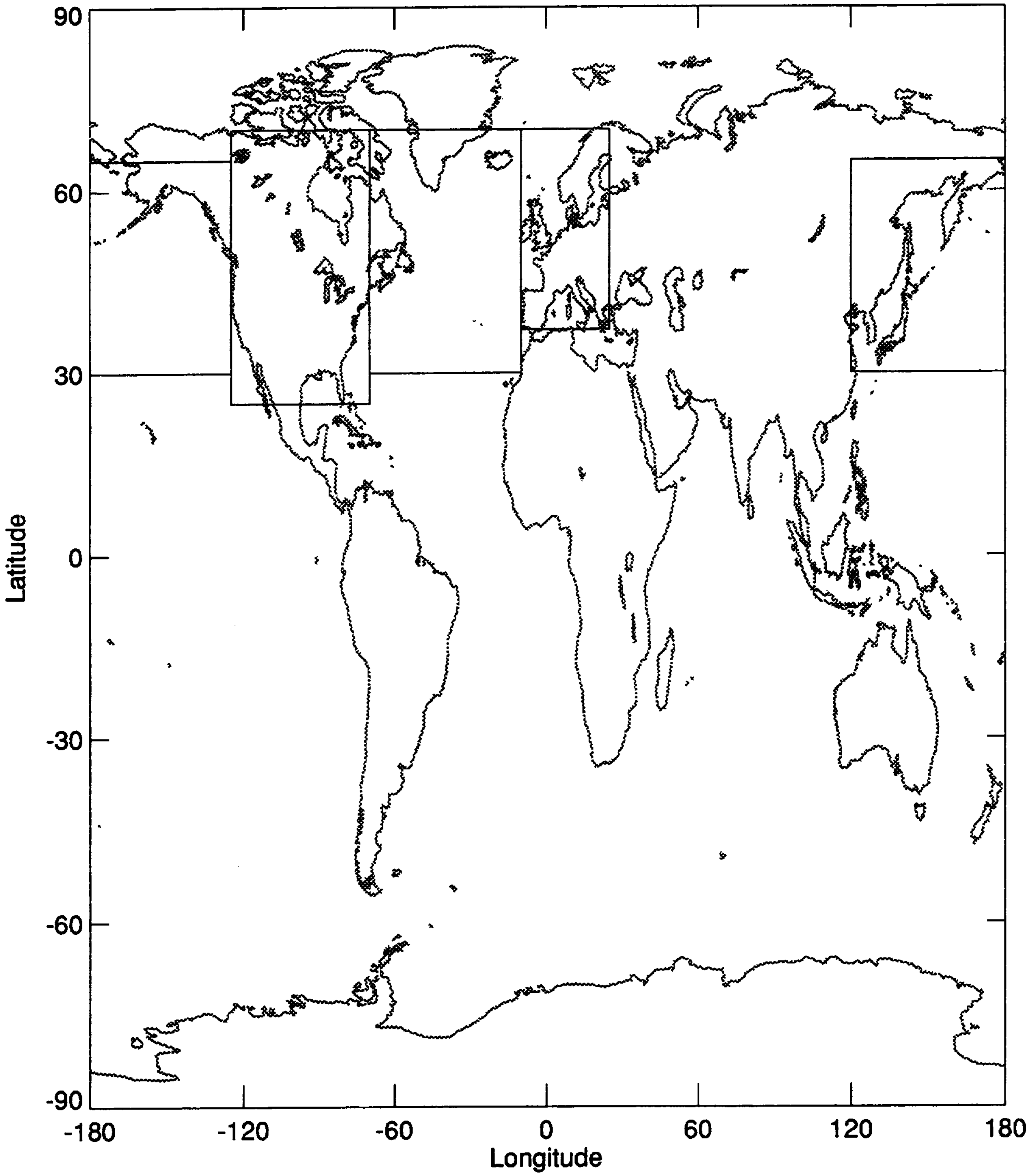


Figure 3-5. Geographical regions used in the seasonal variation analysis.

Figure 3-6 shows the seasonal variation in total fuel burned (summed over all altitudes) for 1992 for the world and for the Northern and Southern hemispheres. The top panel shows the daily fuel use as a function of month. The bottom panel shows the percent deviation from the annual average fuel use for each region. The vast majority of air traffic in 1992 was in the Northern hemisphere with the summer peak in fuel use about 6% higher than the annual average. By contrast, the fuel use in the Southern hemisphere shows relatively little seasonal variation.

The January data seems somewhat anomalous, perhaps because the original data was acquired from a different vendor and had been processed differently as discussed in Section 2.2. The daily departures by airplane type are summarized in Appendix K. Inspection of that table shows that a number of airplane types are not represented in the January database but are present in other months. The total number of departures in January is not very different from February, suggesting that much of the difference in January may be due to the smaller set of aircraft types considered in the January analysis rather than missing flights. Since the equipment matchup for January is not completely consistent with that of the other months, small differences in aircraft performance and emission characteristics may be one factor in the anomalous behavior. This is seen most clearly by checking the globally average emission indices. Emission indices can change significantly depending on the technology involved (see Section 3.2 and Appendix M for more discussion of this). The global average EI(HC) for January was 1.94 while for the other months it ranged from 2.34 to 2.49 (see Appendix E for details). The global average EI(CO) for January was 5.10 and ranged from 5.33 to 5.49 for the other months. Since the hydrocarbon and CO emissions are particularly sensitive to the type of equipment (older technology engines have higher CO and HC), this result suggests that the January data has a bias towards newer technology. From this, we conclude that part of the anomalous behavior of the January data is due to a smaller subset of airplane/engine combinations assigned in the schedule data.

Figure 3-7 shows the variation in fuel use for the four major geographical regions defined in Table 3-3. As the top panel shows, the fuel use in North America is the greatest, followed in order by Europe, the North Pacific and the North Atlantic. As the bottom panel shows, all four geographical regions show a strong seasonal variation with peak fuel use in the months of June-August. The strongest seasonal variation is shown in the North Atlantic (peak of 18% above the annual average) followed by the North Pacific (peak of 9%). The peak variation in North America was 5.5% and in Europe it was 6.2%.

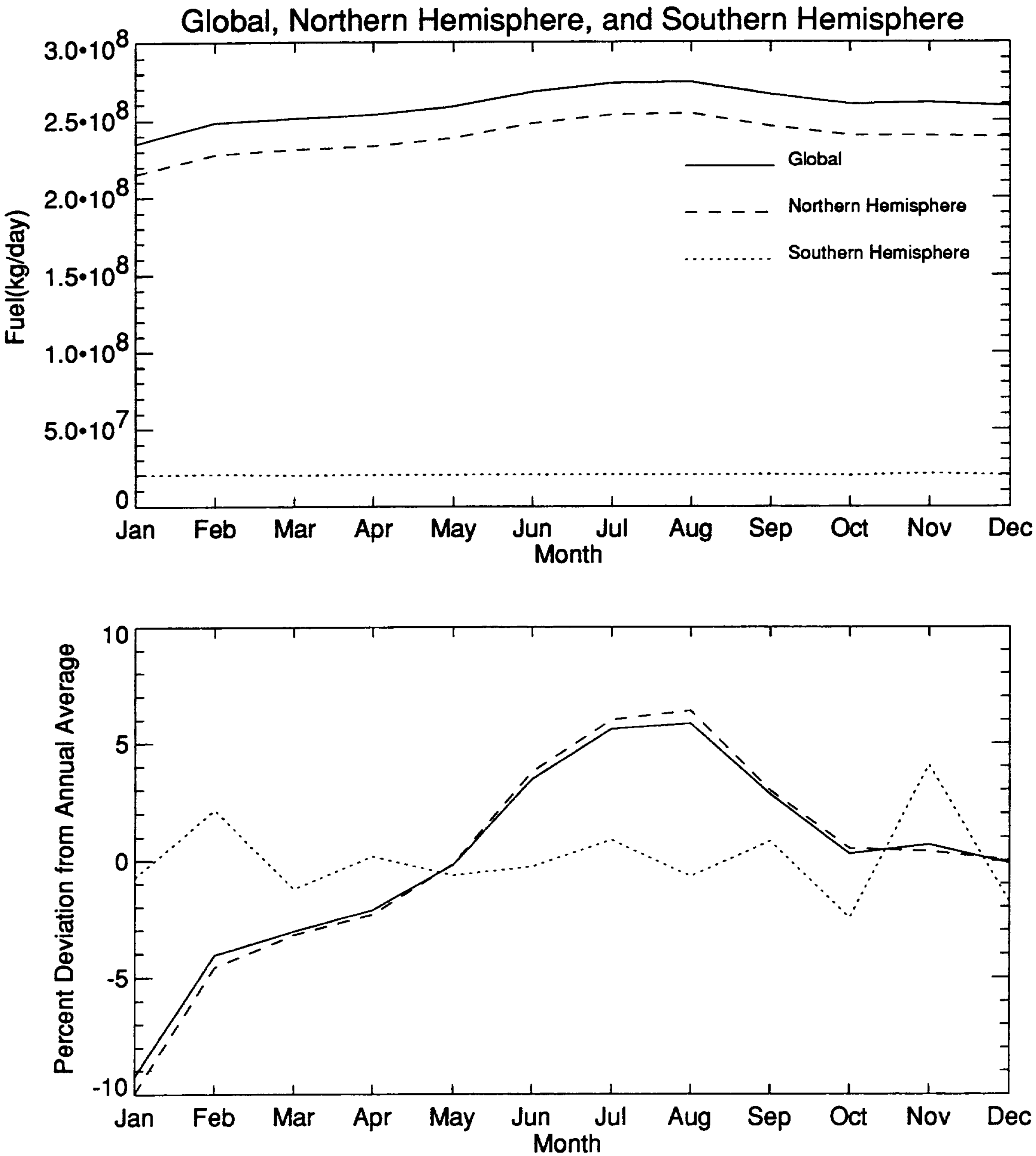


Figure 3-6. Fuel burned in the 0-19 km altitude band for scheduled air traffic for global (solid line), Northern hemisphere (dashed line), and Southern hemisphere (dotted line) for each month of 1992.

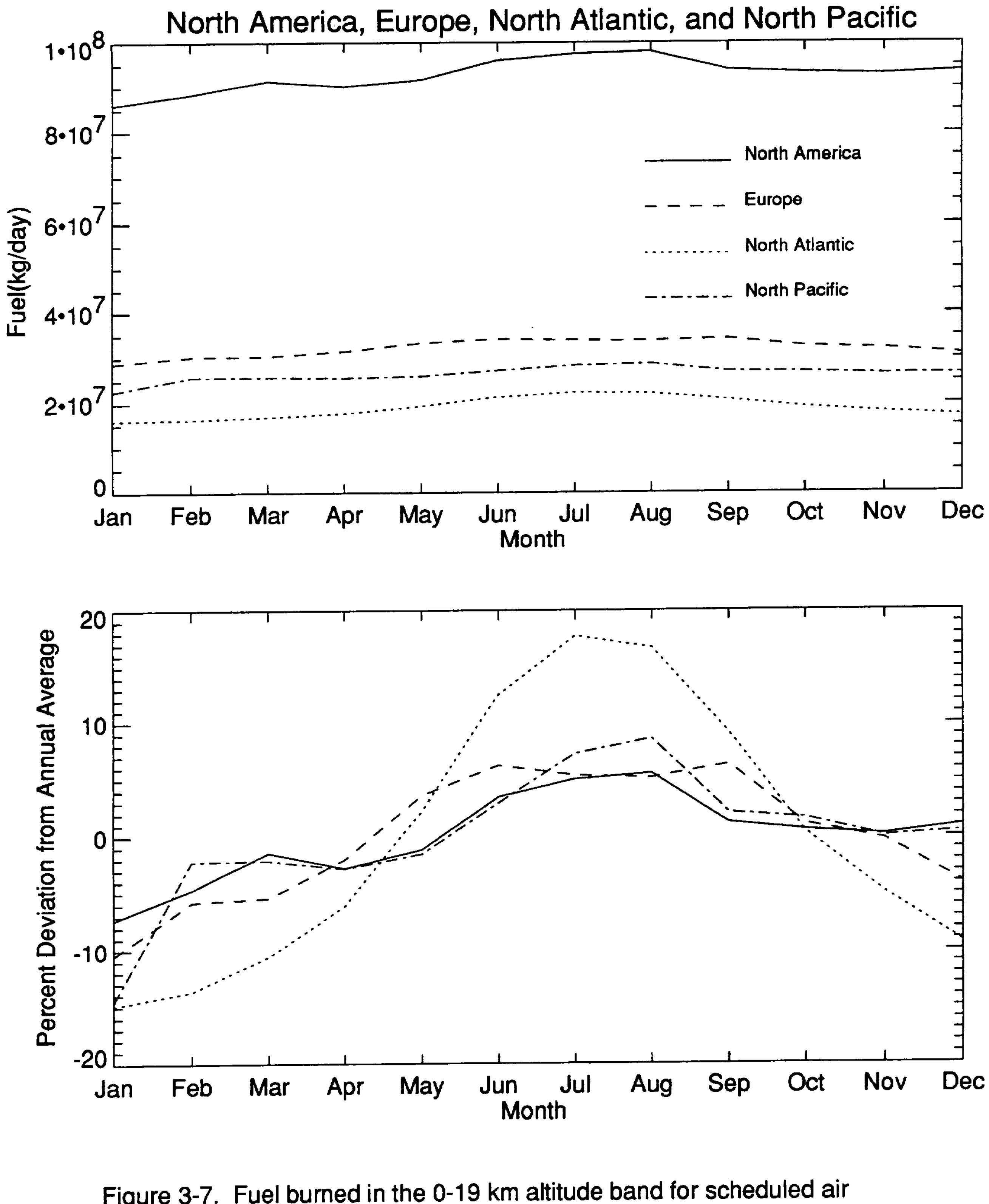


Figure 3-7. Fuel burned in the 0-19 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

Much of the concern about the effects of aircraft emissions is related to possible aircraft-induced perturbations in the upper troposphere. As Figure 3-8 shows, the variation in fuel in the 9-13 kilometer altitude band is similar to that shown when all altitudes (0-19 km) were considered. Peak variations of 18% occur in the North Atlantic with peaks of 9% in the North Pacific. These, of course, match the result considering all altitudes since there are few landings or takeoffs in either the North Pacific or North Atlantic. Over North America and Europe the peak fuel use at cruise altitudes occurs in the summer with peaks of 6.5% and 9.3 %, respectively.

Both water vapor and carbon dioxide emission indices are functions of the hydrogen and carbon content, respectively, of the jet fuel. For typical jet fuel,

$EI(H_2O) =$ 1237 grams H_2O/kg fuel burned
$EI (CO_2) =$ 3155 grams CO_2/kg fuel burned

Thus, the seasonal variation in water and carbon dioxide emissions from the commercial fleet will be the same as that shown above for the fuel usage.

The variation in NOx emissions globally and in the two hemispheres follows that of the fuel use (see Figure 3-9). Peak NOx emissions occur in the summer with peak amplitudes about 6% higher than the annual average. The NOx emissions in the 0-19 km altitude band for the four key regions are shown in Figure 3-10. The seasonal pattern is very similar to that found for fuel usage, as expected. In the 9-13 kilometer altitude band (see Figure 3-11), the peak NOx emission occur during summer.

The seasonal variation of the CO and hydrocarbon emissions are very similar to those for fuel burned and NOx but are shown here for completeness. (see Figures 3-12- 3-15) The peak variations from the annual average are summarized in Table 3-5 (considering all altitudes) and in Table 3-6 (cruise altitudes).

Table 3-5. Peak increases from the annual average for fuel burned and emissions for selected geographical regions and in the 0-19 kilometer altitude band.

Geographical Region	Fuel	NOx	HC	CO
Global	5.8%	6.1%	5.4%	4.9%
Northern Hemisphere	6.4%	6.6%	5.8%	5.3%
Southern Hemisphere	4.1%	4.8%	6.4%	3.8%
North America	5.5%	5.8%	6.4%	5.4%
Europe	6.2%	6.7%	7.3%	6.4%
North Atlantic	17.8%	18.1%	15.0%	17.1%
North Pacific	8.6%	8.3%	7.1%	7.3%

Table 3-6. Peak increases from the annual average for fuel burned and emissions for selected geographical regions and in the 9-13 kilometer altitude band.

Geographical Region	Fuel	NOx	HC	CO
Global	7.1%	7.4%	6.0%	6.4%
Northern Hemisphere	7.7%	8.0%	6.7%	7.0%
Southern Hemisphere	4.1%	4.6%	7.3%	3.6%
North America	6.5%	6.7%	7.2%	6.6%
Europe	9.3%	10.0%	9.0%	8.3%
North Atlantic	17.9%	18.3%	15.3%	17.7%
North Pacific	9.4%	9.2%	8.8%	9.2%

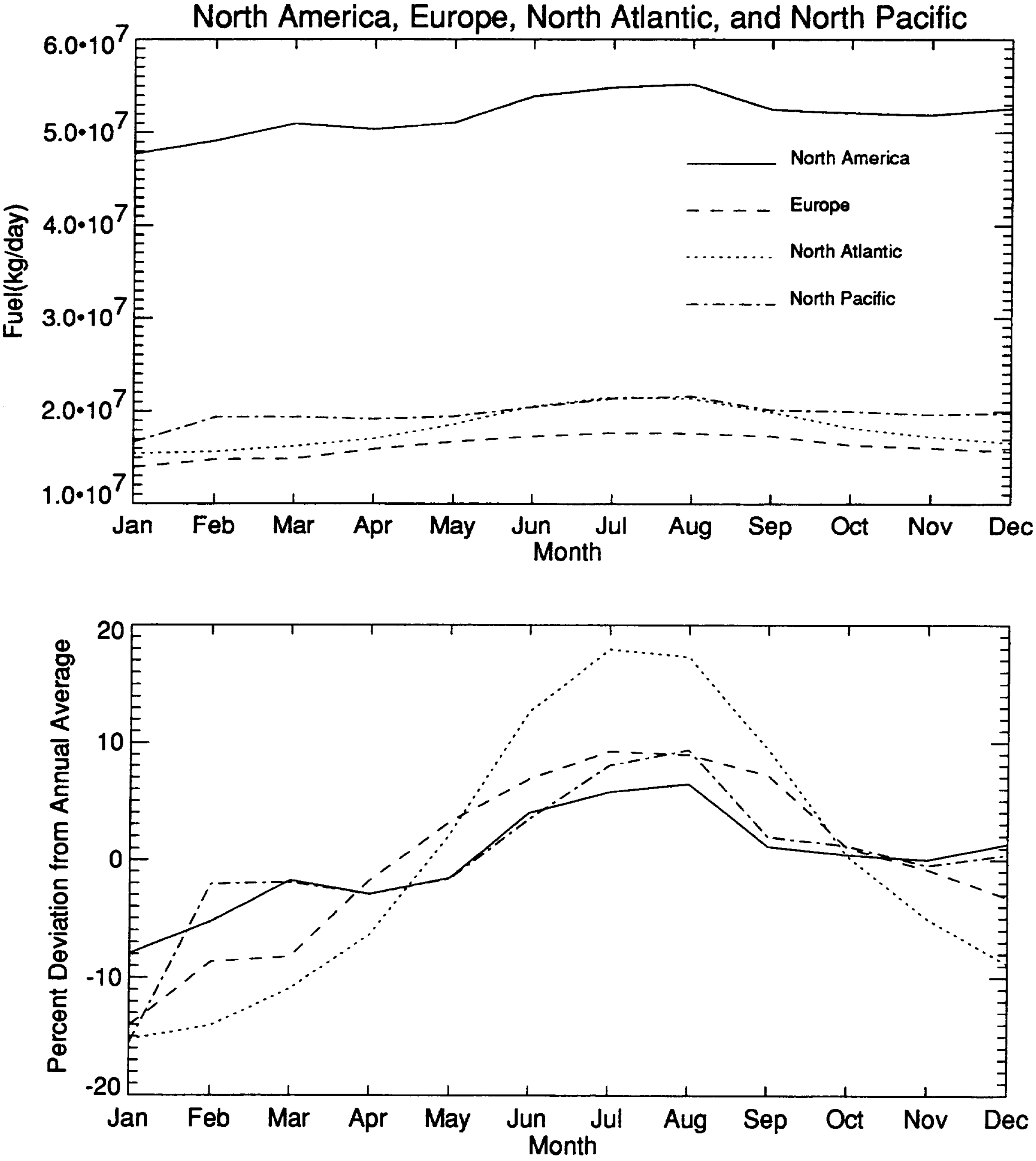


Figure 3-8. Fuel burned in the 9-13 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

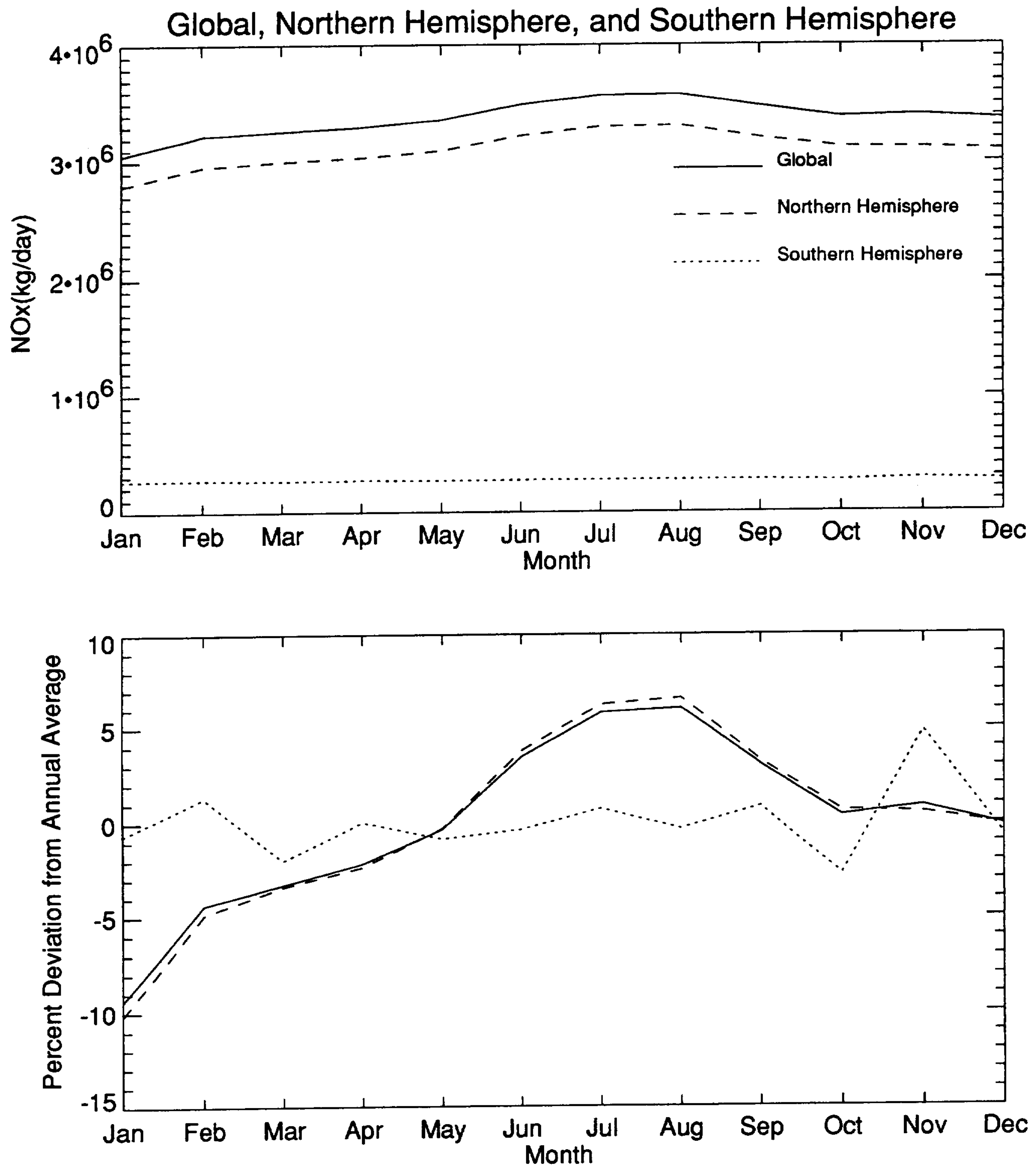


Figure 3-9. NOx emitted in the 0-19 km altitude band for scheduled air traffic for global (solid line), Northern hemisphere (dashed line), and Southern hemisphere (dotted line) for each month of 1992.

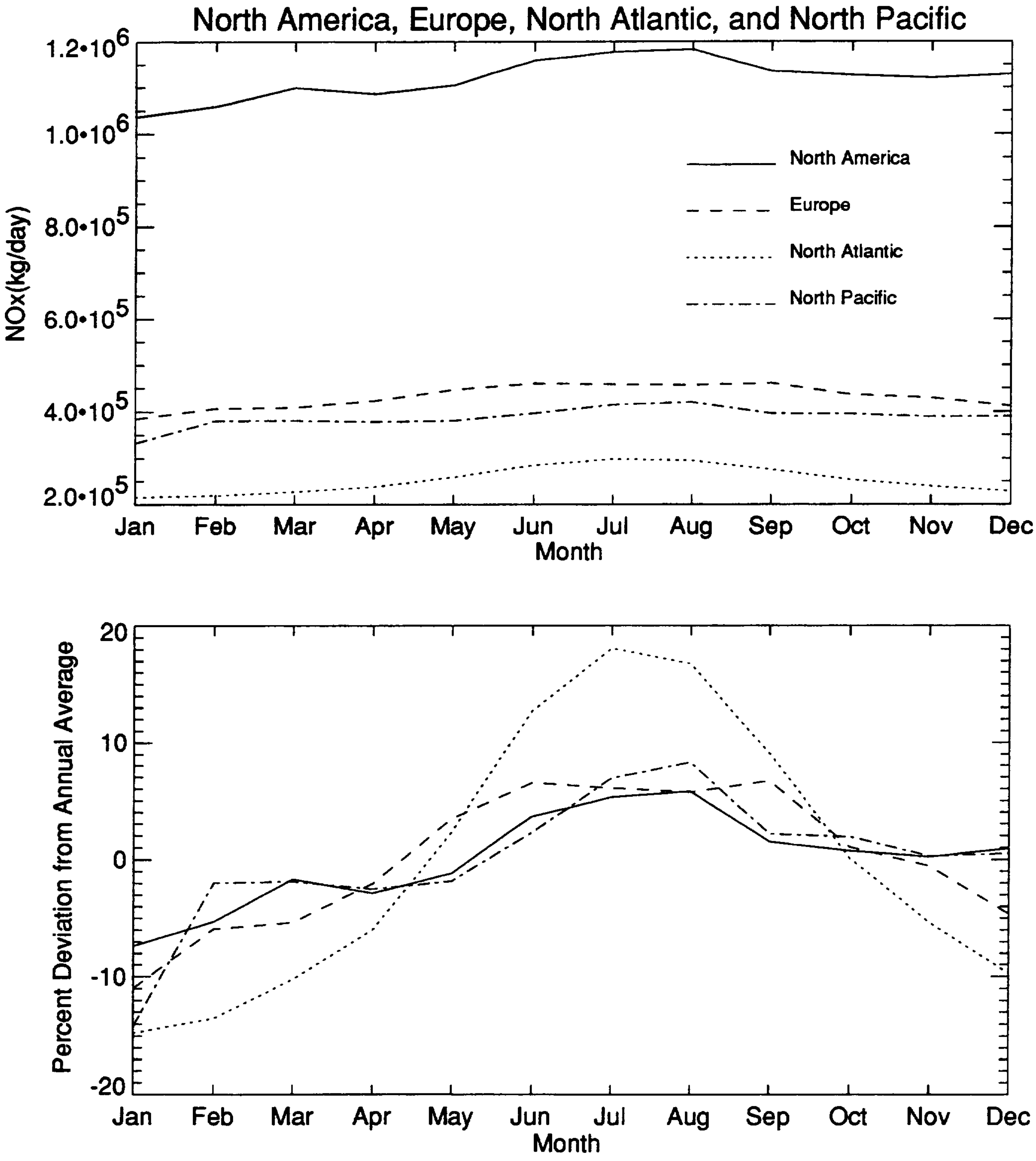


Figure 3-10. NOx emitted in the 0-19 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

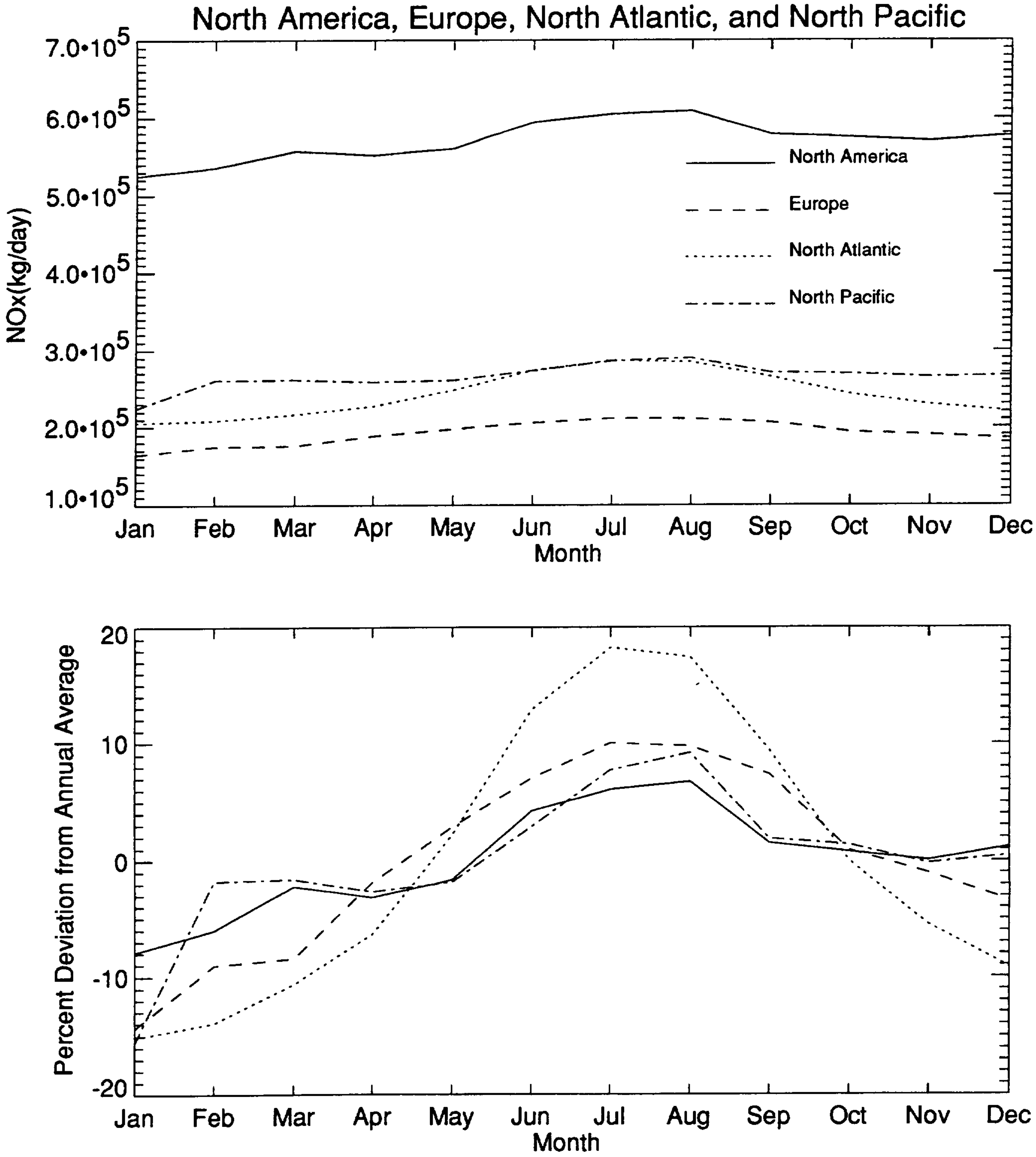


Figure 3-11. NOx emitted in the 9-13 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

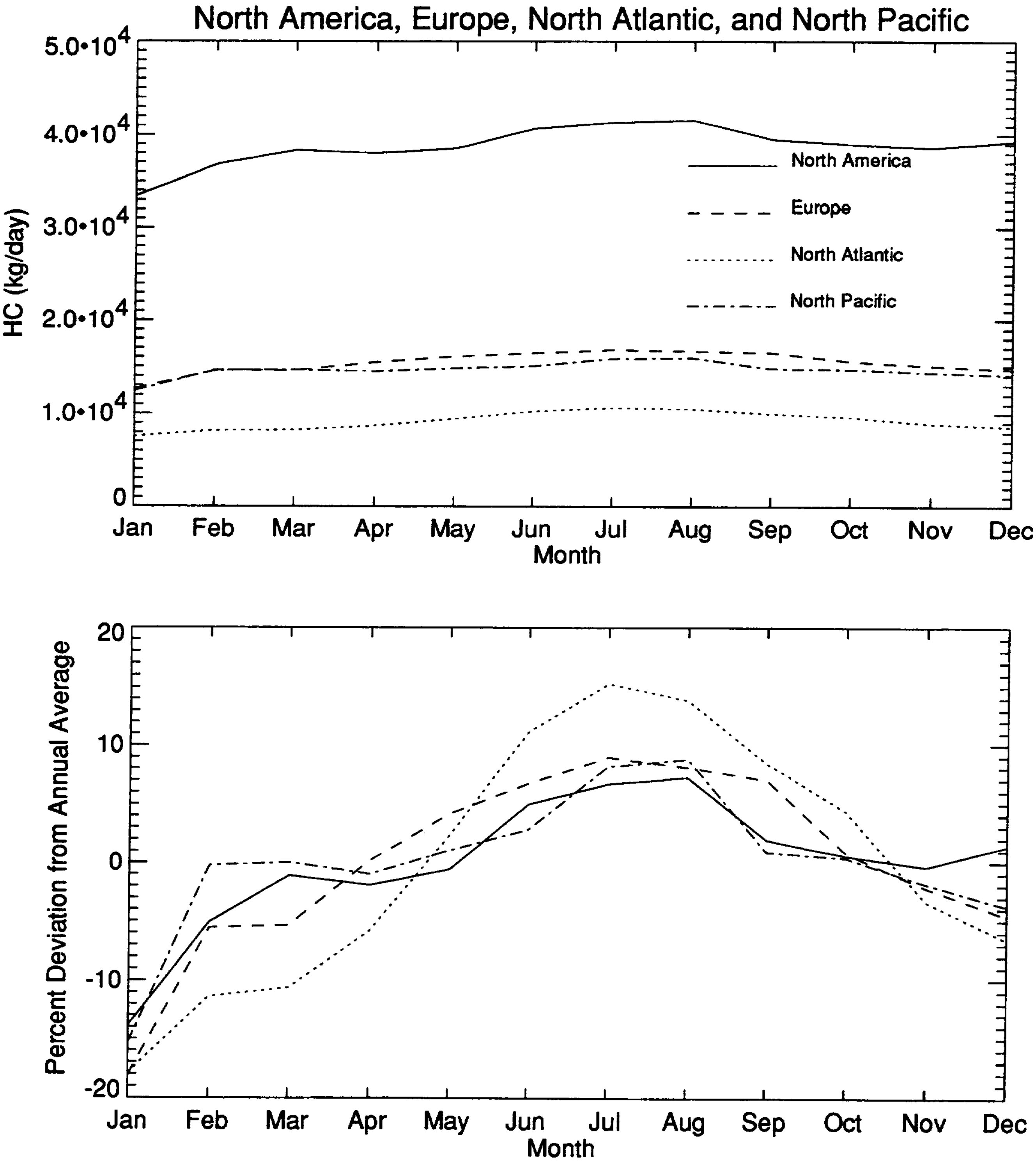


Figure 3-12. Hydrocarbons emitted in the 9-13 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

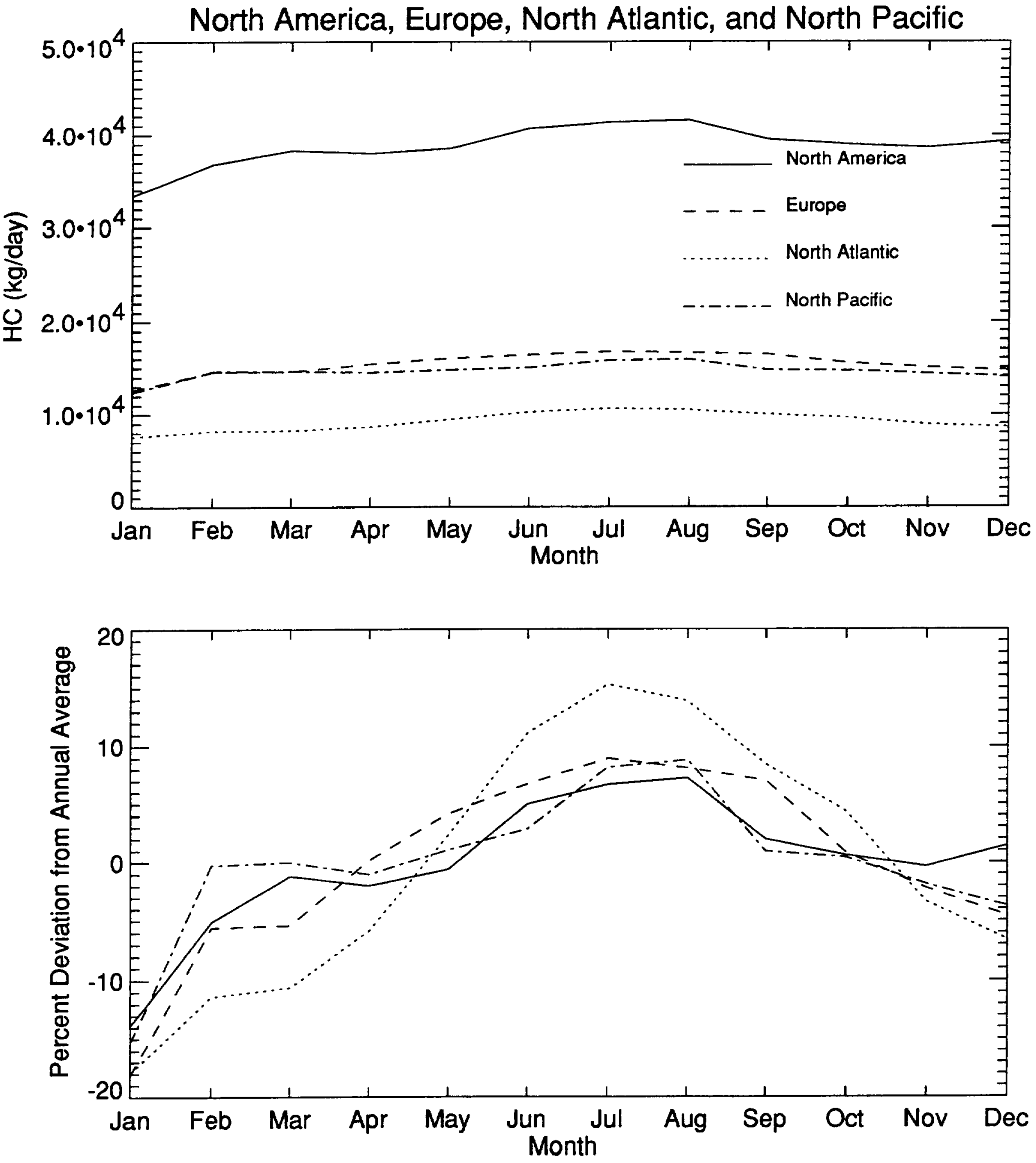


Figure 3-13. Hydrocarbons emitted in the 9-13 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

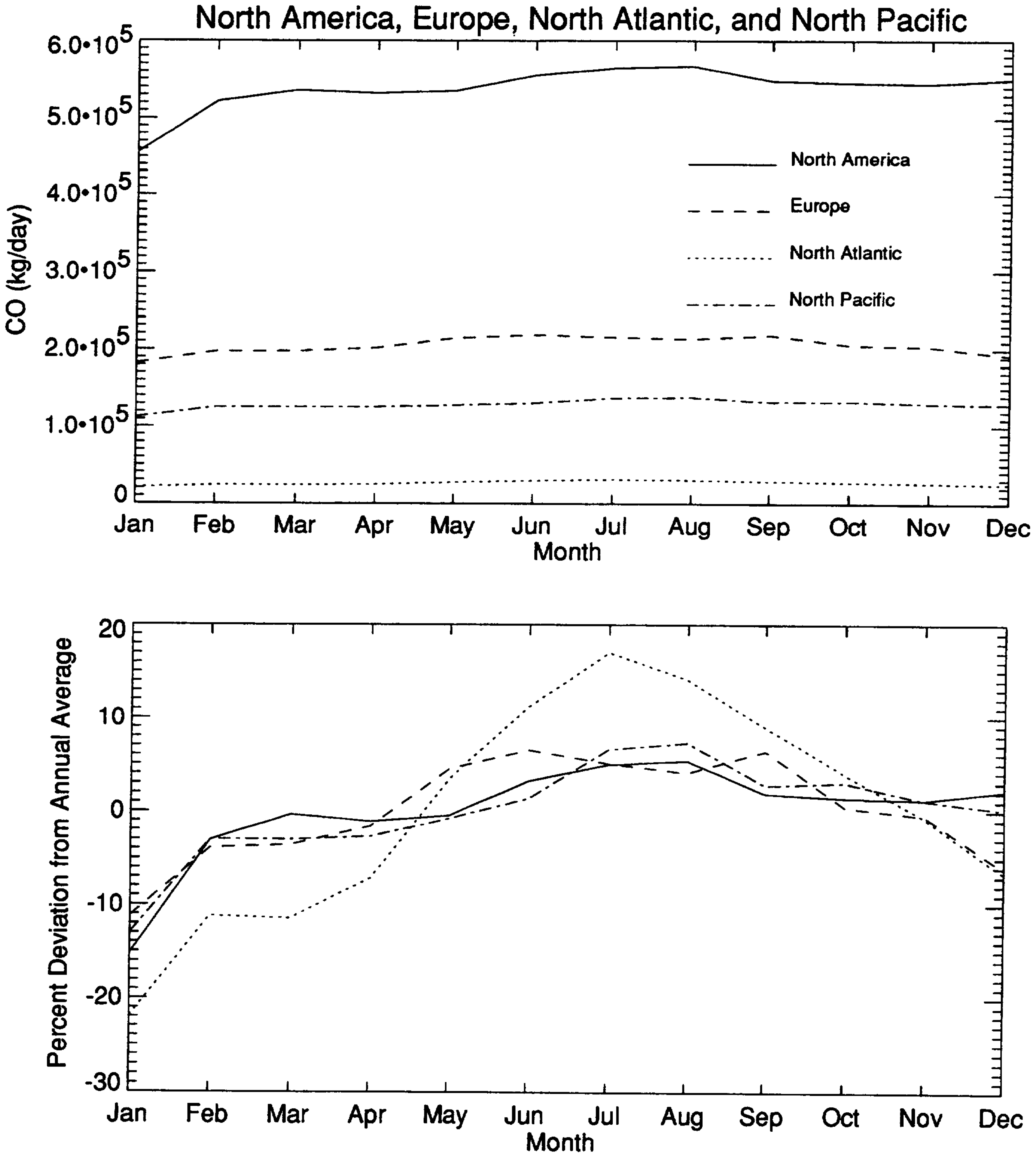
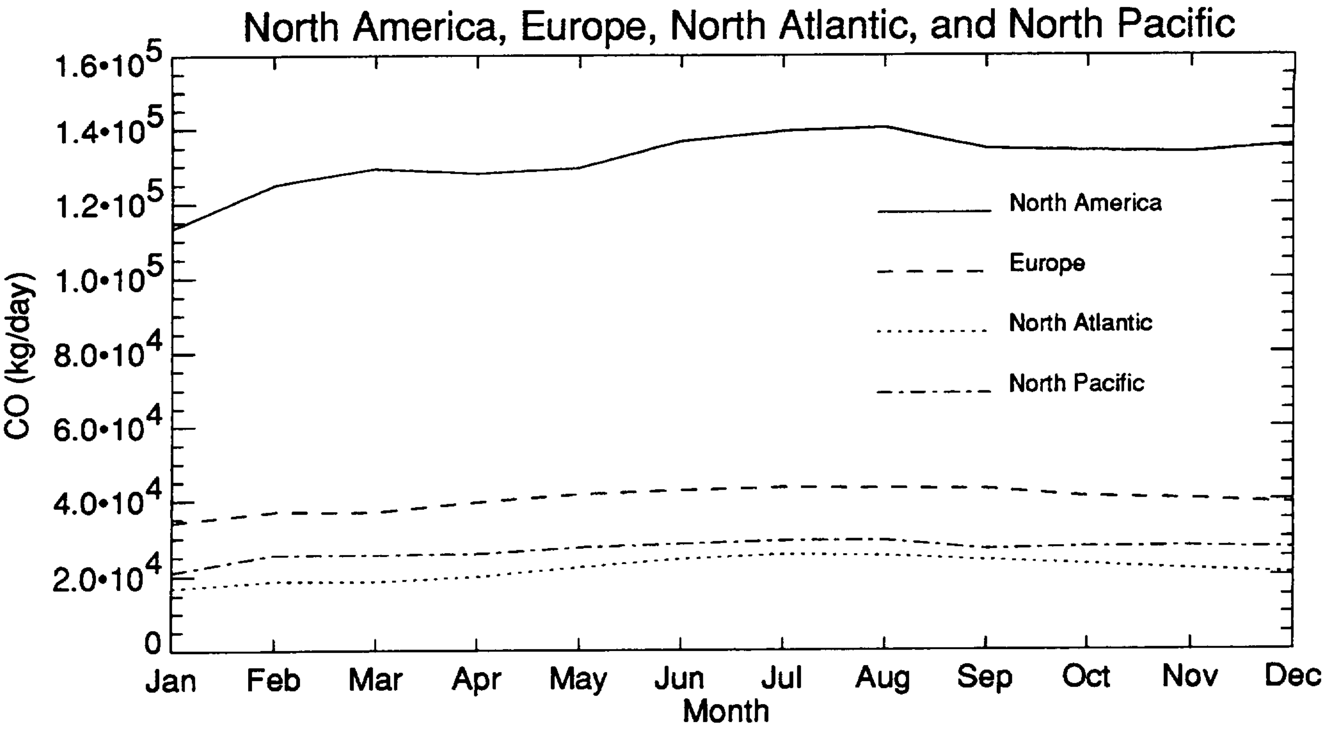


Figure 3-14. Carbon monoxide emitted in the 0-19 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.



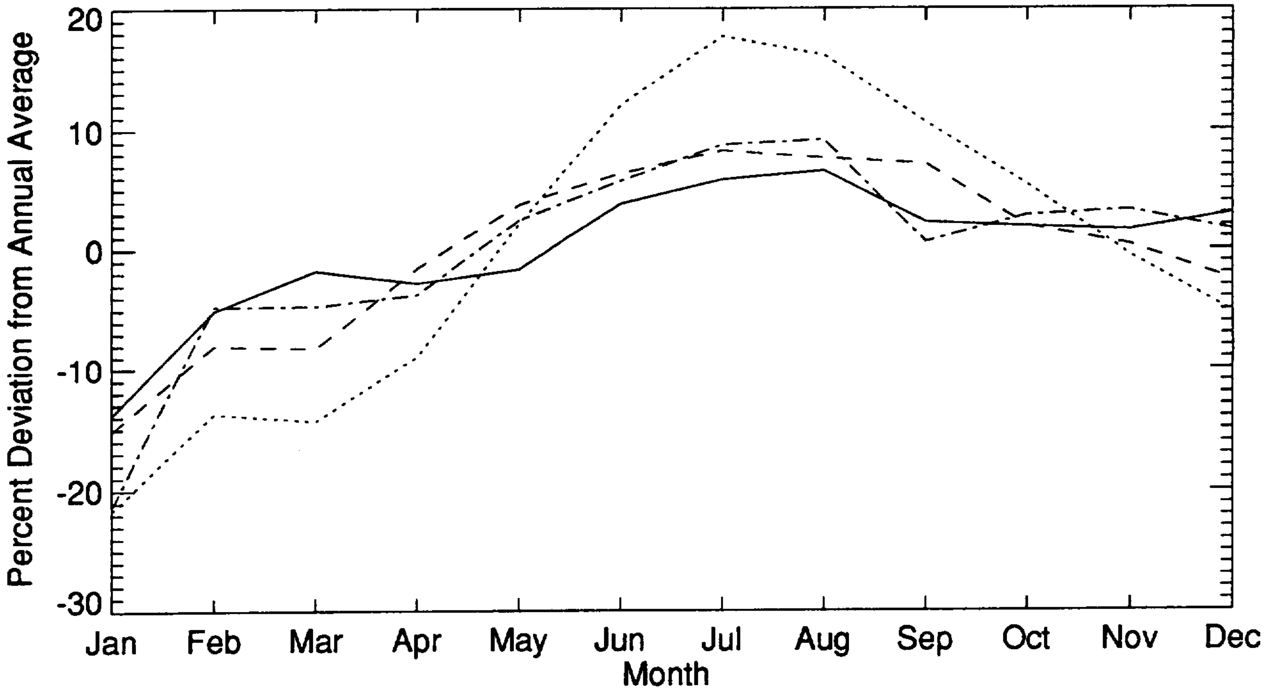


Figure 3-15. Carbon monoxide emitted in the 9-13 km altitude band for scheduled air traffic for North America (solid line), Europe (dashed line), the North Atlantic (dotted line), and the North Pacific (dash-dot line) for each month of 1992.

3.4 Revised May 1990 Results

As was described earlier, the emission inventory for May 1990 scheduled air traffic was recalculated using the identical algorithms that have been used for the calculation of the 1992, 1976, and 1984 emission inventories so that all could be combined in a self-consistent trend analysis. Table 3-7 shows the results calculated for May 1990 using both Boeing method 1 and 2 emission methodologies. For comparison, the results calculated in the earlier study are also shown. Eliminating the double counts from the OAG file and adding additional aircraft performance files resulted in revised calculations with 3.5% less fuel than reported earlier. The effective global averaged emission indices are summarized in Table 3-8. The revised calculations also show significant increases in the calculated hydrocarbon emissions. We believe that this is due to the inclusion of more older aircraft/engine combinations in the performance analysis. The older engines were less efficient and had higher hydrocarbon emissions than do more modern engines. The engine emissions data set was also changed as discussed in Section 2.5.

Table 3-7. Comparison of revised May 1990 fuel burned and emissions with those previously published.

	Fuel (kg/day)	NOx (kg/day)	HC (kg/day)	CO (kg/day)
May 1990 (Baughcum, *et. al.*, 1994)	2.54E+08	3.18E+06	3.77E+05	1.44E+06
May 1990 (revised, Method 1)	2.45E+08	2.83E+06	6.29E+05	1.58E+06
May 1990 (revised, Method 2)	2.45E+08	3.14E+06	5.70E+05	1.36E+06

Table 3-8. Comparison of global emission indices calculated for May 1990 using Boeing Method 1 and Method 2 fuel flow correlation methods.

	EI(NOx)	EI(HC)	EI(CO)
May 1990 (Baughcum, et. al., 1994)	12.5	1.5	5.7
May 1990 (revised, Method 1)	11.6	2.6	6.4
May 1990 (revised, Method 2)	12.8	2.3	5.5

In the results reported in CR-4592, approximately 31% of the flight miles were flown by the more modern generation 2 engines. Our definition of generation 2 engines is shown in Table 3-9; all other engines were considered generation 1. In this new study, only 21 % of the miles were flown by generation 2 engines. This supports the conclusion stated above that the biggest change was caused by the inclusion of more older aircraft in the performance and emission analyses. It also highlights the importance of using a large detailed database of aircraft performance datafiles. The emission results appear to be sensitive to the assumptions made about older aircraft, even when a rather large database had been used initially.

Table 3-9. Generation 2 Engines

CF6-80A	PW2000
CF6-80C	PW4000
CFM56-2	RB211-535C
CFM56-3-B1	RB211-535E4
CFM56-3B-2	RB211-524B4
CFM56-3C-1	RB211-524D4
CFM56-3A1	RB211-524G
V2500	RR TAY

The major differences in the revised May 1990 calculations and those reported in CR-4592 are shown in Figures 3-16 and 3-17. As shown in Figure 3-16, only small changes are calculated in the fuel burned and NOx emissions altitude profiles. Emissions of hydrocarbons at all altitudes are calculated to be higher in the revised calculation. Carbon monoxide emissions at cruise altitudes are calculated to be lower. The fuel burned and emissions as a function of altitude for this revised May 1990 dataset are provided in Table E-13 of Appendix E.

As Figure 3-17 shows, the new results predict somewhat higher NOx emission indices in the 11-13 km altitude range. NOx emission indices below 10 km did not change much. In contrast, the hydrocarbon emission indices calculated in this study are a good bit higher than those considered earlier. As discussed above many of these changes are due to the inclusion of older aircraft/engine combinations in the emission calculations as well as the use of the improved emissions methodology.

The differences above 14 kilometer altitudes are due to the treatment of the Concorde emissions, since no other airplane used in this calculation flies that high. As was described earlier, our treatment of Concorde hydrocarbon and carbon monoxide emissions were revised for this study to be consistent with the altitude chamber measurements made during CIAP (1975).

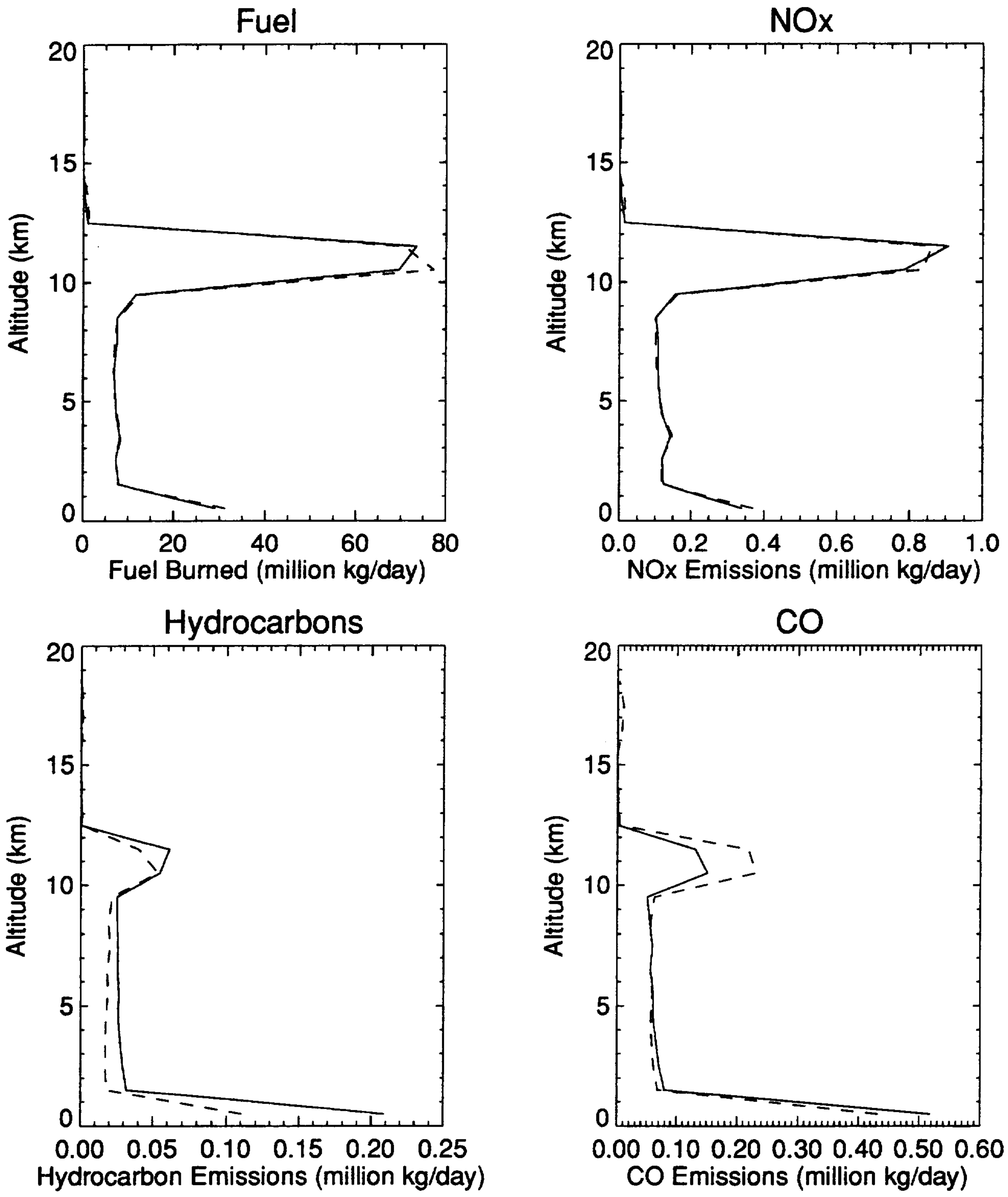


Figure 3-16. Fuel burned and emissions as a function of altitude for May 1990 scheduled air traffic using the Boeing Method 2 fuel flow correlation method (solid line) for emissions compared with the results reported in CR-4592 (dashed line) (summed over latitude and longitude).

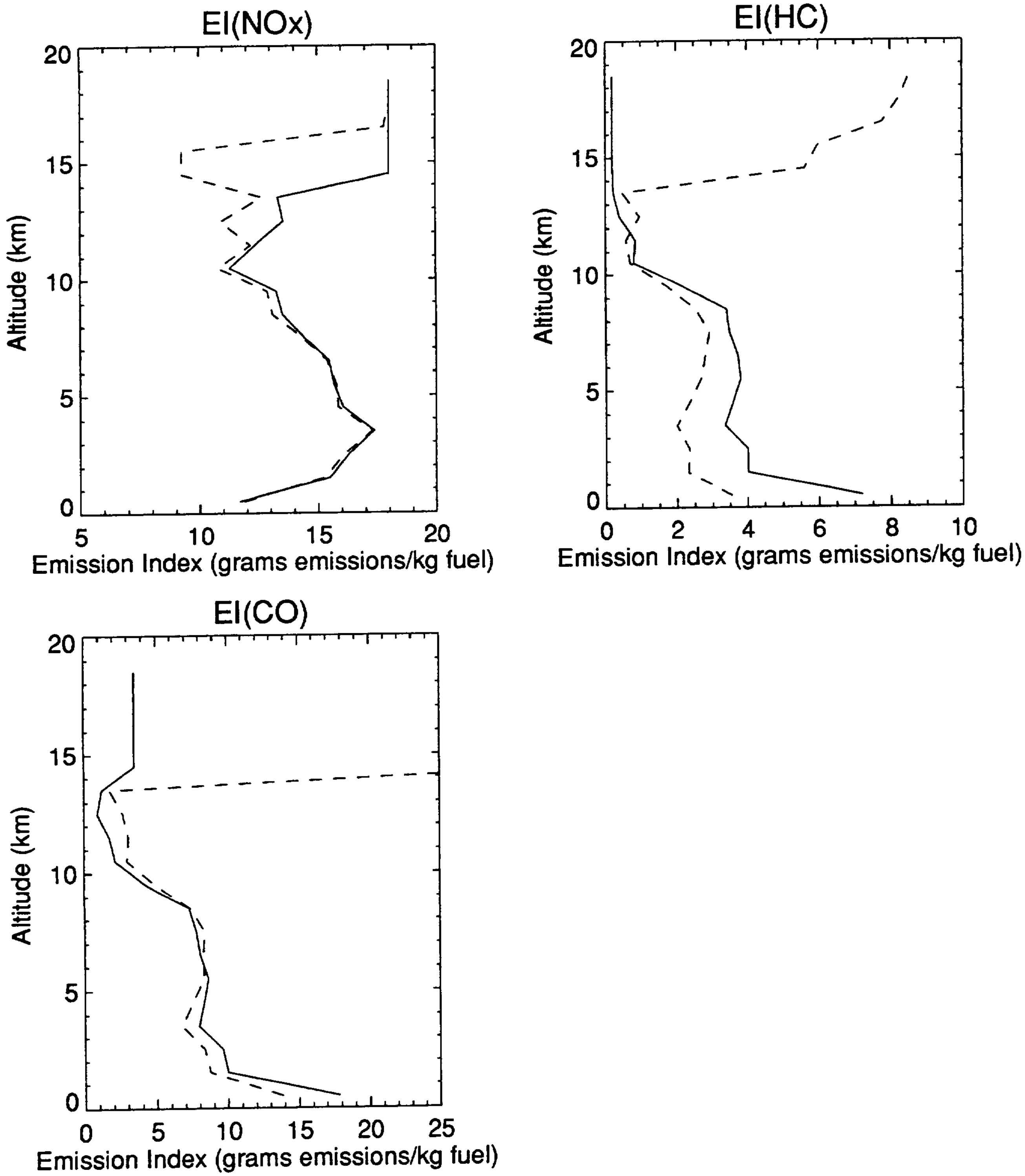


Figure 3-17. Emission indices for May 1990 scheduled air traffic as a function of altitude for Method 2 (solid line) compared with the results reported in CR-4592 (dashed line) (summed over latitude and longitude). (Note that the emissions shown above 14 km altitude are due to the Concorde.)

For a comparison of the effects of switching from the Method 1 fuel flow methodology for calculating emissions to Method 2, the differences in emission indices are shown as a function of altitude in Figure 3-18 . For this calculation, the same aircraft engine combinations were used and only the emission methodology was changed. The NOx emission indices are calculated to be higher at cruise altitudes using Method 2, while both hydrocarbon and carbon monoxide emissions are calculated to be lower. There is little difference between the two methods near ground level. Above 14 kilometers, the emission indices shown are for the Concorde only and were set to the values measured in an altitude chamber during the CIAP program.

It is worthwhile to note that the seasonal variations discussed in Section 3.3 show that the calculated fuel use and emissions for May of 1992 were very close to the average for 1992. This supports the assumption used in earlier NASA-funded studies to use May as representative of the annual average. This assumption had been based on earlier analyses of passenger flow.

3.5 Database Availability

These 3-dimensional aircraft emission inventories of fuel burned and emissions are available on a 1 degree latitude x 1 degree longitude x 1 km altitude grid for each month of 1992 and for May 1990. They can be obtained by contacting Karen H. Sage (sage@uadp2.larc.nasa.gov) at NASA Langley Research Center or by sending a request to the Atmospheric Sciences Division, MS 401A, NASA Langley Research Center, Hampton, VA 23681-0001. Technical questions about the data set should be sent to Steven L. Baughcum (baughcum@atc.boeing.com) at the Boeing Company, P. O. Box 3707, MS 6H-FC, Seattle, WA 98124-2207.

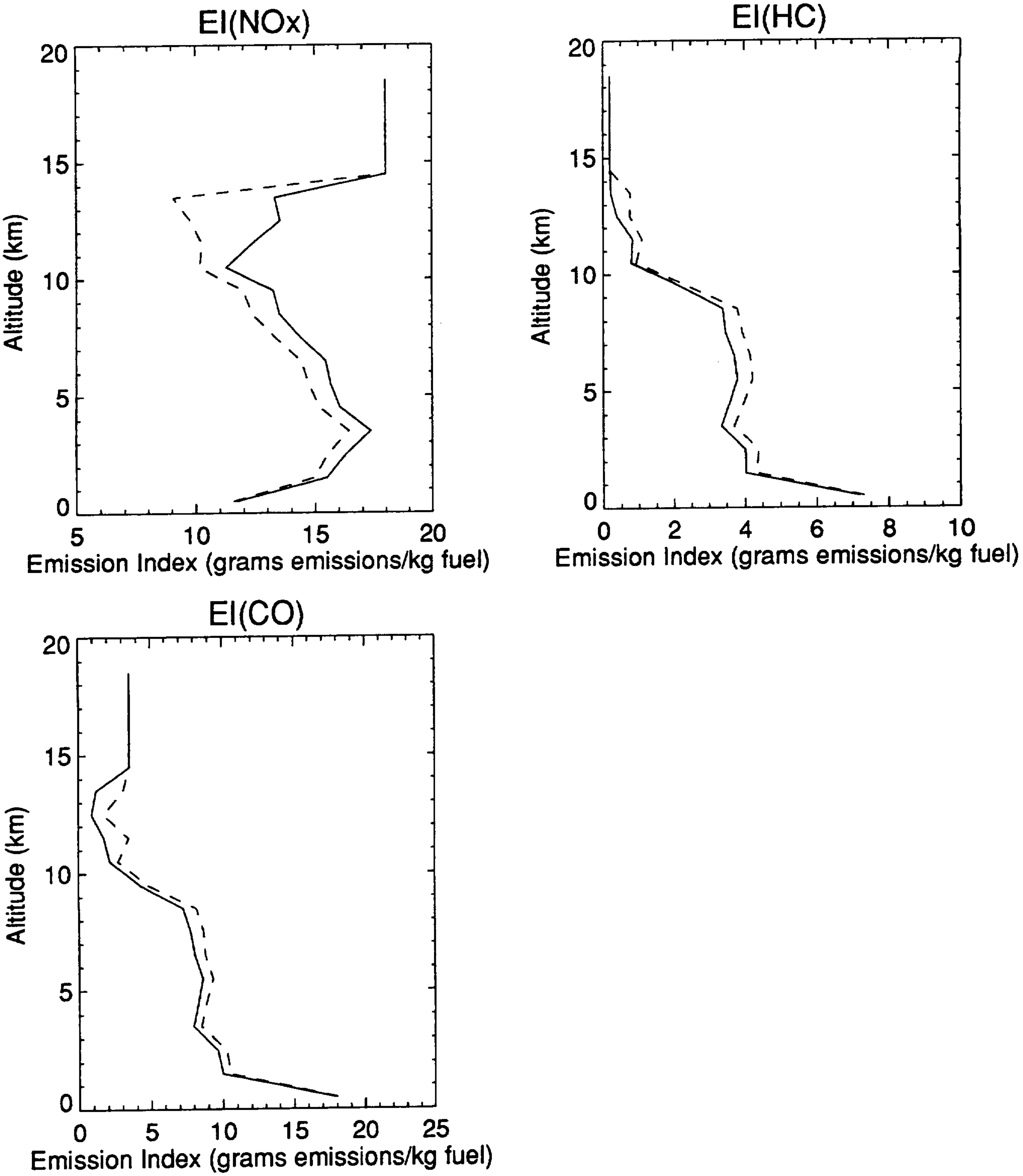


Figure 3-18. Emission indices for May 1990 scheduled air traffic as a function of altitude calculated using Boeing Method 2 (solid line) and Method 1 (dashed line) (summed over latitude and longitude).

4. Parametric Studies

The aircraft emission inventories described in Sections 2 and 3 were calculated using certain simplifications and assumptions in order to be computationally tractable. In order to evaluate the effect of these assumptions on the final results, parametric studies were done using a more comprehensive aerodynamic performance model for a few aircraft and routes. These studies were aimed at establishing the limits, or extremes, of possible results. In many cases it was expected (and found) that realistic changes in the inputs would produce small changes in the database. This would be consistent with the proposition that the baseline database used in these aircraft emission inventories is, in fact, accurate for a first order analysis.

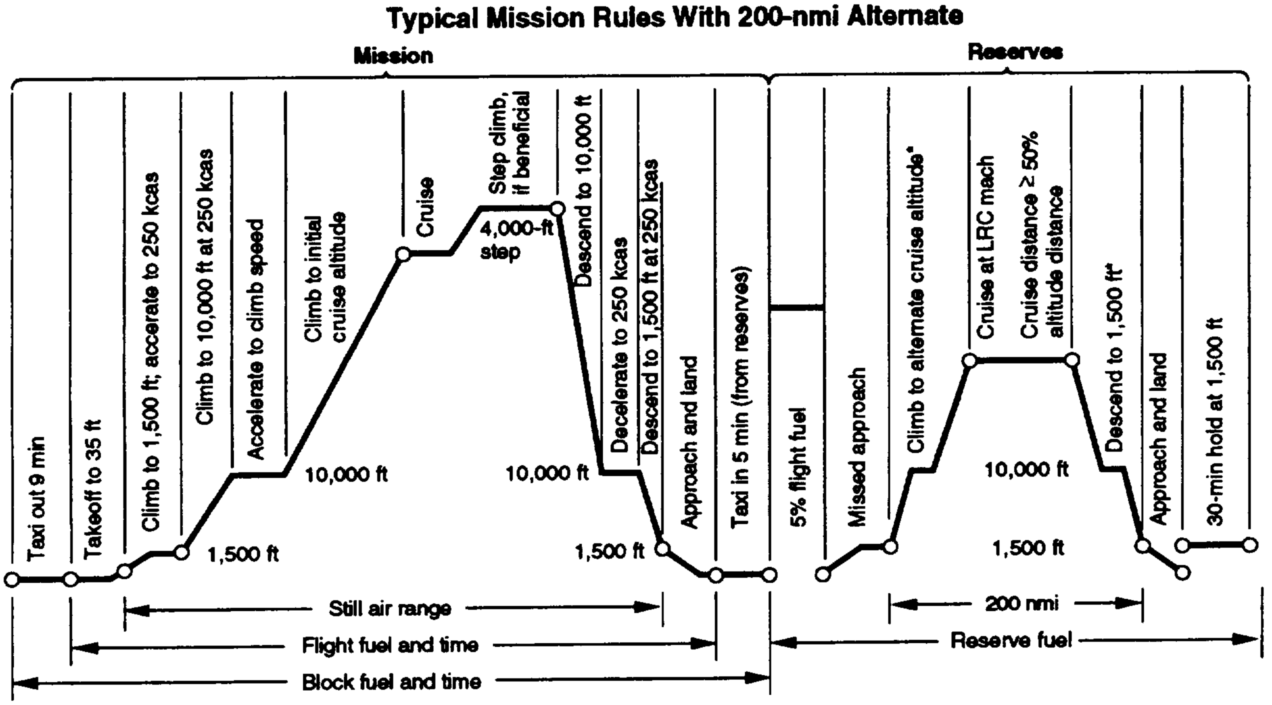
Meteorological effects are evaluated using a database of monthly means and standard deviations of winds and temperatures derived from daily National Meteorological Center (NMC) analyses between July 1976 and June 1985. This database is incorporated into the Boeing WINDTEMP program for use by both airline route planners and design engineers to calculate winds and temperatures enroute between two selected cities. (Boeing, 1991; Boeing, 1992) The code is integrated with Boeing's performance analyses so that the effect of winds and temperatures on fuel consumption on a given route can be calculated explicitly for different months of the year and for different reliabilities.

The Boeing Mission Analysis Program (BMAP) is the principal computing tool used by the Boeing Commercial Airplane Group Aerodynamics and Sales & Marketing organizations to calculate mission performance in support of sales, engineering studies, airline route studies, and competitive evaluations. The following list summarizes the BMAP functions relevant to the calculation of the GAEC database:

- Model complex airplane flight profiles with multiple cruise segments, step cruise, and flight profiles balanced to include required cruise segments
- Make complex route studies
- Make complex parametric studies
- Specify winds and temperatures
- Calculate through-stop missions
- Model complex tracks with enroute and alternate way points
- Make database lookups: Airport information; equivalent winds and temperature (WINDTEMP)
- Solve for payload, range, or takeoff weight with cruise altitude optimization
- Specify job and airplane information
- Specify time, fuel and distance or calculate from a database
- Create electronic file output for other programs

BMAP calculations, as used in this analysis, are based on tables of time, fuel and distance calculated for each airplane. These tables are created from basic performance data by the Aerodynamics organization. BMAP is run by creating input files that list mission information and the names of the databases needed to compute the mission.

The altitude profiles used in this study are based on Boeing Typical Mission Rules. Figure 4-1 shows the mission and reserve profiles for international flights described by the Boeing Typical Mission Rules. These rules are used by Boeing to calculate airplane performance for Boeing and competitor products and are used for (1) internal Boeing studies and comparisons of commercial jet transport performance of a general nature, and (2) performance and economics data prepared for standard brochures used in initial customer airline contacts. They are based on ICAO Annex 6 recommendations.



Conditions:

- Fuel density = 6.75 lb/USG
- Standard day

*Speed restrictions as applied to mission.

Figure 4-1. Typical mission profile.

The tables used in BMAP are an electronic version of airplane performance documents. These documents are the standard for calculating airplane performance. BMAP is upwards of 99.5% accurate when compared to that standard. The data used by BMAP is also used to develop guarantees for Boeing products. Naturally, data for non-Boeing aircraft may be less accurate than for Boeing products depending on its source, but every effort is made by Boeing to ensure a consistent set of data for both Boeing and competitor products.

4.1 Parametric Analysis of Emission Inventory Inputs

To generate the input performance files which serve as the performance database for the calculation of global emission inventories, a number of simplifying assumptions were made. These include:

- o No winds
- o International Standard Atmosphere (ISA) temperatures
- o Westbound cruise altitudes (27,000-31,000-35,000-39,000 ft)
- o No cargo (Payload = passengers + baggage weight)
- o 70% load factor
- o No tankering of fuel
- o Passenger weight equals 200 lb/pax for single aisle and 210 lb/pax for wide body aircraft
- o Boeing typical weight calculations used for Operating Empty Weight, Maximum Landing Weight, Maximum Zero Fuel Weight, etc.
- o Fuel density of 6.75 lb/gallon, fuel energy content of 18,580 BTU/lb
- o Direct great circle routes--no turns or air traffic control directions
- o Sea level airport with no weight or runway restrictions
- o Boeing Typical Mission Rules (see previous section)

Naturally, not all of these conditions are representative of actual flight conditions on a regular basis. In order to include actual conditions in the database, a very large effort would be required to try to quantify their effect, primarily because they vary with time, flight direction, airline, and geographic location, among other things. Rather than try to include these effects in the database in a rigorously detailed manner, it was decided to evaluate their effect upon specific, representative missions by varying individual inputs in a parametric manner. In this way, the possible range of their effect could be bounded.

All of the following analyses, with the exception of the cruise altitude effect, are done for a round trip mission.

4.2 Cruise Altitude Effect

The choice of flying at westbound altitudes was a simplification used in calculating the database. Westbound ICAO cruise altitudes are 27,000-31,000-35,000-39,000 ft. Eastbound cruise altitudes are 29,000-33,000-37,000-41,000 ft. Thus, an airplane's fuel burn on a given route may change by a small amount depending on which direction it is flown. The reason for this change is the fact that the airplane will be flying closer to its optimum cruise altitude in one direction.

The effect of changing flight direction (cruise altitude) is shown in Table 4-1, which shows that for a given route at International Standard Atmosphere (ISA) temperatures and with zero winds the magnitude of the effect of direction on fuel burn is 0.15%, or less. The sign of this effect is dependent more upon the particular airplane and mission weight than the flight direction. This is because the optimum cruise altitude varies with weight and engine. Thus, the impact can be either positive or negative depending on whether the optimum cruise altitude profile is closer to the Eastbound or Westbound cruise altitude profiles. The cause of this effect is the difference between the optimum cruise altitude profile for the mission--which continuously increases as weight decreases (as fuel is burned)--and the allowed flight altitudes that are discrete step functions for air traffic control purposes. Thus, the airplane will try to follow the optimum altitude profile as closely as possible by minimizing the difference between the optimum cruise altitude and the allowed cruise altitude at every point in cruise. When the optimum cruise altitude is closer to the next higher available cruise altitude than to the current altitude, and the airplane is capable of attaining that altitude, a step climb will be made to reduce fuel burn. The flight direction that allows altitudes that more closely match the optimum cruise altitude profile will have the lower fuel consumption.

Table 4-1. Effect of flight altitude on fuel burn for a 747-400 with a PW4056 engine assuming ISA temperatures and zero winds.

North Pacific Route (New York- Tokyo)		
	Fuel Burn	Altitude
Westbound fuel burn	199,042	35,000-39,000
Eastbound fuel burn	199,323	33,000-37,000-41,000
% Difference from westbound	0.14%	
North-South Route (New York- Rio de Janerio)		
	Fuel Burn	Altitude
Northwest bound fuel burn	173,210	35,000-39,000
Southeast bound fuel burn	173,379	33,000-37,000-41,000
% Difference from westbound	0.10%	
North Atlantic Route (New York - London)		
	Fuel Burn	Altitude
Westbound fuel burn	121,521	35,000-39,000
Eastbound fuel burn	121,453	37,000-41,000
% Difference from westbound	-0.06%	

4.3 Winds

The effect of assuming no wind is to significantly simplify the emissions inventory model. This assumption also has a global effect, applying to all airplanes on all routes and affecting them all in a similar way, although the magnitude of the effect may vary depending on geographical area.

The fundamental problem with the no wind assumption is that a round trip flight with a constant wind magnitude and direction (head wind one way, tailwind other) is not equivalent to a round trip with no wind. This is shown in Tables 4-2 and 4-3. The effect of adding a wind component is to increase the round trip fuel burn by approximately 1-2% over the no wind condition. This is due to the increased time spent flying against the headwind relative to the decreased time spent flying with the wind. This also means that a slower airplane, such as the 737, will be impacted by a given headwind to a greater degree than a faster airplane like the 747.

Only the headwind or tailwind component is accounted for in BMAP. No account is taken for increased trim drag or extra miles flown due to cross winds. It will be noted that there is a dramatic difference in wind magnitude between the East-West routes and North-South routes (see Table 4-4). This is due to the predominantly West to East flow of the jet stream in the Northern hemisphere.

Table 4-2. Effect of Wind Variation on airplane block fuel on a North Pacific Route

	No wind	Annual winds	Spring winds	Summer winds	Autumn winds	Winter winds	Four Seaso Averag
Approximate winds (kts)	0	50	54	35	61	48	50
Westbound range (ESAD)	4,725	5,272	5,322	5,105	5,417	5,266	5,278
Eastbound range (ESAD)	4,725	4,312	4,273	4,418	4,223	4,325	4,310
Westbound block fuel (lb)	199,042	225,664	228,160	217,379	232,904	225,365	225,95
Eastbound block fuel (lb)	199,323	179,993	178,221	184,956	175,901	180,619	179,92
Round trip block fuel (lb)	398,365	405,657	406,381	402,335	408,805	405,984	405,87
Percent increase over baseline	0	1.83%	2.01%	1.00%	2.62%	1.91%	1.89%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), Los Angeles to Tokyo, 50% reliability winds, ISA average daily maximum temperature.

Table 4-3. Effect of wind variation on airplane block fuel on a North Atlantic Route.

	No wind	Annual winds	Spring winds	Summer winds	Autumn winds	Winter winds	Four Season Average
Approximate winds (kts)	0	42	33	35	51	50	42
Eastbound range (ESAD)	2,989	2,763	2,809	2,795	2,717	2,725	2,762
Westbound block fuel (lb)	121,521	133,442	130,692	131,435	136,425	136,156	133,677
Eastbound block fuel (lb)	121,453	112,184	114,079	113,486	110,262	110,578	112,101
Round trip block fuel (lb)	242,974	245,626	244,771	244,921	246,687	246,734	245,778
Percent increase over baseline	0	1.09%	0.74%	0.80%	1.53%	1.55%	1.15%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), New York to London, 50% reliability winds, ISA average daily maximum temperature.

Table 4-4. Effect of wind variation on airplane block fuel on a North-South route.

	No wind	Annual winds	Spring winds	Summer winds	Autumn winds	Winter winds	Four Season Average
Approximate winds (kts)	0	8	12	6	6	12	9
Southbound range (ESAD)	4,170	4,108	4,077	4,123	4,161	4,097	4,115
Northbound range (ESAD)	4,170	4,263	4,302	4,231	4,230	4,300	4,266
Southbound block fuel (lb)	173,379	170,561	169,129	171,253	171,588	170,038	170,502
Northbound block fuel (lb)	173,210	177,472	179,292	176,000	175,974	179,178	177,611
Round trip block fuel (lb)	346,589	348,033	348,421	347,253	347,562	349,216	348,113
Percent increase over baseline	0	0.42%	0.53%	0.19%	0.28%	0.76%	0.44%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), New York to Rio de Janerio, 50% reliability winds, ISA average daily maximum temperature.

The effect of cross-winds on airplane performance is not included in these analyses for two reasons. First, the analysis methods used do not include the capability to calculate cross-winds and their effect. Second, the impact of cross winds on high-speed jet aircraft performance is small. Cross-winds have the effect of adding an angular component to the flight between two points. This effectively reduces the ground speed along the mission track. The angle is defined by the arcsine of the cross-wind airspeed divided by the airplane's airspeed. The resulting ground speed is the cosine of this angle multiplied by the plane's airspeed. This reduced ground speed will have the effect of increasing flight time, and hence, fuel burn. Table 4-5 shows the effect of a 20 knot crosswind on 747 and 737 aircraft. For the 747-400 cruising for 2000 nmi at 35,000 ft, the time to fly 2000 nmi is increased by .0034 hours by a 20 kt crosswind. This is a 0.08% increase. Similarly, the 737-300 cruising 500 nmi at 31,000 ft will require .0012 hours longer to complete that distance with a 20 kt crosswind, a 0.10% increase. As with any wind effect, a slower airplane, such as the 737, is affected by crosswinds more than a faster airplane like the 747. But, for any commercial jet transport, the effect is quite small.

Table 4-5. Effect of cross winds on jet airplane performance.

Aircraft	747-400	737-300
Engine	PW 4056	CFM56-3C1
Altitude	35,000	31,000
Mach	0.85	0.745
True Airspeed	489.9	437.2
Cruise Range (nmi)	2,000	500
Cross-Wind	20	20
Ground Speed (kts)	489.5	436.7
Increased cruise time due to crosswind (hours)	0.0034	0.0012
% Increase	0.08%	0.10%

On the Los Angeles to Tokyo route (Table 4-2), the magnitude of the headwind speed averages 50 kts, and is as high as 61 kts in the autumn. This will increase the fuel burn on a round trip mission by about 1.8% over the no wind analysis. On the North Atlantic, the winds average 42 kts, going up to 51 kts in Autumn. These winds will increase fuel burn by approximately 1.1%. On the North-South route from New York to Rio de Janeiro, the headwinds are much lower, averaging 9 kts over the year. This wind speed will increase fuel burn on a round trip mission by 0.4%. This small impact is due to the absence of strong North-South winds.

The effect of headwinds and tailwinds on airplane performance could be included in the global database by factoring the fuel burn for the worldwide fleet upward by a small amount. This is possible because the effect of including any wind in the analysis of a round trip mission is to increase fuel burn in all cases. North-South flights might be treated separately. Cross wind component effects may be neglected due to their small magnitude.

4.4 Temperatures

The effect of assuming standard day temperatures for the emission inventory database is similar to that of assuming no winds, in that it significantly simplifies the model and applies in a similar manner to all airplanes on all routes.

Decreased engine performance is the primary cause of the increase in fuel burn as the ambient temperature increases. Engine performance deteriorates with increasing ambient temperature due to the decreased amount of work the engine can perform at a constant throttle setting because of the temperature limits of the engine. The reduced performance increases time to climb and may lower the initial cruise altitude. Both result in higher fuel burn.

Aerodynamic characteristics have a small dependency on temperature, due to Reynolds Number effects. Increasing ambient temperature decreases the Reynolds Number for the airplane, which in turn increases the skin friction coefficient. This means that skin friction drag and fuel consumption will increase.

Tables 4-6 through 4-8 shows that the effect of using actual, rather than ISA, temperatures on mission performance is small (less than 1%). The biggest effect of temperature is on the North-South route where the temperature average annual temperature increase is 5 deg. F over the International Standard Day value. This increase has the effect of increasing fuel burn by 0.67%. Of this increase, about 0.15% is estimated to be due to the increase in aerodynamic drag. The balance of the increase would be due to reduced engine performance. The East-West routes in the Northern hemisphere are both closer to the ISA temperatures, with the Pacific route averaging 4 deg. F hotter and the North Atlantic 3 deg F hotter. These have the effect of increasing fuel burn by 0.45% and 0.30% respectively.

Table 4-6. Effect of temperature variation on airplane block fuel on North Pacific routes.

	ISA	Annual temps	Spring temps	Summer temps	Autumn temps	Winter temps	Four season Average
Approximate Delta T (deg F)	0	4	2	6	5	4	4
Westbound range (ESAD)	4,725	4,725	4,725	4,725	4,725	4,725	4,725
Eastbound range (ESAD)	4,725	4,725	4,725	4,725	4,725	4,725	4,725
Westbound fuel burn (lb)	199,042	199,971	199,513	200,466	200,145	199,748	199,968
Eastbound fuel burn (lb)	199,323	200,206	199,747	200,768	200,411	199,924	200,213
Round trip block fuel	398,365	400,177	399,260	401,234	400,556	399,672	400,181
Percent increase over baseline	0	0.45%	0.22%	0.72%	0.55%	0.33%	0.46%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), Los Angeles to Tokyo, 50% reliability average daily maximum temperatures, zero wind.

Table 4-7. Effect of temperature variation on airplane block fuel on a North Atlantic Route.

	ISA	Annual temps	Spring temps	Summer temps	Autumn temps	Winter temps	Four season Averag
Approximate Delta T (deg F)	0	3	2	4	3	1	3
Westbound range (ESAD)	2,989	2,989	2,989	2,989	2,989	2,989	2,989
Eastbound range (ESAD)	2,989	2,989	2,989	2,989	2,989	2,989	2,989
Westbound fuel burn (lb)	121,521	121,890	121,787	122,153	121,936	121,582	121,86
Eastbound fuel burn (lb)	121,453	121,838	121,747	122,083	121,875	121,545	121,81
Round trip block fuel	242,974	243,728	243,534	244,236	243,811	243,127	243,67
Percent increase over baseline	0	0.31%	0.23%	0.52%	0.34%	0.06%	0.29%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), New York to London, 50% reliability average daily maximum temperatures, zero wind.

Table 4-8. Effect of temperature variation on airplane block fuel on a North-South Route.

	ISA	Annual temps	Spring temps	Summer temps	Autumn temps	Winter temps	Four season Averag
Approximate Delta T (deg F)	0	5	4	5	5	4	5
Southbound range (ESAD)	4,170	4,170	4,170	4,170	4,170	4,170	4,170
Northbound range (ESAD)	4,170	4,170	4,170	4,170	4,170	4,170	4,170
Southbound fuel burn (lb)	173,379	174,556	174,548	174,543	174,583	174,552	174,55
Northbound fuel burn (lb)	173,210	174,360	174,354	174,344	174,388	174,359	174,36
Round trip block fuel	346,589	348,916	348,902	348,887	348,971	348,911	348,91
Percent increase over baseline	0	0.67%	0.67%	0.66%	0.69%	0.67%	0.67%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), New York to Rio de Janerio, 50% reliability average daily maximum temperatures, zero wind.

The temperature used for the parametrics is the average daily maximum. This assumes that the flights take place during the hottest part of the day. Other options would be the coldest temperature, or some fraction of the difference, but these were not considered.

4.5 Winds and temperatures in combination

Because winds and temperatures affect airplane performance in a similar manner but through different mechanisms, the effect of combining them is additive. Tables 4-9 and 4-10 show the effect of combining the wind and temperature effect for the same cases evaluated in Tables 4-2 through 4-8.

Table 4-9. Effect of wind and temperature variation on airplane block fuel on a North Pacific route.

	ISA, no wind	Annual	Spring	Summer	Autumn	Winter	Four season Average
Approximate winds (kts)	0	50	54	35	61	48	50
Approximate Delta T (deg F)	0	4	2	6	5	4	4
Westbound range (ESAD)	4,725	5,267	5,319	5,099	5,408	5,262	5,272
Eastbound range (ESAD)	4,725	4,315	4,275	4,422	4,228	4,328	4,313
Westbound block fuel (lb)	199,042	226,371	228,452	218,702	233,754	225,741	226,662
Eastbound block fuel (lb)	199,323	180,969	178,705	186,485	177,093	181,326	180,902
Round trip block fuel	398,365	407,340	407,157	405,187	410,847	407,067	407,565
Percent increase over baseline	0	2.25%	2.21%	1.71%	3.13%	2.18%	2.31%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), Los Angeles to Tokyo, 50% reliability winds/temperatures, average daily maximum temperatures.

Table 4-9, for example, shows that the effect of including annual winds and temperatures in the 747-400 North Pacific mission analysis is 2.25%. This is very nearly identical to the sum of the individual annual wind and temperature effects of 1.83% and 0.45% from Tables 4-2 and 4-6.

Table 4-10. Effect of wind and temperature variation on airplane block fuel on a North Atlantic route.

	No wind	Annual winds	Spring winds	Summer winds	Autumn winds	Winter winds	Four season Averag
Approximate winds (kts)	0	42	33	35	51	50	42
Approximate Delta T (deg F)	0	3	2	4	3	1	3
Westbound range (ESAD)	2,989	3,268	3,205	3,220	3,336	3,332	3,273
Eastbound range (ESAD)	2,989	2,765	2,810	2,797	2,719	2,725	2,763
Westbound block fuel (lb)	121,521	133,769	130,943	132,012	136,779	136,199	133,98
Eastbound block fuel (lb)	121,453	112,595	114,372	114,164	110,732	110,667	112,48
Round trip block fuel	242,974	246,364	245,315	246,176	247,511	246,866	246,46
Percent increase over baseline	0	1.40%	0.96%	1.32%	1.87%	1.60%	1.44%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), New York to London, 50% reliability winds/temperatures, average daily maximum temperatures.

Tables 4-10 and 4-11 show the difference between an East-West route and a North-South route. The average temperature increase above standard day is very similar for both routes. The primary difference is in the wind effect, with the North Pacific route having winds averaging 50 knots, which is more than five times the average North-South wind of 9 knots. This leads to a substantial increase in block fuel for the East-West route, compared to the North-South route.

Table 4-11. Effect of wind and temperature variation on airplane block fuel on a North-South route.

	No wind	Annual winds	Spring winds	Summer winds	Autumn winds	Winter winds	Four season Averag
Approximate winds (kts)	0	8	12	6	6	12	9
Approximate Delta T (deg F)	0	5	4	5	5	4	5
Southbound range (ESAD)	4,170	4,108	4,077	4,122	4,130	4,098	4,107
Northbound range (ESAD)	4,170	4,262	4,301	4,231	4,230	4,298	4,265
Southbound block fuel (lb)	173,379	171,547	170,104	172,181	172,600	171,087	171,49
Northbound block fuel (lb)	173,210	178,634	180,449	177,162	177,164	180,311	178,77
Round trip block fuel	346,589	350,181	350,553	349,343	349,764	351,398	350,26
Percent increase over baseline	0	1.04%	1.14%	0.79%	0.92%	1.39%	1.06%

Notes: Boeing 747-400/PW4056, cruise mach = 0.85 (nominal), New York to Rio de Janerio, 50% reliability winds/temperatures, average daily maximum temperatures.

Table 4-12 shows the effect of wind and temperature on the 767 aircraft on US transcontinental and North Atlantic routes. Comparing the 767 North Atlantic performance with the 747 performance in Tables 4-10, the increased impact of headwinds on the slower aircraft is apparent. Although small, the difference between the 1.44% increase for the 747 and the 1.62% increase for the 767 is due to the .05 M (nominal) faster cruise speed of the 747.

Table 4-12. Effect of seasonal winds and temperature variations on airplane block fuel on selected routes for a Boeing 767-300ER.

North Atlantic Route: New York to/from London

	ISA, No wind	Annual	Spring	Summer	Autumn	Winter	Four Season Average
Approximate wind (kts)	0	42	33	35	51	50	42
Approximate delta T (deg F)	0	3	2	4	3	1	3
Westbound range (ESAD)	2,989	3,291	3,223	3,239	3,365	3,360	3,297
Eastbound range (ESAD)	2,989	2,752	2,800	2,786	2,704	2,713	2,751
Westbound block fuel (lb)	62,681	69,591	68,004	68,588	71,301	70,962	69,714
Eastbound block fuel (lb)	62,661	57,720	58,703	58,578	56,695	56,660	57,659
Round trip block fuel (lb)	125,342	127,311	126,707	127,166	127,996	127,622	127,373
Percent increase over baseline	0	1.57%	1.09%	1.46%	2.12%	1.82%	1.62%

US Transcontinental Route: New York to/from Los Angeles

	ISA, No wind	Annual	Spring	Summer	Autumn	Winter	Four season Average
Approximate wind (kts)	0	45	47	32	45	57	45
Approximate delta T (deg F)	0	2	1	4	2	1	2
Westbound range (ESAD)	2,145	2,379	2,392	2,307	2,383	2,457	2,385
Eastbound range (ESAD)	2,145	1,963	1,953	2,012	1,961	1,917	1,961
Westbound block fuel (lb)	44,584	49,639	49,837	48,144	49,749	51,226	48,051
Eastbound block fuel (lb)	44,615	40,985	40,704	42,083	40,951	39,995	42,097
Round trip block fuel (lb)	89199	90624	90541	90227	90700	91221	90147.75
Percent increase over baseline	0	1.60%	1.50%	1.15%	1.68%	2.27%	1.65%

Notes: Boeing 767-300ER/PW4060, cruise mach = 0.80 (nominal), 50% reliability winds and temperatures, Average Daily Maximum temperature

4.6 Wind Confidence Level

In order to assess the likelihood of encountering a given wind level, confidence levels are used. For these parametric studies, a confidence level of 50% is used, corresponding to the mean wind.

In order to provide a statistical assessment of that impact, cases were also run at 15% and 85% confidence levels to provide 1 sigma boundaries. As Table 4-13 shows, the North Pacific 50% reliability wind of 49 kts is very nearly the average of the 15% and 85% winds. The effect of increasing confidence level on fuel burn is not linear, though. The fuel burn increases more than the increase in wind magnitude because of the increasing time spend flying against the higher headwinds (as discussed in the section on winds).

The 50% wind is not exactly the mean of the 15% and 85% winds because WINDTEMP calculates winds based on a worst case scenario: maximum headwinds and minimum tailwinds. This approach is useful for evaluating performance when writing sales guarantees, but is not correct for evaluating the effect of a fixed wind on a round trip mission. Thus, in order to calculate the effect of varying confidence levels, the wind magnitudes were determined for the 15% and 85% cases and were input to BMAP as fixed values. For the 50% case, WINDTEMP is allowed to select the wind itself, since the 50% headwinds and tailwinds are identical. In this way, a consistent wind magnitude and direction were maintained for both legs of round trip missions.

Table 4-13. Effect of wind confidence variation on airplane block fuel on a North Pacific route (Los Angeles to/from Tokyo).

Effect of wind confidence level:

	No wind	50%	15% (Lower Bound)	85% (Upper Bound)
Westbound range (ESAD)	4,725	5,243	5,008	5,515
Eastbound range (ESAD)	4,725	4,298	4,472	4,130
Westbound block fuel (lb)	199,042	224,203	212,635	237,857
Eastbound block fuel (lb)	199,323	179,349	187,391	171,617
Round trip block fuel (lb)	398,365	403,552	400,026	409,474
Percent increase over baseline	0	1.30%	0.42%	2.79%
Wind magnitude (kts)	0	49	28	71

Notes: Boeing 747-400/PW4056, cruise Mach = 0.85 (nominal), annual winds, ISA temperatures, Average daily maximum temperature.

4.7 Payload

In order to determine the effect of possible errors in assumptions relating to load factor, passenger weight allowance and cargo carried, these values were varied parametrically. Load factor and passenger allowance variations were found to have a small effect on block fuel for large airplanes on long range missions, and a larger effect on smaller airplanes.

Table 4-14 shows that for a 747 on a long range mission, increasing the load factor to 75% causes only a 0.80% increase in block fuel. Increasing the passenger weight allowance to 230 lb/pax increases the block fuel by 1.06%. Table 4-14 also shows that for a 737, the increase in block fuel due to an increase in load factor is 2.5%, a significant increase relative to the 747 number as well as to temperature and wind effects. This is because block fuel is roughly proportional to the sum of Operating Empty Weight plus Payload. Thus, increasing payload will have a greater effect on a smaller airplane due to the lower OEW.

The effect of carrying cargo is potentially much larger than load factor or passenger allowance variations. Cargo, though, is not a global variable for the emission inventory database, as winds, temperatures and, even load factor and passenger weights are. That is, cargo carried on a given flight can vary depending on the type of aircraft, its route, and the direction of flight, as well as many other parameters. This makes it very difficult to make any general corrections to the database to account for cargo. For the case of the 747-400, a flight from Los Angeles to Tokyo, Table 4-14 shows that with the maximum possible cargo of 71,660 lbs plus passengers, block fuel would increase by 13%. A more typical payload for the 747 would be to use a density of 10 lb/ft^3 for cargo in the lower hold. If the entire hold were filled with baggage and cargo at this density, the block fuel on the Los Angeles to Tokyo route would be increased by 7.68%. Smaller aircraft, such as the 737, do not have this large cargo capability nor are they often used to carry such large amounts of cargo.

Table 4-14. Effect of payload, load factor, and passenger allowance on block fuel.

Effect on large, long-range airplane (747-400):

	70% Load Factor	Increase Pax allow to 230 lb	Increase LF to 75%	MZFW Takeoff	Volume Limited Cargo
Passengers	294	294	315	294	294
Cargo	0	0	0	71,660	41,350
Total payload	61,740	67,620	66,150	133,400	103,090
Westbound block fuel (lb)	198,363	200,471	199,943	224,493	213,597
Percent increase over baseline	0	1.06%	0.80%	13.17%	7.68%

Notes: Boeing 747-400/PW4056, Los Angeles to Tokyo, ISA temperatures, No wind, 0.85 Mach (nominal)

Effect on small, short-range aircraft 737-300):

	70% Load factor	Increase LF to 75%
Passengers	90	96
Cargo	0	0
Total payload	18,000	19,200
Northbound block fuel (lb)	4,767	4,888
Percent increase over baseline	0	2.54%

Notes: Boeing 737-300/CFM56-3C1, Los Angeles to San Francisco, ISA temperatures, no wind, 0.745 M (nominal)

4.8 Tankering fuel

Smaller aircraft on short routes often carry sufficient fuel to complete several flight segments without refueling in order to minimize time spent at intermediate stations. A 737-300 with 90 passengers (70% load factor) is capable of flying four 293 nmi (Los Angeles to San Francisco) missions without refueling. The fuel burn increase is 8.15% on the first segment over the baseline, non-tankering case due to the weight of the excess fuel carried to complete the next three legs. The fuel burn penalty decreases with each mission, so that for the last mission there is no penalty because there is no extra fuel. The fuel burn penalty averaged over the four legs of the mission outlined in Table 4-15 is 4.0%

As with cargo for large aircraft, the fuel burn increase for tankering depends on the mission flown, type of aircraft, and which mission leg is being evaluated. Tankering is much more prevalent for small aircraft such as the 737 or DC-9 that fly shorter missions than for large, long range aircraft such as the 747 or 767.

Table 4-15. Effect of tankering fuel on block fuel for four flight segments between Los Angeles and San Francisco (293 nmi.).

	Baseline Mission	Block Fuel on first leg of four leg mission	Block Fuel on second leg of mission	Block Fuel on third leg of mission	Block Fuel on fourth leg of mission	Average increase
Passengers	90	90	90	90	90	
Cargo	0	0	0	0	0	
Tankered fuel	0	14366	9463	4644	0	
Block fuel (lb)	4835	5229	5080	4977	4835	
Percent increase over baseline		8.15%	5.07%	2.94%	0.00%	4.04%

Notes: Boeing 737-300/CFM56-3B-2, ISA temperatures, no winds, 0.745 M (nominal)

5. World Jet Fuel Consumption

The emission inventories described in this work and previously reported (Baughcum, *et. al.*, 1994; Landau, *et. al.;* 1994; Wuebbles, *et. al.*, 1993) have involved a "bottoms-up" approach to calculating emissions by combining departure schedules and aircraft performance and emissions data. As a check or "validation" of these inventories, one would like to compare the calculated fuel use with the fuel that was actually purchased and loaded onto aircraft. An earlier comparison (Wuebbles, *et. al.*, 1993) of the results for 1990 with published apparent consumption of jet fuel showed about a 20% difference. As will be discussed below, such comparisons are limited by the quality of both the emission inventories and of the available fuel data.

Ideally, such a comparison would use the detailed records of jet fuel delivered to all airports and used by aircraft. To our knowledge, no such comprehensive, global database exists. In this section, the types of data available for comparison with the earlier study of 1990 emissions and their limitations are presented and discussed.

5.1 Introduction

Widespread misunderstanding exists as to what the term "jet fuel" means as reported by airlines, suppliers, government agencies, and various groups that use the data. In the past, an understanding of what constituted "jet fuel" was important only to those directly involved in the sale, purchase, and delivery of distillate fuels. Now, however, it is important to understand what is meant by "jet fuel" because the consumption of fuel by aircraft is being used by a variety of organizations to:

- Develop and evaluate emission scenarios
- Calculate the possible contribution of aircraft to global warming, sulfur deposition, and local cloud cover changes
- Establish aircraft fleet efficiencies and efficiency trends
- Estimate the revenue obtained from or cost to airlines of various fuel tax schemes

Jet fuel is a refined petroleum product which satisfies the specifications that allow its use in aircraft. When quantities of jet fuel produced, stored, sold, or delivered are reported by government agencies or suppliers, they are usually reporting the availability of a fuel that satisfies a specification, not fuel that has been or will be consumed by aircraft. Jet fuel usage reported by airlines and records of fuel delivered to an airport are the more accurate indicators of fuel consumed by aircraft. However, these reports are not universally available; and they often include fuel used in ground vehicles, engine testing, and other uses.

Data Sources

Sources of data on world jet fuel consumption are fragmented and the origin of the data is usually not traceable. The most available energy consumption data are for The Organisation for Economic Co-operation and Development (OECD) countries*. These OECD countries account for nearly 2/3 of the jet fuel consumed in the world. The U.S. Department of Energy (DOE) publishes jet fuel consumption data in the International Energy Annual (DOE, 1991). Non-U.S. jet fuel consumption data reported in the International Energy Annual comes primarily from the DATA Group of the International Energy Agency (IEA). This group has associates in the oil industry and attempts to understand the bases and validity of their numbers. Table 5-1 shows apparent jet fuel consumption by region from the International Energy Annual using 6.66 pounds per gallon as the conversion factor to weight. (See Appendix L for derivation of the world average density.)

Table 5-1. World apparent consumption of jet fuel for 1990.

Sector	Barrels/day	Billion kg/year	Percent
North America			
United States	1,522,000	70.4	40.3
Canada	90,000	4.2	2.4
Central & South America	185,000	8.5	4.9
Western Europe	624,000	28.9	16.5
Eastern Europe	36,000	1.7	1.0
Former Soviet Union	548,000	25.4	14.5
Middle East	179,000	8.3	4.7
Africa	110,000	5.1	2.9
Far East	482,000	22.3	12.8
World Total	3,776,000	174.8	100.0

The United States consumes over 40% of what is listed as the world's jet fuel. The second largest user is Western Europe - 16.5%. In 1990, the former U.S.S.R. jet fuel consumption was estimated at 548,000 barrels per day which was approximately 14.5% of world demand. (DOE, 1991). Detailed fuel consumption data for non-OECD and communist countries including the former U.S.S.R. are not readily available by geographic area nor can its use be implicitly identified. Data on jet fuel consumption are still considered to be proprietary by Russia (Sergey Kravchenko, Boeing Technical Research Center, Moscow, private communication to Oren Hadaller).

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* These countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Guam, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Puerto Rico, Spain, Sweden, Switzerland, Turkey, U.S. Virgin Islands, United Kingdom, and United States.

Sources of Data Error

The task of identifying jet fuel users in 1990 is made difficult by:

- The lack of detailed data, especially from the former U.S.S.R.;
- The lack of separate accounting for government, military, and commercial airline fuel in most countries outside the OECD;
- The disconnect between where jet fuel is refined and the airports where it is used;
- The use of jet fuel for many other applications including diesel fuel blending, heating oil, power generation, and cooking fuel;
- The use of fungible distillate fuels as jet fuel;
- Airline fuel marketing companies who buy fungible distillate fuels and resell them as jet fuel;
- The lack of information on the airline practice of tankering fuel from one airport to another; and
- The Persian Gulf War.

In North America, fuel is often handled in co-mingled airport and pipeline systems that are fed by many suppliers. Accountability is also made difficult by independent distributors and airline fuel companies who buy jet fuel and fungible distillate fuels on the open market and sell them as jet fuel. This fuel is also fed into the co-mingled systems. Some jet fuel is "bonded" for import into the U.S. to avoid tax liability. With so many entities involved in the jet fuel delivery system, volume accountability is difficult.

The statistical data often reflect the intended use at the refinery or point of sale and not the final use.

In the U.S., fuel often flows into a fuel pool before distribution to airports. Jet fuel is diverted out of the pool for emergency supplies of home heating oil and for blending with diesel fuel to improve cold weather operation of diesel vehicles during severe winter weather conditions. In developing countries, jet fuel is often diverted to the kerosene pool for residential cooking and heating or for diesel fuel or heating oil.

The purchase of jet fuel by an airline does not ensure that the fuel will be used on a scheduled flight. In addition to the fuel consumed in auxiliary power units (APU), airlines must ferry airplanes, train pilots, and test engines. Fuel is also used at airports in some ground support equipment. Sometimes economic conditions and fuel availability necessitate airline tankering of fuel from one airport to another. These conditions cloud the issue of how to check jet fuel consumption data with the scheduled flight data.

The task of accounting for jet fuel burned in 1990 and 1991 is made even more difficult by the Persian Gulf War. Troops and supplies were airlifted to the Middle East in the Fall of 1990 and the first two months of 1991 followed by troop and equipment withdrawal throughout 1991. Most of these flights were military but some were civilian charters. Scheduled service was also greatly affected.

5.2 U.S. Jet Fuel Consumption

Jet fuel reported consumed in 1990 by U.S. Certificated Air Carriers for both major and national airlines in domestic operations was 12.2 billion gallons. (DOE, 1992) These airlines reportedly consumed an additional 3.6 billion gallons of fuel for international operations. This accounts for only 68% of jet fuel consumed in the U.S. if data reported in the International Energy Annual and The National Transportation Statistics are correct (DOE, 1991a; DOE, 1992).

Fuel consumed by helicopters, air taxis, and other aircraft accounted for another 0.6 billion gallons. These data are for all U.S. certificated aircraft and include scheduled service, air cargo carriers, and most charter aircraft. For this study, all U.S. charters for passengers and cargo are assumed to be conducted by certificated aircraft. These data do not include any foreign-registered aircraft fueling in the U.S. Some jet fuel is used by the airlines for non-passenger carrying operations such as ferry and delivery flights, crew training, engine testing, auxiliary power unit operation, and in airport ground support equipment. Additional jet fuel is consumed by airlines for deviations from great circle routes. Airline experience indicates that on very long flights the fuel burn is typically 2% more than predicted from great circle route calculations. This fuel along with any fuel that is burned because of delays is included on Form 41 which the airline reports to the U.S. Department of Transportation (DOT). All jet fuel used by the airline is reported and allocated by aircraft type on Form 41 and the distribution has several percent error variability in the allocations (Al Domke, United Airlines, private communication to Oren Hadaller). U.S. jet fuel reported consumed by certificated air carriers (DOE, 1992) is shown in Table 5-2.

Table 5-2. Reported U.S. jet fuel consumption in 1990 for certificated air carriers.

U. S. Certificated Carriers	Billion gallons/yr	Billion kg/year	Percent of US Carrier fuel use
U. S. Domestic			
Majors and Nationals	12.2	36.9	74.5
Others	0.2	0.6	1.2
U. S. International			
Majors	3.6	10.8	21.9
Other	0.4	1.2	2.4
Total	16.4	49.5	100.0

Note: Assumed jet fuel density = 6.66 pounds per gallon (3.02 kg per gallon)

Table 5-2 only shows the reported jet fuel for US certificated air carriers. Reliable data from other users (foreign airliners, military, cargo, charter) are not available.

In 1990, Military JP-4 (naphtha based) jet fuel consumption was 8.4 billion kilograms (DOE, 1991b) and military kerosene jet fuel consumption was estimated at 2.25 billion kilograms (Erwin, 1993). General aviation accounts for 2.0 billion kilograms of jet fuel (DOE,1991b).

Additional jet fuel is consumed by airlines for deviations from great circle route calculations and for non-revenue operations such as ferry and delivery flights, crew training, engine testing, APU operation, and airport ground support equipment. In addition, airline experience indicates that on very long flights the fuel burn is typically 2% more than great circle route calculations.

In addition to aviation use of jet fuel, electric utilities use jet fuel for peak electric power generation. This fuel use could account for up to 2.1 billion kilograms/year (45,000 barrels per day). Other users of jet fuel are aircraft manufacturers and government agencies. Their consumption is estimated to be approximately 0.3 billion kilograms.

The international jet fuel data as reported to the DOT on Form 41 for U.S. airlines may contain some double bookkeeping. Some of this jet fuel (up to one half of the 8.6 billion kilograms/year of international jet fuel or about 6.1% of the 1990 U.S. consumption) could also have been reported as jet fuel consumption by the country where the fuel is loaded on board the aircraft.

5.3 Jet Fuel Consumption in the former Soviet Union

Since the break up of the U.S.S.R., some data on Russian jet fuel are becoming available. However, detailed data for 1990 equivalent to that for the U.S. are not available for nations of the former U.S.S.R.

The apparent world consumption of jet fuel for 1990 was 25.4 billion kilograms in the former Soviet Union. (see Table 5-3) Using the OAG departure data for May 1990, we have calculated that 2.3 billion kilograms were used by scheduled aircraft taking off from airports within the former Soviet Union. The fuel use calculated for non-OAG flights in the former Soviet Union and China was 8.3 billion kilograms/year. (Landau, *et. al.*, 1994) Analysis of that 3-D data file indicates that approximately 80% of the non-OAG traffic was in the former Soviet Union. Military fuel use within the former Soviet Union was calculated to be 8.1 billion kilograms/year. (van Alstyne, private communication) Thus, there is a discrepancy of 8.4 billion kilograms between the fuel reported by DOE and that calculated in the NASA studies for the former Soviet Union. This amounts to 4.8% of the global fuel use reported by the DOE.

Table 5-3. Summary of jet fuel use in the former Soviet Union.

	Fuel burned (billion kg/year)	Reference
Apparent former Soviet Union Jet Fuel Consumption	25.4	DOE,1991
Calculated emission inventories for flights departing airports in the former Soviet Union:		
OAG Scheduled Traffic	2.3	this work
Non-OAG traffic in the former Soviet Union	6.6	(Landau, et. al, 1994), this work
Military	8.1	(D. van Alstyne, private communication)
Total Calculated	17.0	

This discrepancy can arise from several factors. First, the jet fuel data reported in the DOE Energy Annual for the former Soviet Union are not reliable. Second, flight schedules for Aeroflot for 1990 were not available to McDonnell Douglas but had to be estimated. Third, aircraft in the former Soviet Union may not operate as efficiently as both Boeing and McDonnell Douglas assume in their calculations of emission inventories.

Recent estimates of world air traffic (Boeing, 1995) estimate that revenue passenger miles within the former Soviet Union were about 11% of the world total in 1990. In the NASA studies, the fuel burned for flights (excluding military) departing the former Soviet Union were 8.2% of the calculated fuel use by non-military air traffic. Non-OAG flights (domestic former Soviet Union and China) only accounted for 4.7% of the apparent world fuel consumption (Wuebbles, *et. al.*, 1993). This suggests that flights within the former Soviet Union were underestimated in the NASA studies.

5.4 Conclusions

There is no perfect database with which to validate or evaluate emission inventories. As we have shown, the quality of the available data varies from country to country and depends on what use was originally intended for the data. The available tabulations of the data frequently do not include any critical analysis but, rather, are compilations of data as reported from another source. No error bars are reported in these compilations.

The compilations of data on jet fuel consumption can be used to check "bottoms up" fuel use calculations only to a first order of magnitude. The assumption that differences between a "bottoms up" inventory calculation and these data compilations represent errors only in the inventory calculation is unwarranted.

The United States probably has the most data available for detailed analysis. Each US airline reports fuel use for each airplane type to the US Department of Transportation on DOT-41. In principle, fuel use for each airline and airplane type in domestic service can be calculated from the OAG schedules and compared with that reported by the airline. This was done as a spot check in the earlier Boeing analyses. (see Table 5-5 of NASA CR-4592)

By choosing a relatively broad spectrum of both airlines and aircraft types, a more statistical check of the methods used in calculating the fuel use by US domestic and international flights could be done. Such a study is beyond the scope of the current analysis but seems tractable.

The most accurate approach to this problem would be to contact the world's major airports to obtain individual airport fuel consumption data. These fuel consumption data could then be correlated with departure traffic.

6. Conclusions

A detailed database of fuel burned and emissions (NOx, CO, and hydrocarbons) for scheduled air traffic has been calculated for each month of 1992. In addition, the emissions for May 1990 have been recalculated using the same methodology. The data are on a 1° latitude x 1° longitude x 1 km altitude grid. The datafiles were delivered to NASA Langley Research Center electronically (see Section 3.5 for details of how to obtain the datafiles).

Global fuel use for 1992 by scheduled air traffic was calculated to be 9.5×10^{10} kilograms/year. Global NOx emissions by scheduled air traffic in 1992 were calculated to be 1.2×10^9 kilograms(as NO_2)/year.The calculated emissions show a clear seasonal variation, peaking in the summer with a minimum in the winter. The North Atlantic region showed the most marked seasonal variation with a peak of about 18% above the annual average. In North America and Europe the amplitude of the seasonal variation was about 6% above the annual average, considering all altitudes. Emissions for May 1992 were close to the average for the year, confirming that using May as an 'average' month (as was done in the earlier work) is reasonable.

The methods used in this study to extract departures from the Official Airline Guide have been improved from those used in the earlier NASA work (Baughcum, et. al., 1994) to eliminate flight duplications. In addition, the emission calculations have been upgraded to use Boeing fuel flow method 2 (see Appendix D), which corrects for ambient temperature, pressure, humidity, and aircraft speed. Performance data on more older technology aircraft were also added to the aircraft performance database.

Using the revised methodology, the fuel predicted for May 1990 scheduled air traffic decreased by 3.5% compared to the value reported in NASA CR-4592. This appears to be due primarily to the elimination of duplicate flights from the OAG data. In the revised database, global NOx emissions were calculated to be about 1% lower than reported previously. The global average EI(NOx) increased by about 2% compared to that calculated earlier. Hydrocarbon emissions for May 1990 were calculated to be about 50% greater than the values reported earlier in NASA CR-4592, because of the inclusion of many more older aircraft/engine combinations in this work and the use of a newly published engine emission database.

A series of parametric studies were conducted to evaluate the effects of wind, temperature, payload, tankering, and cargo on the calculated fuel use. Altitude effects, due to whether a flight is an East bound or West bound flight, have approximately a 0.1% effect on fuel burn and are negligible. Wind and temperature have a combined effect of 1.4 - 2.3% on round trip fuel burn (annual average) for East-West flights and about 1% for North-South flights, based on analyses for a Boeing 747-400. The effect is largest in the North Pacific. Since the airlines will try to fly routes which take advantage of the wind (rather than great circle routes), this may overestimate the effects of winds in the real world. Typically, an airline, given its choice of flight corridors, would try to maximize its tail wind and minimize the head wind on the return flight.

The parametric studies show that increasing the payload from 70 to 75% can increase the fuel burn by 2.5% for a 737 flying between San Francisco and Los Angeles. Similarly, the use of tankering fuel on the same flight could increase the average fuel burn on the route by up to 4%. For a 747-400 on a longer route, increasing the load factor from 70 to 75% increased the fuel consumption by 0.8%. The 747-400 can carry a significant amount of cargo, and, if the aircraft was loaded to its maximum weight limit, it would use 13% more fuel. More reasonably, if the cargo was volume limited, the fuel burn would increase by 7.7%. The effect of both fuel tankering and cargo loads on the global inventory has not been evaluated. Fuel tankering will primarily be an issue for small aircraft, while cargo load will be important for large aircraft, particularly the 747 and the DC-10.

The results of the parametric studies have not yet been incorporated into the emission inventory code or into the 3-dimensional inventories. None of the parametric studies have yet looked at combined fuel burn/emissions effects. Increased fuel burn will have an obvious effect on total emissions but will change the emission indices if the increased fuel use is due to higher fuel burn rates. These combined effects should be examined to see if they cause a significant change in the database as calculated.

Based on available fuel data from the US Department of Energy, it appears that the earlier NASA study (Wuebbles, et. al., 1993) underestimated the jet fuel used by aircraft within the former Soviet Union. The reason for this has not been identified although it appears that the number of flights may have been underestimated.

7. References

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Appendix A - Example of Fleet Information Database

Carrier	Model/Series	Engine	Reg. No.	Delivery Date	Date Acquired
Japan Airlines	747 -100	JT9D-7A	JA8115	OCT72	OCT94
Japan Airlines	747 -100B	JT9D-7A	JA8142	JAN80	OCT94
	-100B	JT9D-7A	JA8143	FEB80	OCT94
	-100B	JT9D-7A	JA8164	DEC84	DEC84
Japan Airlines	747 -100SR	JT9D-7A	JA8170	MAR86	MAR86
	-100SR	JT9D-7A	JA8176	SEP86	SEP86
Japan Airlines	747 -200B	JT9D-7A	JA8104	FEB71	OCT94
	-200B	JT9D-7A	JA8105	MAR71	OCT94
	-200B	JT9D-7A	JA8106	MAY71	OCT94
	-200B	JT9D-7A	JA8108	NOV71	OCT94
	-200B	JT9D-7A	JA8110	MAR72	OCT93
	-200B	JT9D-7A	JA8111	MAR72	OCT93
	-200B	JT9D-7A	JA8113	JUN72	NOV94
	-200B	JT9D-7A	JA8114	NOV72	OCT93
	-200B	JT9D-7A	JA8122	MAR74	OCT94
	-200B	JT9D-7A	JA8125	DEC74	OCT94
	-200B	JT9D-7A	JA8127	MAY75	OCT90
	-200B	JT9D-7Q	JA8130	JUN79	JUN79
	-200B	JT9D-7Q	JA8131	JUN79	JUN79
	-200B	JT9D-7Q	JA8140	NOV79	NOV79
	-200B	JT9D-7Q	JA8141	DEC79	DEC79
	-200B	JT9D-7Q	JA8149	MAR81	SEP93
	-200B	JT9D-7Q	JA8150	MAR81	SEP93
	-200B	JT9D-7Q	JA8154	NOV81	NOV93
	-200B	JT9D-7R4G2	JA8161	JUN83	JUN83
	-200B	JT9D-7R4G2	JA8162	JUN83	JUN83
	-200B	JT9D-7R4G2	JA8169	MAR86	MAR86
Japan Airlines	747 -200F	JT9D-7Q	JA8123	SEP74	JUN80
	-200F	JT9D-7Q	JA8132	JUL79	JUL79
	-200F	JT9D-7Q	JA8165	JUL79	MAY84
	-200F	JT9D-7Q	JA8160	AUG79	OCT92
	-200F	JT9D-7Q	JA8193	JUN80	JUL94
	-200F	JT9D-7Q	N211JL	DEC82	DEC82
	-200F	JT9D-7R4G2	JA8171	AUG86	AUG86
	-200F	JT9D-7R4G2	JA8180	AUG87	AUG87

Carrier	Model/Series	Engine	Reg. No.	Delivery Date	Date Acquired
Japan Airlines	747 -300	JT9D-7R4G2	N212JL	NOV83	NOV83
	-300	JT9D-7R4G2	N213JL	DEC83	DEC83
	-300	JT9D-7R4G2	JA8163	DEC84	DEC84
	-300	JT9D-7R4G2	JA8166	FEB85	FEB85
	-300	JT9D-7R4G2	JA8173	APR86	APR86
	-300	JT9D-7R4G2	JA8177	OCT86	OCT86
Japan Airlines	747 -300	JT9D-7R4G2	JA8178	DEC86	DEC86
	-300	JT9D-7R4G2	JA8179	FEB87	FEB87
	-300	JT9D-7R4G2	JA8185	MAR88	MAR88
Japan Airlines	747 -300SR	JT9D-7R4G2	JA8183	DEC87	DEC87
	-300SR	JT9D-7R4G2	JA8184	JAN88	JAN88
	-300SR	JT9D-7R4G2	JA8186	FEB88	FEB88
	-300SR	JT9D-7R4G2	JA8187	FEB88	FEB88
Japan Airlines	747 -400	CF6-80C2B1F	JA8071	JAN90	JAN90
	-400	CF6-80C2B1F	JA8072	JAN90	JAN90
	-400	CF6-80C2B1F	JA8073	FEB90	FEB90
	-400	CF6-80C2B1F	JA8074	FEB90	FEB90
	-400	CF6-80C2B1F	JA8075	MAR90	MAR90
	-400	CF6-80C2B1F	JA8076	JUL90	JUL90
	-400	CF6-80C2B1F	JA8077	JUL90	JUL90
	-400	CF6-80C2B1F	JA8078	NOV90	NOV90
	-400	CF6-80C2B1F	JA8079	DEC90	DEC90
	-400	CF6-80C2B1F	JA8080	DEC90	DEC90
	-400	CF6-80C2B1F	JA8081	MAY91	MAY91
	-400	CF6-80C2B1F	JA8082	AUG91	AUG91
	-400	CF6-80C2B1F	JA8085	SEP91	SEP91
	-400	CF6-80C2B1F	JA8086	NOV91	NOV91
	-400	CF6-80C2B1F	JA8088	FEB92	FEB92
	-400	CF6-80C2B1F	JA8089	MAR92	MAR92
	-400	CF6-80C2B1F	JA8902	AUG92	MAR94
	-400	CF6-80C2B1F	JA8087	FEB92	MAR92
	-400	CF6-80C2B1F	JA8906	MAR93	MAR93
	-400	CF6-80C2B1F	JA8909	JUN93	JUN93
	-400	CF6-80C2B1F	JA8910	MAR94	MAR94
	-400	CF6-80C2B1F	JA8911	MAR94	MAR94
	-400	CF6-80C2B1F	JA8912	MAY94	JUN94

Carrier	Model/Series	Engine	Reg. No.	Delivery Date	Date Acquired
Japan Airlines	747 -400D	CF6-80C2B1F	JA8083	OCT91	OCT91
	-400D	CF6-80C2B1F	JA8084	OCT91	OCT91
	-400D	CF6-80C2B1F	JA8901	JUN92	APR94
	-400D	CF6-80C2B1F	JA8903	SEP92	SEP92
	-400D	CF6-80C2B1F	JA8090	MAR92	MAR92
	-400D	CF6-80C2B1F	JA8904	NOV92	NOV92
	-400D	CF6-80C2B1F	JA8905	DEC92	DEC92
	-400D	CF6-80C2B1F	JA8907	MAR93	MAR93
	-400D	CF6-80C2B1F	JA8908	JUN93	JUN93

Appendix B. Airplane/Engine Substitution Tables for 1992 Emission Inventory Calculations

OAG Airplane	OAG Engine	Performance Airplane	Performance Engine	Emissions Engine
146-100	ALF502R-3	BAE146-300	ALF502R-5	ALF502R-3
146-100	ALF502R-5	BAE146-300	ALF502R-5	ALF502R-5
146-200	ALF502R-3	BAE146-300	ALF502R-5	ALF502R-3
146-200	ALF502R-5	BAE146-300	ALF502R-5	ALF502R-5
146-300	ALF502R-5	BAE146-300	ALF502R-5	ALF502R-5
146-300	LF507-1F	BAE146-300	ALF502R-5	LF507-1F,-1H
14F-300QT	ALF502R-5	BAE146-300	ALF502R-5	ALF502R-5
720-000	JT3C-12	720	JT3C-7	JT3C
727-100	JT8D-7A	727-100	JT8D-7	JT8D-7seriesRedemiss
727-100	JT8D-7B	727-100	JT8D-7	JT8D-7seriesRedemiss
727-100	JT8D-9	727-100	JT8D-9	JT8D-9seriesRedemiss
727-100	JT8D-9A	727-100	JT8D-9	JT8D-9seriesRedemiss
72C-100F	JT8D-7B	727-100	JT8D-7	JT8D-7seriesRedemiss
72C-100F	JT8D-9A	727-100	JT8D-9	JT8D-9seriesRedemiss
72S-200	JT8D-15	727-200	JT8D-15-15A	JT8D-15Redemiss
72S-200	JT8D-17	727-200	JT8D-15-15A	JT8D-17Redemiss
72S-200	JT8D-17R	727-200	JT8D-15-15A	JT8D-17R
72S-200	JT8D-7B	727-200	JT8D-9	JT8D-7seriesRedemiss
72S-200	JT8D-9	727-200	JT8D-9	JT8D-9seriesRedemiss
72S-200	JT8D-9A	727-200	JT8D-9	JT8D-9seriesRedemiss
737-100	JT8D-7A	737-100	JT8D-9	JT8D-7seriesRedemiss
737-200	JT8D-15	737-200	JT8D-15	JT8D-15Redemiss
737-200	JT8D-15A	737-200	JT8D-15	JT8D-15A
737-200	JT8D-17	737-200	JT8D-15	JT8D-17Redemiss
737-200	JT8D-17A	737-200	JT8D-15	JT8D-17A
737-200	JT8D-7B	737-200	JT8D-7	JT8D-7seriesRedemiss
737-200	JT8D-9	737-200ADV	JT8D-9-9A	JT8D-9seriesRedemiss
737-200	JT8D-9A	737-200ADV	JT8D-9-9A	JT8D-9seriesRedemiss
73C-200C	JT8D-15	737-200	JT8D-15	JT8D-15Redemiss
73C-200C	JT8D-17	737-200	JT8D-15	JT8D-17Redemiss
73C-200C	JT8D-17A	737-200ADV	JT8D-15A	JT8D-17A
73C-200C	JT8D-9A	737-200ADV	JT8D-9-9A	JT8D-9seriesRedemiss
73C-200F	JT8D-17	737-200	JT8D-15	JT8D-17Redemiss
73L-500	CFM56-3C	737-500	CFM56-3-B1-18.5	CFM56-3C-1
73Y-300	CFM56-3B	737-300	CFM56-3-B1	CFM56-3-B1
73Z-400	CFM56-3B	737-300	CFM56-3-B1	CFM56-3B-2
747-100	JT9D-3A	747-100	JT9D-3A1	JT9D-7A
747-100	JT9D-3AW	747-100	JT9D-3A1	JT9D-7A
747-100	JT9D-7A	747-100-200	JT9D-7A	JT9D-7A
747-100	JT9D-7AH	747-100-200	JT9D-7A	JT9D-7A
747-100B	JT9D-7F	747-100-200	JT9D-7A	JT9D-7FModVI
747-100B	RB211-524C2	747-200	RB211-524C	RB211-524C2
747-200B	CF6-50E2	747-100-200	CF6-50E2	CF6-50E2
747-200B	JT9D-7A	747-100-200	JT9D-7A	JT9D-7A

Appendix B. Airplane/Engine Substitution Tables for 1992 Emission Inventory Calculations

OAG Airplane	OAG Engine	Performance Airplane	Performance Engine	Emissions Engine
747-200B	JT9D-7AW	747-100-200	JT9D-7A	JT9D-7A
747-200B	JT9D-7F	747-200	JT9D-7J	JT9D-7FModVI
747-200B	JT9D-7J	747-200	JT9D-7J	JT9D-7J
747-200B	JT9D-7Q	747-200B-C-F	JT9D-7Q	JT9D-7Q
747-200B	JT9D-7R4G2	747-200	JT9D-7R4G2	JT9D-7R4G2
747-200B	JT9D-7W	747-100-200	JT9D-7A	JT9D-7
747-200B	RB211-524C2	747-200	RB211-524C	RB211-524C2
747-200B	RB211-524D4	747-200	RB211-524D4U	RB211-524D4Package1
74C-100F	JT9D-7A	747-100-200	JT9D-7A	JT9D-7A
74C-200F	CF6-50E2	747-100-200	CF6-50E2	CF6-50E2
74C-200F	JT9D-7A	747-100-200	JT9D-7A	JT9D-7A
74C-200F	JT9D-7F	747-200	JT9D-7J	JT9D-7FModVI
74C-200F	JT9D-7FW	747-200	JT9D-7J	JT9D-7FModVI
74C-200F	JT9D-7J	747-200	JT9D-7J	JT9D-7J
74C-200F	JT9D-7Q	747-200B-C-F	JT9D-7Q	JT9D-7Q
74C-200F	RB211-524D4	747-200	RB211-524D4U	RB211-524D4Package1
74I-400	CF6-80C2	747-400	CF6-80C2-B1F	CF6-80C2B1F
74I-400	PW4056	747-400	PW4056	PW4056
74I-400	RB211-524G	747-400	RB211-524G	RB211-524G
74I-400	RB211-524H	747-400	RB211-524G	RB211-524H
74P-SP	JT9D-7A	747SP	JT9D-7A	JT9D-7A
74P-SP	JT9D-7F	747SP	JT9D-7A	JT9D-7FModVI
74P-SP	JT9D-7FW	747SP	JT9D-7A	JT9D-7FModVI
74P-SP	RB211-524C2	747SP	RB211-524C2	RB211-524C2
74P-SP	RB211-524D4	747SP	RB211-524C2	RB211-524D4Phase2
74Q-200M	CF6-50E2	747-100-200	CF6-50E2	CF6-50E2
74Q-200M	JT9D-7J	747-200	JT9D-7J	JT9D-7J
74U-300	CF6-80C2	747-300	CF6-80C2B1	CF6-80C2B1
74U-300	JT9D-7R4G2	747-300	JT9D-7R4G2	JT9D-7R4G2
74U-300	RB211-524C2	747-200	RB211-524C	RB211-524C2
74U-300	RB211-524D4	747-300	RB211-524D4UP	RB211-524D4Package1
74X-100SR	CF6-45A2	747-100-100SR	CF6-45A2	CF6-45A2
757-200	PW2037	757-200	PW2037	PW2037
757-200	PW2040	757-200	PW2040	PW2040
757-200	RB211-535C	757-200	RB211-535C	RB211-535C
757-200	RB211-535E4	757-200	RB211-535E4	RB211-535E4
75F	*	757-200	PW2040	PW2040
767-200	CF6-80A	767-200	CF6-80A	CF6-80A
767-200	CF6-80A2	767-200	CF6-80A	CF6-80A2
767-200	JT9D-7R4D	767-200	JT9D-7R4D	JT9D-7R4D,-7R4D1
76M-300	CF6-80A2	767-300	CF6-80A2	CF6-80A2
76M-300	CF6-80C2	767-300ER	CF6-80C2B6F	CF6-80C2B2
7IQ-400M	CF6-80C2	747-400	CF6-80C2-B1F	CF6-80C2B1F
7UQ-300M	CF6-50E2	747-300	CF6-50E2	CF6-50E2

Appendix B. Airplane/Engine Substitution Tables for 1992 Emission Inventory Calculations

OAG Airplane	OAG Engine	Performance Airplane	Performance Engine	Emissions Engine
7UQ-300M	CF6-80C2	747-300	CF6-80C2B1	CF6-80C2B1
7UQ-300M	JT9D-7R4G2	747-300	JT9D-7R4G2	JT9D-7R4G2
A0CC4-200	CF6-50C2	A300-B2-B4	CF6-50C2	CF6-50C1,-C2
A30B2-100	CF6-50C	A300-B2-B4	CF6-50C2	CF6-50C
A30B2-100	CF6-50C2R	A300-B2-B4	CF6-50C2	CF6-50C2R
A30B2-200	CF6-50C2	A300-B2-B4	CF6-50C2	CF6-50C1,-C2
A30B2-200	CF6-50C2R	A300-B2-B4	CF6-50C2	CF6-50C2R
A30B4-100	CF6-50C2	A300-B2-B4	CF6-50C2	CF6-50C1,-C2
A30B4-100	JT9D-59A	A300-621R-ER	JT9D-7R4H1	JT9D-59A
A30B4-200	CF6-50C2	A300-B2-B4	CF6-50C2	CF6-50C1,-C2
A30B4-200	JT9D-59A	A300-621R-ER	JT9D-7R4H1	JT9D-59A
A31-200	CF6-80A3	A310-300	CF6-80A3	CF6-80A3
A31-200	CF6-80C2A2	A310-300	CF6-80C2A2	CF6-80C2A2
A31-200	JT9D-7R4D1	A310-300	JT9D-7R4E1	JT9D-7R4D,-7R4D1
A31-200	JT9D-7R4E1	A310-300	JT9D-7R4E1	JT9D-7R4E,-7R4E1
A32-100	CFM56-5A1	A320-200	CFM56-5-A1	CFM56-5-A1
A32-200	CFM56-5A1	A320-200	CFM56-5-A1	CFM56-5-A1
A32-200	CFM56-5A3	A320-200	CFM56-5-A1	CFM56-5A3
A32-200	V2500-A1	A320-200	V2525-A5	V2500-A1
A34	*	A340-300	CFM56-5C3	CFM56-5C3
A36-600	CF6-80C2A1	A300-600R	CF6-80C2	CF6-80C2A1
A36-600	JT9D-7R4H1	A300-621R-ER	JT9D-7R4H1	JT9D-7R4H1
A36-600	PW4158	A300-622R-ER	PW4056	PW4158Redsmoke
A3L-300	CF6-80C2	A310-300	CF6-80C2A2	CF6-80C2A2
A3L-300	CF6-80C2A2	A310-300	CF6-80C2A2	CF6-80C2A2
A3L-300	CF6-80C2A8	A310-300	CF6-80C2A2	CF6-80C2A8
A3L-300	JT9D-7R4E1	A310-300	JT9D-7R4E1	JT9D-7R4E,-7R4E1
A3L-300	PW4152	A330-300	PW4164	PW4152
AN4	LGTURB	LGTURB	PW125B	PW125B
AT4	LGTURB	LGTURB	PW125B	PW125B
AT7	LGTURB	LGTURB	PW125B	PW125B
ATP	LGTURB	LGTURB	PW125B	PW125B
ATR	LGTURB	LGTURB	PW125B	PW125B
B3C-320C	JT3D-3B	707-320B-C	JT3D-3B	JT3D-3B
B3C-320CH	JT3D-3B	707-320B-C	JT3D-3B	JT3D-3B
B3F-320B	JT3D	707-320B-C	JT3D-3B	JT3D-3B
B3F-320B	JT3D-3B	707-320B-C	JT3D-3B	JT3D-3B
BAC-200	RR_SPEY-506	BAC111-500	MK512-14	SPEYMk511Transply
BAC-200	RR_SPEY-511	BAC111-500	MK512-14	SPEYMk511
BAC-500	RR_SPEY-512	BAC111-500	MK512-14	SPEYMk511Transply
BE1	SMTURB	SMTURB	PT6A	PT6A
BE9	SMTURB	SMTURB	PT6A	PT6A
BEK	SMTURB	SMTURB	PT6A	PT6A
CD2	SMTURB	SMTURB	PT6A	PT6A

Appendix B. Airplane/Engine Substitution Tables for 1992 Emission Inventory Calculations

OAG Airplane	OAG Engine	Performance Airplane	Performance Engine	Emissions Engine
CL4	LGTURB	LGTURB	PW125B	PW125B
CNC	SMTURB	SMTURB	PT6A	PT6A
CNJ	*	F-28-4000	MK555-15H	SPEYMk555Transply
CNN	SMTURB	SMTURB	PT6A	PT6A
CON-102	*	Concorde	Olympus-593-610	Olympus-593-610
CRJ	*	F-28-4000	MK555-15H	SPEYMk555Transply
CS5	LGTURB	LGTURB	PW125B	PW125B
CV5	LGTURB	LGTURB	PW125B	PW125B
CV6	LGTURB	LGTURB	PW125B	PW125B
CVF	LGTURB	LGTURB	PW125B	PW125B
CVL-10B	JT8D-7	CARAVELLE-10B	JT8D-1	JT8D-7seriesRedemiss
CVL-12	JT8D-9	CARAVELLE-10B	JT8D-1	JT8D-9seriesRedemiss
D10-10	CF6-6D	DC-10-30	CF6-50C2	CF6-50C1,-C2
D10-15	CF6-50C2F	DC-10-30	CF6-50C2	CF6-50C1,-C2
D1C-10F	CF6-6D	DC10-10	CF6-6D	CF6-6D
D8C-33F	JT4A-11	DC-8-21-31-33	JT4A-9	JT4A
D8S-62H	JT3D-3B	DC-8-63-63CF	JT3D-7	JT3D-3B
D8S-62H	JT3D-7	DC-8-63-63CF	JT3D-7	JT3D-7series
D8S-63H	JT3D-7	DC-8-63-63CF	JT3D-7	JT3D-7series
D8S-73F	CFM56-2C	DC-8-71-71CF	CFM56-1B	CFM56-2-C5
D9C-30C	JT8D-9A	DC9-30	JT8D-7	JT8D-9seriesRedemiss
D9C-30F	JT8D-7B	DC9-30	JT8D-7	JT8D-7seriesRedemiss
D9M-87	JT8D-217	MD-87	JT8D-217C	JT8D-217series
D9M-87	JT8D-219	MD-87	JT8D-217C	JT8D-219
D9S-30	JT8D-17	DC9-31	JT8D-15	JT8D-17Redemiss
D9S-30	JT8D-7B	DC9-30	JT8D-7	JT8D-7seriesRedemiss
D9S-30	JT8D-9A	DC9-30	JT8D-7	JT8D-9seriesRedemiss
D9S-40	JT8D-11	DC9-50	JT8D-15	JT8D-11
D9S-40	JT8D-15	DC9-50	JT8D-15	JT8D-15Redemiss
D9X-50	JT8D-17	DC9-50	JT8D-15	JT8D-17Redemiss
D9Z-81	JT8D-209	MD-81	JT8D-209	JT8D-209
D9Z-81	JT8D-217	MD-82	JT8D-217A	JT8D-217series
D9Z-82	JT8D-217	MD-82	JT8D-217A	JT8D-217series
D9Z-82	JT8D-217C	MD-82	JT8D-217A	JT8D-217series
D9Z-82	JT8D-219	MD-83	JT8D-219	JT8D-219
D9Z-83	JT8D-219	MD-83	JT8D-219	JT8D-219
D9Z-88	JT8D-217	MD-88	JT8D-217C	JT8D-217series
D9Z-88	JT8D-219	MD-83	JT8D-219	JT8D-219
DC8	*	DC-8-63-63CF	JT3D-7	JT3D-7series
DC9-10	JT8D-7A	DC9-30	JT8D-7	JT8D-7seriesRedemiss
DC9-10	JT8D-7B	DC9-30	JT8D-7	JT8D-7seriesRedemiss
DC9-20	JT8D-11	DC9-31	JT8D-15	JT8D-11
DFL	*	F-28-4000	MK555-15H	SPEYMk555Transply
DH1	MDTURB	MDTURB	PW120	PW120

Appendix B. Airplane/Engine Substitution Tables for 1992 Emission Inventory Calculations

OAG Airplane	OAG Engine	Performance Airplane	Performance Engine	Emissions Engine
DH3	MDTURB	MDTURB	PW120	PW120
DH7	LGTURB	LGTURB	PW125B	PW125B
DH8	MDTURB	MDTURB	PW120	PW120
DHB	SMTURB	SMTURB	PT6A	PT6A
DHT	SMTURB	SMTURB	PT6A	PT6A
DLR-30	CF6-50C	DC-10-30	CF6-50C2	CF6-50C
DLR-30	CF6-50C2	DC-10-30	CF6-50C2	CF6-50C1,-C2
DLR-30	CF6-50C2R	DC-10-30	CF6-50C2	CF6-50C2R
DLR-40	JT9D-20	DC10-40	JT9D-20	JT9D-20
DO8	SMTURB	SMTURB	PT6A	PT6A
EM2	SMTURB	SMTURB	PT6A	PT6A
EMB	SMTURB	SMTURB	PT6A	PT6A
F10-100	TAY620-15	FOKKER-100	TAY-650	TAYMk620-15
F10-100	TAY650-15	FOKKER-100	TAY-650	TAYMk650-15
F27	LGTURB	LGTURB	PW125B	PW125B
F28-1000	RR_SPEY-MK555	F-28-4000	MK555-15H	SPEYMk555Transply
F28-1000C	RR_SPEY-MK555	F-28-4000	MK555-15H	SPEYMk555Transply
F28-2000	RR_SPEY-MK555	F-28-4000	MK555-15H	SPEYMk555Transply
F28-3000	RR_SPEY-MK555	F-28-4000	MK555-15H	SPEYMk555Transply
F28-4000	RR_SPEY-MK555	F-28-4000	MK555-15H	SPEYMk555Transply
F2B	LGTURB	LGTURB	PW125B	PW125B
F2E	LGTURB	LGTURB	PW125B	PW125B
F50	LGTURB	LGTURB	PW125B	PW125B
HEC	SMTURB	SMTURB	PT6A	PT6A
HS7	LGTURB	LGTURB	PW125B	PW125B
I62	SOL	707-320B-C	JT3D-3B	JT3D-3B
I72	*	707-320B-C	JT3D-3B	JT3D-3B
I86	KUZ	707-320B-C	JT3D-3B	JT3D-3B
IL8	LGTURB	LGTURB	PW125B	PW125B
J31	SMTURB	SMTURB	PT6A	PT6A
L10-1	RB211-22B	L-1011-1-100	RB211-22B	RB211-22B(B)
L10-200	RB211-524B	L1011-500AC	RB211-524B4	RB211-524BseriesPhase2
L10-50	RB211-22B	L-1011-1-100	RB211-22B	RB211-22B(B)
L4T	SMTURB	SMTURB	PT6A	PT6A
LLR-500	RB211-524B4	L1011-500AC	RB211-524B4	RB211-524BseriesPhase2
LOE	LGTURB	LGTURB	PW125B	PW125B
LOF	LGTURB	LGTURB	PW125B	PW125B
LOH	LGTURB	LGTURB	PW125B	PW125B
LOM	LGTURB	LGTURB	PW125B	PW125B
LRJ	*	F-28-4000	MK555-15H	SPEYMk555Transply
M1F	*	MD-11	CF6-80C2D1F	CF6-80C2D1F
MDL-11C	CF6-80C2	MD-11	CF6-80C2D1F	CF6-80C2D1F
MDL-11P	CF6-80C2	MD-11	CF6-80C2D1F	CF6-80C2D1F
MDL-11P	PW4460	MD-11	CF6-80C2D1F	PW4460Redsmoke

Appendix B. Airplane/Engine Substitution Tables for 1992 Emission Inventory Calculations

OAG Airplane	OAG Engine	Performance Airplane	Performance Engine	Emissions Engine
MRC-100	JT8D-15	737-200	JT8D-15	JT8D-15Redemiss
MU2	SMTURB	SMTURB	PT6A	PT6A
ND2	MDTURB	MDTURB	PW120	PW120
NDC	*	F-28-4000	MK555-15H	SPEYMk555Transply
PA6	SMTURB	SMTURB	PT6A	PT6A
PL6	SMTURB	SMTURB	PT6A	PT6A
SF3	MDTURB	MDTURB	PW120	PW120
SFF	MDTURB	MDTURB	PW120	PW120
SH3	MDTURB	MDTURB	PW120	PW120
SH6	MDTURB	MDTURB	PW120	PW120
SWM	SMTURB	SMTURB	PT6A	PT6A
T34	SOL	DC9-30	JT8D-7	JT8D-7seriesRedemiss
T54	SOL	727-200	JT8D-15-15A	JT8D-15Redemiss
VC8	LGTURB	LGTURB	PW125B	PW125B
VCV	LGTURB	LGTURB	PW125B	PW125B
WWP	*	SMTURB	PT6A	PT6A
Y40	IVC	727-100	JT8D-7	JT8D-7seriesRedemiss
Y42	*	727-100	JT8D-7	JT8D-7seriesRedemiss
YN2	SMTURB	SMTURB	PT6A	PT6A
YN7	LGTURB	LGTURB	PW125B	PW125B
YS1	LGTURB	LGTURB	PW125B	PW125B

Notes:

SMTURB	Small Turboprop
MDTURB	Medium Turboprop
LGTURB	Large Turboprop

Appendix C. Boeing Method 1 Fuel Flow Methodology Description

This appendix contains the manuscript of a paper, "A Simplified Method for Estimating Aircraft Engine Emissions", by Richard L. Martin, Carlos A. Oncina, and Joe P. Zeeben. Since it is not available elsewhere, it is reproduced here to describe in detail the Boeing Method 1 fuel flow methodology that was used to calculate the earlier scheduled subsonic emission inventories. (Baughcum, *et. al.*, 1994)

Although the work described in the Martin, *et. al.* paper was not funded by this contract, it is reproduced here to provide further documentation of the method used in the earlier analyses.

A SIMPLIFIED METHOD FOR ESTIMATING AIRCRAFT ENGINE EMISSIONS

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ABSTRACT

In recent years, an increased interest has been directed worldwide in understanding aircraft engine emissions during aircraft operation near the airport and during the flight profile elements of climb, cruise, and descent. This paper presents a new method that greatly simplifies the calculations needed to estimate these aircraft engine emissions. This efficient and cost-effective method, which incorporates readily available data from cockpit instrumentation or flight manuals (or both), can be used by airlines as well as by engine and airframe manufacturers.

BACKGROUND

The International Civil Aviation Organization (ICAO) originally developed standards for aircraft engine emissions to help quantify the amount of certain pollutants that aircraft contribute to the airport environment. The ICAO originally set standards for unburned hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), and smoke. For an engine to be certified for use, the United States Federal Aviation Administration requires that the engine meet the ICAO standard for hydrocarbons and smoke. To show compliance, engine manufacturers supply data for a takeoff and landing cycle.

In late 1989, in response to Sweden's tax on total HC and NO_x emissions, airlines began requesting data for an entire airplane mission. These requests required detailed emission calculations to be coordinated between airframe and engine manufacturers. Subsequently, the Swedish tax was revised to include carbon dioxide (CO_2) emissions. CO_2 emissions are about 3.15 times the weight of fuel burned, which resulted in a considerably higher tax rate. As a consequence, the airframe manufacturers, or the airline, had to select a "standard" mission profile that was consistent with block-fuel burned calculations.

Because of these taxes and regulations, airlines are interested in calculating the emissions generated over entire flight missions. Current methodology is complex and cumbersome. To facilitate these calculations, a relatively straightforward methodology is needed that uses readily available data.

T_3-P_3 METHOD

The current method for calculating aircraft engine emissions of HC, CO, and NO_x for an entire airplane mission requires knowledge of the burner inlet temperature (T_3) and pressure (P_3) at sea level (Sarli et al., 1975, and Blazowski et al., 1973). Data elements are needed from three sources:

1. Engine emission information, contained in the ICAO emission data bank.
2. Engine performance data, provided by engine thermodynamic cycle models.
3. Airplane performance data.

This calculation procedure requires a multi-step process to determine the emissions for an entire airplane mission:

1. Calculate the mission profile data, altitude, Mach number, and power setting.
2. Use the engine simulation to calculate P_3 and T_3 for the emission indices correlation.
3. Calculate the emissions for each segment of the flight profile and typical block fuel allowances for the following segments:
   - Taxi out/Taxi in
   - Takeoff (including flap and gear retraction)
   - Climb, Cruise, Descent
   - Approach/Landing

Given the ICAO data sheet (Figure 1), the fuel flow and percent thrust information can be used to obtain referenced (sea level) P_3 and T_3 from an engine simulation, or the original test data, and plotted as shown in Figure 2. The engine simulation can then be used to obtain P_3 and T_3 at any altitude, ambient temperature (amb), power setting, and flight speed. Then, using the sea level (sl) static relationship of the engine P_3 and T_3 (Figure 3) as a reference, the emission indices (EI) are calculated as follows:

$$EI(CO,HC) = EI_{sl} * (P_{3sl}/P_3)^x \tag{1}$$

$$EI(NO_x) = EI_{sl} * (P_3/P_{3sl})^y * e^H \tag{2}$$

$$EI(CO_2) = 3152 - 1.5714(EICO) - 3.152(EIHC) \tag{3}$$

where CO_2 is a carbon balance on the combustion products for an H/C ratio of 0.164; e^H is the humidity correction ($H = -19(\omega - 0.0063)$; ω is the specific humidity at an altitude corresponding to 60% relative humidity). (The exponent, x, is discussed below with equation (7).)

Other combustion products that may be considered are oxides of sulfur (SO_x) and water (H_2O), where

$$EI(SO_x) = 0.22(0.04\%\ \text{avg fuel sample}) \tag{4}$$

$$EI(H_2O) = 1290.7 - 1.2907(EIHC) \tag{5}$$

Equations (1) through (3) use the correlations developed for ambient test site conditions to correct for altitude. EI(XX) is the emission index in grams/kilograms of fuel. NO_x correlates well with T_3 when coupled with corrections for burner inlet pressure (P_3/P_{3sl}) and humidity (ω). The exponent ($y = 0.5$) in the pressure correction, equation (2), varies between 0.37 and 0.6 (Donovan et al., 1977). A humidity correction is not required for HC and CO emissions, and although the data per Sarli et al., (1975) were correlated as a function of the fuel-air ratio, the current practice is to use T_3 with a pressure correction (Donovan et al., 1977). Test data are available for NO_x at altitude (Williams, 1973), but similar data for CO or HC were not found.

Emissions of HC and CO are dependent on the energy-based combustion efficiency, where the experimental data are correlated as a function of the loading parameter (Lefebvre, 1983):

$$\eta_B = \int\left(\frac{P_3^{1.75} v_c e^{T_3/b}}{m}\right) \tag{6}$$

or as a function of T_3 with a pressure correction:

$$EI(HC,CO) = EI_{sl}(HC,CO)(P_{3sl}/P_3)^x \tag{7}$$

Lyons et al., (1979) show the exponent, x, to be 1.5 for EICO and 2.5 for EIHC; however, Sarli et al., (1975) and Donovan et al., (1977) show an exponent of 1 for HC and CO. No pressure correction is required per ICAO Annex 16 (1981). Correlation to be shown later will be based on an exponent of one (1).

The emissions for a particular flight segment are calculated as follows:

$$E = \sum_{i=1}^{n} EI * W_f * \text{time} \tag{8}$$

where W_f = fuel flow
time = incremental time
n = number of points in the mission segment

The total emissions for a particular flight profile derive from adding together each of the segment emissions. The flight profile shown in Figure 4 includes portions of the current landing/take-off cycle (Figure 5), but is based on fuel-flow rates and time, rather than on power setting.

Even with electronic file transfer and automation of the calculations (see Figure 6), the process is time consuming. The preferred process for the airframe manufacturer would be to obtain the emission indices from the engine simulation computer programs and create tabular data similar to that for fuel flow. However, the airlines may prefer a fuel-flow-based correlation that would depend on the data readily available to them.

Fuel flow is available on the ICAO data sheets for each segment of the flight profile. Therefore, a calculation procedure that correlates the emission indices to fuel flow is an attractive alternative to the current process.

BASIS FOR AN ALTERNATE METHOD

As shown in Figure 7, a relationship exists between ICAO-referenced emission indices (REI) when plotted as a function of fuel flow, assuming the following non-dimensional analysis:

$$REI(XX) = \int\left(\frac{W_f}{\delta^a \theta^b}\right) \tag{9}$$

where δ and θ are either total or free-stream ambient pressure and temperature ratios; $P/_{101.32}$ and $T/_{288.16}$ are commonly used to correlate thrust and fuel flow. This is a log-log relationship, whereas the T_3 correlation shown in Figure 2 is a log-linear relationship, as shown in the following equation, which is based on a theoretical analysis of the burner:

$$REI(XX) = \int\left(P^a e^{bT_3}\right) \tag{10}$$

With either relationship, there is an obvious problem for HC and CO indices: the equations are non-linear, and result in a breakpoint in the data (see Figure 7). Therefore, without additional test data, any extrapolation at low power is suspect.

Further analysis reveals that between 70% and 90% of the total emissions are NO_x, as shown in Figure 8. The difference between a 400 nautical mile (nm) mission and a 3,000 nm mission, in percent of HC emissions, is negligible; that for percent of CO emissions relatively minor. As a consequence, refining the process for determining HC and CO to obtain more accurate data is not appropriate.

Investigations undertaken to ascertain the effect of Mach number on T_3 as a function of fuel flow (6,000 meter, 0 to 0.9 Mach number), are shown in Figure 9; Figure 10 shows the effect of altitude for Mach numbers 0 to 0.8 at standard day temperatures. Although T_3 vs. $W_f/\theta_{amb}^{1.5}$ is not a common correlation, the limited amount of flight test data shown in Figure 11 indicates an acceptable data spread; thus, the effect of Mach number is limited: T_3 does not have to be adjusted for Mach number.

The above analyses support the contention that a fuel-flow method of calculating emissions is related to ambient pressure and temperature, and is a simple alternative to the T_3-P_3 method.

FUEL-FLOW METHOD

Using the fuel-flow factor (W_{ff}) shown in equation (11), and the REIs shown in equations (12) and (13), Figures 12, 13, and 14 show how calculations by the T_3-P_3 method correlate with reference emission indices for the fuel-flow method:

$$W_{ff} = \frac{W_f}{\theta_{amb}^{1.5}} \tag{11}$$

$$EI(HC,CO) = REI(HC,CO)/\delta_{amb}^{.4} \tag{12}$$

$$EI_{alt}(NO_x) = REI(NO_x) * \theta_{amb} * e^H \tag{13}$$

where
$$\theta_{amb} = \frac{T_{amb}}{288.16} \tag{14}$$

$$\delta_{amb} = \frac{P_{amb}}{101.32} \tag{15}$$

The exponents θ_{amb} and δ_{amb} in the above equations were chosen solely for their ability to correct the data to sea level referenced conditions for one data set and may vary for specific engines. In Figures 12, 13, and 14, altitude varied from 0 to 10 kilometers, and Mach number varied between 0 and 0.8; ICAO data are shown as solid symbols.

The REIs are then plotted as a function of the fuel-flow factor as shown in Figure 7; thus, the emission indices can be calculated given the fuel flow, and ambient temperature and pressure, for each flight segment.

ICAO data sheets show fuel flow with no environmental control system bleed or horsepower extraction; therefore, the ICAO data must be corrected for installation effects. Figure 15 shows that installation effects on fuel flow are a function of power setting. At idle, the installed fuel flow can be between 6% and 20% higher than uninstalled fuel flow. Figure 16 shows the effect of bleed on T_3 and fuel flow at idle. If the engine control is holding N_2 constant, then the effect of bleed is to increase the fuel flow at near-constant T_3. It is, therefore, appropriate to take ICAO emission indices for each power setting and increase the fuel flow for the installation effects.

The fuel-flow correlation was used for a limited range of ambient pressure and temperature, as well as subsonic Mach numbers, associated with commercial aircraft, and may not be applicable for supersonic flight segments. Data have only been evaluated at high altitude for the Olympus 593 engine (Concorde) at supersonic speeds (Williams, 1973). An engine simulation was not available for this application, so the effect of pressure and temperature (or Mach) could not be evaluated.

CONCLUSIONS AND RECOMMENDATIONS

The fuel-flow method for calculation of emission indices could be validated by test and simulation. Indeed, if the industry agrees on using the T_3-P_3 method with pressure-correction exponents, then simulation and test data could be used to further refine the fuel-flow correlation. Substantiation with full-scale altitude facility tests could be done, but should not be required for new engines before they enter service. The addition of low- and mid-power points in the ICAO data would improve the accuracy of HC and CO indices' correlation.

The proposed fuel-flow method, which uses data readily available from cockpit instrumentation and airplane performance manuals throughout the entire flight profile, is valid. The procedure greatly simplifies the laborious T_3-P_3 method, and is more readily usable by those interested in obtaining airplane engine emission data.

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Williams, M. R., 1973, "Emission Levels of the Olympus 593 Engine at the Stratospheric Cruise Conditions of the Concorde Aircraft," *Proceedings of the Second Conference on the Climatic Impact Assessment Program*, A. J. Broderick, ed., U.S. Department of Transportation DOT-TSC-OST-73-4, Transportation System Center, Cambridge, MA, pp. 173-179.

Engine Type: High bybass turbofan

Engine Status: In production

Data Status: Data obtained from newly-manufactured engines

Emissions Data: Corrected for ambient effects

Test Date: From 11/11/83 to 11/14/83

Accessory Load:
Power extraction *0* (kW) at ____ Power settings(s)
Stage bleed *0* % core flow at ____ Power settings

Atomspheric Conditions:
Barometer *kPa* *95.98-97.49*
Temperature *K* *279-286*
ABS Humidity *kg/kg* *0.002-0.009*

Fuel:
Spec *Jet A*
H/C *1.93*
Arom. *16.0%*

Remarks:

Mode	Power Setting (Foo)	Time (Min)	Fuel Flow (kg/s)	Emissions Indices (g/kg)			Smoke Number
				HC	CO	NOx	
Take-off	100%	0.7	1.14	0.04	0.90	20.70	5.98
Climb out	85%	2.2	0.93	0.05	0.90	17.30	3.00
Aproach	30%	4.0	0.36	0.08	3.10	8.70	2.50
Idle	7%	26.0	0.13	1.25	27.00	4.10	2.20
Number of tests				3	3	3	3
Number of engines				1	1	1	1
DP/Foo (average) or S/N (max.) (g/kN)				2.96	59.17	48.21	5.98
DP/Foo or S/N (sigma) (g/kN)				0.21	1.36	2.22	0.76
DP/Foo (g/kN) or S/N range				2.75-3.16	58.22-60.73	45.81-50.2	5.4-6.8

FIGURE 1. ICAO EXHAUST EMISSIONS DATA BANK, SUBSONIC ENGINES

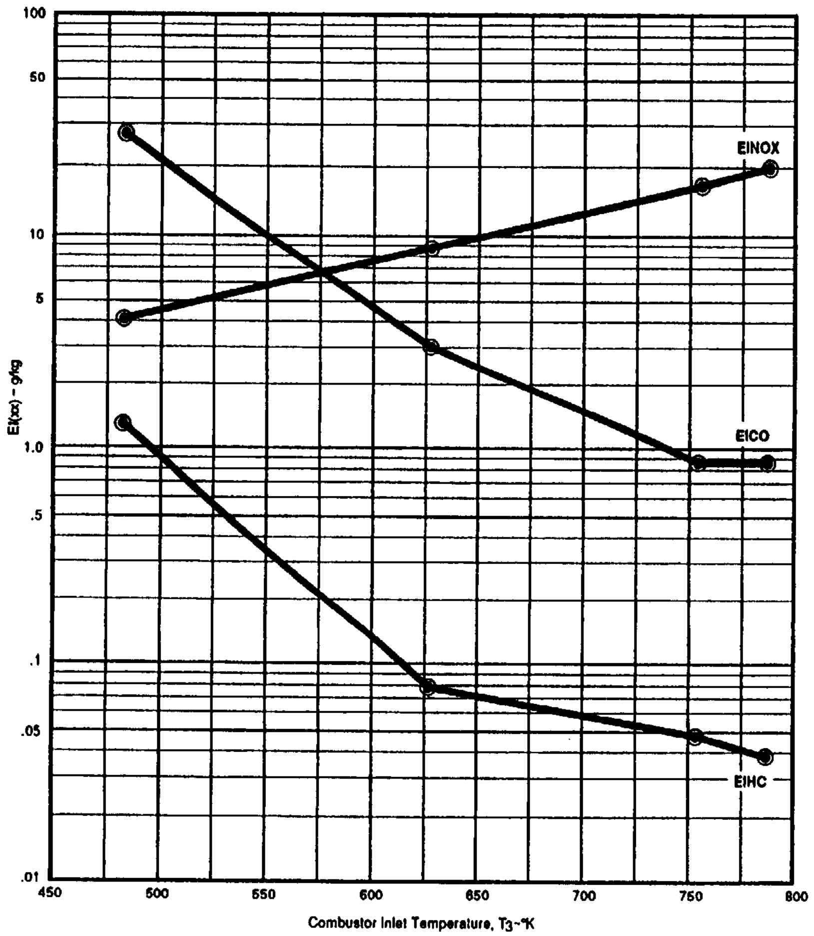


FIGURE 2. EMISSIONS INDEX VARIATION WITH TEMPERATURE

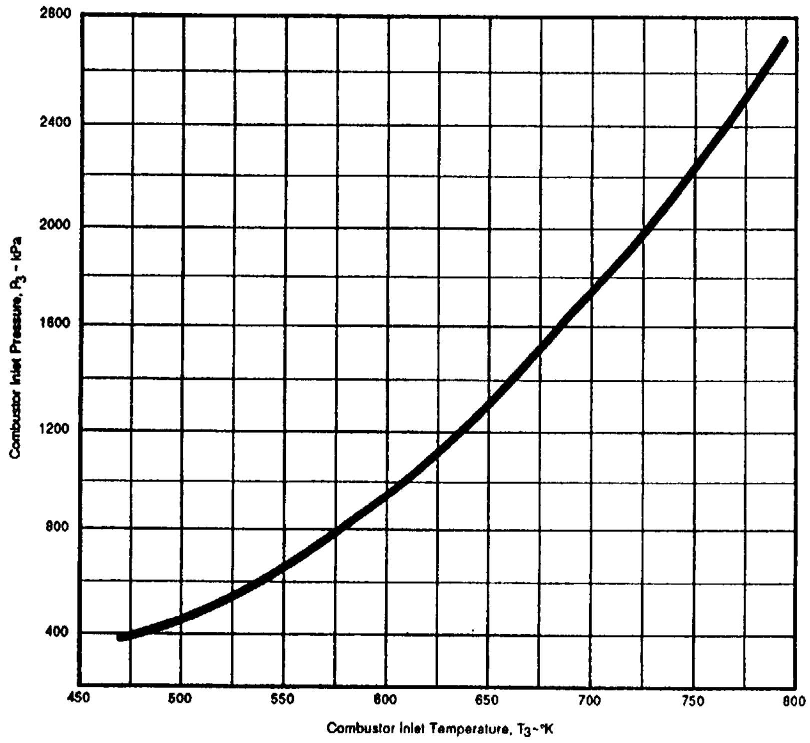


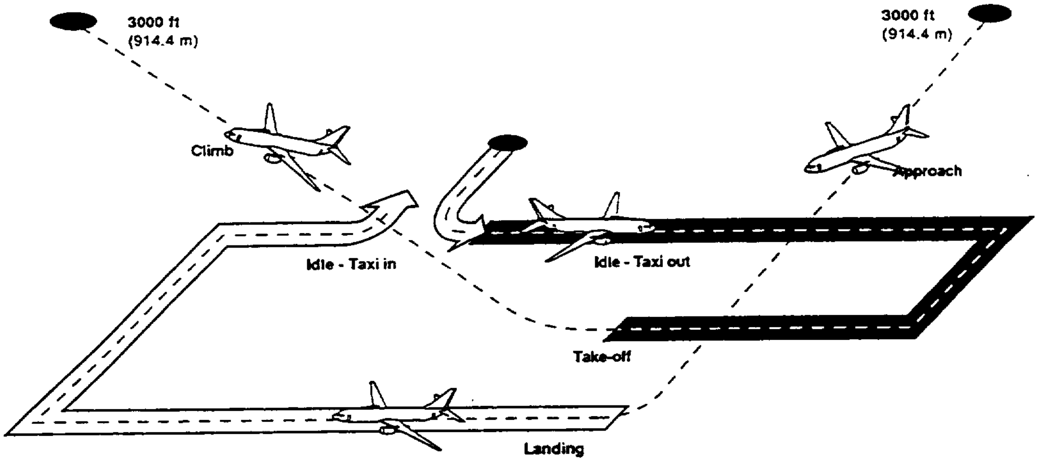
FIGURE 3. COMBUSTER PRESSURE VARIATION WITH TEMPERATURE

	TAXI OUT	TAKE-OFF	CLIMB	STEP CLIMB	CRUISE	DESCENT	APPROACH	LANDING	TAXI IN
Time	9 Min	Perf Doc	Min Fuel Perf Doc	Perf Doc	Perf Doc	Perf Doc	Perf Doc	Perf Doc	5 Min
Distance		35-1500 ft (10.67-457.2 m) (Perf Doc)	Min Fuel Perf Doc	Perf Doc	Perf Doc	Perf Doc	No Credit	No Credit	Perf Doc
Fuel	Perf Doc	Perf Doc	Min Fuel Perf Doc	Perf Doc	Perf Doc	Perf Doc	Perf Doc	Perf Doc	Perf Doc
Temperature	ISA	ISA	ISA	ISA	ISA	ISA	ISA	ISA	ISA
Altitude	Sea Level	SL - 1500 ft (457.2 m)	1500 kft (457.2 m) - Init CRS	West (31,35,39 kft) (9.45, 10.67, 11.88 km)	West (31,35,39 kft) (9.45, 10.67, 11.88 km) Opt Fuel Burn	End CRS to 1500 ft (457.2 m)	1500 ft (457.2 m)	S.L	S.L
Speed	0 KTS	$V_2+\Delta V$ (normal A.E. climb spd)	Min Fuel Perf Doc (US rules)	Same as Cruise	Fixed Mach (LRC) or LRC	Min Fuel Perf Doc (U.S. Rules)	$\frac{V_{APP}+V_{DES}}{2}$	V_{APP}	0 Kts
Thrust	Match Wf (norm idle)	S.L., $V_2+\Delta V$, Max Rating	Max Climb	Max Climb	Thrust Req for Level Flt	Min Idle	Idle	3° Glide Slope	Match Wf (norm idle)
No. of Engines	All	All	All	All	All	All	All	All	All
Bleeds	A/C Off	A/C Off	A/C On	A/C On	A/C On	A/C On	A/C Off	A/C Off	A/C Off
Misc	APU - Off No Power Back, No Start-Up	Max Flap for Weight			For Short Range, 50% of Mission Must Be In Cruise	Max 91.44 km/Min Cabin R/D	Max Landing Flap	Max Landing Flap	APU Off

Reserves: Typical mission
Distance: 500, 1000, 2000 nm (926, 1852, 3704 km) and design range (consistent with economic calculations)

Payload: Full passenger payload, no cargo
OEW: Consistent with performance brochures

FIGURE 4. AIRCRAFT EXHAUST EMISSIONS, STANDARD MISSION PROFILE



Operating Mode	Power Setting	Time in Mode
Taxi/idle (out)	7% take-off thrust	19.0 minutes
Take-off	100% std. day take-off thrust	0.7 minutes
Climb	85% take-off thrust	2.2 minutes
Approach	30% take-off thrust	4.0 minutes
Taxi/idle (in)	7% take-off thrust	7.0 minutes

FIGURE 5. ENGINE EXHAUST EMISSIONS LANDING AND TAKE-OFF

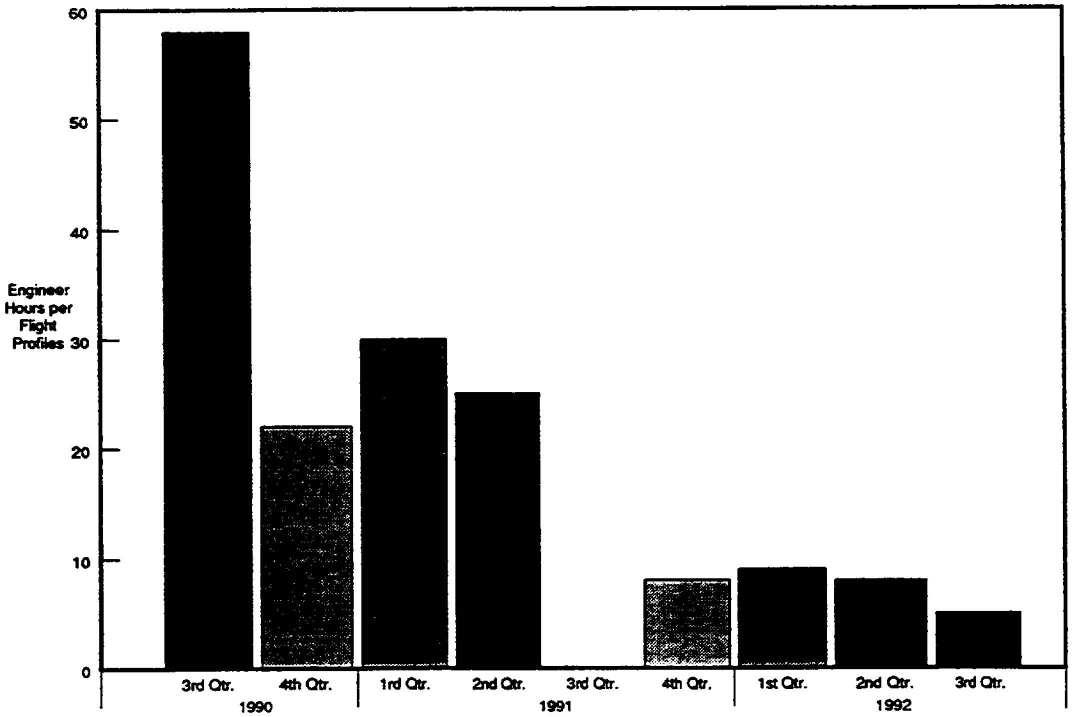


FIGURE 6. TIME PER FLIGHT PROFILES FOR EMISSIONS CALCULATIONS

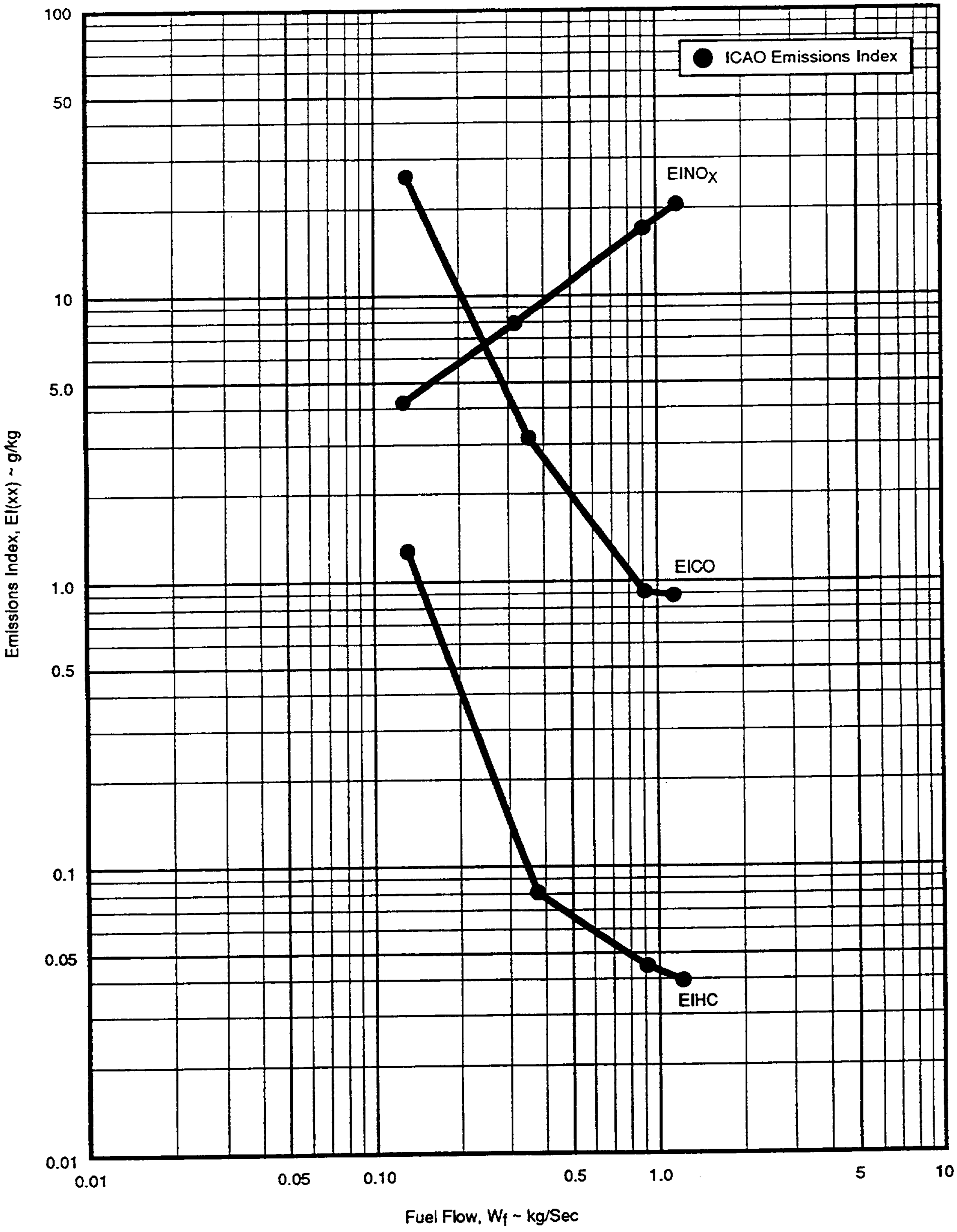


FIGURE 7. VARIATION OF EMISSION INDEX WITH FUEL FLOW

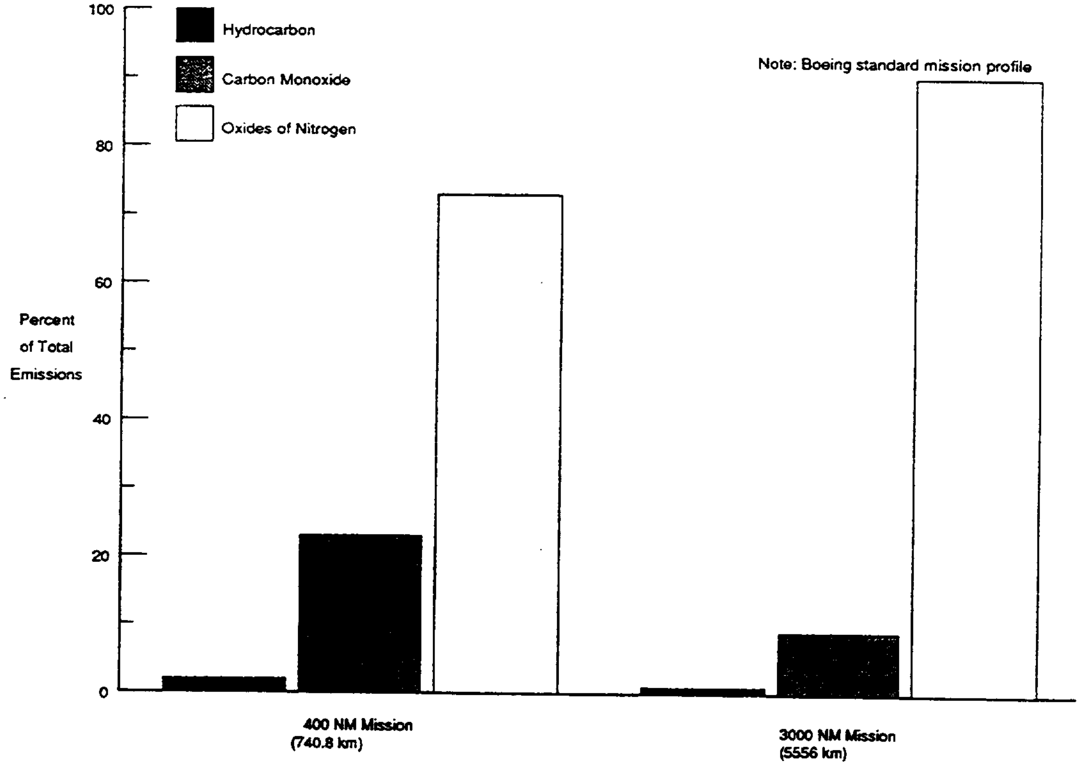


FIGURE 8. EMISSIONS COMPARISON OF 757-200 FOR A 400 NM AND 3000 NM MISSION

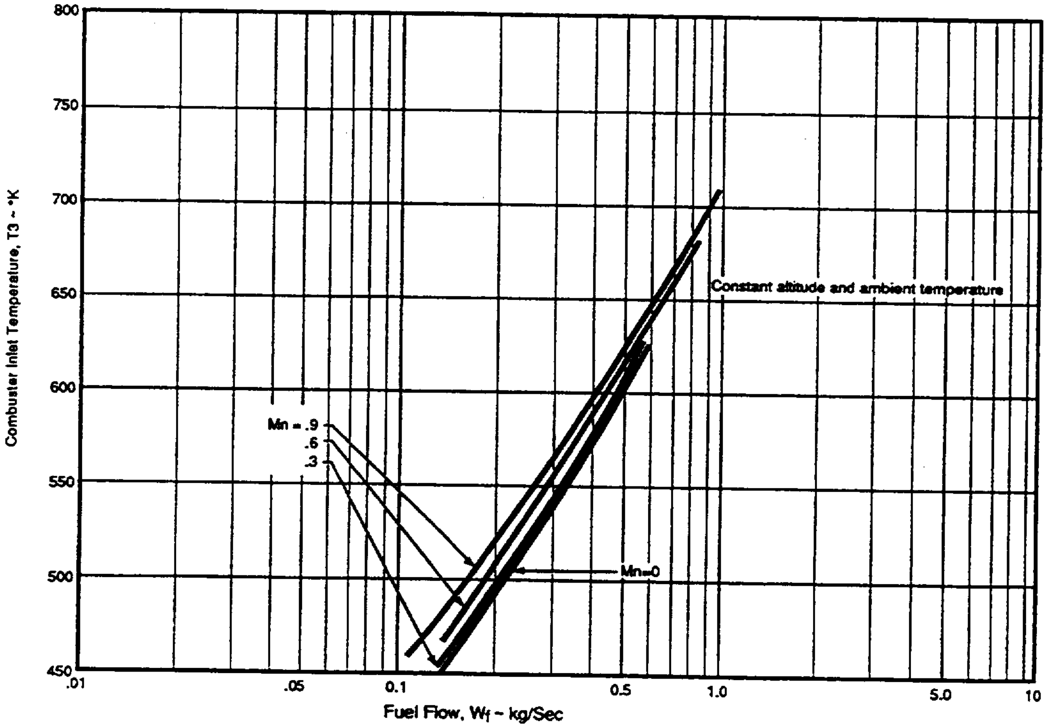


FIGURE 9. EFFECT OF MACH NUMBER, Mn

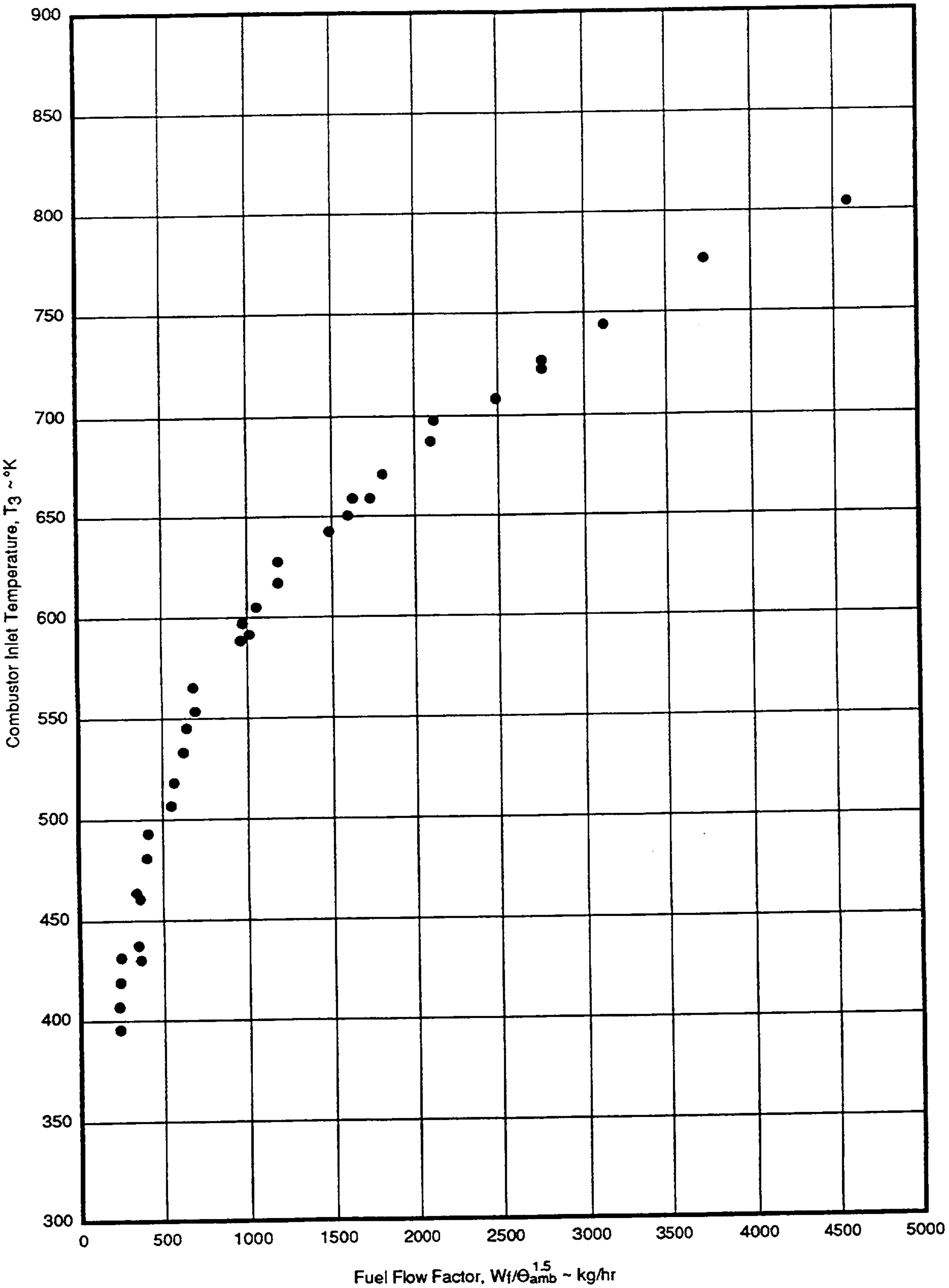


FIGURE 10. SIMULATION DATA CORRELATION

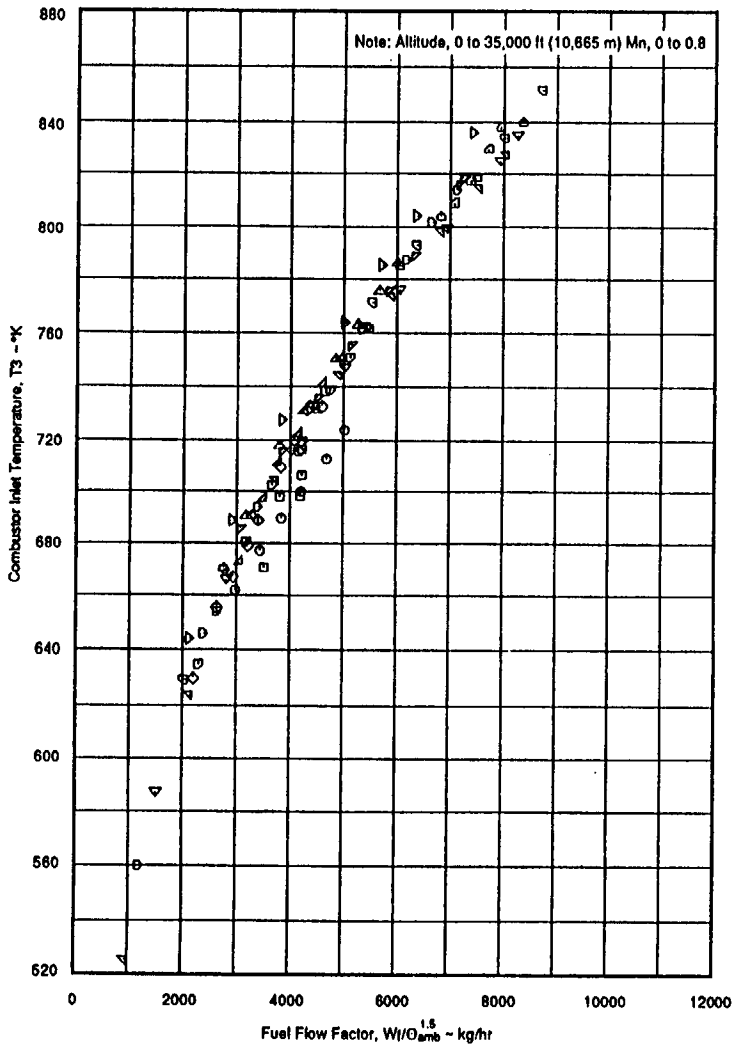


FIGURE 11. FLIGHT TEST DATA CORRELATION

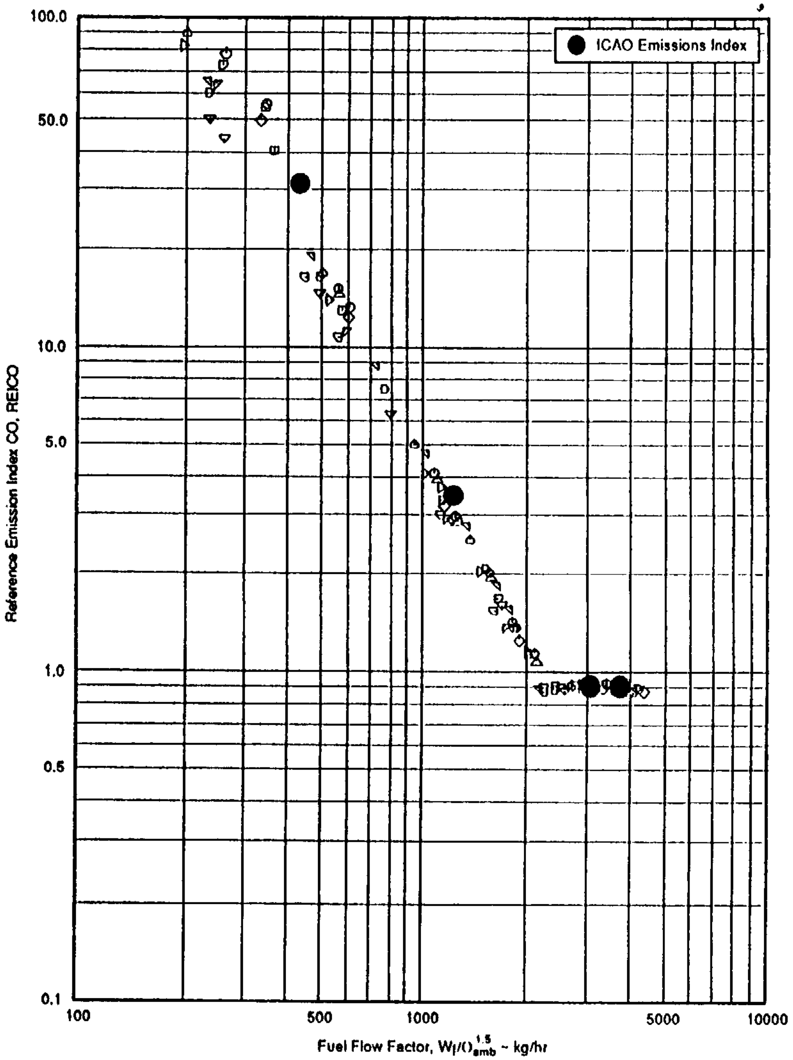


FIGURE 12. CARBON MONOXIDE

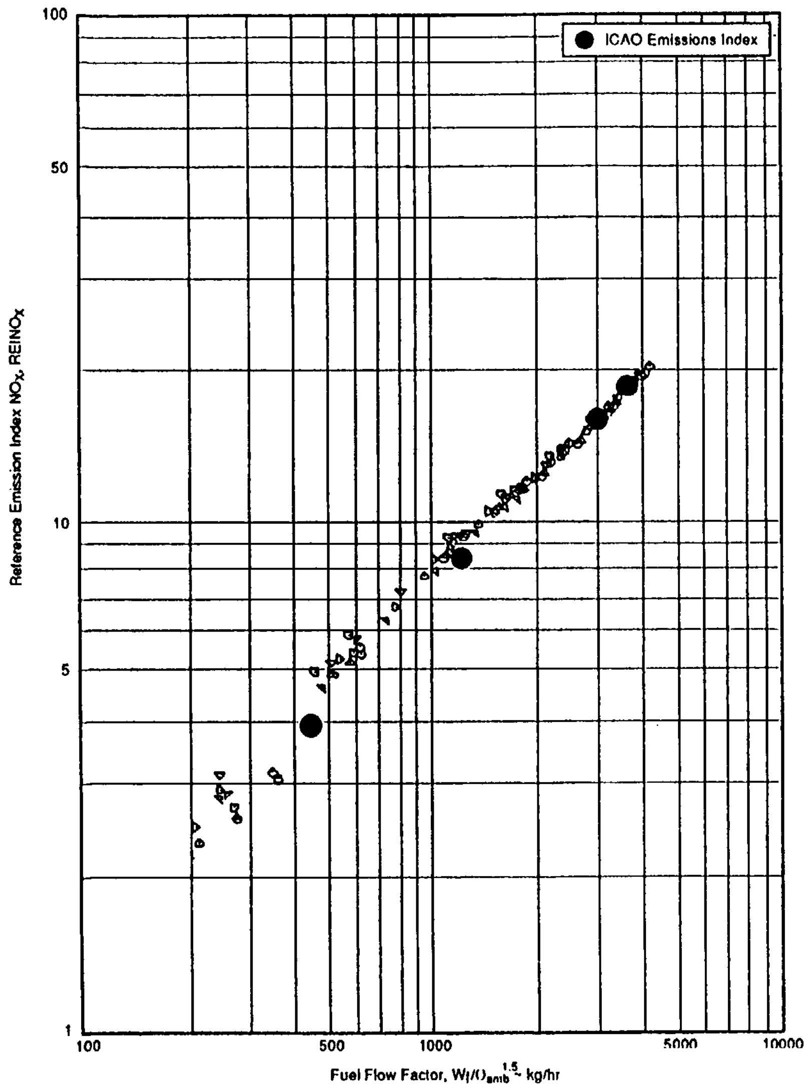


FIGURE 13. OXIDES OF NITROGEN

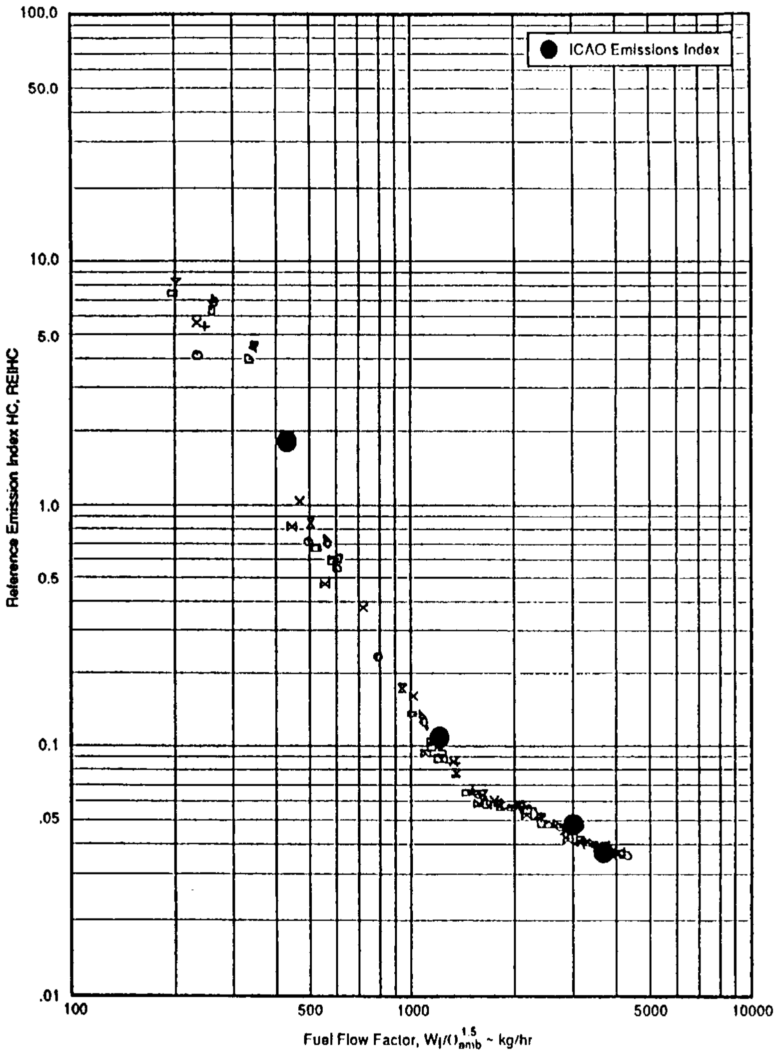


FIGURE 14. HYDROCARBONS

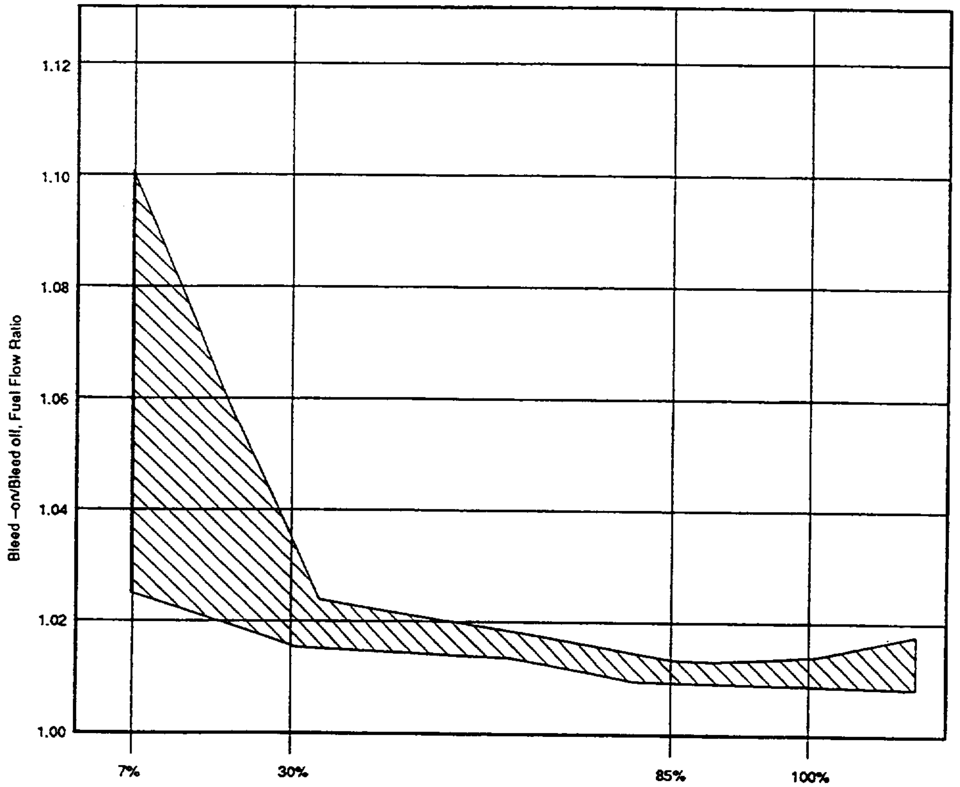


FIGURE 15. BLEED AS A FUNCTION OF POWER SETTING

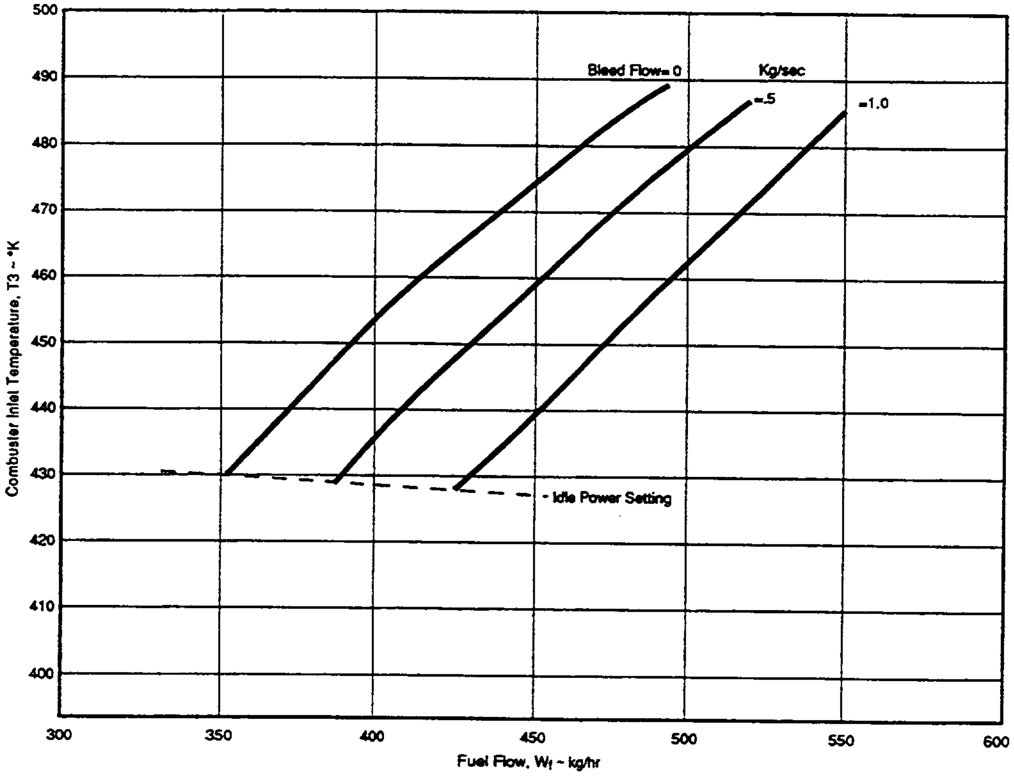


FIGURE 16. INSTALLATION EFFECT OF AIRPLANE AIR BLEED

Appendix D. Boeing Method 2 Fuel Flow Methodology Description

This appendix contains the manuscript of a paper presented to a CAEP Working Group III Certification Subgroup on March 6, 1995 by Richard L. Martin and co-workers. Since it is not available otherwise, it is reproduced here to describe in detail the Boeing Method 2 fuel flow methodology that was used to calculate the scheduled subsonic emission inventories described in this report.

Although the work described in this appendix was not funded by this contract, it is reproduced here to provide further documentation of the method used in our analyses.

Presentation to CAEP
Working Group III Certification Subgroup, March 6, 1995

This paper extends a previously published method to compute in-flight aircraft emissions. The extended method (herein referred to as Method 2) allows for non-standard temperature conditions and expands the previous method's (Method 1) altitude capability.

Background

The current ICAO aircraft engine emissions standards were developed to quantify aircraft contributions to local airport pollution. The current trend in environmental regulations is aimed at reducing total carbon dioxide output and NO_x emissions. Specifically, Sweden initially taxed total emissions of HC and NO_x. Estimating these outputs required a detailed mission emission calculation coordinated between the airframe and the engine manufacturers. Subsequently this tax was revised to encompass CO_2 emissions. At this point the analysis required a more conventional aircraft manufacturer or airline calculation of the fuel used per mission. Regulations currently being considered include non-addition of emissions beyond certain base years. Again, airlines will and are interested in calculating the emissions generated over the entire missions. In order to facilitate the airlines in these calculations, a methodology which uses data readily available to the airline is required.

Current Methodology

The current process for calculating aircraft engine emissions of HC, CO, and NO_x for full airplane missions requires three sources of information: engine emission information as contained in the ICAO emission databank, engine performance data as provided by engine thermodynamic cycle models, and airplane performance data. The following equations which require knowledge of the combustor inlet temperature (T_3) and pressure (P_3) are used:

$$EICO = EICO_{sl} * (P_{3sl}/P_3)$$

$$EIHC = EIHC_{sl} * (P_{3sl}/P_3)$$

$$EINO_x = EINO_{xsl} * (P_3/P_{3sl})^n * e^{(-19(\omega-0.0063))}$$ where n is determined from engine manufacturer tests, range approx. .3–.5

The equations employ the correlations developed for ambient test site corrections to correct for altitude. They do not account for installation effects to the fuel flow.

Proposed Methodology (Method 2)

Method 2 is an expanded version of method 1. Method 1 was a correlation suitable for standard day conditions. Method 2 allows for temperature effects and higher altitudes.

The proposed method 2 methodology uses the following equations:

$$EIHC = REIHC\frac{\theta_{amb}^{3.3}}{\delta_{amb}^{1.02}}$$

$$EICO = REICO\frac{\theta_{amb}^{3.3}}{\delta_{amb}^{1.02}}$$

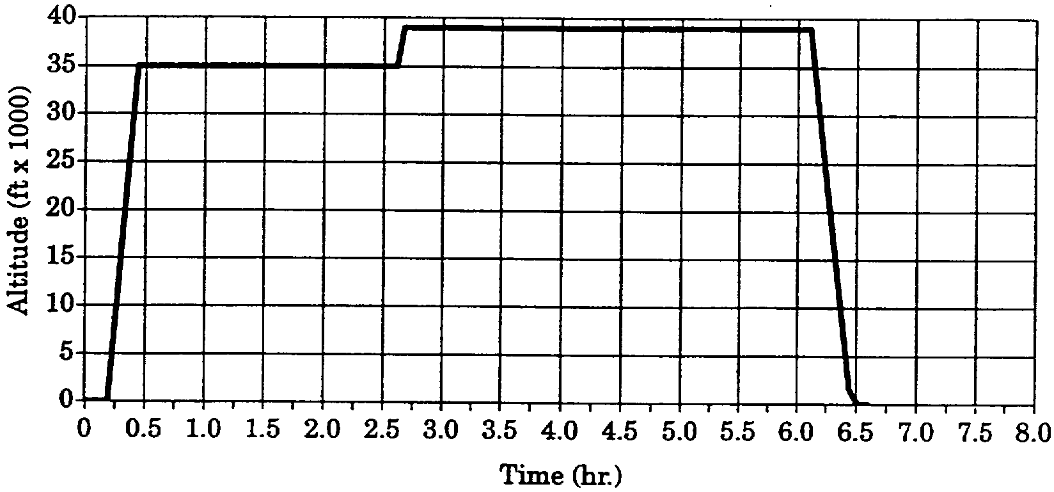
$$EINO_x = REINO_x\ e^{H}\left(\frac{\delta_{amb}^{1.02}}{\theta_{amb}^{3.3}}\right)^{1/2}$$

where $H = -19(\omega - 0.0063)$.

The exponents of δ and θ were chosen solely for their ability to collapse the data.

Method 2 for Computing In–Flight Aircraft Engine Emissions

A method for computing aircraft emissions using an installed fuel flow is described below. This method allows for other than standard day conditions for calculations. It assumes that the engine ICAO data sheets and the fuel flow at various stages of a mission are accessible. A two engine, 3000 nautical mile mission shown below is chosen for an example; however, any mission is possible.


3000 Nautical Mile Mission

ICAO DATA SHEET

The ICAO data sheet must contain complete information about the fuel flow, the Hydrocarbons (HC), the Carbon Monoxides (CO), and the Oxides of Nitrogen (NO_x) for the four power settings, figure 1. The units of fuel flow and emission indices are converted from the S.I. to the English system for this example.

To convert the fuel flow (W_f) from $\frac{Kg}{s}$ to $\frac{lbm}{hr}$, multiply by 7936.

The emission index (EI) values will not change but the English units are $\frac{lbm}{1000 lbm}$.

The fuel flow given does not account for the installation effects of engine air bleed for aircraft use so a correction must be made. The adjusted EI is defined as the reference EI or REI. Figure 2 is a general correction of fuel flow and is used if a curve of installed fuel flow versus thrust levels is unobtainable.

	$\frac{Kg}{s}$	$\frac{lbm}{hr}$	correction	$\frac{lbm}{hr}$
Take–off	2.342	18587	1.010	18773
Climb Out	1.930	15318	1.013	15517
Approach	0.658	5222	1.020	5326
Idle	0.208	1651	1.100	1816

STEP 1. Curve fitting the Data

Once the conversions and corrections are made, the emission indices (EI) are plotted against the corrected W_f on $\log_{10}-\log_{10}$ paper as in figure 3. The data points are curve–fitted to show trends of EI for different fuel flows.

The HC and CO are bi–linear least square fitted curves. The 7% to 30% ratings are linearly curve fitted as are the 85% to 100% ratings. Extrapolating both curves to the point of intersection gives the bi–linear relationship. Some engine emissions data sets do not fit this scheme well and must be manually manipulated. A simple automatic method is in the process of being developed.

The NO_x curve is a simple point–to–point linear fit, on the $\log_{10}$ paper, between the ICAO emission data points.

Step 2. Fuel flow factor

The fuel flow factor, W_{ff}, is:

$$W_{ff} = \frac{W_f}{\delta_{amb}} \Theta_{amb}^{3.8} e^{0.2M^2} \qquad \text{where } \Theta_{amb} = \frac{T_{amb} + 273.15}{288.15}\,.$$

$$\text{and} \quad \text{where } \delta_{amb} = \frac{P_{amb}}{14.696} \qquad \text{(Eq.1)}$$

STEP 3. Compute EI

The new emission indices are calculated by the following equations: (T_{amb} = °C)

$$EIHC = REIHC \frac{\theta_{amb}^{3.3}}{\delta_{amb}^{1.02}} \qquad \text{(Eq.2)}$$

$$EICO = REICO \frac{\theta_{amb}^{3.3}}{\delta_{amb}^{1.02}} \qquad \text{(Eq.3)}$$

$$EINO_x = REINO_x \; e^{H} \left(\frac{\delta_{amb}^{1.02}}{\theta_{amb}^{3.3}}\right)^{1/2} \qquad \text{(Eq.4)}$$

where REIHC, REICO, $REINO_x$=intersection of corresponding curves and W_{ff}.

$$H = -19.0 \times (\omega - 0.0063) \qquad \text{(Eq.4b)}$$

$$\omega = \frac{0.62198(\Phi)P_v}{P_{amb} - (\Phi)P_v} \qquad \text{(Eq.4c)}$$

where ω =specific humidity
Φ =relative humidity
P_v =saturation vapor pressure (psia)
P_{amb} =inlet ambient pressure (psia)

$$P_v = (.014504)10^{\beta} \qquad \text{(Eq.4d)}$$

$$\beta = 7.90298\left(1 - \frac{373.16}{T_{amb} + 273.16}\right) + 3.00571 + (5.02808)\log\left(\frac{373.16}{T_{amb} + 273.16}\right) +$$

$$\left(1.3816 \times 10^{-7}\right)\left[1 - 10^{11.344\left(1 - \frac{T_{amb}+273.16}{373.16}\right)}\right] + \left(8.1328 \times 10^{-3}\right)\left[10^{3.49149\left(1 - \frac{373.16}{T_{amb}+273.16}\right)} - 1\right] \qquad \text{(Eq.4e)}$$

STEP 4. Total pounds of Emissions

The total amount of emissions for a segment is computed by:

$$S(HC, CO, NO_x) = Number\ of\ Engines\ \times \sum_{i=1}^{n} EI(HC, CO, NO_x)_i \times W_{f_i} \times time_i \times 10^{-3}$$

(E

FLIGHT MISSION

An example is given below to illustrate how the equations above are related.

Taxi-Out

Time = 0.15 hour

W_f $= 1500 \frac{lbm}{hr}$

P_{amb} = 14.696 psi (assumed standard pressure)

Φ = 60% (assumed for entire flight)

T_{amb} = 15°C (assumed standard temperature)

M = 0.0

Step 1. (see figure 3)

Step 2. Using Eq.1, the corrected fuel flow is:

$$W_{ff} = \frac{W_f}{\delta_{amb}} \Theta_{amb}^{3.8} e^{0.2M^2} = \frac{1500}{(\frac{14.696}{14.696})} (\frac{15 + 273.15}{288.15})^{3.8} e^{0.2 \times 0.0^2} = 1500 \frac{lbm}{hr}$$

Step 3. For HC, find 1500 on x-axis in figure 3, look across from the intersection of the curve and 1500 to get EIHC. Repeat for CO and NO_x.

REIHC = 3.100 lbm/1000lbm

REICO = 33.400 lbm/1000lbm

$REINO_x$ = 4.200 lbm/1000lbm

Compute β (Eq.4e):

$$\beta = (7.90298)\left(1 - \frac{373.16}{15 + 273.16}\right) + 3.00571 + (5.02808)\log\left(\frac{373.16}{15 + 273.16}\right) +$$

$$(1.3816 \times 10^{-7})\left[1 - 10^{11.344\left(1 - \frac{15 + 273.16}{373.16}\right)}\right] + (8.1328 \times 10^{-3})\left[10^{3.49149\left(1 - \frac{373.16}{15 + 273.16}\right)} - 1\right]$$

$\beta = 1.2328$

Substituting β into Eq.4d, yields $P_v = 0.2479$. From Eq.4c, the specific humidity equates to:

$$\omega = \frac{(0.62198)(\Phi)P_v}{P_{amb} - (\Phi)P_v} = \frac{0.62198(.60)0.2479}{14.696 - (.60)0.2479} = 6.3 \times 10^{-3}$$

This value gives a result of 0 for Eq.4b which leads to a simple solution of Eq.4:

$$EINO_x = REINO_x\ e^{H} (\frac{\delta_{amb}^{1.02}}{\theta_{amb}^{3.3}})^{1/2} = 4.200 \times e^0 \times (\frac{1^{1.02}}{1^{3.3}})^{1/2} = 4.200 \frac{lbm}{1000lbm}$$

The results from Eq.2 & 3 are:

$$EIHC = REIHC\frac{\theta_{amb}^{3.3}}{\delta_{amb}^{1.02}} = 3.100 \times \frac{1^{3.3}}{1^{1.02}} = 3.100\frac{lbm}{1000lbm}$$

$$EICO = REICO\frac{\theta_{amb}^{3.3}}{\delta_{amb}^{1.02}} = 33.400 \times \frac{1^{3.3}}{1^{1.02}} = 33.400\frac{lbm}{1000lbm}$$

Step 4. Compute the emissions in that time interval from Eq.5. In this example, there is only one interval for the taxi–out so a summation is not necessary.

$$SHC = 2 \times REIHC \times W_f \times time \times 10^{-3} = 2 \times 3.100 \times 1500 \times 0.150 \times 10^{-3}.$$
$$= 1.394 lbm\ of\ HC$$

$SCO = 15.030 lbm\ of\, CO$
$SNO_x = 1.890 lbm\ of\, NO_x$

Step 5. Repeat steps 2 thru 4 until the flight segment is completed.

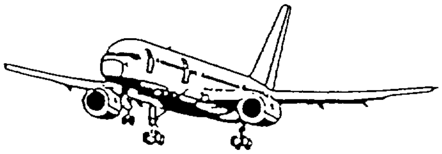
Step 6. Repeat step 5 until the entire profile is completed.

Computer Simulation

A computer program would simplify emission calculations by a considerable amount. It would store the curve fits as equations instead of looking up the EI values from a plot. The equations would give more accurate results than a look–up. Time would be conserved in steps 5 and 6 if the program was equipped with a recursive procedure.

Nomenclature

HC	Unburned hydrocarbons
CO	Unburned carbon monoxide
NO_x	Oxides of nitrogen
W_f	Installed fuel flow from airplane performance manual or cockpit instrumentation (Kilogram/second, Kg/s) or (pound mass/hour, lbm/hr)
REIHC	Reference Emission Index Hydrocarbon (pound mass of HC/1000 pound mass of fuel, lbm/1000lbm), corrected for installations effects
REICO	Reference Emission Index Carbon Monoxide (pound mass of CO/1000 pound mass of fuel, lbm/1000lbm), corrected for installations effects
$REINO_x$	Reference Emission Index Oxides of Nitrogen (pound mass of NO_x/1000 pound mass of fuel, lbm/1000lbm), corrected for installations effects
W_{ff}	Fuel flow factor includes installation effects caused by engine air bleed (Kilogram/second,Kg/s) or (pound mass/hour, lbm/hr)
T_{amb}	Inlet ambient temperature (degree Celsius, °C)
Θ_{amb}	$\frac{T_{amb} + 273.15}{288.15}$, ratio of inlet temperature sea level temperature
P_{amb}	Inlet ambient pressure (pound force/square inch, psia)
δ	$\frac{P_{amb}}{14.696}$, ratio of inlet pressure over sea level pressure
EIHC	Emission Index of Hydrocarbon (pound mass of HC/1000 pound mass of fuel, lbm/1000lbm)
EICO	Emission Index of Carbon Monoxide (pound mass of CO/1000 pound mass of fuel, lbm/1000lbm)
$EINO_x$	Emission Index of Oxides of Nitrogen (pound mass of NO_x/1000 pound mass of fuel, lbm/1000lbm)
ω	Specific humidity (pounds mass of water/pounds mass of air, lbm H_20/lbm air)
Φ	Relative humidity
P_v	Saturation vapor pressure (pound force/square inch, psia)
SHC	Summation of Hydrocarbon emission (pound mass of HC, lbm)
SCO	Summation of Carbon Monoxide emission (pound mass of CO, lbm)
SNO_x	Summation of Oxides of nitrogen emission (pound mass of NO_x, lbm)



ICAO EXHAUST EMISSIONS DATA BANK

SUBSONIC ENGINES

ENGINE IDENTIFICATION:
ENGINE TYPE: Turbofan
BYPASS RATIO:
PRESSURE RATIO:
RATED DRY OUTPUT:

ENGINE STATUS
☒ IN PRODUCTION
☐ UNDER DEVELOPMENT,ANTICIPATED CERTIFICATION DATE:
☐ OTHER (EXPLAIN)

DATA STATUS
☒ DATA OBTAINED FROM NEWLY-MANUFACTURED ENGINES
☐ DATA OBTAINED FROM IN-SERVICE ENGINES
  ☐ BEFORE OVERHAUL
  ☐ AFTER OVERHAUL
☐ OTHER (EXPLAIN)

EMISSIONS DATA
☐ UNCORRECTED DATA
☒ CORRECTED FOR AMBIENT EFFECTS

MODE	POWER SETTING (FN)	TIME MIN	FUEL FLOW kg/s	EMISSIONS INDICES (g/kg)			SMOKE NUMBER
				HC	CO	NOx	
TAKE-OFF	100%	0.7	2.342	0.06	0.44	28.10	7.8
CLIMB OUT	85%	2.2	1.930	0.01	0.57	22.90	
APPROACH	30%	4.0	0.658	0.13	2.00	11.60	
IDLE	7%	26.0	0.208	1.92	21.86	4.80	
NUMBER OF TESTS				3	3	3	3
NUMBER OF ENGINES				1	1	1	1
DP/F (AVERAGE) OR S/N (MAX.) (g/kN)				2.6	30.5	48.1	7.8
DP/F OR S/N (SIGMA) (g/kN)							
DP/F (g/kN) OR S/N RANGE							

ACCESSORY LOAD

POWER EXTRACTION 0 (kW) AT ________ POWER SETTING(S)
STAGE BLEED 0 % CORE FLOW AT ________ POWER SETTING

ATMOSPHERIC CONDITIONS

BAROMETER	kPa	100.2
TEMPERATURE	K	299
ABS HUMIDITY	kg/kg	.010

FUEL

SPEC	H/C	AROM.
JET A	13.65%W	19.7%V

MANUFACTURER:
TEST ORGANIZATION:
TEST LOCATION:
TEST DATE: FROM ________ TO ________

REMARKS:

Figure 1. Typical ICAO Data Sheet

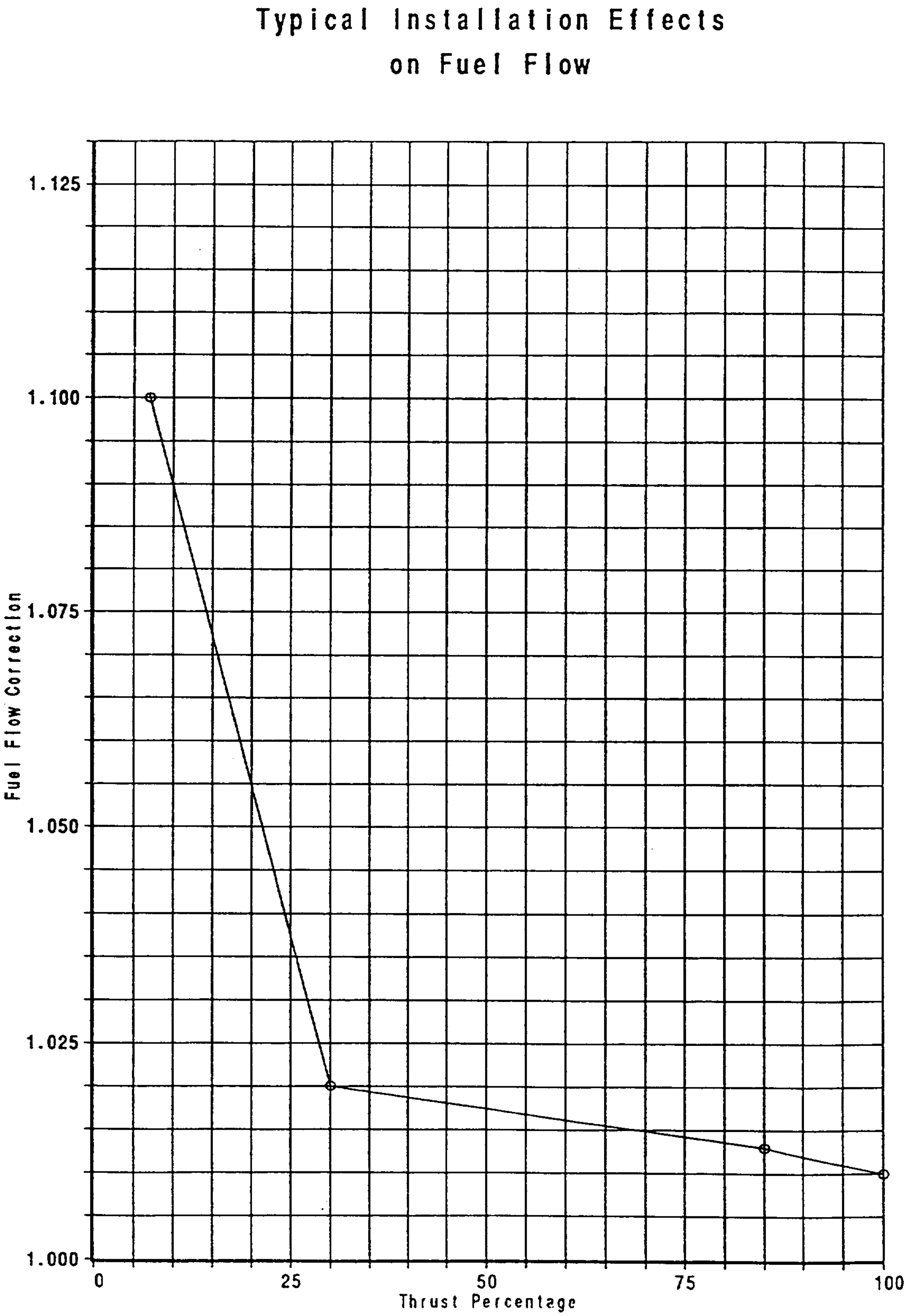


Figure 2. Installation effects on Fuel Flow

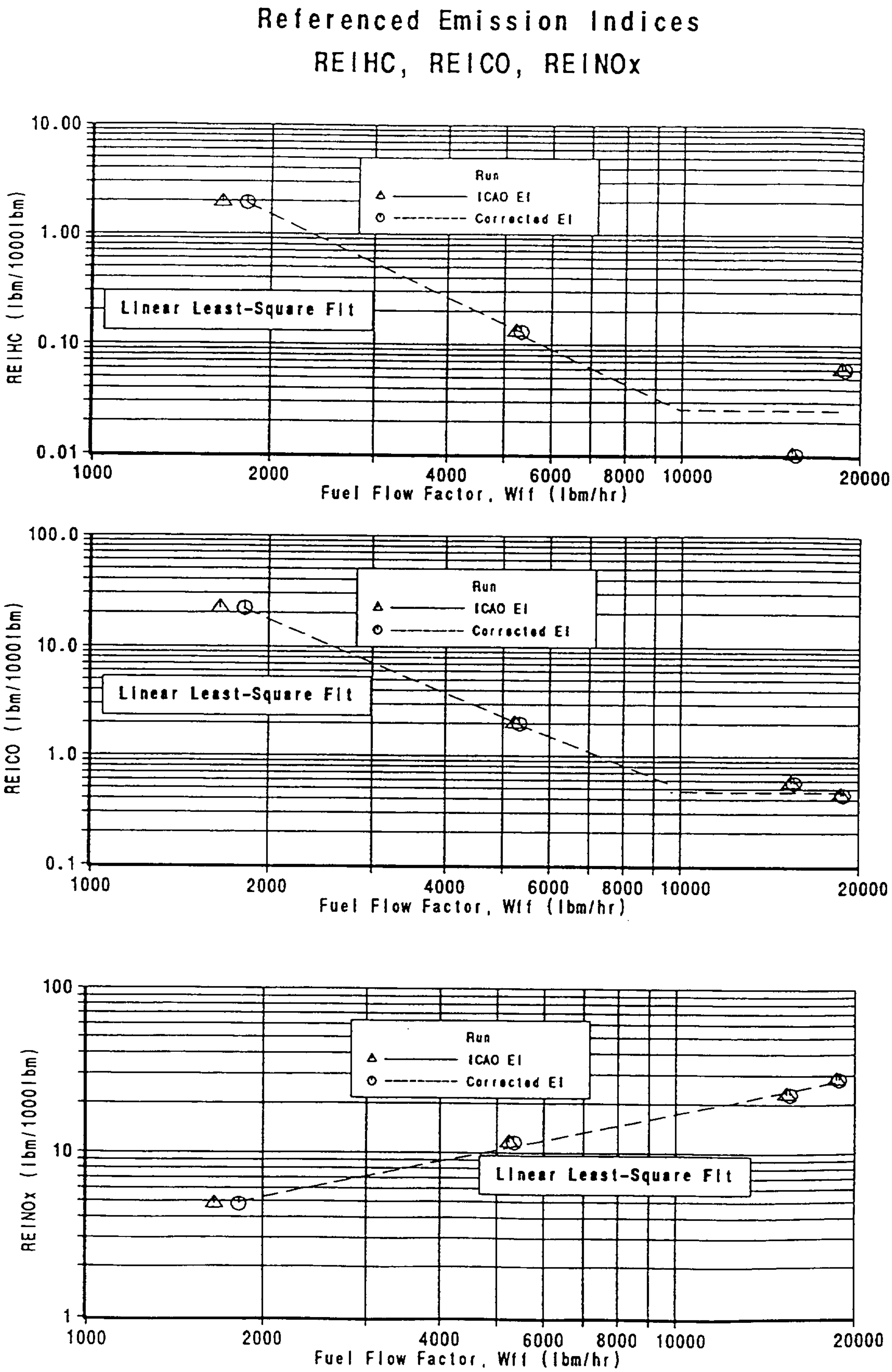


Figure 3. Reference EI vs Fuel Flow Factor

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-1. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in January 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.68E+07	11.39%	3.19E+05	10.45%	1.46E+05	34.27%	4.38E+05	37.23%	11.91	5.46	16.35
1 - 2	7.41E+06	14.55%	1.17E+05	14.26%	2.33E+04	39.73%	7.02E+04	43.19%	15.71	3.14	9.47
2 - 3	6.84E+06	17.45%	1.14E+05	17.99%	2.11E+04	44.66%	6.09E+04	48.37%	16.63	3.08	8.90
3 - 4	7.72E+06	20.73%	1.37E+05	22.46%	2.02E+04	49.40%	5.65E+04	53.17%	17.71	2.62	7.32
4 - 5	6.92E+06	23.68%	1.13E+05	26.16%	1.93E+04	53.92%	5.29E+04	57.67%	16.32	2.79	7.65
5 - 6	6.70E+06	26.53%	1.06E+05	29.64%	1.96E+04	58.51%	5.33E+04	62.20%	15.83	2.93	7.95
6 - 7	6.72E+06	29.39%	1.05E+05	33.07%	1.89E+04	62.95%	4.93E+04	66.39%	15.61	2.82	7.33
7 - 8	7.14E+06	32.42%	1.05E+05	36.50%	1.93E+04	67.47%	5.08E+04	70.71%	14.67	2.71	7.11
8 - 9	6.91E+06	35.36%	9.53E+04	39.62%	1.90E+04	71.92%	4.78E+04	74.77%	13.80	2.75	6.92
9 - 10	1.17E+07	40.35%	1.57E+05	44.77%	1.90E+04	76.37%	4.42E+04	78.53%	13.41	1.62	3.77
10 - 11	7.03E+07	70.26%	8.04E+05	71.08%	5.04E+04	88.16%	1.45E+05	90.87%	11.42	0.72	2.06
11 - 12	6.81E+07	99.21%	8.56E+05	99.11%	4.98E+04	99.84%	1.05E+05	99.78%	12.58	0.73	1.54
12 - 13	1.20E+06	99.72%	1.68E+04	99.66%	5.24E+02	99.96%	1.11E+03	99.87%	14.01	0.44	0.93
13 - 14	3.71E+05	99.87%	5.03E+03	99.83%	1.18E+02	99.99%	4.46E+02	99.91%	13.55	0.32	1.20
14 - 15	1.13E+04	99.88%	2.03E+02	99.83%	2.30E+00	99.99%	3.94E+01	99.92%	18.00	0.20	3.50
15 - 16	1.13E+04	99.88%	2.03E+02	99.84%	2.30E+00	99.99%	3.94E+01	99.92%	18.00	0.20	3.50
16 - 17	1.01E+05	99.93%	1.82E+03	99.90%	2.02E+01	99.99%	3.54E+02	99.95%	18.00	0.20	3.50
17 - 18	1.33E+05	99.98%	2.40E+03	99.98%	2.67E+01	100.00%	4.67E+02	99.99%	18.00	0.20	3.50
18 - 19	3.84E+04	100.00%	6.91E+02	100.00%	7.70E+00	100.00%	1.34E+02	100.00%	18.00	0.20	3.50
Global Total	2.35E+08		3.05E+06		4.27E+05		1.18E+06		12.99	1.82	5.00

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-2. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in February 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.80E+07	11.28%	3.36E+05	10.41%	1.95E+05	36.25%	5.00E+05	37.55%	11.97	6.96	17.84
1 - 2	7.80E+06	14.42%	1.24E+05	14.25%	2.98E+04	41.79%	7.87E+04	43.46%	15.85	3.82	10.08
2 - 3	7.20E+06	17.31%	1.20E+05	17.97%	2.73E+04	46.85%	6.89E+04	48.63%	16.67	3.79	9.58
3 - 4	8.06E+06	20.55%	1.43E+05	22.42%	2.52E+04	51.53%	6.25E+04	53.32%	17.81	3.13	7.76
4 - 5	7.21E+06	23.45%	1.18E+05	26.09%	2.47E+04	56.11%	5.94E+04	57.78%	16.39	3.42	8.23
5 - 6	7.03E+06	26.28%	1.11E+05	29.54%	2.50E+04	60.76%	5.94E+04	62.24%	15.84	3.56	8.45
6 - 7	7.06E+06	29.12%	1.10E+05	32.95%	2.44E+04	65.29%	5.60E+04	66.44%	15.57	3.45	7.93
7 - 8	7.55E+06	32.16%	1.10E+05	36.38%	2.45E+04	69.84%	5.76E+04	70.76%	14.63	3.24	7.63
8 - 9	7.25E+06	35.08%	1.00E+05	39.49%	2.37E+04	74.25%	5.40E+04	74.81%	13.83	3.27	7.44
9 - 10	1.16E+07	39.74%	1.56E+05	44.32%	2.31E+04	78.55%	4.94E+04	78.52%	13.44	2.00	4.26
10 - 11	7.06E+07	68.13%	8.07E+05	69.34%	5.28E+04	88.36%	1.52E+05	89.96%	11.42	0.75	2.16
11 - 12	7.73E+07	99.23%	9.61E+05	99.14%	6.19E+04	99.87%	1.31E+05	99.80%	12.42	0.80	1.70
12 - 13	1.21E+06	99.72%	1.70E+04	99.67%	5.35E+02	99.97%	1.15E+03	99.89%	14.00	0.44	0.95
13 - 14	3.87E+05	99.88%	5.24E+03	99.83%	1.20E+02	99.99%	4.71E+02	99.92%	13.56	0.31	1.22
14 - 15	1.22E+04	99.88%	2.19E+02	99.84%	2.40E+00	99.99%	4.26E+01	99.92%	18.00	0.20	3.50
15 - 16	1.22E+04	99.89%	2.19E+02	99.84%	2.40E+00	99.99%	4.26E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.90%	2.06E+01	99.99%	3.60E+02	99.95%	18.00	0.20	3.50
17 - 18	1.36E+05	99.98%	2.46E+03	99.98%	2.73E+01	100.00%	4.78E+02	99.99%	18.00	0.20	3.50
18 - 19	3.97E+04	100.00%	7.15E+02	100.00%	7.90E+00	100.00%	1.39E+02	100.00%	18.00	0.20	3.50
Global Total	2.49E+08		3.22E+06		5.38E+05		1.33E+06		12.97	2.16	5.36

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-3. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in March 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.84E+07	11.30%	3.40E+05	10.44%	1.96E+05	36.21%	5.04E+05	37.55%	12.00	6.90	17.76
1 - 2	7.88E+06	14.43%	1.25E+05	14.28%	2.99E+04	41.75%	7.93E+04	43.46%	15.88	3.80	10.07
2 - 3	7.27E+06	17.33%	1.21E+05	18.00%	2.74E+04	46.82%	6.95E+04	48.64%	16.71	3.77	9.57
3 - 4	8.15E+06	20.57%	1.46E+05	22.46%	2.53E+04	51.50%	6.31E+04	53.34%	17.84	3.11	7.73
4 - 5	7.28E+06	23.47%	1.20E+05	26.13%	2.48E+04	56.09%	5.98E+04	57.79%	16.42	3.40	8.22
5 - 6	7.09E+06	26.29%	1.13E+05	29.58%	2.51E+04	60.73%	5.99E+04	62.25%	15.87	3.54	8.44
6 - 7	7.13E+06	29.13%	1.11E+05	32.99%	2.45E+04	65.26%	5.64E+04	66.46%	15.60	3.43	7.91
7 - 8	7.64E+06	32.17%	1.12E+05	36.42%	2.46E+04	69.80%	5.81E+04	70.78%	14.64	3.21	7.60
8 - 9	7.33E+06	35.09%	1.02E+05	39.53%	2.38E+04	74.20%	5.42E+04	74.82%	13.85	3.24	7.39
9 - 10	1.17E+07	39.76%	1.58E+05	44.38%	2.32E+04	78.50%	4.98E+04	78.53%	13.46	1.98	4.24
10 - 11	7.11E+07	68.08%	8.14E+05	69.32%	5.33E+04	88.36%	1.54E+05	90.00%	11.44	0.75	2.16
11 - 12	7.82E+07	99.22%	9.72E+05	99.13%	6.22E+04	99.86%	1.32E+05	99.81%	12.43	0.79	1.68
12 - 13	1.28E+06	99.73%	1.79E+04	99.67%	5.59E+02	99.96%	1.13E+03	99.89%	14.00	0.44	0.89
13 - 14	3.99E+05	99.89%	5.42E+03	99.84%	1.32E+02	99.99%	4.67E+02	99.93%	13.59	0.33	1.17
14 - 15	1.04E+04	99.89%	1.87E+02	99.85%	2.10E+00	99.99%	3.64E+01	99.93%	18.00	0.20	3.50
15 - 16	1.04E+04	99.89%	1.87E+02	99.85%	2.10E+00	99.99%	3.64E+01	99.93%	18.00	0.20	3.50
16 - 17	9.88E+04	99.93%	1.78E+03	99.91%	1.98E+01	99.99%	3.46E+02	99.96%	18.00	0.20	3.50
17 - 18	1.31E+05	99.99%	2.35E+03	99.98%	2.61E+01	100.00%	4.57E+02	99.99%	18.00	0.20	3.50
18 - 19	3.76E+04	100.00%	6.77E+02	100.00%	7.50E+00	100.00%	1.32E+02	100.00%	18.00	0.20	3.50
Global Total	2.51E+08		3.26E+06		5.41E+05		1.34E+06		12.98	2.15	5.34

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-4. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in April 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.84E+07	11.18%	3.41E+05	10.34%	1.96E+05	36.20%	5.06E+05	37.49%	12.03	6.93	17.85
1 - 2	7.86E+06	14.28%	1.25E+05	14.13%	3.00E+04	41.72%	7.94E+04	43.38%	15.94	3.81	10.11
2 - 3	7.27E+06	17.15%	1.22E+05	17.82%	2.76E+04	46.81%	6.99E+04	48.56%	16.74	3.79	9.61
3 - 4	8.14E+06	20.36%	1.46E+05	22.24%	2.54E+04	51.48%	6.31E+04	53.23%	17.91	3.11	7.75
4 - 5	7.28E+06	23.23%	1.20E+05	25.88%	2.48E+04	56.06%	5.99E+04	57.67%	16.48	3.41	8.23
5 - 6	7.09E+06	26.03%	1.13E+05	29.30%	2.51E+04	60.69%	5.99E+04	62.11%	15.90	3.54	8.44
6 - 7	7.12E+06	28.83%	1.12E+05	32.68%	2.44E+04	65.19%	5.64E+04	66.29%	15.67	3.43	7.93
7 - 8	7.61E+06	31.84%	1.12E+05	36.07%	2.45E+04	69.71%	5.81E+04	70.60%	14.72	3.22	7.63
8 - 9	7.24E+06	34.69%	1.01E+05	39.13%	2.36E+04	74.06%	5.40E+04	74.59%	13.96	3.27	7.46
9 - 10	1.18E+07	39.36%	1.60E+05	43.98%	2.33E+04	78.36%	5.02E+04	78.31%	13.50	1.97	4.23
10 - 11	7.23E+07	67.88%	8.31E+05	69.18%	5.38E+04	88.29%	1.56E+05	89.86%	11.50	0.74	2.15
11 - 12	7.97E+07	99.30%	9.91E+05	99.23%	6.30E+04	99.90%	1.34E+05	99.82%	12.44	0.79	1.69
12 - 13	1.12E+06	99.74%	1.54E+04	99.70%	4.10E+02	99.97%	9.91E+02	99.89%	13.75	0.37	0.88
13 - 14	3.50E+05	99.88%	4.66E+03	99.84%	8.10E+01	99.99%	4.24E+02	99.92%	13.31	0.23	1.21
14 - 15	1.08E+04	99.89%	1.95E+02	99.84%	2.20E+00	99.99%	3.79E+01	99.92%	18.00	0.20	3.50
15 - 16	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.90%	2.06E+01	99.99%	3.60E+02	99.95%	18.00	0.20	3.50
17 - 18	1.36E+05	99.98%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.54E+08		3.30E+06		5.42E+05		1.35E+06		13.01	2.14	5.32

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-5. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in May 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.90E+07	11.20%	3.48E+05	10.34%	1.96E+05	36.00%	5.12E+05	37.30%	12.00	6.77	17.68
1 - 2	8.01E+06	14.30%	1.27E+05	14.13%	3.01E+04	41.51%	8.06E+04	43.17%	15.91	3.75	10.06
2 - 3	7.40E+06	17.16%	1.24E+05	17.81%	2.74E+04	46.54%	7.06E+04	48.32%	16.70	3.70	9.54
3 - 4	8.31E+06	20.37%	1.49E+05	22.23%	2.54E+04	51.20%	6.41E+04	52.99%	17.87	3.05	7.71
4 - 5	7.46E+06	23.25%	1.23E+05	25.88%	2.48E+04	55.75%	6.09E+04	57.43%	16.43	3.33	8.17
5 - 6	7.24E+06	26.05%	1.15E+05	29.30%	2.51E+04	60.36%	6.08E+04	61.86%	15.88	3.47	8.40
6 - 7	7.29E+06	28.87%	1.14E+05	32.69%	2.44E+04	64.85%	5.73E+04	66.03%	15.65	3.35	7.86
7 - 8	7.78E+06	31.88%	1.14E+05	36.09%	2.46E+04	69.37%	5.94E+04	70.36%	14.69	3.17	7.64
8 - 9	7.46E+06	34.77%	1.04E+05	39.18%	2.39E+04	73.75%	5.56E+04	74.41%	13.90	3.20	7.45
9 - 10	1.21E+07	39.43%	1.62E+05	44.01%	2.34E+04	78.04%	5.10E+04	78.13%	13.46	1.94	4.23
10 - 11	7.37E+07	67.92%	8.46E+05	69.20%	5.48E+04	88.10%	1.59E+05	89.74%	11.49	0.74	2.16
11 - 12	8.11E+07	99.27%	1.01E+06	99.19%	6.43E+04	99.89%	1.38E+05	99.81%	12.43	0.79	1.70
12 - 13	1.23E+06	99.74%	1.70E+04	99.69%	4.36E+02	99.97%	1.11E+03	99.89%	13.79	0.35	0.90
13 - 14	3.66E+05	99.88%	4.88E+03	99.84%	8.47E+01	99.99%	4.39E+02	99.92%	13.32	0.23	1.20
14 - 15	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
15 - 16	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.91%	2.06E+01	99.99%	3.60E+02	99.96%	18.00	0.20	3.50
17 - 18	1.36E+05	99.98%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.59E+08		3.36E+06		5.45E+05		1.37E+06		12.99	2.11	5.31

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-6. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in June 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.96E+07	11.03%	3.55E+05	10.19%	1.98E+05	35.91%	5.21E+05	37.15%	12.02	6.68	17.61
1 - 2	8.19E+06	14.09%	1.30E+05	13.93%	3.03E+04	41.41%	8.19E+04	42.99%	15.93	3.70	9.99
2 - 3	7.57E+06	16.91%	1.26E+05	17.55%	2.75E+04	46.40%	7.18E+04	48.12%	16.71	3.63	9.49
3 - 4	8.51E+06	20.08%	1.52E+05	21.92%	2.56E+04	51.05%	6.52E+04	52.77%	17.91	3.00	7.67
4 - 5	7.61E+06	22.93%	1.25E+05	25.51%	2.50E+04	55.58%	6.20E+04	57.19%	16.46	3.28	8.14
5 - 6	7.41E+06	25.69%	1.18E+05	28.89%	2.53E+04	60.17%	6.19E+04	61.61%	15.91	3.41	8.35
6 - 7	7.46E+06	28.47%	1.17E+05	32.25%	2.46E+04	64.63%	5.83E+04	65.77%	15.68	3.30	7.81
7 - 8	7.95E+06	31.43%	1.17E+05	35.60%	2.48E+04	69.13%	6.03E+04	70.07%	14.73	3.12	7.59
8 - 9	7.61E+06	34.27%	1.06E+05	38.64%	2.41E+04	73.51%	5.65E+04	74.11%	13.96	3.17	7.43
9 - 10	1.27E+07	39.00%	1.72E+05	43.57%	2.38E+04	77.83%	5.24E+04	77.85%	13.56	1.87	4.13
10 - 11	7.68E+07	67.66%	8.85E+05	68.94%	5.63E+04	88.05%	1.65E+05	89.63%	11.52	0.73	2.15
11 - 12	8.47E+07	99.28%	1.06E+06	99.21%	6.52E+04	99.89%	1.43E+05	99.83%	12.46	0.77	1.69
12 - 13	1.25E+06	99.74%	1.72E+04	99.70%	4.70E+02	99.97%	9.58E+02	99.90%	13.69	0.37	0.76
13 - 14	3.87E+05	99.89%	5.10E+03	99.85%	9.41E+01	99.99%	4.10E+02	99.92%	13.20	0.24	1.06
14 - 15	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
15 - 16	1.08E+04	99.90%	1.95E+02	99.86%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.91%	2.06E+01	99.99%	3.60E+02	99.96%	18.00	0.20	3.50
17 - 18	1.36E+05	99.99%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.68E+08		3.49E+06		5.51E+05		1.40E+06		13.01	2.05	5.23

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-7. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in July 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.98E+07	10.91%	3.60E+05	10.09%	2.02E+05	35.89%	5.30E+05	37.11%	12.06	6.76	17.75
1 - 2	8.29E+06	13.94%	1.32E+05	13.80%	3.10E+04	41.41%	8.35E+04	42.96%	15.97	3.74	10.08
2 - 3	7.64E+06	16.73%	1.28E+05	17.40%	2.81E+04	46.41%	7.32E+04	48.09%	16.80	3.68	9.58
3 - 4	8.62E+06	19.88%	1.55E+05	21.75%	2.60E+04	51.04%	6.63E+04	52.73%	17.99	3.02	7.69
4 - 5	7.70E+06	22.69%	1.27E+05	25.31%	2.55E+04	55.57%	6.30E+04	57.14%	16.51	3.31	8.18
5 - 6	7.51E+06	25.43%	1.20E+05	28.66%	2.58E+04	60.17%	6.29E+04	61.55%	15.94	3.44	8.38
6 - 7	7.50E+06	28.17%	1.18E+05	31.98%	2.50E+04	64.62%	5.90E+04	65.68%	15.75	3.34	7.87
7 - 8	8.03E+06	31.11%	1.19E+05	35.31%	2.53E+04	69.13%	6.13E+04	69.97%	14.78	3.15	7.63
8 - 9	7.67E+06	33.91%	1.08E+05	38.32%	2.46E+04	73.50%	5.74E+04	74.00%	14.02	3.20	7.49
9 - 10	1.28E+07	38.58%	1.74E+05	43.18%	2.42E+04	77.81%	5.31E+04	77.71%	13.57	1.89	4.15
10 - 11	7.83E+07	67.21%	9.04E+05	68.53%	5.72E+04	87.99%	1.68E+05	89.46%	11.54	0.73	2.14
11 - 12	8.79E+07	99.32%	1.10E+06	99.25%	6.69E+04	99.89%	1.48E+05	99.83%	12.47	0.76	1.68
12 - 13	1.20E+06	99.76%	1.65E+04	99.71%	4.49E+02	99.97%	1.01E+03	99.90%	13.72	0.37	0.84
13 - 14	3.70E+05	99.89%	4.89E+03	99.85%	8.86E+01	99.99%	4.10E+02	99.93%	13.23	0.24	1.11
14 - 15	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
15 - 16	1.08E+04	99.90%	1.95E+02	99.86%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.94%	1.85E+03	99.91%	2.06E+01	99.99%	3.60E+02	99.96%	18.00	0.20	3.50
17 - 18	1.36E+05	99.99%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.74E+08		3.57E+06		5.62E+05		1.43E+06		13.04	2.05	5.22

Table E-8. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in August 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.99E+07	10.89%	3.60E+05	10.08%	2.01E+05	35.83%	5.29E+05	37.07%	12.06	6.73	17.72
1 - 2	8.31E+06	13.92%	1.33E+05	13.79%	3.11E+04	41.37%	8.37E+04	42.94%	15.97	3.74	10.08
2 - 3	7.66E+06	16.71%	1.29E+05	17.39%	2.80E+04	46.36%	7.31E+04	48.06%	16.80	3.66	9.54
3 - 4	8.64E+06	19.86%	1.56E+05	21.74%	2.60E+04	50.99%	6.62E+04	52.69%	18.01	3.01	7.67
4 - 5	7.73E+06	22.68%	1.28E+05	25.31%	2.54E+04	55.52%	6.31E+04	57.11%	16.51	3.29	8.15
5 - 6	7.52E+06	25.42%	1.20E+05	28.66%	2.58E+04	60.11%	6.30E+04	61.52%	15.94	3.42	8.37
6 - 7	7.50E+06	28.16%	1.18E+05	31.97%	2.50E+04	64.57%	5.91E+04	65.66%	15.75	3.33	7.87
7 - 8	8.02E+06	31.08%	1.19E+05	35.28%	2.53E+04	69.07%	6.13E+04	69.96%	14.80	3.15	7.65
8 - 9	7.67E+06	33.88%	1.08E+05	38.29%	2.45E+04	73.44%	5.75E+04	73.99%	14.03	3.20	7.50
9 - 10	1.28E+07	38.56%	1.74E+05	43.17%	2.42E+04	77.75%	5.32E+04	77.72%	13.58	1.88	4.14
10 - 11	7.86E+07	67.21%	9.07E+05	68.54%	5.74E+04	87.98%	1.68E+05	89.50%	11.54	0.73	2.14
11 - 12	8.81E+07	99.34%	1.10E+06	99.28%	6.69E+04	99.90%	1.48E+05	99.85%	12.48	0.76	1.68
12 - 13	1.22E+06	99.78%	1.67E+04	99.75%	4.51E+02	99.98%	9.75E+02	99.92%	13.69	0.37	0.80
13 - 14	3.66E+05	99.92%	4.85E+03	99.89%	8.56E+01	99.99%	3.87E+02	99.94%	13.24	0.23	1.05
14 - 15	8.25E+03	99.92%	1.49E+02	99.89%	1.70E+00	99.99%	2.89E+01	99.95%	18.00	0.20	3.50
15 - 16	8.25E+03	99.92%	1.49E+02	99.89%	1.70E+00	99.99%	2.89E+01	99.95%	18.00	0.20	3.50
16 - 17	7.93E+04	99.95%	1.43E+03	99.93%	1.59E+01	100.00%	2.77E+02	99.97%	18.00	0.20	3.50
17 - 18	1.03E+05	99.99%	1.85E+03	99.99%	2.05E+01	100.00%	3.59E+02	99.99%	18.00	0.20	3.50
18 - 19	2.95E+04	100.00%	5.32E+02	100.00%	5.90E+00	100.00%	1.03E+02	100.00%	18.00	0.20	3.50
Global Total	2.74E+08		3.58E+06		5.61E+05		1.43E+06		13.04	2.05	5.21

Table E-9. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in September 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.94E+07	11.04%	3.55E+05	10.21%	1.99E+05	36.11%	5.23E+05	37.25%	12.06	6.77	17.77
1 - 2	8.18E+06	14.11%	1.31E+05	13.97%	3.04E+04	41.63%	8.23E+04	43.12%	15.97	3.72	10.06
2 - 3	7.54E+06	16.95%	1.27E+05	17.61%	2.76E+04	46.63%	7.21E+04	48.26%	16.77	3.66	9.56
3 - 4	8.50E+06	20.14%	1.53E+05	22.01%	2.56E+04	51.27%	6.53E+04	52.91%	17.98	3.01	7.69
4 - 5	7.62E+06	23.00%	1.26E+05	25.63%	2.51E+04	55.80%	6.22E+04	57.35%	16.51	3.29	8.17
5 - 6	7.46E+06	25.80%	1.19E+05	29.05%	2.53E+04	60.40%	6.23E+04	61.78%	15.92	3.40	8.34
6 - 7	7.47E+06	28.60%	1.17E+05	32.42%	2.47E+04	64.87%	5.86E+04	65.96%	15.70	3.31	7.84
7 - 8	7.97E+06	31.60%	1.18E+05	35.81%	2.49E+04	69.38%	6.06E+04	70.27%	14.75	3.12	7.60
8 - 9	7.59E+06	34.44%	1.06E+05	38.86%	2.41E+04	73.75%	5.65E+04	74.30%	13.99	3.18	7.45
9 - 10	1.26E+07	39.17%	1.70E+05	43.76%	2.37E+04	78.06%	5.24E+04	78.04%	13.49	1.88	4.16
10 - 11	7.51E+07	67.35%	8.68E+05	68.74%	5.55E+04	88.11%	1.62E+05	89.58%	11.57	0.74	2.16
11 - 12	8.52E+07	99.32%	1.06E+06	99.26%	6.50E+04	99.90%	1.44E+05	99.84%	12.45	0.76	1.69
12 - 13	1.19E+06	99.77%	1.63E+04	99.73%	4.42E+02	99.98%	9.76E+02	99.91%	13.66	0.37	0.82
13 - 14	3.58E+05	99.90%	4.76E+03	99.87%	8.32E+01	99.99%	4.07E+02	99.94%	13.28	0.23	1.14
14 - 15	9.21E+03	99.91%	1.66E+02	99.87%	1.80E+00	99.99%	3.22E+01	99.94%	18.00	0.20	3.50
15 - 16	9.21E+03	99.91%	1.66E+02	99.88%	1.80E+00	99.99%	3.22E+01	99.94%	18.00	0.20	3.50
16 - 17	8.67E+04	99.94%	1.56E+03	99.92%	1.73E+01	99.99%	3.04E+02	99.96%	18.00	0.20	3.50
17 - 18	1.16E+05	99.99%	2.09E+03	99.98%	2.32E+01	100.00%	4.07E+02	99.99%	18.00	0.20	3.50
18 - 19	3.35E+04	100.00%	6.02E+02	100.00%	6.70E+00	100.00%	1.17E+02	100.00%	18.00	0.20	3.50
Global Total	2.66E+08		3.47E+06		5.52E+05		1.40E+06		13.04	2.07	5.27

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-10. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in October 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.89E+07	11.14%	3.48E+05	10.27%	1.93E+05	36.12%	5.11E+05	37.19%	12.01	6.67	17.65
1 - 2	8.05E+06	14.24%	1.28E+05	14.06%	2.97E+04	41.69%	8.08E+04	43.08%	15.91	3.69	10.03
2 - 3	7.42E+06	17.09%	1.24E+05	17.72%	2.67E+04	46.68%	7.05E+04	48.21%	16.70	3.60	9.49
3 - 4	8.36E+06	20.31%	1.50E+05	22.15%	2.47E+04	51.32%	6.39E+04	52.86%	17.91	2.96	7.64
4 - 5	7.51E+06	23.20%	1.24E+05	25.80%	2.42E+04	55.86%	6.09E+04	57.30%	16.45	3.23	8.12
5 - 6	7.37E+06	26.03%	1.17E+05	29.25%	2.45E+04	60.44%	6.10E+04	61.74%	15.87	3.32	8.28
6 - 7	7.37E+06	28.87%	1.15E+05	32.66%	2.39E+04	64.91%	5.74E+04	65.92%	15.65	3.24	7.78
7 - 8	7.82E+06	31.88%	1.15E+05	36.06%	2.40E+04	69.41%	5.93E+04	70.23%	14.72	3.07	7.58
8 - 9	7.44E+06	34.74%	1.04E+05	39.13%	2.33E+04	73.76%	5.54E+04	74.26%	13.96	3.12	7.44
9 - 10	1.23E+07	39.46%	1.65E+05	44.01%	2.29E+04	78.05%	5.13E+04	78.00%	13.45	1.87	4.18
10 - 11	7.33E+07	67.67%	8.45E+05	68.99%	5.42E+04	88.19%	1.60E+05	89.61%	11.53	0.74	2.18
11 - 12	8.23E+07	99.36%	1.03E+06	99.29%	6.25E+04	99.90%	1.40E+05	99.84%	12.45	0.76	1.70
12 - 13	1.06E+06	99.77%	1.45E+04	99.72%	3.99E+02	99.97%	8.19E+02	99.90%	13.67	0.38	0.77
13 - 14	3.08E+05	99.88%	4.07E+03	99.84%	7.52E+01	99.99%	3.72E+02	99.92%	13.22	0.24	1.21
14 - 15	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
15 - 16	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.91%	2.06E+01	99.99%	3.60E+02	99.96%	18.00	0.20	3.50
17 - 18	1.36E+05	99.98%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.60E+08		3.38E+06		5.34E+05		1.37E+06		13.02	2.05	5.28

Table E-11. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in November 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.90E+07	11.10%	3.48E+05	10.24%	1.91E+05	36.16%	5.11E+05	37.14%	12.03	6.59	17.66
1 - 2	8.06E+06	14.19%	1.29E+05	14.02%	2.94E+04	41.73%	8.11E+04	43.03%	15.94	3.65	10.05
2 - 3	7.44E+06	17.04%	1.25E+05	17.68%	2.64E+04	46.72%	7.06E+04	48.16%	16.74	3.54	9.50
3 - 4	8.39E+06	20.26%	1.51E+05	22.11%	2.45E+04	51.36%	6.40E+04	52.81%	17.96	2.92	7.63
4 - 5	7.52E+06	23.14%	1.24E+05	25.76%	2.39E+04	55.87%	6.09E+04	57.24%	16.49	3.17	8.10
5 - 6	7.40E+06	25.98%	1.18E+05	29.22%	2.41E+04	60.44%	6.13E+04	61.69%	15.89	3.26	8.28
6 - 7	7.37E+06	28.80%	1.16E+05	32.62%	2.34E+04	64.88%	5.74E+04	65.86%	15.70	3.18	7.79
7 - 8	7.85E+06	31.81%	1.16E+05	36.03%	2.38E+04	69.38%	5.98E+04	70.20%	14.75	3.03	7.61
8 - 9	7.48E+06	34.68%	1.05E+05	39.10%	2.30E+04	73.74%	5.58E+04	74.25%	13.99	3.08	7.45
9 - 10	1.25E+07	39.48%	1.68E+05	44.05%	2.27E+04	78.04%	5.20E+04	78.03%	13.46	1.82	4.15
10 - 11	7.37E+07	67.73%	8.51E+05	69.07%	5.41E+04	88.28%	1.61E+05	89.69%	11.55	0.73	2.18
11 - 12	8.25E+07	99.36%	1.03E+06	99.29%	6.14E+04	99.90%	1.40E+05	99.83%	12.45	0.74	1.69
12 - 13	1.04E+06	99.76%	1.43E+04	99.71%	3.89E+02	99.97%	8.54E+02	99.89%	13.78	0.37	0.82
13 - 14	3.24E+05	99.88%	4.30E+03	99.84%	7.58E+01	99.99%	4.09E+02	99.92%	13.28	0.23	1.26
14 - 15	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
15 - 16	1.08E+04	99.89%	1.95E+02	99.85%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.91%	2.06E+01	99.99%	3.60E+02	99.96%	18.00	0.20	3.50
17 - 18	1.36E+05	99.98%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.61E+08		3.40E+06		5.28E+05		1.38E+06		13.04	2.02	5.28

Table E-12. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for scheduled air traffic in December 1992.

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.86E+07	11.04%	3.43E+05	10.19%	1.89E+05	36.15%	5.02E+05	36.97%	12.00	6.61	17.57
1 - 2	7.99E+06	14.13%	1.27E+05	13.96%	2.90E+04	41.70%	8.03E+04	42.88%	15.90	3.63	10.05
2 - 3	7.37E+06	16.98%	1.23E+05	17.62%	2.60E+04	46.68%	6.97E+04	48.01%	16.71	3.53	9.45
3 - 4	8.31E+06	20.19%	1.49E+05	22.04%	2.42E+04	51.30%	6.30E+04	52.64%	17.93	2.91	7.59
4 - 5	7.45E+06	23.06%	1.23E+05	25.68%	2.36E+04	55.82%	6.01E+04	57.07%	16.45	3.17	8.07
5 - 6	7.32E+06	25.89%	1.16E+05	29.12%	2.38E+04	60.38%	6.04E+04	61.51%	15.84	3.25	8.25
6 - 7	7.28E+06	28.70%	1.14E+05	32.51%	2.31E+04	64.80%	5.65E+04	65.67%	15.67	3.18	7.76
7 - 8	7.72E+06	31.68%	1.14E+05	35.89%	2.34E+04	69.28%	5.87E+04	69.99%	14.74	3.03	7.61
8 - 9	7.32E+06	34.51%	1.02E+05	38.93%	2.28E+04	73.63%	5.50E+04	74.04%	14.00	3.11	7.51
9 - 10	1.23E+07	39.26%	1.66E+05	43.85%	2.24E+04	77.92%	5.14E+04	77.82%	13.48	1.82	4.18
10 - 11	7.34E+07	67.62%	8.46E+05	68.99%	5.39E+04	88.24%	1.60E+05	89.61%	11.53	0.74	2.18
11 - 12	8.23E+07	99.43%	1.02E+06	99.37%	6.10E+04	99.91%	1.39E+05	99.87%	12.43	0.74	1.69
12 - 13	9.93E+05	99.81%	1.37E+04	99.78%	3.66E+02	99.98%	7.99E+02	99.92%	13.76	0.37	0.80
13 - 14	3.03E+05	99.93%	4.03E+03	99.90%	6.82E+01	99.99%	3.55E+02	99.95%	13.31	0.23	1.17
14 - 15	8.10E+03	99.93%	1.46E+02	99.90%	1.60E+00	99.99%	2.84E+01	99.95%	18.00	0.20	3.50
15 - 16	8.10E+03	99.93%	1.46E+02	99.91%	1.60E+00	99.99%	2.84E+01	99.95%	18.00	0.20	3.50
16 - 17	6.46E+04	99.96%	1.16E+03	99.94%	1.29E+01	100.00%	2.26E+02	99.97%	18.00	0.20	3.50
17 - 18	8.54E+04	99.99%	1.54E+03	99.99%	1.71E+01	100.00%	2.99E+02	99.99%	18.00	0.20	3.50
18 - 19	2.50E+04	100.00%	4.50E+02	100.00%	5.00E+00	100.00%	8.75E+01	100.00%	18.00	0.20	3.50
Global Total	2.59E+08		3.37E+06		5.22E+05		1.36E+06		13.01	2.02	5.25

Appendix E. Fuel Burned and Emissions as a Function of Altitude for each Month

Table E-13. Fuel burned, emissions, cumulative fractions of emissions, and emission indices as a function of altitude (Summed over Latitude and Longitude) for the scheduled air traffic for May 1990 using the Method 2 fuel flow method. (revised from NASA CR-4592)

Altitude Band (km)	Fuel (kg/day)	cum fuel (%)	NOx (kg/day)	cum NOx (%)	HC (kg/day)	cum HC (%)	CO (kg/day)	cum CO (%)	EI(NOx)	EI(HC)	EI(CO)
0 - 1	2.91E+07	11.84%	3.40E+05	10.82%	2.09E+05	36.69%	5.18E+05	38.12%	11.70	7.20	17.85
1 - 2	7.97E+06	15.09%	1.23E+05	14.75%	3.20E+04	42.31%	7.98E+04	43.98%	15.49	4.02	10.01
2 - 3	7.32E+06	18.07%	1.19E+05	18.54%	2.93E+04	47.45%	7.06E+04	49.17%	16.29	4.01	9.65
3 - 4	8.23E+06	21.42%	1.43E+05	23.09%	2.75E+04	52.28%	6.56E+04	53.99%	17.35	3.35	7.97
4 - 5	7.32E+06	24.41%	1.18E+05	26.83%	2.62E+04	56.88%	6.09E+04	58.47%	16.06	3.58	8.32
5 - 6	7.06E+06	27.28%	1.11E+05	30.35%	2.67E+04	61.57%	6.09E+04	62.95%	15.67	3.79	8.63
6 - 7	6.99E+06	30.13%	1.08E+05	33.79%	2.59E+04	66.11%	5.64E+04	67.09%	15.46	3.71	8.08
7 - 8	7.55E+06	33.20%	1.09E+05	37.25%	2.62E+04	70.70%	5.88E+04	71.42%	14.41	3.47	7.79
8 - 9	7.53E+06	36.27%	1.02E+05	40.48%	2.56E+04	75.18%	5.48E+04	75.44%	13.51	3.39	7.27
9 - 10	1.17E+07	41.06%	1.56E+05	45.44%	2.52E+04	79.61%	5.04E+04	79.15%	13.25	2.15	4.29
10 - 11	6.95E+07	69.40%	7.84E+05	70.40%	5.47E+04	89.20%	1.51E+05	90.25%	11.28	0.79	2.17
11 - 12	7.34E+07	99.32%	9.06E+05	99.25%	6.11E+04	99.91%	1.30E+05	99.82%	12.34	0.83	1.77
12 - 13	1.00E+06	99.73%	1.36E+04	99.68%	3.90E+02	99.98%	9.17E+02	99.89%	13.54	0.39	0.92
13 - 14	3.57E+05	99.88%	4.76E+03	99.83%	7.99E+01	99.99%	4.39E+02	99.92%	13.32	0.22	1.23
14 - 15	1.08E+04	99.88%	1.95E+02	99.83%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
15 - 16	1.08E+04	99.89%	1.95E+02	99.84%	2.20E+00	99.99%	3.79E+01	99.93%	18.00	0.20	3.50
16 - 17	1.03E+05	99.93%	1.85E+03	99.90%	2.06E+01	99.99%	3.60E+02	99.95%	18.00	0.20	3.50
17 - 18	1.36E+05	99.98%	2.45E+03	99.98%	2.73E+01	100.00%	4.77E+02	99.99%	18.00	0.20	3.50
18 - 19	3.93E+04	100.00%	7.07E+02	100.00%	7.90E+00	100.00%	1.37E+02	100.00%	18.00	0.20	3.50
Global Total	2.45E+08		3.14E+06		5.70E+05		1.36E+06		12.80	2.32	5.54

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
146-100/ALF502R-3	0	28	28	31	31	33	33	32	32	31	15	15
146-100/ALF502R-5	42	50	52	45	45	45	45	43	42	43	26	26
146-200/ALF502R-3	74	77	72	67	79	75	77	78	78	81	79	78
146-200/ALF502R-5	1,100	1,090	1,130	1,180	1,230	1,260	1,280	1,280	1,180	1,150	1,150	1,080
146-300/ALF502R-5	260	238	238	212	213	213	193	190	192	191	142	132
146-300/LF507-1F	10	10	10	10	10	10	10	10	10	25	29	27
14F-300QT/ALF502R-5	0	0	0	0	0	0	0	0	0	0	0	0
720-000/JT3C-12	0	32	33	29	28	41	44	42	36	37	34	28
727-100/JT8D-7A	163	183	183	188	184	163	163	163	143	143	122	116
727-100/JT8D-7B	2,000	1,950	1,990	1,870	1,910	1,980	1,850	1,690	1,720	1,600	1,570	1,480
727-100/JT8D-9	63	65	24	24	24	24	24	24	24	26	26	26
727-100/JT8D-9A	84	84	84	91	94	94	87	110	89	89	90	90
72C-100F/JT8D-7B	0	933	916	909	882	896	894	874	859	858	831	943
72C-100F/JT8D-9A	0	14	14	21	21	21	21	21	21	21	21	21
72S-200/JT8D-15	17,000	15,300	15,800	14,800	15,500	16,100	16,400	16,400	15,000	14,600	14,300	14,500
72S-200/JT8D-17	702	683	690	625	631	712	709	631	433	337	430	406
72S-200/JT8D-17R	1,760	1,730	1,630	1,640	1,550	1,540	1,510	1,470	1,500	1,570	1,490	1,570
72S-200/JT8D-7B	0	0	0	29	29	29	29	61	133	133	133	188
72S-200/JT8D-9	0	0	83	83	89	89	88	89	88	94	98	98
72S-200/JT8D-9A	4,200	4,180	4,200	4,270	3,990	4,200	4,260	4,220	4,120	4,010	4,160	4,280
737-100/JT8D-7A	0	0	54	54	54	66	66	66	56	56	56	56
737-200/JT8D-15	5,070	5,110	5,070	5,320	5,420	5,400	5,250	5,280	5,460	5,490	5,340	5,400
737-200/JT8D-15A	1,990	2,000	1,980	1,850	1,960	1,960	1,910	1,970	1,960	1,980	1,940	1,950
737-200/JT8D-17	1,210	1,170	1,150	1,230	1,230	1,240	1,240	1,320	1,230	1,160	1,240	1,110
737-200/JT8D-17A	875	880	864	852	853	854	973	1,020	979	959	969	1,010
737-200/JT8D-7B	2,740	2,790	2,700	2,570	2,670	2,840	2,920	2,960	2,820	2,780	2,920	3,050
737-200/JT8D-9	67	67	66	66	58	54	57	52	52	52	52	50
737-200/JT8D-9A	3,370	3,400	3,350	3,250	3,350	3,440	3,480	3,350	3,380	3,350	3,300	3,310
73C-200C/JT8D-15	0	16	16	16	16	16	16	0	0	0	0	0
73C-200C/JT8D-17	84	88	89	89	94	109	109	109	90	88	89	90
73C-200C/JT8D-17A	90	93	82	89	89	130	131	127	94	94	93	93
73C-200C/JT8D-9A	37	229	221	210	206	213	212	244	243	239	244	247
73C-200F/JT8D-17	0	18	18	18	18	18	18	18	18	18	18	18
73L-500/CFM56-3C	1,250	1,270	1,350	1,500	1,630	1,770	1,870	1,990	2,170	2,130	2,210	2,320

Appendix F. Fuel Burned by Airplane Type and Month

OAG Airplane/engine	1992 Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Fuel burned in thousand kilograms/day											
73Y-300/CFM56-3B	10,000	9,960	9,650	9,830	10,000	10,400	10,600	10,500	10,200	9,990	10,200	9,050
73Z-400/CFM56-3B	1,760	1,740	1,790	1,790	1,850	1,970	2,040	1,990	2,000	2,050	2,070	2,240
747-100/JT9D-3A	2,470	1,380	1,480	1,770	1,630	1,780	1,950	1,950	1,480	1,300	1,540	1,500
747-100/JT9D-3AW	122	122	156	190	246	321	321	312	304	172	156	156
747-100/JT9D-7A	19,500	16,100	16,200	15,900	15,400	15,700	16,400	16,600	15,400	14,500	14,800	14,500
747-100/JT9D-7AH	1,170	1,290	1,390	1,260	1,250	1,680	1,700	1,700	1,400	869	703	962
747-100B/JT9D-7F	31	31	31	31	31	31	31	31	31	31	31	18
747-100B/RB211-524C2	336	408	389	370	370	380	424	424	451	388	421	421
747-200B/CF6-50E2	5,470	5,860	5,930	6,490	6,780	7,290	7,390	6,940	6,490	6,450	5,810	5,750
747-200B/JT9D-7A	186	330	260	239	328	306	329	438	387	361	322	339
747-200B/JT9D-7AW	4,700	4,020	4,080	4,040	3,870	4,130	4,360	4,420	4,240	4,210	4,140	4,200
747-200B/JT9D-7F	882	882	850	895	886	1,010	1,010	1,010	715	649	667	644
747-200B/JT9D-7J	1,140	2,080	2,070	1,910	2,240	2,410	2,850	2,710	2,220	2,520	2,290	2,150
747-200B/JT9D-7Q	3,840	4,000	3,760	3,860	4,050	3,940	4,050	3,900	4,130	3,310	3,440	3,020
747-200B/JT9D-7R4G2	314	432	432	397	382	406	392	420	499	434	384	390
747-200B/JT9D-7W	810	837	837	1,030	1,090	1,190	1,210	1,210	1,210	1,160	984	949
747-200B/RB211-524C2	1,280	1,220	1,200	1,120	1,170	1,290	1,290	1,210	691	711	677	670
747-200B/RB211-524D4	816	885	1,080	1,140	1,140	1,140	1,180	1,050	1,090	895	1,050	1,070
74C-100F/JT9D-7A	0	2,790	3,150	2,990	2,740	2,790	2,660	2,680	2,760	2,780	2,900	2,950
74C-200F/CF6-50E2	0	1,230	1,320	1,210	1,160	1,140	1,300	1,670	1,900	1,760	2,190	1,960
74C-200F/JT9D-7A	0	351	351	351	351	351	351	351	351	351	351	351
74C-200F/JT9D-7F	0	726	726	722	722	724	724	808	811	807	810	757
74C-200F/JT9D-7FW	0	63	63	63	63	63	63	63	63	63	63	63
74C-200F/JT9D-7J	0	277	277	277	277	277	277	277	277	277	277	277
74C-200F/JT9D-7Q	0	2,300	2,190	2,260	2,270	2,270	2,280	2,320	2,350	2,490	2,600	2,470
74C-200F/RB211-524D4	0	419	344	342	342	333	402	405	432	512	475	446
74I-400/CF6-80C2	2,790	2,790	2,800	2,650	3,040	3,100	3,190	3,270	3,290	3,310	3,330	3,860
74I-400/PW4056	4,520	4,370	4,670	4,470	4,270	4,870	5,230	5,470	5,670	5,490	5,500	5,800
74I-400/RB211-524G	2,330	4,310	4,010	4,780	4,610	4,830	5,040	5,030	5,010	4,770	5,060	4,940
74I-400/RB211-524H	1,300	1,370	1,370	1,490	1,430	1,440	1,440	1,550	1,690	1,660	1,740	1,760
74P-SP/JT9D-7A	1,980	2,070	2,090	1,900	2,010	2,130	2,060	2,060	1,990	1,850	1,700	1,590
74P-SP/JT9D-7F	206	218	218	237	237	202	212	212	212	212	227	222
74P-SP/JT9D-7FW	345	348	305	429	514	396	392	399	399	278	312	319
74P-SP/RB211-524C2	14	33	34	11	11	13	39	39	39	26	13	13

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
74P-SP/RB211-524D4	188	188	201	0	0	0	0	0	0	0	0	0
74Q-200M/CF6-50E2	0	0	0	18	0	0	0	0	0	0	0	0
74Q-200M/JT9D-7J	0	0	0	0	0	0	0	0	0	0	142	142
74U-300/CF6-80C2	429	602	601	587	565	580	557	557	557	556	721	738
74U-300/JT9D-7R4G2	1,910	1,930	2,010	2,370	2,410	2,450	2,350	2,290	2,020	2,060	2,150	1,950
74U-300/RB211-524C2	0	0	0	0	0	0	0	0	400	400	393	393
74U-300/RB211-524D4	1,160	1,150	1,110	1,190	1,330	1,170	1,190	1,210	1,190	1,130	1,160	1,190
74X-100SR/CF6-45A2	0	595	595	673	719	710	790	790	645	645	605	541
757-200/PW2037	4,260	4,180	4,520	4,540	4,630	4,740	4,850	4,910	4,790	4,820	4,970	5,140
757-200/PW2040	1,420	1,450	1,580	1,650	1,720	1,760	1,830	1,840	1,800	1,900	2,070	2,100
757-200/RB211-535C	721	737	784	657	893	965	1,020	1,060	954	956	1,050	999
757-200/RB211-535E4	989	929	912	831	855	922	996	966	959	916	1,040	1,050
75F/*	0	336	336	368	428	446	446	452	446	474	464	490
767-200/CF6-80A	7,880	7,910	7,820	7,640	8,080	8,360	8,920	8,890	8,670	8,410	8,350	8,410
767-200/CF6-80A2	522	530	530	525	569	532	572	572	584	523	497	504
767-200/JT9D-7R4D	2,250	1,920	2,100	1,920	1,960	2,050	2,070	2,060	2,030	1,940	1,980	1,830
76M-300/CF6-80A2	3,560	3,630	3,660	3,920	4,130	5,010	4,960	5,200	5,340	5,240	5,350	5,320
76M-300/CF6-80C2	498	475	481	613	613	587	605	597	568	602	638	643
7IQ-400M/CF6-80C2	917	989	995	1,400	1,460	1,480	1,520	1,520	1,490	1,420	1,390	1,360
7UQ-300M/CF6-50E2	506	733	734	651	585	658	549	625	580	491	516	543
7UQ-300M/CF6-80C2	135	139	139	158	174	178	174	174	174	174	139	139
7UQ-300M/JT9D-7R4G2	682	662	673	811	658	852	822	807	850	785	699	658
A0CC4-200/CF6-50C2	0	71	71	63	63	63	63	63	81	81	81	70
A30B2-100/CF6-50C	343	381	357	351	334	345	345	345	334	334	345	345
A30B2-100/CF6-50C2R	4,000	3,210	3,280	3,270	3,420	3,400	3,170	3,240	3,380	3,230	3,300	2,930
A30B2-200/CF6-50C2	189	249	249	189	198	136	136	136	136	210	210	225
A30B2-200/CF6-50C2R	678	636	695	669	660	727	866	757	844	853	796	841
A30B4-100/CF6-50C2	1,470	652	655	736	742	727	793	790	725	721	656	666
A30B4-100/JT9D-59A	206	233	196	239	239	239	325	313	324	238	206	205
A30B4-200/CF6-50C2	2,560	2,430	2,410	2,580	2,610	2,760	2,820	2,760	2,670	2,530	2,600	2,560
A30B4-200/JT9D-59A	817	436	436	461	470	470	470	439	437	432	367	378
A31-200/CF6-80A3	3,240	2,790	2,700	3,000	2,920	3,250	3,360	3,330	3,340	3,210	3,100	3,000
A31-200/CF6-80C2A2	86	57	57	54	54	54	54	54	54	54	54	54
A31-200/JT9D-7R4D1	326	187	202	203	218	232	212	235	204	222	187	140

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A31-200/JT9D-7R4E1	1,630	1,360	1,360	1,420	1,400	1,470	1,450	1,460	1,370	1,380	1,280	1,330
A32-100/CFM56-5A1	106	106	107	116	131	131	100	125	123	122	122	119
A32-200/CFM56-5A1	2,170	2,270	2,330	2,580	2,820	2,890	2,960	3,040	3,020	3,140	3,100	2,960
A32-200/CFM56-5A3	74	87	87	87	87	102	128	128	125	143	161	165
A32-200/V2500-A1	654	747	756	868	884	976	1,050	1,040	985	994	1,050	1,040
A34/*	0	0	0	0	0	0	0	0	8	8	8	8
A36-600/CF6-80C2A1	0	367	367	435	435	462	462	483	483	483	474	471
A36-600/JT9D-7R4H1	0	765	709	757	763	749	763	814	760	751	860	887
A36-600/PW4158	0	331	328	347	343	339	322	313	350	353	364	362
A3L-300/CF6-80C2	0	0	0	0	0	29	29	29	29	29	29	29
A3L-300/CF6-80C2A2	0	373	381	373	376	379	403	399	362	361	340	344
A3L-300/CF6-80C2A8	0	133	136	132	132	139	174	259	268	268	254	292
A3L-300/JT9D-7R4E1	0	123	123	115	133	141	101	141	116	118	138	113
A3L-300/PW4152	0	493	505	567	580	572	563	569	569	569	600	579
AN4/LGTURB	84	86	56	57	59	64	70	67	81	84	78	74
AT4/LGTURB	0	51	54	76	80	83	82	87	85	84	65	73
AT7/LGTURB	110	116	121	140	148	140	142	155	168	166	158	168
ATP/LGTURB	93	93	91	86	98	100	102	102	111	107	107	97
ATR/LGTURB	609	525	526	523	537	559	570	543	566	552	602	609
B3C-320C/JT3D-3B	0	134	125	125	108	108	108	108	108	108	105	100
B3C-320CH/JT3D-3B	0	1,180	1,200	1,190	1,260	1,240	1,240	1,230	1,240	1,170	1,190	1,250
B3F-320B/JT3D	17	17	17	38	38	21	0	0	0	0	0	0
B3F-320B/JT3D-3B	815	801	759	746	699	624	575	563	549	510	485	324
BAC-200/RR_SPEY-506	0	0	12	12	12	14	14	21	8	7	8	8
BAC-200/RR_SPEY-511	8	91	16	18	18	18	30	22	22	20	20	23
BAC-500/RR_SPEY-512	520	525	526	514	613	608	615	579	577	515	466	430
BE1/SMTURB	512	536	509	504	513	533	549	562	549	563	589	597
BE9/SMTURB	75	70	55	53	53	61	60	57	56	61	59	58
BEK/SMTURB	0	44	47	43	39	43	42	41	42	45	44	46
CD2/SMTURB	4	6	6	4	7	7	11	4	4	2	2	2
CL4/LGTURB	0	15	15	15	15	15	15	15	17	3	3	3
CNC/SMTURB	0	2	2	2	2	2	2	2	3	3	3	3
CNJ/*	3	3	3	1	1	1	1	1	1	1	1	1
CNN/SMTURB	0	3	3	3	3	3	3	3	3	3	3	3

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CONCORDE	398	409	387	404	404	404	404	306	343	404	404	258
CRJ/*	0	0	0	0	0	0	0	0	0	0	29	49
CS5/LGTURB	15	15	15	15	15	15	15	15	15	15	15	15
CV5/LGTURB	0	1	1	4	4	4	4	3	3	4	7	7
CV6/LGTURB	0	4	3	3	3	3	3	3	7	7	7	7
CVF/LGTURB	0	12	12	12	13	13	14	14	15	15	16	15
CVL-10B/JT8D-7	14	10	10	9	9	8	12	16	16	16	16	16
CVL-12/JT8D-9	16	15	15	15	18	20	8	8	6	6	3	3
D10-10/CF6-6D	18,100	14,000	14,500	14,300	14,200	14,400	14,900	14,800	13,800	13,900	13,900	14,100
D10-15/CF6-50C2F	699	277	277	274	242	293	328	328	267	203	336	336
D1C-10F/CF6-6D	0	1,070	1,070	1,090	1,120	1,040	1,110	1,100	1,160	1,140	1,150	1,150
D8C-33F/JT4A-11	0	3,710	3,650	3,860	3,720	3,800	3,810	3,810	3,910	3,820	4,000	4,020
D8S-62H/JT3D-3B	127	161	161	113	113	113	133	137	105	105	105	140
D8S-62H/JT3D-7	64	98	100	100	86	123	98	106	106	131	119	105
D8S-63H/JT3D-7	21	90	88	88	88	88	89	103	62	75	81	85
D8S-73F/CFM56-2C	146	119	138	110	116	116	116	108	103	103	103	102
D9C-30C/JT8D-9A	0	17	0	0	17	17	17	17	17	17	17	17
D9C-30F/JT8D-7B	0	257	275	289	275	270	271	276	269	269	269	269
D9M-87/JT8D-217	722	927	962	1,130	1,150	1,140	1,100	1,040	1,160	1,150	1,200	1,190
D9M-87/JT8D-219	0	4	4	14	14	15	16	17	16	6	25	41
D9S-30/JT8D-17	301	252	254	258	258	266	343	343	326	316	331	326
D9S-30/JT8D-7B	4,360	3,870	3,870	3,650	3,590	3,670	3,710	3,710	3,520	3,450	3,340	3,180
D9S-30/JT8D-9A	1,680	1,670	1,690	1,710	1,700	1,800	1,830	1,700	1,710	1,670	1,610	1,680
D9S-40/JT8D-11	449	435	419	443	446	448	361	401	394	391	459	413
D9S-40/JT8D-15	297	330	318	331	316	218	277	321	322	332	316	302
D9X-50/JT8D-17	0	525	525	534	507	520	514	502	536	533	552	564
D9Z-81/JT8D-209	1,480	1,480	1,470	1,420	1,480	1,490	1,480	1,480	1,460	1,460	1,410	1,370
D9Z-81/JT8D-217	991	736	760	799	792	798	725	697	789	770	792	828
D9Z-82/JT8D-217	9,090	8,070	8,970	8,760	9,210	9,850	9,810	10,000	9,850	9,950	10,200	10,200
D9Z-82/JT8D-217C	363	363	363	419	417	419	433	415	419	409	338	338
D9Z-82/JT8D-219	245	243	243	250	248	232	228	241	374	374	383	384
D9Z-83/JT8D-219	988	1,010	1,010	1,080	1,130	1,200	1,430	1,460	1,350	1,580	1,370	1,480
D9Z-88/JT8D-217	102	102	100	0	0	0	0	0	0	0	0	0
D9Z-88/JT8D-219	2,100	2,140	2,180	2,250	2,330	2,330	2,330	2,330	2,350	2,350	2,390	2,430

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
DC8/*	123	125	112	132	129	156	184	174	114	114	47	56
DC9-10/JT8D-7A	218	220	220	220	220	220	220	220	218	218	218	218
DC9-10/JT8D-7B	1,560	1,690	1,590	1,610	1,580	1,610	1,610	1,580	1,620	1,620	1,550	1,560
DC9-20/JT8D-11	115	0	0	0	0	0	0	0	0	0	0	0
DFL/*	1	7	7	7	7	1	1	1	8	8	8	8
DH1/MDTURB	0	1	1	12	17	16	16	16	15	13	13	19
DH3/MDTURB	0	50	50	57	63	63	60	61	63	65	62	66
DH7/LGTURB	161	147	154	144	142	154	149	150	146	140	134	144
DH8/MDTURB	843	781	795	791	836	867	914	921	934	909	928	873
DHB/SMTURB	6	6	6	6	18	18	23	19	16	6	6	6
DHT/SMTURB	272	276	268	262	256	259	261	263	261	254	244	252
DLR-30/CF6-50C	0	162	45	178	146	178	146	107	44	37	92	92
DLR-30/CF6-50C2	0	2,090	2,030	2,060	2,020	2,520	2,340	2,300	2,200	2,200	2,390	2,140
DLR-30/CF6-50C2R	0	275	324	299	276	279	341	341	274	274	272	332
DLR-40/JT9D-20	0	1,210	1,180	964	1,050	1,050	1,020	1,020	1,100	1,060	923	923
DO8/SMTURB	92	92	94	94	100	101	101	104	103	101	97	105
EM2/SMTURB	663	658	672	679	695	712	722	732	741	739	748	746
EMB/SMTURB	185	176	169	168	177	172	136	140	148	151	156	158
F10-100/TAY620-15	113	109	107	107	171	180	172	173	171	161	208	210
F10-100/TAY650-15	789	819	870	897	998	1,030	1,050	1,130	1,140	1,160	1,240	1,330
F27/LGTURB	356	363	360	338	336	337	337	340	336	318	297	287
F28-1000/RR_SPEY-MK555	193	179	183	169	170	163	179	139	129	135	140	139
F28-1000C/RR_SPEY-MK55	9	7	7	7	7	7	7	7	7	7	7	7
F28-2000/RR_SPEY-MK555	24	25	20	25	25	27	29	27	25	22	24	23
F28-3000/RR_SPEY-MK555	10	10	10	10	11	11	11	11	11	11	11	12
F28-4000/RR_SPEY-MK555	1,500	1,500	1,510	1,470	1,500	1,450	1,410	1,490	1,460	1,400	1,410	1,260
F2B/LGTURB	0	5	5	5	6	6	6	5	4	4	4	4
F2E/LGTURB	0	6	6	7	7	7	7	7	7	7	6	4
F50/LGTURB	326	322	337	359	380	396	369	387	392	384	396	386
HEC/SMTURB	0	0	0	2	2	3	3	3	3	2	1	1
HS7/LGTURB	114	119	118	116	112	118	121	120	116	118	114	113
I62/SOL	2,080	2,040	2,020	1,970	2,300	2,070	2,130	2,170	1,870	1,770	1,610	1,640
I72/*	0	261	261	248	248	248	248	248	250	267	282	290
I86/KUZ	991	1,230	1,220	1,260	1,220	1,200	1,230	1,200	1,520	1,350	1,140	1,140

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
IL8/LGTURB	11	11	8	6	5	5	5	5	2	2	1	2
J31/SMTURB	599	578	587	564	565	594	603	616	610	583	589	584
L10-1/RB211-22B	4,830	5,140	5,000	5,260	5,440	5,440	5,520	5,550	5,230	5,000	4,220	4,180
L10-200/RB211-524B	607	570	587	584	586	569	611	610	612	561	654	654
L10-50/RB211-22B	251	252	252	251	251	289	299	278	345	311	331	352
L4T/SMTURB	4	3	3	3	4	4	3	2	2	3	4	6
LLR-500/RB211-524B4	2,580	2,610	2,620	2,750	2,910	3,210	3,370	3,360	3,300	2,970	2,910	2,730
LOE/LGTURB	37	30	16	10	10	10	10	10	10	10	10	10
LOF/LGTURB	0	29	29	30	37	41	38	38	37	31	33	33
LOH/LGTURB	2	9	7	6	6	6	6	6	6	6	5	4
LOM/LGTURB	3	3	3	3	3	3	3	3	2	2	1	1
LRJ/*	0	13	13	13	13	7	7	7	4	4	4	4
M1F/*	0	254	254	231	290	294	288	288	287	295	278	278
MDL-11C/CF6-80C2	172	173	173	173	247	247	354	429	426	401	426	426
MDL-11P/CF6-80C2	318	326	391	557	630	656	730	743	743	722	1,020	1,020
MDL-11P/PW4460	1,600	1,540	1,720	1,880	2,340	2,740	2,970	2,980	2,930	2,850	3,150	3,180
MRC-100/JT8D-15	58	45	46	71	91	89	71	73	96	83	78	60
MU2/SMTURB	0	5	5	5	7	5	5	5	5	5	4	4
ND2/MDTURB	7	5	5	7	7	5	5	5	9	9	8	5
NDC/*	0	0	0	0	0	0	0	0	0	0	0	1
PA6/SMTURB	0	2	2	2	2	2	2	2	2	2	2	2
PL6/SMTURB	0	1	1	0	0	0	0	0	0	0	0	0
SF3/MDTURB	781	797	803	830	856	848	850	871	885	885	914	900
SFF/MDTURB	0	0	0	0	0	0	0	0	0	2	2	1
SH3/MDTURB	18	19	20	22	27	30	24	25	28	29	31	33
SH6/MDTURB	238	228	226	225	238	230	227	226	213	208	198	188
SWM/SMTURB	527	566	582	581	593	581	582	574	572	575	576	582
T34/SOL	829	860	860	846	850	833	821	832	646	655	661	702
T54/SOL	5,450	5,540	5,400	5,610	5,590	5,440	5,390	5,370	4,500	4,430	4,330	4,260
VC8/LGTURB	0	11	11	11	11	11	11	11	11	11	11	11
VCV/LGTURB	17	6	6	6	6	6	6	6	6	6	6	6
WWP/*	4	4	4	4	4	4	4	5	6	6	6	6
Y40/IVC	81	80	80	54	95	106	109	99	177	247	203	214
Y42/*	452	458	457	460	462	432	432	420	482	432	491	468

Appendix F. Fuel Burned by Airplane Type and Month

	1992	Fuel burned in thousand kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
YN2/SMTURB	0	0	0	0	0	0	0	1	1	2	2	2
YN7/LGTURB	72	77	50	49	49	49	49	49	49	53	27	21
YS1/LGTURB	94	106	105	106	108	102	104	104	99	97	97	96
Total	235,037	248,515	250,921	253,479	258,522	267,952	273,604	274,212	266,232	259,735	260,701	258,632

Appendix G. NOx Emitted by Airplane Type and Month

	1992	NOx Emitted in kilograms (as NO2)/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
146-100/ALF502R-3	0	215	215	242	242	258	258	246	250	240	114	114
146-100/ALF502R-5	348	417	434	375	369	374	369	357	350	357	213	213
146-200/ALF502R-3	583	603	565	526	615	585	605	614	614	635	617	610
146-200/ALF502R-5	9,260	9,210	9,530	9,960	10,300	10,600	10,800	10,800	9,930	9,640	9,700	9,120
146-300/ALF502R-5	2,220	2,040	2,040	1,820	1,820	1,820	1,660	1,630	1,650	1,640	1,210	1,130
146-300/LF507-1F	89	89	89	89	89	89	89	89	89	223	254	239
14F-300QT/ALF502R-5	0	3	3	3	3	3	3	3	3	3	3	3
720-000/JT3C-12	0	158	167	143	140	206	220	215	184	189	168	140
727-100/JT8D-7A	1,610	1,790	1,790	1,840	1,800	1,600	1,600	1,600	1,400	1,400	1,200	1,140
727-100/JT8D-7B	19,100	18,700	19,100	18,000	18,300	19,000	17,600	16,000	16,300	15,200	15,000	14,100
727-100/JT8D-9	615	647	255	255	255	255	255	255	255	270	270	270
727-100/JT8D-9A	878	878	878	951	974	974	904	1,120	932	932	937	937
72C-100F/JT8D-7B	0	8,640	8,470	8,410	8,170	8,290	8,290	8,110	7,980	7,960	7,700	8,720
72C-100F/JT8D-9A	0	123	123	193	193	193	193	193	193	193	193	193
72S-200/JT8D-15	171,000	154,000	160,000	149,000	156,000	163,000	165,000	165,000	152,000	148,000	145,000	147,000
72S-200/JT8D-17	7,230	7,040	7,110	6,460	6,530	7,340	7,310	6,510	4,470	3,490	4,450	4,200
72S-200/JT8D-17R	18,900	18,500	17,400	17,600	16,600	16,500	16,200	15,700	16,100	16,800	16,000	16,800
72S-200/JT8D-7B	0	0	0	295	295	295	295	608	1,320	1,320	1,320	1,890
72S-200/JT8D-9	0	0	815	815	878	878	868	872	864	925	968	968
72S-200/JT8D-9A	41,400	41,200	41,400	42,100	39,500	41,600	42,200	41,700	40,800	39,800	41,300	42,400
737-100/JT8D-7A	0	0	461	461	461	560	560	560	479	479	479	479
737-200/JT8D-15	48,300	48,700	48,300	50,700	51,600	51,400	49,900	50,100	52,000	52,300	50,900	51,500
737-200/JT8D-15A	18,500	18,500	18,300	17,100	18,200	18,200	17,800	18,300	18,200	18,400	18,000	18,000
737-200/JT8D-17	11,900	11,600	11,400	12,200	12,200	12,300	12,300	13,000	12,200	11,500	12,300	11,100
737-200/JT8D-17A	8,030	8,080	7,940	7,770	7,790	7,800	8,840	9,290	8,910	8,740	8,830	9,190
737-200/JT8D-7B	23,300	23,700	22,900	21,900	22,700	24,200	24,800	25,200	24,000	23,700	24,900	26,000
737-200/JT8D-9	598	598	591	591	519	488	515	468	468	468	468	450
737-200/JT8D-9A	30,500	30,700	30,300	29,300	30,200	31,100	31,500	30,300	30,600	30,200	29,800	29,900
73C-200C/JT8D-15	0	144	144	144	144	144	144	0	0	0	0	0
73C-200C/JT8D-17	826	863	870	870	928	1,070	1,070	1,070	890	867	884	894
73C-200C/JT8D-17A	782	802	712	772	767	1,130	1,140	1,110	820	820	811	811
73C-200C/JT8D-9A	326	2,030	1,960	1,870	1,830	1,890	1,880	2,170	2,160	2,120	2,160	2,180
73C-200F/JT8D-17	0	171	171	171	171	171	171	171	171	171	171	171
73L-500/CFM56-3C	13,300	13,500	14,500	16,000	17,400	18,800	19,900	21,100	22,900	22,600	23,400	24,500

Appendix G. NOx Emitted by Airplane Type and Month

	1992	NOx Emitted in kilograms (as NO2)/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
73Y-300/CFM56-3B	107,000	107,000	104,000	105,000	107,000	111,000	113,000	112,000	109,000	107,000	110,000	97,100
73Z-400/CFM56-3B	19,400	19,100	19,600	19,600	20,300	21,600	22,300	21,800	21,900	22,400	22,700	24,400
747-100/JT9D-3A	38,200	21,000	22,500	27,000	24,700	26,900	29,600	29,700	22,400	19,700	23,500	22,900
747-100/JT9D-3AW	1,790	1,790	2,290	2,790	3,610	4,720	4,720	4,590	4,460	2,540	2,290	2,290
747-100/JT9D-7A	301,000	248,000	251,000	246,000	238,000	242,000	254,000	256,000	238,000	224,000	228,000	225,000
747-100/JT9D-7AH	17,600	19,500	20,900	19,000	18,800	25,500	25,700	25,800	21,200	13,100	10,700	14,600
747-100B/JT9D-7F	555	555	555	555	555	555	555	555	555	555	555	316
747-100B/RB211-524C2	5,230	6,400	6,110	5,830	5,830	5,990	6,670	6,670	7,090	6,100	6,600	6,600
747-200B/CF6-50E2	86,500	92,200	93,500	102,000	106,000	114,000	116,000	109,000	102,000	102,000	91,800	90,800
747-200B/JT9D-7A	2,950	5,080	4,010	3,680	5,120	4,760	5,110	6,710	5,960	5,580	5,060	5,370
747-200B/JT9D-7AW	76,000	63,000	63,900	63,400	60,700	64,600	68,300	69,100	66,400	65,900	64,800	65,800
747-200B/JT9D-7F	15,500	15,500	14,900	15,700	15,600	17,600	17,600	17,600	12,600	11,400	11,700	11,300
747-200B/JT9D-7J	20,300	37,400	37,500	34,500	40,300	43,100	51,200	48,800	40,000	45,200	41,400	38,800
747-200B/JT9D-7Q	52,300	54,600	51,300	52,800	55,300	53,700	55,300	53,300	56,400	45,100	47,000	41,200
747-200B/JT9D-7R4G2	4,750	6,570	6,570	6,060	5,860	6,220	6,010	6,420	7,600	6,610	5,880	5,980
747-200B/JT9D-7W	12,400	12,900	12,900	15,900	16,800	18,400	18,700	18,700	18,700	17,800	15,200	14,700
747-200B/RB211-524C2	20,300	19,400	19,000	17,700	18,500	20,500	20,500	19,100	10,900	11,200	10,600	10,500
747-200B/RB211-524D4	13,600	14,800	18,100	19,100	19,000	19,000	19,700	17,400	18,200	14,800	17,400	17,800
74C-100F/JT9D-7A	0	42,600	48,200	45,800	41,900	42,700	40,700	41,000	42,300	42,600	44,500	45,200
74C-200F/CF6-50E2	0	18,600	20,000	18,300	17,600	17,200	19,700	25,200	28,900	26,700	33,300	29,800
74C-200F/JT9D-7A	0	5,360	5,360	5,360	5,360	5,360	5,360	5,360	5,360	5,360	5,360	5,360
74C-200F/JT9D-7F	0	12,800	12,800	12,700	12,700	12,800	12,800	14,200	14,300	14,200	14,300	13,400
74C-200F/JT9D-7FW	0	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120
74C-200F/JT9D-7J	0	4,810	4,810	4,810	4,810	4,810	4,810	4,810	4,810	4,810	4,810	4,810
74C-200F/JT9D-7Q	0	30,600	29,200	30,000	30,200	30,200	30,300	30,900	31,300	33,100	34,500	32,900
74C-200F/RB211-524D4	0	6,870	5,660	5,640	5,640	5,500	6,620	6,660	7,140	8,410	7,820	7,350
74I-400/CF6-80C2	35,200	35,200	35,400	33,500	38,300	39,000	40,400	41,300	41,600	41,900	42,200	48,800
74I-400/PW4056	67,500	65,000	69,600	66,700	63,800	72,700	78,000	81,500	84,400	81,800	82,000	86,300
74I-400/RB211-524G	39,900	73,100	68,100	81,000	78,300	81,900	85,400	85,200	84,900	80,800	86,300	84,300
74I-400/RB211-524H	24,000	25,400	25,400	27,800	26,600	26,800	26,800	28,700	31,400	30,800	32,400	32,700
74P-SP/JT9D-7A	29,700	31,200	31,500	28,600	30,200	32,000	30,900	30,900	29,900	27,800	25,600	23,900
74P-SP/JT9D-7F	3,420	3,630	3,630	3,950	3,950	3,370	3,540	3,540	3,540	3,540	3,780	3,690
74P-SP/JT9D-7FW	5,780	5,840	5,120	7,210	8,610	6,660	6,620	6,740	6,710	4,700	5,270	5,390
74P-SP/RB211-524C2	210	485	497	169	169	202	589	589	589	389	199	199

Appendix G. NOx Emitted by Airplane Type and Month

	1992	NOx Emitted in kilograms (as NO_2)/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
74P-SP/RB211-524D4	3,700	3,700	3,950	0	0	0	0	0	0	0	0	0
74Q-200M/CF6-50E2	0	0	0	262	0	0	0	0	0	0	0	0
74Q-200M/JT9D-7J	0	0	0	0	0	0	0	0	0	0	2,530	2,530
74U-300/CF6-80C2	5,650	7,950	7,930	7,700	7,410	7,620	7,290	7,290	7,290	7,260	9,470	9,650
74U-300/JT9D-7R4G2	30,700	31,200	32,400	38,000	38,500	39,200	37,500	36,800	32,600	33,200	34,500	31,400
74U-300/RB211-524C2	0	0	0	0	0	0	0	0	6,290	6,290	6,180	6,180
74U-300/RB211-524D4	20,500	20,200	19,600	21,000	23,400	20,600	21,000	21,300	21,000	19,800	20,400	21,100
74X-100SR/CF6-45A2	0	9,860	9,860	11,000	11,800	11,700	13,000	13,000	10,600	10,600	9,980	8,940
757-200/PW2037	62,600	61,700	66,600	66,900	68,200	69,600	71,300	72,100	70,500	70,900	73,100	75,600
757-200/PW2040	19,300	19,800	21,600	22,500	23,500	24,000	24,900	25,000	24,700	26,000	28,500	28,700
757-200/RB211-535C	9,150	9,340	9,880	8,300	11,200	11,900	12,300	12,900	11,700	11,800	12,800	12,000
757-200/RB211-535E4	12,900	12,200	12,100	11,000	11,300	12,200	13,200	12,800	12,700	12,200	13,900	13,900
75F/*	0	4,810	4,810	5,230	6,050	6,320	6,320	6,400	6,320	6,690	6,550	6,850
767-200/CF6-80A	109,000	110,000	108,000	106,000	112,000	116,000	123,000	123,000	120,000	116,000	116,000	116,000
767-200/CF6-80A2	7,570	7,700	7,700	7,620	8,150	7,650	8,190	8,190	8,360	7,530	7,220	7,280
767-200/JT9D-7R4D	31,300	27,100	29,500	27,100	27,600	28,700	28,800	28,700	28,600	27,100	27,700	25,700
76M-300/CF6-80A2	52,100	53,100	53,600	57,400	60,700	73,200	72,500	76,000	78,000	76,500	78,200	77,700
76M-300/CF6-80C2	6,550	6,300	6,380	8,160	8,170	7,810	8,020	7,910	7,580	8,030	8,510	8,590
7IQ-400M/CF6-80C2	11,400	12,400	12,500	17,400	18,200	18,400	18,900	18,900	18,500	17,600	17,400	17,100
7UQ-300M/CF6-50E2	8,200	11,900	11,900	10,600	9,520	10,700	8,920	10,100	9,400	7,980	8,360	8,810
7UQ-300M/CF6-80C2	1,730	1,780	1,780	2,020	2,220	2,270	2,220	2,220	2,220	2,220	1,780	1,780
7UQ-300M/JT9D-7R4G2	10,700	10,400	10,600	12,800	10,300	13,400	12,900	12,700	13,400	12,300	11,000	10,400
A0CC4-200/CF6-50C2	0	1,180	1,180	1,060	1,060	1,060	1,060	1,060	1,350	1,350	1,350	1,170
A30B2-100/CF6-50C	6,000	6,660	6,250	6,140	5,830	6,060	6,060	6,060	5,840	5,840	6,060	6,060
A30B2-100/CF6-50C2R	70,000	56,600	57,600	57,200	60,000	59,700	55,400	56,600	59,400	56,700	57,800	50,700
A30B2-200/CF6-50C2	3,370	4,440	4,440	3,370	3,530	2,460	2,460	2,460	2,460	3,740	3,740	4,030
A30B2-200/CF6-50C2R	12,300	11,500	12,600	12,100	11,900	13,200	15,700	13,700	15,400	15,500	14,500	15,300
A30B4-100/CF6-50C2	25,900	11,800	11,900	13,200	13,300	13,000	14,200	14,300	13,000	13,000	12,000	12,200
A30B4-100/JT9D-59A	2,850	3,180	2,680	3,280	3,280	3,280	4,490	4,270	4,480	3,260	2,840	2,820
A30B4-200/CF6-50C2	43,800	41,500	41,300	44,100	44,700	47,200	48,100	46,800	45,500	43,200	44,300	43,600
A30B4-200/JT9D-59A	11,300	6,180	6,180	6,510	6,630	6,630	6,630	6,200	6,180	6,100	5,160	5,320
A31-200/CF6-80A3	46,300	40,000	38,800	42,900	41,700	46,400	47,900	47,600	47,700	45,900	44,200	42,800
A31-200/CF6-80C2A2	1,100	709	709	727	727	727	727	727	727	727	727	727
A31-200/JT9D-7R4D1	5,170	3,130	3,390	3,410	3,670	3,850	3,460	3,890	3,390	3,720	3,160	2,370

Appendix G. NOx Emitted by Airplane Type and Month

	1992	NOx Emitted in kilograms (as NO2)/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A31-200/JT9D-7R4E1	27,300	22,700	22,700	23,700	23,400	24,400	24,000	24,200	22,800	23,100	21,400	22,300
A32-100/CFM56-5A1	1,380	1,390	1,400	1,470	1,670	1,670	1,270	1,600	1,580	1,560	1,570	1,520
A32-200/CFM56-5A1	28,000	29,300	30,000	33,000	36,100	37,000	37,600	38,600	38,500	40,000	39,600	37,500
A32-200/CFM56-5A3	905	1,090	1,090	1,090	1,090	1,280	1,610	1,610	1,580	1,820	2,040	2,090
A32-200/V2500-A1	11,400	13,000	13,200	15,100	15,400	17,000	18,300	18,100	17,200	17,300	18,300	18,200
A34/*	0	0	0	0	0	0	0	0	132	132	132	132
A36-600/CF6-80C2A1	0	5,260	5,260	6,260	6,260	6,650	6,650	6,950	6,950	6,950	6,760	6,710
A36-600/JT9D-7R4H1	0	11,900	11,100	11,800	11,900	11,600	11,800	12,700	11,800	11,700	13,400	13,800
A36-600/PW4158	0	4,790	4,750	4,990	4,930	4,880	4,620	4,520	5,100	5,130	5,280	5,250
A3L-300/CF6-80C2	0	0	0	0	0	354	354	354	354	354	354	354
A3L-300/CF6-80C2A2	0	4,710	4,810	4,640	4,670	4,710	5,000	4,950	4,500	4,480	4,220	4,270
A3L-300/CF6-80C2A8	0	1,490	1,520	1,480	1,480	1,550	1,950	2,900	2,990	2,990	2,830	3,270
A3L-300/JT9D-7R4E1	0	2,040	2,040	1,900	2,190	2,330	1,670	2,330	1,910	1,940	2,270	1,850
A3L-300/PW4152	0	7,790	7,990	8,970	9,180	9,040	8,900	8,970	8,970	8,970	9,470	9,160
AN4/LGTURB	1,110	1,140	749	754	782	844	923	887	1,070	1,110	1,030	970
AT4/LGTURB	0	660	705	998	1,050	1,090	1,070	1,130	1,110	1,090	855	951
AT7/LGTURB	1,430	1,530	1,590	1,830	1,930	1,840	1,850	2,030	2,200	2,170	2,070	2,200
ATP/LGTURB	1,210	1,200	1,180	1,110	1,280	1,290	1,320	1,330	1,440	1,390	1,400	1,270
ATR/LGTURB	8,000	6,910	6,910	6,860	7,060	7,350	7,510	7,140	7,450	7,280	7,940	8,040
B3C-320C/JT3D-3B	0	1,130	1,070	1,060	861	854	854	854	854	854	826	773
B3C-320CH/JT3D-3B	0	10,400	10,600	10,500	10,800	10,600	10,600	10,600	10,700	10,100	10,300	10,800
B3F-320B/JT3D	124	124	124	309	309	185	0	0	0	0	0	0
B3F-320B/JT3D-3B	7,520	7,350	7,030	6,840	6,420	5,640	5,270	5,140	5,010	4,700	4,520	2,970
BAC-200/RR_SPEY-506	0	0	128	128	128	143	143	220	86	73	86	86
BAC-200/RR_SPEY-511	88	899	179	201	201	201	343	246	246	226	226	262
BAC-500/RR_SPEY-512	5,490	5,550	5,560	5,420	6,460	6,410	6,490	6,120	6,100	5,450	4,930	4,550
BE1/SMTURB	4,190	4,390	4,160	4,120	4,190	4,350	4,480	4,600	4,490	4,600	4,820	4,880
BE9/SMTURB	607	564	439	428	423	485	482	455	444	491	472	463
BEK/SMTURB	0	356	389	350	317	347	340	338	341	366	357	373
CD2/SMTURB	33	47	43	33	54	54	85	33	32	18	18	18
CL4/LGTURB	0	202	202	202	202	202	202	202	228	33	33	33
CNC/SMTURB	0	18	18	18	18	18	18	18	28	28	28	24
CNJ/*	28	28	28	13	13	13	13	13	13	13	13	13
CNN/SMTURB	0	26	26	26	26	26	26	26	26	26	26	26

Appendix G. NOx Emitted by Airplane Type and Month

	1992	NOx Emitted in kilograms (as NO2)/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CONCORDE	6,390	6,570	6,220	6,480	6,480	6,480	6,480	4,920	5,510	6,480	6,480	4,150
CRJ/*	0	0	0	0	0	0	0	0	0	0	278	467
CS5/LGTURB	179	179	179	179	179	179	179	179	179	179	179	179
CV5/LGTURB	0	15	15	49	49	49	57	42	42	46	88	88
CV6/LGTURB	0	53	38	37	38	38	38	38	94	94	94	94
CVF/LGTURB	0	159	156	156	160	170	181	181	187	200	207	195
CVL-10B/JT8D-7	118	81	81	73	73	66	96	126	133	133	133	133
CVL-12/JT8D-9	125	119	119	119	143	164	68	68	47	47	23	23
D10-10/CF6-6D	257,000	201,000	208,000	205,000	204,000	206,000	213,000	212,000	198,000	199,000	200,000	202,000
D10-15/CF6-50C2F	10,200	4,120	4,120	4,050	3,520	4,310	4,840	4,840	3,970	3,050	4,950	4,950
D1C-10F/CF6-6D	0	23,200	23,200	23,600	24,400	22,700	24,100	23,900	25,200	24,700	24,900	24,900
D8C-33F/JT4A-11	0	22,300	22,000	23,200	22,400	22,900	22,900	22,900	23,500	23,000	24,000	24,200
D8S-62H/JT3D-3B	1,040	1,330	1,330	937	937	937	1,090	1,120	877	877	877	1,170
D8S-62H/JT3D-7	407	618	630	630	542	777	615	669	669	824	751	662
D8S-63H/JT3D-7	136	582	566	566	566	566	574	667	402	480	520	546
D8S-73F/CFM56-2C	1,540	1,260	1,460	1,160	1,220	1,220	1,220	1,140	1,080	1,080	1,080	1,070
D9C-30C/JT8D-9A	0	152	0	0	152	152	152	152	152	152	152	152
D9C-30F/JT8D-7B	0	2,260	2,410	2,540	2,410	2,360	2,370	2,420	2,360	2,360	2,360	2,360
D9M-87/JT8D-217	8,370	10,800	11,200	13,200	13,500	13,400	12,900	12,200	13,700	13,600	14,100	14,000
D9M-87/JT8D-219	0	40	40	158	158	166	183	200	183	72	307	481
D9S-30/JT8D-17	2,710	2,260	2,280	2,320	2,320	2,400	3,080	3,080	2,930	2,840	2,970	2,930
D9S-30/JT8D-7B	38,600	34,400	34,400	32,400	31,900	32,500	32,800	32,900	31,300	30,700	29,600	28,300
D9S-30/JT8D-9A	14,700	14,600	14,700	14,900	14,800	15,700	15,900	14,800	14,900	14,500	14,000	14,600
D9S-40/JT8D-11	4,460	4,320	4,160	4,390	4,430	4,450	3,590	3,980	3,910	3,860	4,530	4,060
D9S-40/JT8D-15	3,040	3,380	3,260	3,390	3,250	2,240	2,840	3,290	3,300	3,400	3,240	3,100
D9X-50/JT8D-17	0	5,310	5,320	5,410	5,140	5,270	5,220	5,100	5,410	5,380	5,570	5,710
D9Z-81/JT8D-209	17,700	17,700	17,600	16,900	17,800	17,900	17,800	17,800	17,600	17,500	17,000	16,500
D9Z-81/JT8D-217	13,000	9,530	9,850	10,400	10,200	10,300	9,350	9,050	10,200	10,000	10,300	10,800
D9Z-82/JT8D-217	113,000	100,000	112,000	109,000	115,000	122,000	122,000	124,000	122,000	123,000	126,000	126,000
D9Z-82/JT8D-217C	4,860	4,860	4,860	5,610	5,580	5,610	5,780	5,550	5,590	5,460	4,520	4,510
D9Z-82/JT8D-219	3,020	3,000	3,000	3,060	3,040	2,820	2,770	2,940	4,690	4,690	4,780	4,790
D9Z-83/JT8D-219	12,200	12,500	12,500	13,300	13,800	14,700	17,600	18,000	16,800	19,700	16,900	18,300
D9Z-88/JT8D-217	1,280	1,280	1,260	0	0	0	0	0	0	0	0	0
D9Z-88/JT8D-219	26,200	26,700	27,300	28,200	29,100	29,200	29,200	29,200	29,400	29,400	29,900	30,500

Appendix G. NOx Emitted by Airplane Type and Month

	1992					NOx Emitted in kilograms (as NO2)/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
DC8/*	794	812	733	866	837	1,010	1,180	1,120	741	741	302	362
DC9-10/JT8D-7A	1,890	1,910	1,910	1,910	1,910	1,910	1,910	1,910	1,880	1,880	1,880	1,880
DC9-10/JT8D-7B	13,900	15,000	14,200	14,300	14,100	14,300	14,300	14,000	14,300	14,400	13,700	13,800
DC9-20/JT8D-11	938	0	0	0	0	0	0	0	0	0	0	0
DFL/*	9	63	63	63	63	9	9	9	76	76	76	76
DH1/MDTURB	0	10	10	149	203	192	192	192	186	153	153	224
DH3/MDTURB	0	582	582	671	736	743	700	718	740	757	735	775
DH7/LGTURB	2,110	1,920	2,010	1,870	1,840	2,000	1,940	1,960	1,910	1,820	1,740	1,880
DH8/MDTURB	9,970	9,250	9,420	9,360	9,890	10,200	10,800	10,900	11,000	10,700	10,900	10,300
DHB/SMTURB	46	46	46	46	147	147	182	153	130	48	48	48
DHT/SMTURB	2,090	2,120	2,060	2,000	1,960	1,980	1,990	2,010	1,990	1,940	1,870	1,930
DLR-30/CF6-50C	0	2,270	634	2,490	2,060	2,490	2,050	1,490	691	617	1,410	1,410
DLR-30/CF6-50C2	0	29,400	28,400	28,900	28,300	35,300	32,700	32,100	30,900	30,800	33,400	29,900
DLR-30/CF6-50C2R	0	4,070	4,840	4,420	4,060	4,090	5,020	5,020	4,020	4,020	3,990	4,900
DLR-40/JT9D-20	0	19,300	18,800	15,500	16,900	16,800	16,400	16,400	17,700	17,000	14,500	14,500
DO8/SMTURB	729	728	747	747	795	796	798	822	819	799	766	833
EM2/SMTURB	5,450	5,400	5,510	5,570	5,710	5,850	5,940	6,020	6,090	6,070	6,150	6,140
EMB/SMTURB	1,500	1,430	1,370	1,360	1,440	1,400	1,100	1,130	1,200	1,220	1,260	1,280
F10-100/TAY620-15	1,140	1,090	1,060	1,070	1,700	1,790	1,700	1,710	1,690	1,610	2,100	2,130
F10-100/TAY650-15	6,400	6,640	7,050	7,270	8,060	8,280	8,510	9,140	9,210	9,430	10,100	10,800
F27/LGTURB	4,660	4,750	4,700	4,430	4,400	4,410	4,400	4,450	4,410	4,170	3,890	3,750
F28-1000/RR_SPEY-MK555	1,920	1,780	1,820	1,680	1,690	1,620	1,780	1,390	1,290	1,350	1,400	1,390
F28-1000C/RR_SPEY-MK55	89	75	75	75	75	75	75	75	75	75	75	75
F28-2000/RR_SPEY-MK555	241	245	200	248	252	271	290	266	253	219	242	234
F28-3000/RR_SPEY-MK555	91	97	97	97	100	100	100	100	100	100	100	115
F28-4000/RR_SPEY-MK555	15,000	15,000	15,100	14,700	15,000	14,500	14,100	14,900	14,600	14,000	14,100	12,600
F2B/LGTURB	0	58	59	65	74	74	71	59	55	55	55	55
F2E/LGTURB	0	78	77	95	95	95	95	95	95	95	76	49
F50/LGTURB	4,250	4,200	4,400	4,680	4,960	5,150	4,800	5,030	5,100	5,000	5,160	5,020
HEC/SMTURB	2	2	2	13	13	23	23	23	23	13	10	10
HS7/LGTURB	1,470	1,540	1,530	1,490	1,450	1,530	1,560	1,550	1,500	1,530	1,470	1,450
I62/SOL	15,100	14,900	14,800	14,400	16,800	15,100	15,600	15,900	13,700	13,000	11,700	12,000
I72/*	0	2,230	2,230	2,110	2,110	2,110	2,110	2,110	2,130	2,270	2,410	2,440
I86/KUZ	8,610	10,600	10,500	10,900	10,500	10,300	10,600	10,400	12,900	11,400	9,650	9,550

Appendix G. NOx Emitted by Airplane Type and Month

	1992	NOx Emitted in kilograms (as NO2)/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
IL8/LGTURB	139	139	104	81	60	60	60	60	28	28	8	23
J31/SMTURB	4,860	4,690	4,770	4,580	4,590	4,820	4,890	4,990	4,950	4,720	4,770	4,730
L10-1/RB211-22B	76,200	81,100	78,900	82,900	85,800	85,700	86,900	87,400	82,300	78,700	66,500	66,000
L10-200/RB211-524B	11,600	10,900	11,200	11,100	11,200	10,800	11,600	11,600	11,600	10,600	12,300	12,300
L10-50/RB211-22B	3,910	3,930	3,930	3,900	3,910	4,490	4,650	4,330	5,380	4,830	5,140	5,480
L4T/SMTURB	29	26	24	25	31	30	25	19	19	21	32	46
LLR-500/RB211-524B4	44,100	44,600	44,900	47,100	49,300	54,400	57,200	57,000	56,000	50,400	49,400	46,400
LOE/LGTURB	506	406	218	124	130	130	130	130	130	130	130	130
LOF/LGTURB	0	371	371	383	477	526	482	486	473	395	423	421
LOH/LGTURB	32	110	92	71	71	71	71	71	71	71	70	54
LOM/LGTURB	35	37	43	42	42	36	36	36	31	31	17	17
LRJ/*	0	123	123	123	123	68	68	68	36	36	36	36
M1F/*	0	3,110	3,110	2,840	3,570	3,640	3,540	3,540	3,510	3,590	3,420	3,420
MDL-11C/CF6-80C2	2,180	2,190	2,190	2,190	3,100	3,100	4,380	5,330	5,280	4,970	5,280	5,280
MDL-11P/CF6-80C2	3,850	4,050	4,910	6,940	7,800	8,190	9,070	9,230	9,230	9,040	12,600	12,500
MDL-11P/PW4460	21,900	21,200	23,600	25,900	32,300	37,800	40,700	41,100	40,300	39,200	43,400	43,800
MRC-100/JT8D-15	575	446	450	705	906	880	704	720	946	826	772	593
MU2/SMTURB	0	45	45	45	55	40	40	38	38	38	32	32
ND2/MDTURB	87	57	57	87	83	62	60	58	113	109	103	62
NDC/*	2	2	2	2	2	2	2	2	2	2	2	14
PA6/SMTURB	0	13	13	13	13	13	13	13	13	13	13	13
PL6/SMTURB	2	4	4	2	2	2	2	2	2	2	2	2
SF3/MDTURB	9,060	9,280	9,360	9,670	9,970	9,870	9,860	10,100	10,300	10,300	10,600	10,500
SFF/MDTURB	0	0	0	0	0	0	0	1	3	25	25	7
SH3/MDTURB	219	235	249	273	336	365	297	313	342	354	375	409
SH6/MDTURB	2,910	2,790	2,770	2,770	2,920	2,830	2,790	2,770	2,620	2,560	2,450	2,320
SWM/SMTURB	4,290	4,610	4,740	4,740	4,840	4,740	4,750	4,680	4,670	4,690	4,700	4,750
T34/SOL	7,260	7,540	7,540	7,410	7,450	7,310	7,200	7,290	5,660	5,740	5,790	6,150
T54/SOL	53,300	54,100	52,700	54,900	54,700	53,200	52,700	52,400	44,100	43,300	42,300	41,700
VC8/LGTURB	0	144	144	144	144	144	144	144	144	144	144	144
VCV/LGTURB	215	70	70	70	70	70	70	70	70	70	70	70
WWP/*	30	36	36	36	36	36	36	45	50	46	49	54
Y40/IVC	811	800	800	522	942	1,050	1,080	980	1,810	2,440	2,030	2,120
Y42/*	4,180	4,230	4,220	4,260	4,280	4,000	4,000	3,880	4,440	3,980	4,530	4,310

Appendix G. NOx Emitted by Airplane Type and Month

	1992					NOx Emitted in kilograms (as NO2)/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
YN2/SMTURB	0	0	0	0	0	0	0	12	12	14	14	14
YN7/LGTURB	939	1,000	651	636	636	642	642	645	645	687	350	280
YS1/LGTURB	1,180	1,340	1,330	1,340	1,360	1,290	1,310	1,310	1,240	1,220	1,230	1,210
Total	3,052,529	3,222,010	3,260,298	3,298,329	3,359,963	3,486,309	3,566,243	3,573,724	3,473,674	3,382,339	3,399,940	3,366,458

Appendix H. CO Emitted by Airplane Type and Month

	1992	CO Emitted in kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
146-100/ALF502R-3	0	171	171	185	185	194	194	175	190	183	85	85
146-100/ALF502R-5	165	190	201	160	157	161	157	153	151	156	99	99
146-200/ALF502R-3	598	615	601	558	626	605	638	644	644	667	580	565
146-200/ALF502R-5	5,350	5,380	5,600	5,890	6,090	6,240	6,310	6,300	5,760	5,620	5,630	5,380
146-300/ALF502R-5	1,510	1,430	1,430	1,320	1,320	1,310	1,220	1,200	1,210	1,210	862	820
146-300/LF507-1F	43	43	43	43	43	43	43	43	43	96	107	108
14F-300QT/ALF502R-5	0	3	3	3	3	3	3	3	3	3	3	3
720-000/JT3C-12	0	674	713	655	647	908	945	932	822	855	732	624
727-100/JT8D-7A	1,080	1,190	1,190	1,220	1,200	1,060	1,060	1,060	929	929	800	761
727-100/JT8D-7B	11,800	11,500	11,800	11,200	11,400	11,700	10,700	9,760	9,910	9,250	9,080	8,600
727-100/JT8D-9	385	406	179	179	179	179	179	179	179	188	188	188
727-100/JT8D-9A	586	586	586	633	644	644	602	709	620	620	624	624
72C-100F/JT8D-7B	0	5,000	4,890	4,860	4,720	4,770	4,800	4,700	4,640	4,620	4,440	5,020
72C-100F/JT8D-9A	0	59	59	108	108	108	108	108	108	108	108	108
72S-200/JT8D-15	59,900	54,200	55,900	52,400	54,900	57,200	57,900	57,800	53,700	52,400	51,300	51,700
72S-200/JT8D-17	2,310	2,250	2,280	2,090	2,100	2,350	2,340	2,080	1,430	1,130	1,430	1,350
72S-200/JT8D-17R	6,100	5,970	5,640	5,680	5,410	5,400	5,230	5,090	5,270	5,430	5,220	5,450
72S-200/JT8D-7B	0	0	0	110	110	110	110	212	468	468	468	709
72S-200/JT8D-9	0	0	307	307	331	331	325	330	326	349	364	364
72S-200/JT8D-9A	15,500	15,500	15,600	16,000	15,100	16,000	16,200	16,000	15,800	15,400	15,900	16,400
737-100/JT8D-7A	0	0	280	280	280	330	330	330	285	285	285	285
737-200/JT8D-15	23,100	23,300	23,100	24,200	24,600	24,500	23,700	23,800	24,800	25,000	24,400	24,600
737-200/JT8D-15A	8,810	8,830	8,710	8,090	8,690	8,730	8,500	8,750	8,680	8,790	8,560	8,560
737-200/JT8D-17	5,440	5,330	5,230	5,540	5,560	5,620	5,580	5,920	5,550	5,240	5,560	5,090
737-200/JT8D-17A	3,830	3,850	3,790	3,670	3,680	3,690	4,150	4,380	4,200	4,120	4,170	4,330
737-200/JT8D-7B	18,700	19,000	18,300	17,600	18,500	19,500	20,000	20,100	19,400	19,000	19,700	20,600
737-200/JT8D-9	355	355	351	351	312	290	305	279	279	279	279	270
737-200/JT8D-9A	17,800	17,900	17,600	16,900	17,600	18,100	18,300	17,700	17,800	17,600	17,300	17,400
73C-200C/JT8D-15	0	66	66	66	66	66	66	0	0	0	0	0
73C-200C/JT8D-17	376	393	396	396	424	483	483	483	410	400	407	412
73C-200C/JT8D-17A	416	427	378	407	404	598	602	589	438	438	433	433
73C-200C/JT8D-9A	177	1,130	1,100	1,040	1,020	1,050	1,050	1,220	1,220	1,190	1,210	1,210
73C-200F/JT8D-17	0	72	72	72	72	72	72	72	72	72	72	72
73L-500/CFM56-3C	12,000	12,300	13,200	14,500	15,600	16,800	17,500	18,600	19,600	19,400	20,200	21,000

Appendix H. CO Emitted by Airplane Type and Month

	1992					CO Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
73Y-300/CFM56-3B	84,100	83,200	81,300	82,300	84,100	85,400	86,600	86,000	84,200	83,700	86,500	76,900
73Z-400/CFM56-3B	17,000	16,800	17,100	17,000	17,600	18,900	19,300	19,000	19,100	19,300	19,600	20,700
747-100/JT9D-3A	8,300	5,130	5,290	5,850	6,260	6,740	7,010	7,040	6,020	5,130	6,400	6,600
747-100/JT9D-3AW	673	673	865	1,060	1,280	1,680	1,680	1,630	1,580	961	865	865
747-100/JT9D-7A	63,500	57,400	58,200	56,700	54,300	54,700	58,200	58,500	54,800	51,100	53,000	51,400
747-100/JT9D-7AH	4,110	4,970	5,290	4,680	4,320	5,370	5,510	5,570	4,690	2,730	2,800	3,890
747-100B/JT9D-7F	386	386	386	386	386	386	386	386	386	386	386	198
747-100B/RB211-524C2	4,050	6,000	5,670	6,010	6,010	6,280	6,780	6,780	7,090	6,100	6,520	6,520
747-200B/CF6-50E2	27,300	29,500	30,000	31,500	32,200	35,000	36,100	34,400	32,200	32,000	28,500	28,100
747-200B/JT9D-7A	1,220	1,720	1,540	1,420	1,910	1,750	1,750	1,940	1,780	1,690	1,590	1,840
747-200B/JT9D-7AW	25,100	13,900	14,200	13,900	12,700	13,400	14,600	14,900	15,000	14,500	14,200	14,300
747-200B/JT9D-7F	4,290	4,290	4,130	4,370	4,330	4,840	4,840	4,840	3,410	3,100	3,190	3,150
747-200B/JT9D-7J	4,700	8,660	8,230	7,690	9,180	9,890	11,900	11,300	9,180	10,500	9,040	8,500
747-200B/JT9D-7Q	13,500	15,300	14,700	15,600	16,100	15,300	15,400	14,800	16,100	13,400	13,800	12,500
747-200B/JT9D-7R4G2	669	944	944	855	830	886	860	922	1,070	943	825	848
747-200B/JT9D-7W	2,480	2,890	2,890	3,120	3,290	3,540	3,590	3,590	3,590	3,460	3,100	2,990
747-200B/RB211-524C2	13,600	14,100	13,900	12,300	13,300	13,600	13,600	13,200	7,070	7,200	6,860	6,760
747-200B/RB211-524D4	6,040	6,720	7,970	8,230	8,190	8,190	8,430	7,850	8,100	6,940	7,220	7,380
74C-100F/JT9D-7A	0	12,900	14,400	14,100	12,800	13,000	12,400	12,500	13,000	13,200	13,800	14,100
74C-200F/CF6-50E2	0	5,350	5,770	5,220	5,160	5,090	5,590	7,000	7,990	7,470	9,130	8,300
74C-200F/JT9D-7A	0	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470
74C-200F/JT9D-7F	0	4,920	4,920	4,880	4,880	4,880	4,880	5,400	5,410	5,370	5,410	5,150
74C-200F/JT9D-7FW	0	385	385	385	385	385	385	385	385	385	385	385
74C-200F/JT9D-7J	0	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
74C-200F/JT9D-7Q	0	8,150	7,830	8,100	8,160	8,160	8,210	8,300	8,410	8,880	9,090	8,630
74C-200F/RB211-524D4	0	4,410	3,700	3,650	3,680	3,580	4,060	4,110	4,390	5,160	4,710	4,440
74I-400/CF6-80C2	9,020	10,100	10,200	9,480	11,000	11,200	12,000	12,400	12,700	12,800	12,700	14,400
74I-400/PW4056	2,830	2,840	3,040	2,890	2,680	3,000	3,240	3,370	3,440	3,340	3,420	3,590
74I-400/RB211-524G	3,980	7,380	6,900	8,280	7,960	8,380	8,660	8,640	8,620	8,200	8,740	8,560
74I-400/RB211-524H	2,370	2,500	2,500	2,850	2,670	2,680	2,680	2,850	3,090	3,040	3,210	3,240
74P-SP/JT9D-7A	8,710	9,020	9,910	8,340	8,470	9,780	9,590	9,560	9,360	8,810	8,670	8,080
74P-SP/JT9D-7F	1,750	1,910	1,910	2,010	2,010	1,810	1,900	1,900	1,900	1,900	1,930	1,860
74P-SP/JT9D-7FW	1,820	2,000	1,790	2,610	3,350	2,610	2,440	2,570	2,580	1,700	1,890	2,020
74P-SP/RB211-524C2	184	653	654	341	341	421	1,040	1,040	1,040	791	413	413

Appendix H. CO Emitted by Airplane Type and Month

	1992					CO Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
74P-SP/RB211-524D4	427	427	466	0	0	0	0	0	0	0	0	0
74Q-200M/CF6-50E2	0	0	0	66	0	0	0	0	0	0	0	0
74Q-200M/JT9D-7J	0	0	0	0	0	0	0	0	0	0	824	824
74U-300/CF6-80C2	1,410	2,210	2,190	2,140	2,070	2,050	1,930	1,930	1,930	1,900	2,610	2,690
74U-300/JT9D-7R4G2	4,130	4,210	4,380	5,130	5,190	5,290	5,080	4,980	4,470	4,550	4,650	4,270
74U-300/RB211-524C2	0	0	0	0	0	0	0	0	5,920	5,920	5,740	5,740
74U-300/RB211-524D4	8,380	8,930	8,500	9,820	10,600	9,710	9,500	9,610	9,500	9,120	9,820	10,000
74X-100SR/CF6-45A2	0	7,290	7,290	7,650	8,240	8,200	8,680	8,680	7,260	7,260	7,210	6,510
757-200/PW2037	14,700	14,800	15,900	15,900	16,100	16,200	16,500	16,600	16,600	16,800	17,100	17,700
757-200/PW2040	6,020	6,030	6,690	6,940	7,160	7,340	7,670	7,710	7,830	8,330	9,290	9,220
757-200/RB211-535C	9,870	10,100	10,500	8,920	11,900	12,300	12,500	13,200	12,200	12,200	13,100	12,200
757-200/RB211-535E4	4,990	4,800	4,860	4,430	4,530	4,880	5,330	5,170	5,100	4,950	5,680	5,600
75F/*	0	2,010	2,010	2,110	2,380	2,530	2,530	2,550	2,530	2,620	2,590	2,530
767-200/CF6-80A	29,400	29,900	29,600	29,000	30,200	31,200	33,300	33,200	32,600	31,600	31,400	31,300
767-200/CF6-80A2	2,190	2,240	2,240	2,220	2,300	2,190	2,320	2,320	2,370	2,160	2,120	2,130
767-200/JT9D-7R4D	3,560	3,110	3,400	3,130	3,170	3,280	3,260	3,250	3,270	3,090	3,160	2,950
76M-300/CF6-80A2	11,100	11,300	11,500	12,100	12,700	15,200	15,200	15,800	16,200	16,000	16,400	16,100
76M-300/CF6-80C2	6,090	6,120	6,220	8,080	8,080	7,680	7,810	7,660	7,510	7,980	8,450	8,570
7IQ-400M/CF6-80C2	2,730	3,200	3,290	4,820	5,030	5,040	5,190	5,190	5,130	4,920	5,010	4,910
7UQ-300M/CF6-50E2	1,490	2,890	2,910	2,720	2,390	2,630	2,490	2,820	2,640	2,080	2,270	2,260
7UQ-300M/CF6-80C2	645	689	689	750	804	828	804	804	804	804	669	669
7UQ-300M/JT9D-7R4G2	1,490	1,460	1,490	1,770	1,460	1,850	1,790	1,750	1,850	1,690	1,550	1,460
A0CC4-200/CF6-50C2	0	328	328	268	268	268	268	268	348	348	348	296
A30B2-100/CF6-50C	2,990	3,320	3,130	3,050	2,890	3,040	3,040	3,040	2,880	2,880	3,040	3,040
A30B2-100/CF6-50C2R	30,600	25,600	25,400	24,400	26,400	26,400	24,000	24,200	26,900	25,200	25,500	21,100
A30B2-200/CF6-50C2	1,990	2,610	2,610	1,990	2,040	1,480	1,480	1,480	1,480	2,170	2,170	2,410
A30B2-200/CF6-50C2R	7,120	6,640	7,300	6,920	6,850	7,630	9,210	7,910	8,990	9,130	8,490	8,910
A30B4-100/CF6-50C2	14,000	7,800	7,840	8,460	8,480	8,190	9,180	9,360	8,260	8,320	7,980	8,080
A30B4-100/JT9D-59A	2,590	2,730	2,440	3,200	3,200	3,200	4,410	3,660	4,400	3,170	2,520	2,510
A30B4-200/CF6-50C2	19,500	18,600	18,600	19,900	19,900	20,300	20,600	19,400	19,500	18,800	19,200	18,700
A30B4-200/JT9D-59A	9,820	6,490	6,490	6,790	6,850	6,850	6,850	6,420	6,390	6,280	5,310	5,510
A31-200/CF6-80A3	12,600	11,000	10,700	11,400	11,200	12,300	12,700	12,600	12,600	12,200	11,800	11,600
A31-200/CF6-80C2A2	836	435	435	668	668	668	668	668	668	668	668	668
A31-200/JT9D-7R4D1	769	511	557	554	601	612	537	616	540	599	517	391

Appendix H. CO Emitted by Airplane Type and Month

	1992					CO Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A31-200/JT9D-7R4E1	2,850	2,300	2,300	2,380	2,340	2,440	2,400	2,430	2,310	2,340	2,210	2,310
A32-100/CFM56-5A1	503	506	509	490	571	571	429	549	540	532	537	518
A32-200/CFM56-5A1	9,870	10,300	10,500	11,200	12,400	12,700	12,700	13,000	13,100	13,500	13,500	12,600
A32-200/CFM56-5A3	264	336	336	336	334	406	510	513	503	594	660	677
A32-200/V2500-A1	2,250	2,660	2,730	3,080	3,160	3,450	3,620	3,600	3,430	3,460	3,670	3,630
A34/*	0	0	0	0	0	0	0	0	79	79	79	79
A36-600/CF6-80C2A1	0	2,380	2,380	2,940	2,940	3,170	3,170	3,300	3,300	3,300	2,970	2,950
A36-600/JT9D-7R4H1	0	2,680	2,470	2,650	2,690	2,490	2,530	2,820	2,520	2,510	2,970	3,050
A36-600/PW4158	0	1,850	1,830	1,800	1,770	1,740	1,590	1,660	2,140	2,200	2,150	2,140
A3L-300/CF6-80C2	0	0	0	0	0	149	149	149	149	149	149	149
A3L-300/CF6-80C2A2	0	2,970	3,000	2,530	2,520	2,540	2,620	2,610	2,460	2,460	2,290	2,340
A3L-300/CF6-80C2A8	0	871	897	840	840	892	1,180	1,700	1,750	1,750	1,600	1,950
A3L-300/JT9D-7R4E1	0	228	228	208	239	256	185	256	205	213	249	201
A3L-300/PW4152	0	425	445	489	506	491	483	476	476	476	521	507
AN4/LGTURB	363	371	243	244	254	273	301	289	347	360	335	316
AT4/LGTURB	0	221	236	328	346	358	352	374	364	363	282	316
AT7/LGTURB	475	502	524	606	639	606	615	669	726	716	684	727
ATP/LGTURB	403	403	396	374	427	434	442	444	480	463	463	422
ATR/LGTURB	2,620	2,260	2,260	2,250	2,310	2,400	2,450	2,340	2,430	2,370	2,590	2,620
B3C-320C/JT3D-3B	0	2,210	2,130	2,080	1,520	1,500	1,500	1,500	1,500	1,500	1,420	1,280
B3C-320CH/JT3D-3B	0	20,800	20,900	20,700	21,000	20,500	20,500	20,500	20,700	19,600	19,900	21,000
B3F-320B/JT3D	176	176	176	555	555	379	0	0	0	0	0	0
B3F-320B/JT3D-3B	15,900	15,400	14,900	14,300	13,500	11,700	11,100	10,800	10,500	9,940	9,720	6,210
BAC-200/RR_SPEY-506	0	0	102	102	102	113	113	157	70	59	70	70
BAC-200/RR_SPEY-511	196	766	351	428	428	428	759	562	562	519	519	617
BAC-500/RR_SPEY-512	4,550	4,620	4,620	4,450	5,300	5,260	5,330	5,070	5,050	4,540	4,120	3,790
BE1/SMTURB	2,030	2,130	2,020	2,010	2,050	2,120	2,180	2,230	2,180	2,240	2,340	2,370
BE9/SMTURB	308	287	226	221	220	253	251	239	233	256	246	242
BEK/SMTURB	0	168	182	164	151	166	161	161	162	174	171	181
CD2/SMTURB	20	29	26	20	31	31	46	20	19	12	12	12
CL4/LGTURB	0	58	58	58	58	58	58	58	66	10	10	10
CNC/SMTURB	0	8	8	8	8	8	8	8	12	12	12	11
CNJ/*	13	13	13	7	7	7	7	7	7	7	7	7
CNN/SMTURB	0	13	13	13	13	13	13	13	13	13	13	13

Appendix H. CO Emitted by Airplane Type and Month

	1992	CO Emitted in kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CONCORDE	3,800	3,930	3,700	3,860	3,860	3,860	3,860	2,920	3,290	3,860	3,860	2,490
CRJ/*	0	0	0	0	0	0	0	0	0	0	98	171
CS5/LGTURB	65	65	65	65	65	65	65	65	65	65	65	65
CV5/LGTURB	0	5	5	17	17	17	19	15	15	16	30	30
CV6/LGTURB	0	18	13	12	13	13	13	13	30	30	30	30
CVF/LGTURB	0	52	52	52	54	57	60	60	62	66	69	65
CVL-10B/JT8D-7	60	41	41	37	37	35	47	59	63	63	63	63
CVL-12/JT8D-9	67	64	64	64	77	89	38	38	27	27	13	13
D10-10/CF6-6D	93,200	79,700	82,100	81,000	80,100	80,800	83,400	83,300	78,000	78,800	79,300	79,000
D10-15/CF6-50C2F	4,710	2,170	2,170	2,090	1,720	2,160	2,440	2,440	2,080	1,650	2,500	2,500
D1C-10F/CF6-6D	0	3,570	3,580	3,700	3,870	3,590	3,840	3,870	3,870	3,730	3,760	3,760
D8C-33F/JT4A-11	0	73,900	73,100	76,500	72,600	74,300	75,800	75,700	76,700	75,400	78,900	79,200
D8S-62H/JT3D-3B	1,550	2,010	2,010	1,410	1,410	1,410	1,580	1,620	1,330	1,330	1,330	1,800
D8S-62H/JT3D-7	664	1,020	1,060	1,060	914	1,240	990	1,060	1,060	1,280	1,150	1,060
D8S-63H/JT3D-7	179	889	835	835	835	835	862	1,140	699	783	935	1,020
D8S-73F/CFM56-2C	636	539	573	459	482	482	482	450	423	423	423	410
D9C-30C/JT8D-9A	0	142	0	0	142	142	142	142	142	142	142	142
D9C-30F/JT8D-7B	0	1,600	1,730	1,820	1,670	1,630	1,630	1,640	1,630	1,630	1,630	1,630
D9M-87/JT8D-217	3,850	5,000	5,190	6,130	6,240	6,200	5,940	5,650	6,320	6,270	6,500	6,470
D9M-87/JT8D-219	0	11	11	43	43	45	52	58	55	25	100	141
D9S-30/JT8D-17	1,440	1,240	1,250	1,280	1,280	1,290	1,650	1,650	1,590	1,550	1,620	1,590
D9S-30/JT8D-7B	29,700	26,500	26,500	24,900	24,300	24,800	25,000	25,100	24,000	23,600	22,700	21,700
D9S-30/JT8D-9A	12,400	12,300	12,400	12,600	12,500	13,200	13,400	12,400	12,500	12,100	11,500	11,900
D9S-40/JT8D-11	6,290	6,090	5,910	6,160	6,210	6,280	5,080	5,620	5,460	5,400	6,300	5,610
D9S-40/JT8D-15	1,620	1,790	1,730	1,800	1,730	1,190	1,500	1,740	1,740	1,800	1,750	1,670
D9X-50/JT8D-17	0	2,330	2,330	2,400	2,340	2,390	2,380	2,310	2,300	2,290	2,370	2,590
D9Z-81/JT8D-209	6,450	6,440	6,410	6,130	6,490	6,540	6,500	6,520	6,440	6,440	6,200	6,030
D9Z-81/JT8D-217	4,980	3,630	3,750	3,940	3,900	3,920	3,550	3,450	3,900	3,810	3,940	4,110
D9Z-82/JT8D-217	41,100	36,400	40,700	39,700	41,700	44,300	44,100	45,100	44,400	44,700	45,700	45,600
D9Z-82/JT8D-217C	1,870	1,870	1,870	2,170	2,150	2,160	2,230	2,140	2,150	2,110	1,740	1,740
D9Z-82/JT8D-219	667	664	664	654	651	586	582	632	1,070	1,070	1,080	1,090
D9Z-83/JT8D-219	2,730	2,780	2,790	2,930	2,990	3,160	3,980	4,090	3,890	4,630	3,940	4,260
D9Z-88/JT8D-217	531	531	522	0	0	0	0	0	0	0	0	0
D9Z-88/JT8D-219	6,270	6,430	6,630	6,860	7,100	7,060	7,070	7,070	7,090	7,100	7,220	7,430

Appendix H. CO Emitted by Airplane Type and Month

	1992					CO Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
DC8/*	1,730	1,670	1,780	2,000	1,270	1,590	1,770	1,600	1,390	1,390	464	579
DC9-10/JT8D-7A	1,220	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230
DC9-10/JT8D-7B	10,900	11,600	11,100	11,200	11,000	11,100	11,000	10,700	11,000	11,000	10,600	10,700
DC9-20/JT8D-11	1,510	0	0	0	0	0	0	0	0	0	0	0
DFL/*	3	21	21	21	21	3	3	3	30	30	30	30
DH1/MDTURB	0	5	5	62	86	81	81	81	78	64	64	95
DH3/MDTURB	0	250	250	286	319	321	303	311	320	328	314	335
DH7/LGTURB	693	634	665	624	619	666	645	647	630	605	580	622
DH8/MDTURB	4,280	3,970	4,050	4,030	4,260	4,420	4,660	4,690	4,760	4,640	4,740	4,460
DHB/SMTURB	24	24	24	24	74	74	93	79	67	25	25	25
DHT/SMTURB	1,230	1,250	1,230	1,210	1,180	1,190	1,200	1,220	1,200	1,170	1,120	1,160
DLR-30/CF6-50C	0	555	144	571	455	571	445	369	537	613	836	836
DLR-30/CF6-50C2	0	9,700	9,440	9,670	9,390	11,400	10,600	10,400	9,940	9,860	10,800	9,490
DLR-30/CF6-50C2R	0	1,930	2,350	2,040	1,860	1,870	2,370	2,370	1,850	1,850	1,830	2,310
DLR-40/JT9D-20	0	2,160	2,090	1,590	1,720	2,020	1,910	1,910	2,260	2,200	2,000	2,000
DO8/SMTURB	398	397	407	408	433	435	435	449	445	433	418	453
EM2/SMTURB	2,560	2,550	2,610	2,640	2,690	2,750	2,780	2,820	2,860	2,850	2,890	2,880
EMB/SMTURB	748	711	680	676	714	693	554	567	601	615	637	642
F10-100/TAY620-15	1,190	1,130	1,090	1,110	1,690	1,810	1,690	1,700	1,690	1,660	2,200	2,260
F10-100/TAY650-15	16,900	17,500	18,600	19,200	21,200	21,800	22,400	24,000	24,300	24,900	26,700	28,700
F27/LGTURB	1,530	1,560	1,550	1,460	1,450	1,450	1,450	1,460	1,440	1,370	1,280	1,240
F28-1000/RR_SPEY-MK555	952	883	896	812	823	791	873	702	657	681	712	708
F28-1000C/RR_SPEY-MK55	47	38	38	38	38	38	38	38	38	38	38	38
F28-2000/RR_SPEY-MK555	146	149	120	153	155	165	174	158	153	137	151	145
F28-3000/RR_SPEY-MK555	37	41	41	41	43	43	43	43	43	43	43	52
F28-4000/RR_SPEY-MK555	7,260	7,300	7,360	7,200	7,380	7,150	6,920	7,320	7,080	6,800	6,940	6,200
F2B/LGTURB	0	19	20	22	25	25	24	20	19	19	19	19
F2E/LGTURB	0	26	25	32	32	32	32	32	32	32	26	17
F50/LGTURB	1,420	1,400	1,460	1,550	1,640	1,710	1,590	1,670	1,690	1,660	1,710	1,670
HEC/SMTURB	2	2	2	13	13	20	20	20	20	10	8	8
HS7/LGTURB	494	518	511	502	485	512	525	521	505	513	493	489
I62/SOL	21,700	21,800	21,600	20,800	24,300	21,900	22,700	23,000	19,800	18,800	16,800	17,300
I72/*	0	4,450	4,450	4,200	4,200	4,200	4,200	4,200	4,230	4,530	4,810	4,810
I86/KUZ	17,600	21,300	21,100	21,800	21,300	20,800	21,300	20,900	25,400	22,300	18,800	18,500

Appendix H. CO Emitted by Airplane Type and Month

	1992					CO Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
IL8/LGTURB	44	44	33	25	18	18	18	18	9	9	3	7
J31/SMTURB	2,430	2,340	2,380	2,290	2,290	2,410	2,450	2,500	2,480	2,380	2,400	2,380
L10-1/RB211-22B	48,400	51,500	50,700	52,300	52,000	51,100	52,100	52,700	49,800	48,400	42,000	43,500
L10-200/RB211-524B	1,730	1,630	1,680	1,680	1,680	1,630	1,730	1,730	1,730	1,570	1,790	1,790
L10-50/RB211-22B	1,600	1,630	1,630	1,620	1,640	1,870	1,940	1,810	2,230	2,140	2,270	2,300
L4T/SMTURB	14	13	11	12	15	14	12	9	9	10	16	23
LLR-500/RB211-524B4	2,150	2,260	2,270	2,380	2,420	2,690	2,860	2,840	2,770	2,470	2,490	2,430
LOE/LGTURB	149	120	66	39	41	41	41	41	41	41	41	41
LOF/LGTURB	0	125	125	128	158	174	160	161	157	131	140	140
LOH/LGTURB	10	36	31	24	24	24	24	24	24	24	24	18
LOM/LGTURB	12	12	14	14	14	12	12	12	10	10	5	5
LRJ/*	0	40	40	40	40	28	28	28	14	14	14	14
M1F/*	0	986	986	912	1,040	1,090	1,030	1,030	1,020	1,040	1,050	1,050
MDL-11C/CF6-80C2	503	514	514	514	741	741	1,030	1,260	1,230	1,180	1,230	1,230
MDL-11P/CF6-80C2	856	1,000	1,390	1,810	2,200	2,320	2,490	2,530	2,530	2,510	3,490	3,440
MDL-11P/PW4460	3,350	3,370	3,790	4,220	5,370	6,250	6,730	6,840	6,730	6,570	7,350	7,420
MRC-100/JT8D-15	286	220	223	353	452	439	350	358	470	412	383	294
MU2/SMTURB	0	20	20	20	25	18	18	17	17	17	14	14
ND2/MDTURB	36	24	24	37	35	26	25	24	46	45	42	25
NDC/*	2	2	2	2	2	2	2	2	2	2	2	10
PA6/SMTURB	0	6	6	6	6	6	6	6	6	6	6	6
PL6/SMTURB	1	3	3	1	1	1	1	1	1	1	1	1
SF3/MDTURB	4,000	4,090	4,110	4,250	4,390	4,350	4,360	4,470	4,540	4,540	4,690	4,610
SFF/MDTURB	0	0	0	0	0	0	0	0	1	10	10	3
SH3/MDTURB	90	98	104	114	139	151	122	129	142	147	154	169
SH6/MDTURB	1,200	1,150	1,140	1,140	1,200	1,160	1,150	1,140	1,080	1,050	999	946
SWM/SMTURB	2,120	2,260	2,320	2,310	2,360	2,320	2,310	2,280	2,270	2,290	2,290	2,310
T34/SOL	4,880	5,080	5,070	4,990	5,030	4,950	4,870	4,930	3,810	3,830	3,840	4,130
T54/SOL	16,900	17,200	16,700	17,400	17,400	16,900	16,700	16,600	13,700	13,500	13,200	13,000
VC8/LGTURB	0	49	49	49	49	49	49	49	49	49	49	49
VCV/LGTURB	72	23	23	23	23	23	23	23	23	23	23	23
WWP/*	11	13	13	13	13	13	13	18	20	19	19	22
Y40/IVC	551	543	543	337	632	707	727	658	1,290	1,650	1,400	1,450
Y42/*	2,540	2,590	2,580	2,600	2,610	2,450	2,450	2,370	2,670	2,390	2,730	2,590

Appendix H. CO Emitted by Airplane Type and Month

	1992					CO Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
YN2/SMTURB	0	0	0	0	0	0	0	6	6	6	6	6
YN7/LGTURB	312	334	217	212	212	214	214	216	216	230	117	93
YS1/LGTURB	418	471	468	471	478	455	463	461	440	433	432	426
Total	1,081,687	1,232,700	1,243,190	1,247,115	1,267,616	1,297,156	1,321,472	1,320,254	1,301,586	1,273,953	1,281,634	1,262,600

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992	Hydrocarbons Emitted in kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
146-100/ALF502R-3	0	19	19	21	21	22	22	20	21	20	9	9
146-100/ALF502R-5	16	18	20	16	15	16	15	15	15	15	10	10
146-200/ALF502R-3	66	68	67	62	69	67	70	71	71	74	64	63
146-200/ALF502R-5	512	515	536	564	583	597	604	603	552	538	540	515
146-300/ALF502R-5	144	136	136	126	126	125	116	114	116	115	82	78
146-300/LF507-1F	4	4	4	4	4	4	4	4	4	10	11	11
14F-300QT/ALF502R-5	0	0	0	0	0	0	0	0	0	0	0	0
720-000/JT3C-12	0	688	729	684	677	942	974	963	858	894	756	650
727-100/JT8D-7A	324	356	356	363	357	317	317	317	276	276	239	227
727-100/JT8D-7B	3,480	3,390	3,460	3,290	3,350	3,450	3,140	2,860	2,900	2,710	2,660	2,530
727-100/JT8D-9	75	80	35	35	35	35	35	35	35	37	37	37
727-100/JT8D-9A	117	117	117	126	128	128	120	141	123	123	124	124
72C-100F/JT8D-7B	0	1,460	1,420	1,420	1,380	1,390	1,400	1,370	1,350	1,350	1,290	1,460
72C-100F/JT8D-9A	0	11	11	21	21	21	21	21	21	21	21	21
72S-200/JT8D-15	10,600	9,580	9,890	9,270	9,700	10,100	10,200	10,200	9,450	9,210	9,020	9,120
72S-200/JT8D-17	403	392	396	360	363	408	407	362	248	194	247	233
72S-200/JT8D-17R	1,020	998	939	946	892	890	871	846	865	903	861	904
72S-200/JT8D-7B	0	0	0	28	28	28	28	53	118	118	118	179
72S-200/JT8D-9	0	0	62	62	67	67	66	67	66	71	74	74
72S-200/JT8D-9A	3,140	3,130	3,150	3,240	3,070	3,250	3,290	3,230	3,200	3,130	3,230	3,320
737-100/JT8D-7A	0	0	77	77	77	91	91	91	78	78	78	78
737-200/JT8D-15	3,780	3,810	3,780	3,960	4,030	4,020	3,900	3,920	4,070	4,090	3,980	4,020
737-200/JT8D-15A	1,620	1,630	1,610	1,500	1,600	1,600	1,560	1,610	1,600	1,620	1,580	1,580
737-200/JT8D-17	829	807	793	845	848	854	849	903	844	798	849	768
737-200/JT8D-17A	1,650	1,660	1,640	1,570	1,580	1,580	1,770	1,870	1,790	1,760	1,790	1,850
737-200/JT8D-7B	5,520	5,620	5,400	5,200	5,480	5,750	5,920	5,960	5,730	5,630	5,830	6,090
737-200/JT8D-9	75	75	74	74	66	61	65	59	59	59	59	57
737-200/JT8D-9A	3,740	3,770	3,700	3,560	3,690	3,810	3,860	3,720	3,750	3,700	3,640	3,650
73C-200C/JT8D-15	0	11	11	11	11	11	11	0	0	0	0	0
73C-200C/JT8D-17	58	60	61	61	65	75	75	75	62	60	62	62
73C-200C/JT8D-17A	179	183	163	174	173	257	259	254	190	190	188	188
73C-200C/JT8D-9A	37	237	230	219	214	221	220	256	255	249	253	254
73C-200F/JT8D-17	0	12	12	12	12	12	12	12	12	12	12	12
73L-500/CFM56-3C	707	726	778	856	916	984	1,020	1,090	1,140	1,130	1,180	1,220

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992					Hydrocarbons Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
73Y-300/CFM56-3B	6,650	6,570	6,430	6,500	6,650	6,740	6,830	6,790	6,650	6,620	6,850	6,090
73Z-400/CFM56-3B	1,190	1,170	1,190	1,190	1,230	1,320	1,340	1,330	1,330	1,340	1,370	1,440
747-100/JT9D-3A	4,280	2,630	2,720	3,030	3,200	3,450	3,600	3,620	3,070	2,620	3,260	3,340
747-100/JT9D-3AW	334	334	429	525	639	836	836	812	789	477	429	429
747-100/JT9D-7A	39,100	34,800	35,300	34,400	33,000	33,300	35,400	35,600	33,300	31,100	32,200	31,300
747-100/JT9D-7AH	2,520	3,010	3,190	2,840	2,640	3,300	3,380	3,420	2,870	1,690	1,710	2,350
747-100B/JT9D-7F	210	210	210	210	210	210	210	210	210	210	210	106
747-100B/RB211-524C2	3,040	4,650	4,380	4,730	4,730	4,960	5,330	5,330	5,560	4,780	5,100	5,100
747-200B/CF6-50E2	17,000	18,300	18,600	19,600	20,200	21,900	22,600	21,400	20,000	19,900	17,800	17,500
747-200B/JT9D-7A	714	1,020	913	841	1,120	1,030	1,040	1,170	1,070	1,020	950	1,080
747-200B/JT9D-7AW	14,500	8,430	8,600	8,440	7,740	8,150	8,870	9,080	9,100	8,800	8,620	8,690
747-200B/JT9D-7F	1,850	1,850	1,780	1,890	1,870	2,070	2,070	2,070	1,450	1,320	1,360	1,360
747-200B/JT9D-7J	1,840	3,430	3,160	2,980	3,590	3,880	4,710	4,470	3,610	4,170	3,460	3,270
747-200B/JT9D-7Q	6,080	6,800	6,520	6,910	7,120	6,790	6,830	6,560	7,120	5,910	6,070	5,490
747-200B/JT9D-7R4G2	112	157	157	142	138	147	143	153	179	157	138	141
747-200B/JT9D-7W	1,550	1,770	1,770	1,940	2,050	2,200	2,240	2,240	2,240	2,160	1,920	1,850
747-200B/RB211-524C2	10,000	10,500	10,400	9,110	9,890	9,940	9,940	9,710	5,100	5,170	4,940	4,850
747-200B/RB211-524D4	3,700	4,170	4,910	5,010	4,980	4,980	5,110	4,830	4,970	4,310	4,290	4,400
74C-100F/JT9D-7A	0	7,700	8,600	8,420	7,660	7,740	7,400	7,470	7,720	7,830	8,220	8,360
74C-200F/CF6-50E2	0	3,420	3,690	3,350	3,290	3,240	3,580	4,510	5,150	4,810	5,900	5,340
74C-200F/JT9D-7A	0	891	891	891	891	891	891	891	891	891	891	891
74C-200F/JT9D-7F	0	2,400	2,400	2,380	2,380	2,380	2,380	2,630	2,630	2,610	2,630	2,520
74C-200F/JT9D-7FW	0	180	180	180	180	180	180	180	180	180	180	180
74C-200F/JT9D-7J	0	835	835	835	835	835	835	835	835	835	835	835
74C-200F/JT9D-7Q	0	3,640	3,500	3,610	3,640	3,640	3,660	3,700	3,750	3,970	4,070	3,860
74C-200F/RB211-524D4	0	2,910	2,470	2,430	2,460	2,400	2,680	2,710	2,920	3,400	3,100	2,930
74I-400/CF6-80C2	2,030	2,310	2,330	2,170	2,520	2,570	2,760	2,870	2,940	2,970	2,950	3,310
74I-400/PW4056	1,190	1,160	1,230	1,180	1,120	1,280	1,370	1,440	1,490	1,440	1,450	1,530
74I-400/RB211-524G	1,390	2,590	2,410	2,870	2,780	2,910	3,030	3,030	3,020	2,870	3,040	2,970
74I-400/RB211-524H	810	856	856	931	895	904	904	969	1,060	1,040	1,090	1,100
74P-SP/JT9D-7A	6,030	6,240	6,820	5,760	5,870	6,740	6,600	6,570	6,430	6,020	5,920	5,510
74P-SP/JT9D-7F	1,030	1,140	1,140	1,190	1,190	1,090	1,140	1,140	1,140	1,140	1,140	1,090
74P-SP/JT9D-7FW	910	1,040	931	1,390	1,820	1,430	1,300	1,390	1,400	898	996	1,090
74P-SP/RB211-524C2	129	482	486	250	250	304	781	781	781	584	302	302

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992					Hydrocarbons Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
74P-SP/RB211-524D4	186	186	200	0	0	0	0	0	0	0	0	0
74Q-200M/CF6-50E2	0	0	0	43	0	0	0	0	0	0	0	0
74Q-200M/JT9D-7J	0	0	0	0	0	0	0	0	0	0	381	381
74U-300/CF6-80C2	340	537	533	519	503	495	462	462	462	454	630	652
74U-300/JT9D-7R4G2	692	703	731	858	869	885	849	833	743	757	778	712
74U-300/RB211-524C2	0	0	0	0	0	0	0	0	4,650	4,650	4,500	4,500
74U-300/RB211-524D4	5,720	6,200	5,850	6,920	7,430	6,850	6,630	6,710	6,630	6,380	6,960	7,100
74X-100SR/CF6-45A2	0	4,500	4,500	4,760	5,140	5,090	5,490	5,490	4,530	4,530	4,460	4,020
757-200/PW2037	1,530	1,530	1,650	1,650	1,670	1,680	1,710	1,730	1,730	1,750	1,780	1,840
757-200/PW2040	536	538	597	619	638	654	684	688	698	743	829	822
757-200/RB211-535C	858	874	934	797	1,070	1,160	1,230	1,280	1,150	1,160	1,270	1,220
757-200/RB211-535E4	348	340	351	321	326	350	386	375	367	361	416	404
75F/*.	0	179	179	188	213	226	226	228	226	234	231	226
767-200/CF6-80A	6,490	6,580	6,510	6,390	6,660	6,880	7,340	7,310	7,190	6,960	6,910	6,910
767-200/CF6-80A2	505	516	516	512	531	504	534	534	547	498	487	488
767-200/JT9D-7R4D	604	524	572	526	534	554	554	552	552	521	533	496
76M-300/CF6-80A2	2,730	2,760	2,820	2,970	3,120	3,730	3,730	3,880	3,990	3,930	4,020	3,960
76M-300/CF6-80C2	1,690	1,700	1,720	2,240	2,240	2,130	2,150	2,110	2,070	2,210	2,340	2,370
7IQ-400M/CF6-80C2	606	721	743	1,090	1,140	1,140	1,180	1,180	1,160	1,120	1,150	1,120
7UQ-300M/CF6-50E2	1,030	1,880	1,890	1,740	1,530	1,700	1,570	1,790	1,670	1,330	1,440	1,450
7UQ-300M/CF6-80C2	166	178	178	193	205	212	205	205	205	205	172	172
7UQ-300M/JT9D-7R4G2	249	244	248	296	243	310	300	293	309	284	258	243
A0CC4-200/CF6-50C2	0	155	155	130	130	130	130	130	167	167	167	143
A30B2-100/CF6-50C	1,280	1,420	1,340	1,310	1,240	1,300	1,300	1,300	1,240	1,240	1,300	1,300
A30B2-100/CF6-50C2R	13,400	11,200	11,100	10,800	11,600	11,600	10,600	10,700	11,700	11,000	11,200	9,340
A30B2-200/CF6-50C2	800	1,050	1,050	800	823	594	594	594	594	876	876	966
A30B2-200/CF6-50C2R	2,980	2,780	3,060	2,900	2,870	3,200	3,850	3,310	3,760	3,820	3,550	3,730
A30B4-100/CF6-50C2	5,720	3,080	3,100	3,360	3,370	3,260	3,640	3,700	3,280	3,300	3,150	3,190
A30B4-100/JT9D-59A	882	904	798	1,010	1,010	1,010	1,440	1,220	1,430	1,010	855	847
A30B4-200/CF6-50C2	8,250	7,850	7,830	8,380	8,430	8,630	8,760	8,320	8,320	7,970	8,160	7,980
A30B4-200/JT9D-59A	3,360	2,190	2,190	2,300	2,310	2,310	2,310	2,170	2,160	2,120	1,790	1,850
A31-200/CF6-80A3	2,940	2,570	2,500	2,660	2,630	2,890	2,980	2,960	2,960	2,850	2,760	2,720
A31-200/CF6-80C2A2	244	127	127	198	198	198	198	198	198	198	198	198
A31-200/JT9D-7R4D1	127	82	89	89	97	99	88	100	87	96	83	62

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992	Hydrocarbons Emitted in kilograms/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A31-200/JT9D-7R4E1	508	410	410	427	420	438	431	437	413	419	394	413
A32-100/CFM56-5A1	61	61	61	64	73	73	55	70	69	68	68	67
A32-200/CFM56-5A1	1,220	1,280	1,310	1,440	1,570	1,620	1,640	1,680	1,680	1,740	1,730	1,630
A32-200/CFM56-5A3	35	42	42	42	42	50	63	63	62	72	80	82
A32-200/V2500-A1	139	157	158	183	186	206	222	220	208	210	222	221
A34/*	0	0	0	0	0	0	0	0	23	23	23	23
A36-600/CF6-80C2A1	0	655	655	811	811	877	877	912	912	912	817	811
A36-600/JT9D-7R4H1	0	399	368	395	400	377	382	421	381	379	445	457
A36-600/PW4158	0	161	160	157	155	152	139	145	186	191	187	186
A3L-300/CF6-80C2	0	0	0	0	0	38	38	38	38	38	38	38
A3L-300/CF6-80C2A2	0	839	846	707	703	709	730	726	687	687	640	653
A3L-300/CF6-80C2A8	0	238	246	228	228	243	325	465	480	480	435	540
A3L-300/JT9D-7R4E1	0	40	40	37	42	45	33	45	36	38	44	36
A3L-300/PW4152	0	103	106	119	122	120	118	119	119	119	126	122
AN4/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
AT4/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
AT7/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
ATP/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
ATR/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
B3C-320C/JT3D-3B	0	2,400	2,300	2,250	1,660	1,630	1,630	1,630	1,630	1,630	1,550	1,400
B3C-320CH/JT3D-3B	0	22,800	23,000	22,800	23,000	22,500	22,500	22,500	22,700	21,600	21,900	23,000
B3F-320B/JT3D	192	192	192	607	607	415	0	0	0	0	0	0
B3F-320B/JT3D-3B	17,500	17,000	16,400	15,800	14,900	12,900	12,300	11,900	11,600	11,000	10,700	6,880
BAC-200/RR_SPEY-506	0	0	14	14	14	15	15	21	9	8	9	9
BAC-200/RR_SPEY-511	114	409	203	246	246	246	438	325	325	301	301	356
BAC-500/RR_SPEY-512	615	624	625	602	717	713	722	685	683	614	557	512
BE1/SMTURB	108	113	108	108	110	114	116	119	116	120	125	126
BE9/SMTURB	17	16	13	12	12	14	14	14	13	14	14	14
BEK/SMTURB	0	9	9	8	8	9	8	8	8	9	9	9
CD2/SMTURB	1	2	2	1	2	2	3	1	1	1	1	1
CL4/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
CNC/SMTURB	0	0	0	0	0	0	0	0	1	1	1	1
CNJ/*	1	1	1	1	1	1	1	1	1	1	1	1
CNN/SMTURB	0	1	1	1	1	1	1	1	1	1	1	1

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992					Hydrocarbons Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CONCORDE	514	534	502	524	524	524	524	394	447	524	524	338
CRJ/*	0	0	0	0	0	0	0	0	0	0	12	21
CS5/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
CV5/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
CV6/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
CVF/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
CVL-10B/JT8D-7	15	10	10	9	9	9	12	15	16	16	16	16
CVL-12/JT8D-9	14	13	13	13	16	19	8	8	6	6	3	3
D10-10/CF6-6D	42,500	35,500	36,700	36,100	35,800	36,100	37,300	37,200	34,800	35,100	35,300	35,300
D10-15/CF6-50C2F	2,040	909	909	880	732	916	1,030	1,030	872	687	1,060	1,060
D1C-10F/CF6-6D	0	1,340	1,340	1,380	1,440	1,340	1,430	1,440	1,450	1,400	1,410	1,410
D8C-33F/JT4A-11	0	52,400	51,800	54,200	51,300	52,500	53,600	53,500	54,200	53,400	55,800	56,100
D8S-62H/JT3D-3B	1,700	2,190	2,190	1,550	1,550	1,550	1,740	1,780	1,460	1,460	1,460	1,970
D8S-62H/JT3D-7	432	663	696	696	602	802	641	686	686	821	734	685
D8S-63H/JT3D-7	113	578	538	538	538	538	558	760	466	512	627	688
D8S-73F/CFM56-2C	39	33	34	28	29	29	29	27	25	25	25	25
D9C-30C/JT8D-9A	0	29	0	0	29	29	29	29	29	29	29	29
D9C-30F/JT8D-7B	0	480	522	549	500	487	487	492	490	487	487	487
D9M-87/JT8D-217	1,220	1,580	1,640	1,930	1,960	1,950	1,870	1,780	1,990	1,970	2,040	2,040
D9M-87/JT8D-219	0	4	4	14	14	15	17	18	17	7	30	43
D9S-30/JT8D-17	216	183	184	188	188	192	247	247	237	230	240	237
D9S-30/JT8D-7B	9,020	8,040	8,050	7,560	7,350	7,510	7,560	7,600	7,300	7,170	6,900	6,600
D9S-30/JT8D-9A	2,500	2,480	2,500	2,540	2,530	2,670	2,720	2,510	2,520	2,440	2,320	2,400
D9S-40/JT8D-11	2,020	1,960	1,900	1,980	1,990	2,020	1,630	1,800	1,750	1,730	2,010	1,790
D9S-40/JT8D-15	239	265	256	266	255	175	222	258	258	266	257	245
D9X-50/JT8D-17	0	348	348	357	343	351	349	340	350	347	360	382
D9Z-81/JT8D-209	2,070	2,070	2,060	1,970	2,090	2,100	2,090	2,090	2,070	2,070	1,990	1,940
D9Z-81/JT8D-217	1,520	1,110	1,150	1,210	1,200	1,210	1,090	1,060	1,200	1,170	1,200	1,260
D9Z-82/JT8D-217	13,100	11,600	12,900	12,600	13,200	14,100	14,000	14,400	14,100	14,200	14,600	14,500
D9Z-82/JT8D-217C	563	563	563	650	646	650	670	643	648	633	524	523
D9Z-82/JT8D-219	206	206	206	204	203	184	182	197	326	326	332	332
D9Z-83/JT8D-219	844	860	861	906	928	982	1,230	1,270	1,200	1,420	1,210	1,310
D9Z-88/JT8D-217	164	164	161	0	0	0	0	0	0	0	0	0
D9Z-88/JT8D-219	1,910	1,960	2,020	2,090	2,160	2,150	2,150	2,150	2,160	2,160	2,200	2,260

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992					Hydrocarbons Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
DC8/*	1,190	1,140	1,250	1,400	831	1,040	1,150	1,020	941	941	304	383
DC9-10/JT8D-7A	361	366	366	366	366	366	366	366	367	367	367	367
DC9-10/JT8D-7B	3,340	3,530	3,380	3,420	3,360	3,370	3,360	3,270	3,340	3,350	3,240	3,250
DC9-20/JT8D-11	496	0	0	0	0	0	0	0	0	0	0	0
DFL/*	0	3	3	3	3	0	0	0	3	3	3	3
DH1/MDTURB	0	1	1	7	10	10	10	10	9	8	8	11
DH3/MDTURB	0	29	29	34	38	38	36	37	39	39	38	42
DH7/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
DH8/MDTURB	536	498	508	508	540	558	587	591	600	586	599	563
DHB/SMTURB	1	1	1	1	4	4	5	4	4	1	1	1
DHT/SMTURB	75	76	75	74	72	73	74	75	74	72	69	71
DLR-30/CF6-50C	0	286	76	299	241	299	237	189	206	227	335	335
DLR-30/CF6-50C2	0	4,540	4,420	4,510	4,390	5,370	5,000	4,890	4,690	4,660	5,070	4,500
DLR-30/CF6-50C2R	0	847	1,030	907	828	831	1,040	1,040	821	821	813	1,020
DLR-40/JT9D-20	0	1,040	1,010	780	844	964	916	916	1,070	1,040	935	935
DO8/SMTURB	23	23	24	24	26	26	26	27	26	25	25	27
EM2/SMTURB	130	130	133	135	137	139	140	142	144	144	146	145
EMB/SMTURB	41	39	37	37	39	38	31	31	33	34	35	35
F10-100/TAY620-15	189	181	176	177	276	294	277	278	276	266	348	355
F10-100/TAY650-15	1,750	1,810	1,930	1,990	2,200	2,260	2,320	2,490	2,520	2,580	2,760	2,960
F27/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
F28-1000/RR_SPEY-MK555	93	86	88	80	81	78	85	67	63	65	68	67
F28-1000C/RR_SPEY-MK55	4	4	4	4	4	4	4	4	4	4	4	4
F28-2000/RR_SPEY-MK555	13	13	10	13	13	14	15	14	13	12	13	12
F28-3000/RR_SPEY-MK555	4	5	5	5	5	5	5	5	5	5	5	5
F28-4000/RR_SPEY-MK555	710	711	716	699	714	693	672	711	691	664	673	601
F2B/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
F2E/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
F50/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
HEC/SMTURB	0	0	0	1	1	1	1	1	1	1	1	1
HS7/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
I62/SOL	23,600	23,800	23,600	22,700	26,500	23,900	24,800	25,100	21,600	20,600	18,400	18,900
I72/*	0	4,890	4,890	4,620	4,620	4,620	4,620	4,620	4,650	4,970	5,290	5,280
I86/KUZ	19,300	23,500	23,200	24,000	23,400	22,800	23,400	22,900	27,900	24,500	20,700	20,300

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992					Hydrocarbons Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
IL8/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
J31/SMTURB	134	128	130	126	126	133	135	138	137	131	132	132
L10-1/RB211-22B	31,700	33,700	33,300	34,200	33,700	32,900	33,600	33,900	32,200	31,300	27,400	28,700
L10-200/RB211-524B	397	374	386	386	387	376	400	399	401	365	419	419
L10-50/RB211-22B	932	951	951	950	960	1,100	1,130	1,060	1,300	1,270	1,340	1,350
L4T/SMTURB	1	1	1	1	1	1	1	0	0	1	1	1
LLR-500/RB211-524B4	939	961	966	1,010	1,060	1,170	1,240	1,240	1,210	1,080	1,070	1,020
LOE/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
LOF/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
LOH/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
LOM/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
LRJ/*	0	5	5	5	5	3	3	3	2	2	2	2
M1F/*	0	190	190	176	197	210	197	197	194	196	200	200
MDL-11C/CF6-80C2	93	95	95	95	137	137	189	230	225	216	225	225
MDL-11P/CF6-80C2	151	185	265	340	417	443	470	479	479	478	659	648
MDL-11P/PW4460	318	318	358	397	503	587	633	642	631	616	688	694
MRC-100/JT8D-15	45	35	35	55	71	69	55	56	74	64	60	46
MU2/SMTURB	0	1	1	1	1	1	1	1	1	1	1	1
ND2/MDTURB	5	3	3	5	5	4	4	4	7	7	7	4
NDC/*	0	0	0	0	0	0	0	0	0	0	0	1
PA6/SMTURB	0	0	0	0	0	0	0	0	0	0	0	0
PL6/SMTURB	0	0	0	0	0	0	0	0	0	0	0	0
SF3/MDTURB	499	512	516	534	551	547	545	559	567	568	586	578
SFF/MDTURB	0	0	0	0	0	0	0	0	0	1	1	0
SH3/MDTURB	11	12	12	13	16	18	14	15	17	17	19	21
SH6/MDTURB	148	141	139	138	147	143	141	139	131	128	123	116
SWM/SMTURB	115	121	125	123	125	124	123	122	121	122	122	123
T34/SOL	1,460	1,520	1,510	1,490	1,500	1,480	1,460	1,480	1,140	1,140	1,150	1,230
T54/SOL	3,180	3,230	3,140	3,270	3,260	3,180	3,140	3,130	2,600	2,560	2,500	2,460
VC8/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
VCV/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
WWP/*	0	0	0	0	0	0	0	1	1	1	1	1
Y40/IVC	164	161	161	99	187	210	216	195	389	494	420	433
Y42/*	746	759	758	765	767	719	719	695	781	701	800	757

Appendix I. Hydrocarbons Emitted by Airplane Type and Month

	1992					Hydrocarbons Emitted in kilograms/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
YN2/SMTURB	0	0	0	0	0	0	0	0	0	0	0	0
YN7/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
YS1/LGTURB	0	0	0	0	0	0	0	0	0	0	0	0
Total	426,912	538,234	540,505	542,417	545,019	550,650	562,210	561,129	551,753	533,875	528,210	522,327

Appendix J. Distance Flown by Airplane Type and Month

	1992				Distance Flown in Thousands of nautical miles/day							
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
146-100/ALF502R-3	0.0	4.0	4.0	4.6	4.6	4.9	4.9	4.8	4.8	4.5	2.2	2.2
146-100/ALF502R-5	6.4	7.8	8.0	7.1	7.0	7.1	7.0	6.8	6.6	6.8	4.0	4.0
146-200/ALF502R-3	9.4	9.8	8.9	8.3	10.0	9.4	9.6	9.8	9.8	10.1	10.6	10.5
146-200/ALF502R-5	157.4	155.7	160.6	167.4	173.9	178.0	182.8	182.3	168.4	163.1	164.6	153.5
146-300/ALF502R-5	34.7	31.2	31.2	27.2	27.3	27.4	24.6	24.2	24.4	24.3	18.5	16.9
146-300/LF507-1F	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	4.1	4.7	4.3
14F-300QT/ALF502R-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
720-000/JT3C-12	0.0	2.4	2.5	2.1	2.0	3.0	3.2	3.1	2.6	2.7	2.5	2.0
727-100/JT8D-7A	14.7	16.9	16.9	17.4	17.0	14.9	14.9	14.9	13.1	13.1	11.0	10.5
727-100/JT8D-7B	196.1	191.4	196.3	182.3	185.1	193.1	185.5	168.0	171.6	159.7	157.5	146.1
727-100/JT8D-9	6.3	6.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.2
727-100/JT8D-9A	6.9	6.9	6.9	7.8	8.1	8.1	7.5	10.2	7.6	7.6	7.7	7.7
72C-100F/JT8D-7B	0.0	100.2	98.5	97.5	94.4	96.2	95.6	93.3	91.3	91.3	89.0	101.1
72C-100F/JT8D-9A	0.0	1.8	1.8	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
72S-200/JT8D-15	1,612.2	1,451.9	1,501.3	1,404.9	1,463.9	1,528.7	1,549.8	1,553.9	1,412.5	1,374.2	1,344.1	1,371.7
72S-200/JT8D-17	68.2	66.0	66.6	60.0	60.5	68.8	68.6	61.2	41.8	32.1	41.2	39.1
72S-200/JT8D-17R	168.6	166.3	155.6	157.0	146.3	146.2	144.8	140.2	140.9	149.5	141.1	149.4
72S-200/JT8D-7B	0.0	0.0	0.0	2.7	2.7	2.7	2.7	5.9	12.9	12.9	12.9	17.2
72S-200/JT8D-9	0.0	0.0	7.9	7.9	8.5	8.5	8.5	8.4	8.3	9.0	9.4	9.4
72S-200/JT8D-9A	410.9	408.3	409.8	413.4	384.2	403.3	409.5	406.5	393.5	384.1	399.5	410.8
737-100/JT8D-7A	0.0	0.0	8.2	8.2	8.2	10.5	10.5	10.5	8.8	8.8	8.8	8.8
737-200/JT8D-15	673.5	678.4	675.6	709.1	725.2	721.3	706.2	709.5	729.9	729.4	707.6	718.3
737-200/JT8D-15A	276.0	278.7	276.8	260.1	271.2	269.9	264.2	272.5	272.4	275.8	270.7	273.6
737-200/JT8D-17	152.0	145.3	143.1	155.1	155.3	155.0	154.5	165.3	153.6	145.6	156.1	136.7
737-200/JT8D-17A	119.4	120.1	117.7	118.7	118.6	118.8	137.4	143.5	136.9	134.0	135.2	141.6
737-200/JT8D-7B	403.7	408.7	396.8	376.4	387.7	414.3	426.0	433.3	409.2	404.7	426.9	446.7
737-200/JT8D-9	8.8	8.8	8.7	8.7	7.5	7.1	7.5	6.8	6.8	6.8	6.8	6.5
737-200/JT8D-9A	439.7	443.7	439.3	429.1	439.7	448.6	456.4	437.2	440.8	437.9	434.3	435.7
73C-200C/JT8D-15	0.0	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0	0.0	0.0	0.0
73C-200C/JT8D-17	10.6	11.1	11.1	11.1	11.7	14.0	14.0	14.0	10.9	10.6	10.8	11.0
73C-200C/JT8D-17A	12.2	13.1	11.3	12.4	12.5	17.5	17.5	17.0	12.2	12.2	12.1	12.1

Appendix J. Distance Flown by Airplane Type and Month

	1992					Distance Flown in Thousands of nautical miles/day						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
73C-200C/JT8D-9A	5.4	31.7	30.5	29.1	28.5	29.5	29.3	33.5	33.3	33.1	33.9	34.3
73C-200F/JT8D-17	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
73L-500/CFM56-3C	187.1	188.2	202.0	223.7	246.1	266.7	286.3	304.2	338.4	332.3	341.6	361.8
73Y-300/CFM56-3B	1,624.6	1,619.0	1,563.7	1,596.4	1,626.9	1,705.8	1,727.7	1,722.3	1,659.3	1,624.6	1,659.2	1,464.0
73Z-400/CFM56-3B	269.7	265.3	274.7	274.0	283.4	300.9	312.9	303.1	306.2	314.8	318.2	348.2
747-100B/JT9D-7F	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.8
747-100B/RB211-524C2	16.3	19.1	18.3	17.2	17.2	17.6	19.8	19.8	21.1	18.2	19.7	19.7
747-100/JT9D-3A	113.3	63.9	69.5	82.2	76.0	82.5	90.2	90.5	68.4	60.1	71.1	69.2
747-100/JT9D-3AW	5.5	5.5	7.1	8.6	11.2	14.7	14.7	14.3	13.9	7.8	7.1	7.1
747-100/JT9D-7A	931.4	764.1	773.8	758.3	732.9	745.9	782.8	789.9	733.9	690.6	705.6	693.9
747-100/JT9D-7AH	57.3	62.8	67.3	61.2	60.5	81.3	81.9	82.1	67.9	42.1	34.2	46.7
747-200B/CF6-50E2	255.0	274.1	277.1	303.9	318.7	341.9	346.7	324.7	303.2	301.4	270.8	267.8
747-200B/JT9D-7A	8.6	15.8	12.4	11.3	15.5	14.5	15.6	20.9	18.5	17.2	15.1	15.8
747-200B/JT9D-7AW	214.8	188.5	191.5	190.0	182.0	194.6	205.2	207.8	199.1	197.9	194.3	197.5
747-200B/JT9D-7F	42.0	42.0	40.5	42.7	42.2	48.0	48.0	48.0	34.0	30.9	31.7	30.7
747-200B/JT9D-7J	52.8	95.9	94.6	87.5	103.1	111.0	131.5	125.2	102.4	116.4	105.1	98.5
747-200B/JT9D-7Q	175.2	181.8	171.0	174.8	183.8	178.8	183.9	176.7	187.6	150.4	155.9	137.4
747-200B/JT9D-7R4G2	15.6	21.5	21.5	19.6	18.8	20.0	19.3	20.8	24.7	21.5	18.8	19.1
747-200B/JT9D-7W	38.8	39.8	39.8	49.1	51.9	56.8	57.7	57.7	57.7	55.0	46.6	44.9
747-200B/RB211-524C2	60.1	57.5	56.5	52.6	54.9	60.7	60.7	56.9	32.7	33.6	32.0	31.7
747-200B/RB211-524D4	40.8	44.1	54.1	57.2	57.1	57.1	59.2	52.5	54.6	44.9	52.5	53.6
74C-100F/JT9D-7A	0.0	135.3	152.3	145.0	132.3	135.0	128.8	129.5	133.6	134.1	140.2	142.3
74C-200F/CF6-50E2	0.0	60.4	65.0	59.8	57.2	56.0	64.2	81.9	93.7	86.8	108.0	96.6
74C-200F/JT9D-7A	0.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
74C-200F/JT9D-7F	0.0	34.5	34.5	34.2	34.2	34.4	34.4	38.4	38.6	38.3	38.5	35.9
74C-200F/JT9D-7FW	0.0	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
74C-200F/JT9D-7J	0.0	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
74C-200F/JT9D-7Q	0.0	107.6	102.5	105.4	106.1	106.1	106.4	108.5	109.9	116.4	121.3	115.6
74C-200F/RB211-524D4	0.0	21.0	17.1	17.0	17.0	16.6	20.1	20.3	21.6	25.6	23.8	22.4
74I-400/CF6-80C2	143.3	143.4	144.0	136.0	156.0	159.5	163.3	167.1	168.1	168.8	170.7	197.3
74I-400/PW4056	228.0	220.5	235.5	224.7	215.1	244.7	263.3	275.5	285.7	276.8	277.5	293.0

Appendix J. Distance Flown by Airplane Type and Month

	1992	Distance Flown in Thousands of nautical miles/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
74I-400/RB211-524G	116.6	216.7	201.7	240.2	231.9	242.9	253.6	253.3	252.4	240.5	253.9	247.6
74I-400/RB211-524H	63.9	67.5	67.5	72.9	70.2	71.1	71.1	76.2	83.1	81.6	85.5	86.4
74P-SP/JT9D-7A	106.3	110.9	112.1	101.5	107.6	115.2	110.5	111.0	107.3	98.8	91.2	85.4
74P-SP/JT9D-7F	11.5	12.2	12.2	13.4	13.4	11.3	11.9	11.9	11.9	11.9	12.8	12.5
74P-SP/JT9D-7FW	18.7	18.7	16.4	23.1	27.7	21.4	21.2	21.5	21.5	14.9	16.7	17.1
74P-SP/RB211-524C2	0.8	1.8	1.8	0.5	0.5	0.6	1.9	1.9	1.9	1.2	0.6	0.6
74P-SP/RB211-524D4	10.9	10.9	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74Q-200M/CF6-50E2	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74Q-200M/JT9D-7J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	6.7
74U-300/CF6-80C2	21.4	29.9	29.8	29.3	28.2	28.9	27.9	27.9	27.9	27.9	35.8	36.9
74U-300/JT9D-7R4G2	90.4	91.4	95.1	112.6	114.1	116.0	111.3	108.4	95.5	97.3	101.7	92.0
74U-300/RB211-524C2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	19.0	18.8	18.8
74U-300/RB211-524D4	56.2	55.3	53.6	57.2	64.0	56.0	57.0	57.9	57.0	54.1	55.5	57.2
74X-100SR/CF6-45A2	0.0	23.6	23.6	27.6	29.5	28.9	33.2	33.2	26.7	26.7	24.3	21.7
757-200/PW2037	575.4	563.0	609.1	612.4	625.0	641.2	657.1	665.2	645.3	647.6	671.1	695.0
757-200/PW2040	196.5	202.2	220.0	229.6	240.4	244.7	253.3	254.6	248.6	261.9	284.6	289.2
757-200/RB211-535C	70.3	71.3	77.6	67.0	90.7	100.9	109.4	112.6	100.4	101.0	111.7	109.1
757-200/RB211-535E4	131.0	122.6	119.1	108.4	112.0	120.7	129.7	125.7	125.3	118.8	134.4	136.3
75F/*	0.0	43.0	43.0	47.5	56.0	58.0	58.0	58.8	58.0	61.9	60.5	65.0
767-200/CF6-80A	823.8	824.2	813.6	795.0	843.0	873.7	932.9	930.0	904.6	878.4	871.6	879.0
767-200/CF6-80A2	53.3	54.0	54.0	53.3	58.8	54.6	59.1	59.1	60.2	53.6	50.5	51.0
767-200/JT9D-7R4D	236.0	199.9	218.9	199.7	203.7	213.3	217.9	216.8	212.0	202.2	206.5	190.5
76M-300/CF6-80A2	351.0	356.5	359.6	385.0	404.3	492.7	487.7	510.8	525.1	516.0	526.4	524.5
76M-300/CF6-80C2	42.6	39.8	40.2	50.7	50.9	48.8	50.0	49.5	46.6	49.4	52.4	52.7
7IQ-400M/CF6-80C2	47.7	51.4	51.6	72.8	76.3	77.3	79.5	79.5	77.7	73.9	72.1	70.5
7UQ-300M/CF6-50E2	23.3	33.6	33.6	29.8	26.7	30.1	25.2	28.7	26.6	22.5	23.6	24.9
7UQ-300M/CF6-80C2	7.0	7.2	7.2	8.2	9.0	9.2	9.0	9.0	9.0	9.0	7.2	7.2
7UQ-300M/JT9D-7R4G2	33.0	32.0	32.5	39.2	31.8	41.1	39.7	39.0	41.0	38.0	33.8	31.8
A0CC4-200/CF6-50C2	0.0	5.4	5.4	4.9	4.9	4.9	4.9	4.9	6.2	6.2	6.2	5.4
A30B2-100/CF6-50C	24.4	27.1	25.3	25.0	23.7	24.4	24.4	24.4	23.8	23.8	24.4	24.4
A30B2-100/CF6-50C2R	285.2	226.7	232.6	234.7	243.0	241.0	227.1	233.0	239.4	229.9	234.6	211.5

Appendix J. Distance Flown by Airplane Type and Month

	1992	Distance Flown in Thousands of nautical miles/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A30B2-200/CF6-50C2	12.9	16.9	16.9	12.8	13.5	9.2	9.2	9.2	9.2	14.3	14.3	15.1
A30B2-200/CF6-50C2R	45.5	42.7	46.6	45.1	44.4	48.8	57.9	50.9	56.3	56.9	53.1	56.2
A30B4-100/CF6-50C2	100.2	41.2	41.4	47.2	47.7	47.0	50.7	49.9	46.6	46.1	41.1	41.8
A30B4-100/JT9D-59A	17.2	19.4	16.2	19.4	19.4	19.4	26.5	26.3	26.5	19.3	17.3	17.1
A30B4-200/CF6-50C2	185.6	175.9	175.0	186.6	189.6	202.2	206.8	203.2	195.2	184.9	189.8	187.5
A30B4-200/JT9D-59A	68.5	35.5	35.5	37.6	38.4	38.4	38.4	35.8	35.7	35.3	30.0	30.8
A31-200/CF6-80A3	322.8	276.2	267.6	299.8	291.3	325.1	335.8	333.2	334.8	321.8	311.0	299.9
A31-200/CF6-80C2A2	8.7	6.2	6.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
A31-200/JT9D-7R4D1	30.7	16.5	17.9	18.1	19.3	21.0	19.5	21.4	18.4	19.9	16.7	12.4
A31-200/JT9D-7R4E1	168.2	139.9	139.9	146.8	144.6	150.9	148.8	150.1	140.6	142.7	132.7	137.6
A32-100/CFM56-5A1	16.7	16.8	16.9	19.4	21.5	21.5	16.6	20.6	20.3	20.1	20.2	19.8
A32-200/CFM56-5A1	348.2	364.6	375.4	425.0	461.6	473.0	491.5	505.8	498.2	520.2	511.5	492.2
A32-200/CFM56-5A3	13.2	15.2	15.2	15.2	15.2	17.4	21.8	21.8	21.2	24.0	27.1	27.8
A32-200/V2500-A1	116.6	130.3	130.9	151.5	154.1	170.9	185.1	183.2	173.2	174.9	185.0	184.2
A34/*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4
A36-600/CF6-80C2A1	0.0	32.9	32.9	38.9	38.9	41.3	41.3	43.2	43.2	43.2	42.9	42.5
A36-600/JT9D-7R4H1	0.0	64.4	59.8	63.9	64.3	64.4	65.6	69.1	65.4	64.5	73.1	75.4
A36-600/PW4158	0.0	27.4	27.2	29.3	29.0	28.7	27.6	26.3	27.5	27.4	28.7	28.6
A3L-300/CF6-80C2	0.0	0.0	0.0	0.0	0.0	3.1	3.1	3.1	3.1	3.1	3.1	3.1
A3L-300/CF6-80C2A2	0.0	38.6	39.5	39.6	39.9	40.3	43.0	42.5	38.4	38.2	36.1	36.4
A3L-300/CF6-80C2A8	0.0	14.4	14.8	14.4	14.4	15.1	18.9	28.2	29.2	29.2	27.7	31.8
A3L-300/JT9D-7R4E1	0.0	12.9	12.9	12.1	14.0	14.8	10.5	14.8	12.2	12.3	14.5	11.8
A3L-300/PW4152	0.0	40.4	41.2	46.4	47.4	46.9	46.2	46.6	46.6	46.6	48.8	47.0
AN4/LGTURB	31.4	32.1	20.5	20.8	21.5	23.0	25.5	24.5	29.5	30.7	28.9	27.2
AT4/LGTURB	0.0	17.9	19.2	26.9	28.5	29.3	28.9	30.4	29.7	29.2	22.7	25.5
AT7/LGTURB	39.2	41.4	43.3	49.9	52.8	50.2	50.6	54.9	60.1	59.0	56.7	60.3
ATP/LGTURB	32.3	32.1	31.6	29.8	34.1	34.6	35.3	35.5	39.1	37.8	37.9	34.2
ATR/LGTURB	218.0	188.3	188.3	187.7	193.0	201.0	204.8	195.0	203.6	199.0	216.9	218.7
B3C-320CH/JT3D-3B	0.0	102.0	104.1	103.0	110.4	108.3	108.3	108.1	109.1	102.1	103.8	109.6
B3C-320C/JT3D-3B	0.0	11.7	11.0	11.0	9.7	9.7	9.7	9.7	9.7	9.7	9.5	9.0
B3F-320B/JT3D	1.6	1.6	1.6	3.4	3.4	1.9	0.0	0.0	0.0	0.0	0.0	0.0

Appendix J. Distance Flown by Airplane Type and Month

	1992	Distance Flown in Thousands of nautical miles/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
B3F-320B/JT3D-3B	69.5	68.2	64.5	63.9	59.7	53.9	49.3	48.4	47.2	43.7	41.4	27.7
BAC-200/RR_SPEY-506	0.0	0.0	1.8	1.8	1.8	2.0	2.0	3.3	1.2	1.0	1.2	1.2
BAC-200/RR_SPEY-511	1.0	19.2	2.3	2.5	2.5	2.5	4.1	2.8	2.8	2.6	2.6	2.9
BAC-500/RR_SPEY-512	76.1	76.5	76.7	75.6	90.4	89.6	90.6	85.0	84.6	75.1	67.8	62.8
BE1/SMTURB	233.0	244.3	231.5	229.2	232.8	242.2	249.8	256.0	250.1	256.1	268.3	272.2
BE9/SMTURB	33.6	31.2	24.1	23.5	23.2	26.6	26.4	24.8	24.2	27.0	25.9	25.4
BEK/SMTURB	0.0	20.5	22.4	20.0	18.3	20.1	19.7	19.5	19.7	21.1	20.5	21.4
CD2/SMTURB	1.7	2.4	2.2	1.6	2.9	2.9	4.6	1.7	1.7	0.9	0.9	0.9
CL4/LGTURB	0.0	6.8	6.8	6.8	6.8	6.8	6.8	6.8	7.7	1.1	1.1	1.1
CNC/SMTURB	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.7	1.7	1.7	1.4
CNJ/*	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
CNN/SMTURB	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
CRJ/*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	8.9
CS5/LGTURB	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
CV5/LGTURB	0.0	0.4	0.4	1.5	1.5	1.5	1.8	1.4	1.4	1.5	2.8	2.8
CV6/LGTURB	0.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	2.5	2.5	2.5	2.5
CVF/LGTURB	0.0	5.0	4.9	4.9	5.1	5.3	5.5	5.5	5.7	6.1	6.3	6.0
CVL-10B/JT8D-7	2.0	1.4	1.4	1.3	1.3	1.1	1.8	2.4	2.5	2.5	2.5	2.5
CVL-12/JT8D-9	2.3	2.2	2.2	2.2	2.5	2.9	1.1	1.1	0.8	0.8	0.4	0.4
D10-10/CF6-6D	1,235.5	948.0	986.1	967.7	965.3	982.0	1,014.9	1,007.0	938.6	943.6	943.1	955.7
D10-15/CF6-50C2F	47.4	18.3	18.3	18.2	16.3	19.6	22.0	22.0	17.6	13.3	22.4	22.4
D1C-10F/CF6-6D	0.0	69.2	69.1	70.2	72.2	67.1	71.2	70.7	74.8	73.5	74.1	74.1
D8C-33F/JT4A-11	0.0	244.5	240.0	253.8	243.9	249.0	249.9	249.5	256.7	251.5	262.7	265.1
D8S-62H/JT3D-3B	9.8	12.5	12.5	8.7	8.7	8.7	10.3	10.6	8.1	8.1	8.1	10.7
D8S-62H/JT3D-7	5.0	7.6	7.8	7.8	6.6	9.7	7.7	8.4	8.4	10.3	9.4	8.3
D8S-63H/JT3D-7	1.6	6.9	6.7	6.7	6.7	6.7	6.8	7.9	4.7	5.7	6.1	6.4
D8S-73F/CFM56-2C	13.3	10.9	12.7	10.1	10.6	10.6	10.6	10.0	9.5	9.5	9.5	9.4
D9C-30C/JT8D-9A	0.0	2.3	0.0	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
D9C-30F/JT8D-7B	0.0	38.5	40.8	43.0	41.5	40.9	41.1	42.1	40.6	40.6	40.6	40.6
D9M-87/JT8D-217	106.0	134.1	138.9	162.1	164.5	163.5	157.6	148.7	165.3	164.2	170.7	170.1
D9M-87/JT8D-219	0.0	0.6	0.6	2.3	2.3	2.4	2.5	2.6	2.3	0.7	3.3	5.8

Appendix J. Distance Flown by Airplane Type and Month

	1992				Distance Flown in Thousands of nautical miles/day							
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
D9S-30/JT8D-17	43.5	35.6	35.8	36.6	36.6	38.7	49.7	49.7	46.8	45.1	47.2	46.4
D9S-30/JT8D-7B	619.7	549.3	549.0	517.7	513.9	523.9	530.6	530.1	500.4	490.3	474.2	451.6
D9S-30/JT8D-9A	235.4	233.7	236.0	238.5	237.5	252.4	255.1	238.3	240.3	237.1	229.4	241.3
D9S-40/JT8D-11	53.1	51.5	49.2	52.5	52.8	53.0	42.6	47.4	46.9	46.8	55.3	49.9
D9S-40/JT8D-15	33.2	37.2	35.8	37.4	35.3	24.4	31.3	36.3	36.6	37.7	35.4	33.9
D9X-50/JT8D-17	0.0	66.2	66.3	66.8	62.8	64.2	63.2	62.0	69.0	68.4	70.9	70.2
D9Z-81/JT8D-209	187.1	188.4	186.1	181.3	186.1	186.9	185.8	186.1	182.7	181.7	178.3	172.7
D9Z-81/JT8D-217	116.1	89.4	92.2	96.9	96.6	97.3	88.7	83.7	95.2	92.6	94.5	99.0
D9Z-82/JT8D-217	1,228.3	1,087.4	1,205.0	1,176.6	1,238.5	1,331.8	1,328.2	1,354.6	1,332.6	1,350.7	1,389.3	1,393.9
D9Z-82/JT8D-217C	41.1	41.1	41.1	47.1	47.1	47.4	49.1	46.9	47.6	46.4	38.3	38.4
D9Z-82/JT8D-219	33.5	33.1	33.1	34.8	34.5	32.9	32.1	33.4	50.1	50.1	51.5	51.6
D9Z-83/JT8D-219	131.3	134.9	135.3	145.4	153.4	163.5	188.2	190.5	176.1	203.6	176.9	191.9
D9Z-88/JT8D-217	10.8	10.8	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D9Z-88/JT8D-219	269.5	273.4	276.9	284.4	294.3	297.0	297.6	297.7	300.3	300.0	306.1	307.1
DC8/*	9.2	9.4	8.2	9.6	9.7	11.8	14.0	13.3	8.5	8.5	3.5	4.2
DC9-10/JT8D-7A	34.4	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.1	34.1	34.1	34.1
DC9-10/JT8D-7B	217.6	238.6	222.4	225.2	220.7	227.5	228.4	224.4	230.4	229.6	218.3	220.1
DC9-20/JT8D-11	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DFL/*	0.2	1.2	1.2	1.2	1.2	0.2	0.2	0.2	1.4	1.4	1.4	1.4
DH1/MDTURB	0.0	0.4	0.4	4.0	5.8	5.4	5.4	5.4	5.2	4.2	4.2	6.4
DH3/MDTURB	0.0	19.7	19.7	22.2	24.7	24.9	23.5	24.1	24.8	25.5	24.3	25.7
DH7/LGTURB	55.7	50.6	53.2	49.8	49.2	53.1	51.6	51.6	50.5	48.2	46.0	49.5
DH8/MDTURB	324.9	299.8	305.7	303.5	322.5	334.7	353.9	357.3	362.9	353.4	361.8	339.6
DHB/SMTURB	2.5	2.5	2.5	2.5	8.4	8.4	10.4	8.7	7.4	2.6	2.6	2.6
DHT/SMTURB	108.7	110.2	106.2	103.2	101.0	102.4	102.9	103.6	102.4	100.1	96.5	99.6
DLR-30/CF6-50C	0.0	11.3	3.1	12.2	10.0	12.2	10.0	7.4	2.1	1.4	5.1	5.1
DLR-30/CF6-50C2	0.0	144.8	140.4	142.4	139.3	174.8	162.3	159.3	152.8	152.7	165.2	148.4
DLR-30/CF6-50C2R	0.0	18.7	21.9	20.5	19.0	19.2	23.2	23.2	18.8	18.8	18.7	22.6
DLR-40/JT9D-20	0.0	70.8	69.0	56.3	61.5	60.8	59.3	59.3	63.9	61.6	54.3	54.3
DO8/SMTURB	40.0	40.0	41.1	41.0	43.7	43.6	43.7	45.0	44.9	43.9	42.0	45.7
EM2/SMTURB	317.1	313.8	320.5	323.8	332.1	340.9	346.1	351.1	355.2	354.0	358.5	358.0

Appendix J. Distance Flown by Airplane Type and Month

	1992				Distance Flown in Thousands of nautical miles/day							
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
EMB/SMTURB	84.7	80.4	76.9	76.6	80.8	78.6	61.8	63.4	67.2	68.2	70.6	71.5
F10-100/TAY620-15	19.0	18.3	18.0	18.0	29.9	31.0	30.0	30.1	29.7	27.5	34.9	34.9
F10-100/TAY650-15	131.2	136.6	144.9	149.6	167.3	172.3	176.7	189.3	189.7	192.4	204.0	219.0
F27/LGTURB	127.5	129.5	128.3	120.9	120.1	120.9	120.7	121.8	120.5	114.3	106.7	103.4
F28-1000C/RR_SPEY-MK	1.3	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
F28-1000/RR_SPEY-MK5	29.5	27.1	28.0	26.1	26.1	25.1	27.4	20.8	19.3	20.3	20.9	20.8
F28-2000/RR_SPEY-MK5	3.1	3.1	2.6	3.1	3.2	3.4	3.7	3.4	3.2	2.7	3.0	2.9
F28-3000/RR_SPEY-MK5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.9
F28-4000/RR_SPEY-MK5	230.0	229.2	230.1	223.8	227.4	220.8	215.3	227.1	223.2	214.3	214.9	191.2
F2B/LGTURB	0.0	1.8	1.8	2.0	2.2	2.2	2.2	1.8	1.7	1.7	1.7	1.7
F2E/LGTURB	0.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.1	1.4
F50/LGTURB	119.1	117.3	124.1	132.6	140.0	146.2	136.0	142.9	144.7	142.2	147.0	142.8
HEC/SMTURB	0.1	0.1	0.1	0.6	0.6	1.0	1.0	1.0	1.0	0.6	0.4	0.4
HS7/LGTURB	41.4	43.4	42.9	42.0	40.7	43.0	43.9	43.6	42.3	42.8	41.0	40.7
I62/SOL	187.8	184.1	182.9	178.4	208.0	186.4	192.4	195.6	168.6	159.8	145.0	147.8
I72/*	0.0	23.6	23.6	22.5	22.5	22.5	22.5	22.5	22.6	24.1	25.5	26.3
I86/KUZ	88.9	111.2	109.6	113.8	110.2	107.8	110.9	108.4	136.2	120.7	102.8	102.7
IL8/LGTURB	4.4	4.4	3.2	2.4	1.9	1.9	1.9	1.9	0.8	0.8	0.3	0.8
J31/SMTURB	275.5	266.5	270.6	259.3	260.4	273.3	277.1	283.3	280.3	267.3	270.1	267.4
L10-1/RB211-22B	308.5	328.3	319.6	336.0	349.3	350.3	355.1	356.7	335.4	321.2	269.4	265.1
L10-200/RB211-524B	37.1	34.7	35.6	35.1	35.4	34.3	37.0	36.9	37.0	34.2	40.2	40.2
L10-50/RB211-22B	17.0	17.0	17.0	16.9	17.0	19.5	20.2	18.8	23.3	20.8	22.1	23.7
L4T/SMTURB	1.6	1.5	1.4	1.4	1.8	1.7	1.4	1.1	1.1	1.2	1.8	2.6
LLR-500/RB211-524B4	185.2	186.6	187.9	197.0	209.0	230.4	242.4	241.7	237.2	213.7	209.0	196.1
LOE/LGTURB	13.9	11.3	6.6	4.2	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
LOF/LGTURB	0.0	11.7	11.7	12.1	15.1	16.5	15.1	15.2	14.8	12.6	13.5	13.2
LOH/LGTURB	0.9	3.4	2.9	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.7
LOM/LGTURB	1.2	1.2	1.4	1.4	1.4	1.2	1.2	1.2	1.0	1.0	0.6	0.6
LRJ/*	0.0	2.4	2.4	2.4	2.4	1.3	1.3	1.3	0.7	0.7	0.7	0.7
M1F/*	0.0	18.3	18.3	16.6	20.6	20.8	20.5	20.5	20.4	21.1	19.9	19.9
MDL-11C/CF6-80C2	11.6	11.7	11.7	11.7	16.8	16.8	24.4	29.4	29.3	27.5	29.3	29.3

Appendix J. Distance Flown by Airplane Type and Month

	1992	Distance Flown in Thousands of nautical miles/day										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
MDL-11P/CF6-80C2	22.1	22.4	27.0	38.4	44.0	45.6	50.8	51.7	51.7	49.9	71.4	70.9
MDL-11P/PW4460	112.1	107.7	120.6	131.7	163.8	192.9	208.9	209.4	206.1	200.7	221.2	223.5
MRC-100/JT8D-15	7.0	5.6	5.6	8.4	11.0	10.7	8.6	8.8	11.7	10.0	9.5	7.4
MU2/SMTURB	0.0	2.6	2.6	2.6	3.2	2.3	2.3	2.2	2.2	2.2	1.8	1.8
ND2/MDTURB	2.4	1.6	1.6	2.7	2.5	2.0	1.9	1.8	3.5	3.4	3.1	1.9
NDC/*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
PA6/SMTURB	0.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
PL6/SMTURB	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
SF3/MDTURB	314.0	318.7	320.4	331.8	342.2	339.9	342.8	350.1	356.7	356.8	368.7	362.4
SFF/MDTURB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.7	0.2
SH3/MDTURB	6.0	6.4	6.8	7.1	8.7	9.5	7.6	8.0	9.0	9.4	10.1	11.2
SH6/MDTURB	81.8	78.4	77.4	76.8	81.2	79.0	77.6	76.9	72.3	70.5	67.2	63.5
SWM/SMTURB	241.6	261.0	268.4	268.7	274.5	268.3	268.3	264.8	264.2	265.6	266.3	269.2
T34/SOL	127.8	132.4	132.5	130.2	130.5	127.9	126.0	127.7	99.5	101.2	102.3	107.9
T54/SOL	560.0	568.5	553.5	574.7	573.3	558.0	553.4	550.9	462.1	454.9	444.4	438.0
VC8/LGTURB	0.0	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
VCV/LGTURB	6.9	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
WWP/*	1.9	2.2	2.2	2.2	2.2	2.2	2.2	2.7	3.0	2.8	2.9	3.3
Y40/IVC	6.9	6.8	6.8	4.8	8.1	9.2	9.4	8.6	14.2	22.0	17.3	18.8
Y42/*	48.5	48.9	48.8	49.1	49.4	46.1	46.1	44.9	52.2	46.6	53.0	50.7
YN2/SMTURB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.7	0.7	0.7
YN7/LGTURB	27.6	29.6	19.1	18.5	18.5	18.7	18.7	18.8	18.8	19.9	10.1	8.1
YS1/LGTURB	32.3	36.9	36.5	36.9	37.6	35.6	36.1	36.2	34.5	33.8	34.1	33.8
Concorde	20.7	21.3	20.2	21.0	21.0	21.0	21.0	15.9	17.9	21.0	21.0	13.4
Total	23,966.0	24,781.1	24,996.8	25,202.3	25,835.2	26,748.8	27,235.0	27,325.6	26,656.2	26,191.8	26,321.1	26,127.1

Appendix K. Daily Departures by Aircraft Type and Month

	1992				Daily Departures							
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
146-100/ALF502R-3	0	12	12	13	13	13	13	12	13	12	6	6
146-100/ALF502R-5	15	17	18	14	14	15	14	14	14	14	9	9
146-200/ALF502R-3	45	46	45	42	47	45	48	49	49	51	43	41
146-200/ALF502R-5	499	503	523	549	567	582	589	588	537	524	526	506
146-300/ALF502R-5	138	131	131	122	122	122	113	111	113	112	80	76
146-300/LF507-1F	3	3	3	3	3	3	3	3	3	7	8	8
14F-300QT/ALF502R-5	0	1	1	1	1	1	1	1	1	1	1	1
720-000/JT3C-12	0	5	6	6	5	7	7	7	7	7	6	5
727-100/JT8D-7A	51	55	55	56	55	50	50	50	44	44	38	36
727-100/JT8D-7B	515	504	511	492	504	516	454	418	427	397	390	374
727-100/JT8D-9	15	17	9	9	9	9	9	9	9	9	9	9
727-100/JT8D-9A	31	31	31	32	32	32	30	34	31	31	32	32
72C-100F/JT8D-7B	0	190	186	186	181	183	185	182	181	180	172	193
72C-100F/JT8D-9A	0	2	2	3	3	3	3	3	3	3	3	3
72S-200/JT8D-15	2,764	2,507	2,584	2,422	2,548	2,647	2,674	2,660	2,528	2,472	2,420	2,412
72S-200/JT8D-17	103	102	104	95	96	106	105	93	64	52	65	60
72S-200/JT8D-17R	290	282	270	272	266	264	249	244	263	261	257	263
72S-200/JT8D-7B	0	0	0	5	5	5	5	10	21	21	21	37
72S-200/JT8D-9	0	0	13	13	15	15	14	15	15	15	16	16
72S-200/JT8D-9A	661	663	667	694	665	708	720	703	705	686	703	723
737-100/JT8D-7A	0	0	20	20	20	22	22	22	20	20	20	20
737-200/JT8D-15	1,811	1,826	1,801	1,889	1,910	1,905	1,833	1,840	1,928	1,957	1,915	1,923
737-200/JT8D-15A	648	645	632	584	639	646	628	644	638	645	625	621
737-200/JT8D-17	483	481	472	492	495	505	500	527	498	469	493	467
737-200/JT8D-17A	299	300	296	276	278	278	305	324	313	308	312	321
737-200/JT8D-7B	976	1,010	965	938	985	1,040	1,069	1,078	1,043	1,023	1,062	1,105
737-200/JT8D-9	27	27	26	26	24	22	23	21	21	21	21	20
737-200/JT8D-9A	1,365	1,376	1,347	1,289	1,342	1,394	1,406	1,362	1,371	1,351	1,321	1,322
73C-200C/JT8D-15	0	5	5	5	5	5	5	0	0	0	0	0
73C-200C/JT8D-17	34	35	36	36	39	42	42	42	38	37	38	38
73C-200C/JT8D-17A	33	33	30	32	31	48	49	48	37	37	37	37

Appendix K. Daily Departures by Aircraft Type and Month

	1992					Daily Departures						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
73C-200C/JT8D-9A	12	82	79	75	74	76	76	88	88	86	86	87
73C-200F/JT8D-17	0	4	4	4	4	4	4	4	4	4	4	4
73L-500/CFM56-3C	527	545	581	641	679	735	758	803	834	829	873	898
73Y-300/CFM56-3B	3,105	3,068	3,008	3,036	3,099	3,124	3,168	3,145	3,083	3,077	3,179	2,841
73Z-400/CFM56-3B	664	657	667	665	690	743	756	749	751	754	765	799
747-100/JT9D-3A	40	25	26	28	31	33	35	35	30	26	32	33
747-100/JT9D-3AW	4	4	5	6	7	10	10	9	9	6	5	5
747-100/JT9D-7A	317	292	296	287	275	276	295	296	278	258	268	260
747-100/JT9D-7AH	20	25	27	23	22	27	27	28	23	13	14	19
747-100B/JT9D-7F	2	2	2	2	2	2	2	2	2	2	2	1
747-100B/RB211-524C2	11	17	16	18	18	19	20	20	21	18	19	19
747-200B/CF6-50E2	140	151	155	160	162	177	183	174	164	163	145	143
747-200B/JT9D-7A	6	9	8	7	10	9	9	10	9	8	8	9
747-200B/JT9D-7AW	130	70	72	71	65	68	74	76	76	74	71	72
747-200B/JT9D-7F	14	14	13	14	14	16	16	16	11	10	10	10
747-200B/JT9D-7J	14	26	24	22	27	29	35	34	27	31	26	24
747-200B/JT9D-7Q	71	82	78	84	86	82	82	78	85	71	74	67
747-200B/JT9D-7R4G2	5	8	8	7	7	7	7	8	8	8	7	7
747-200B/JT9D-7W	12	15	15	16	17	18	18	18	18	18	16	15
747-200B/RB211-524C2	37	39	38	34	36	37	37	36	19	19	18	18
747-200B/RB211-524D4	15	17	20	21	21	21	21	20	21	18	18	18
74C-100F/JT9D-7A	0	65	72	71	65	65	63	63	65	67	70	71
74C-200F/CF6-50E2	0	25	27	24	24	24	26	33	37	35	42	39
74C-200F/JT9D-7A	0	7	7	7	7	7	7	7	7	7	7	7
74C-200F/JT9D-7F	0	19	19	18	18	18	18	20	20	20	20	19
74C-200F/JT9D-7FW	0	1	1	1	1	1	1	1	1	1	1	1
74C-200F/JT9D-7J	0	6	6	6	6	6	6	6	6	6	6	6
74C-200F/JT9D-7Q	0	42	41	42	42	42	43	43	44	46	47	45
74C-200F/RB211-524D4	0	12	10	10	10	10	11	11	12	14	13	12
74I-400/CF6-80C2	51	60	61	55	64	65	71	75	77	78	76	86
74I-400/PW4056	68	69	74	70	64	71	77	80	81	78	81	84

Appendix K. Daily Departures by Aircraft Type and Month

	1992					Daily Departures						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
74I-400/RB211-524G	36	67	63	77	73	78	79	79	79	75	81	79
74I-400/RB211-524H	23	24	24	30	27	27	27	28	30	29	32	32
74P-SP/JT9D-7A	39	40	45	38	38	44	43	43	42	40	39	37
74P-SP/JT9D-7F	6	7	7	7	7	6	7	7	7	7	7	6
74P-SP/JT9D-7FW	5	6	5	8	11	8	8	8	8	5	6	6
74P-SP/RB211-524C2	1	2	2	1	1	1	4	4	4	3	1	1
74P-SP/RB211-524D4	3	3	3	0	0	0	0	0	0	0	0	0
74Q-200M/CF6-50E2	0	0	0	1	0	0	0	0	0	0	0	0
74Q-200M/JT9D-7J	0	0	0	0	0	0	0	0	0	0	3	3
74U-300/CF6-80C2	7	12	12	12	12	11	11	11	11	10	15	15
74U-300/JT9D-7R4G2	36	38	39	45	46	47	45	45	42	43	41	39
74U-300/RB211-524C2	0	0	0	0	0	0	0	0	17	17	16	16
74U-300/RB211-524D4	23	25	24	28	30	28	27	27	27	26	28	29
74X-100SR/CF6-45A2	0	52	52	54	58	58	60	60	51	51	51	46
757-200/PW2037	637	645	693	690	697	699	712	716	727	737	744	768
757-200/PW2040	180	178	198	206	211	218	228	230	238	255	285	280
757-200/RB211-535C	172	178	180	144	194	192	184	200	187	186	196	174
757-200/RB211-535E4	118	115	121	111	113	122	135	132	128	128	150	143
75F/*	0	69	69	72	80	86	86	86	86	88	87	83
767-200/CF6-80A	585	613	608	600	607	622	661	658	661	637	634	623
767-200/CF6-80A2	63	65	65	65	63	61	63	63	65	61	62	62
767-200/JT9D-7R4D	165	152	165	154	154	157	150	149	158	146	150	143
76M-300/CF6-80A2	203	206	214	220	230	266	270	279	286	282	291	280
76M-300/CF6-80C2	90	91	93	122	122	116	120	117	115	122	129	131
7IQ-400M/CF6-80C2	14	17	18	27	28	28	29	29	29	28	29	28
7UQ-300M/CF6-50E2	7	15	15	14	13	14	13	15	14	11	12	12
7UQ-300M/CF6-80C2	4	4	4	4	4	5	4	4	4	4	4	4
7UQ-300M/JT9D-7R4G2	13	13	13	16	14	16	16	15	16	14	14	13
A0CC4-200/CF6-50C2	0	4	4	3	3	3	3	3	4	4	4	3
A30B2-100/CF6-50C	39	43	41	39	37	39	39	39	37	37	39	39
A30B2-100/CF6-50C2R	410	349	344	325	356	356	320	321	363	339	343	278

Appendix K. Daily Departures by Aircraft Type and Month

	1992					Daily Departures						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A30B2-200/CF6-50C2	28	36	36	28	29	21	21	21	21	30	30	33
A30B2-200/CF6-50C2R	96	90	99	93	92	103	125	107	122	124	115	121
A30B4-100/CF6-50C2	189	110	111	119	119	114	129	133	116	117	113	114
A30B4-100/JT9D-59A	23	25	23	31	31	31	41	34	41	31	23	23
A30B4-200/CF6-50C2	243	232	232	248	248	250	253	236	241	232	237	231
A30B4-200/JT9D-59A	85	57	57	60	60	60	60	56	56	55	47	49
A31-200/CF6-80A3	325	292	285	287	289	310	320	319	315	305	296	299
A31-200/CF6-80C2A2	12	6	6	10	10	10	10	10	10	10	10	10
A31-200/JT9D-7R4D1	50	36	40	39	42	42	36	42	37	41	36	27
A31-200/JT9D-7R4E1	110	88	88	88	87	91	90	90	86	88	83	88
A32-100/CFM56-5A1	36	37	37	33	39	39	29	37	37	36	37	35
A32-200/CFM56-5A1	702	733	743	775	860	885	863	880	897	925	931	854
A32-200/CFM56-5A3	16	22	22	22	22	27	34	35	34	42	46	47
A32-200/V2500-A1	174	219	227	252	259	280	289	288	277	278	294	292
A34/*	0	0	0	0	0	0	0	0	1	1	1	1
A36-600/CF6-80C2A1	0	32	32	40	40	43	43	45	45	45	39	39
A36-600/JT9D-7R4H1	0	75	69	73	75	63	64	75	63	64	79	81
A36-600/PW4158	0	53	53	50	50	49	44	47	67	70	68	67
A3L-300/CF6-80C2	0	0	0	0	0	2	2	2	2	2	2	2
A3L-300/CF6-80C2A2	0	43	44	35	35	35	36	36	34	34	32	33
A3L-300/CF6-80C2A8	0	10	10	9	9	10	13	19	19	19	17	21
A3L-300/JT9D-7R4E1	0	9	9	8	9	10	7	10	8	9	10	8
A3L-300/PW4152	0	33	34	38	39	38	37	37	37	37	41	40
AN4/LGTURB	147	150	110	109	115	127	134	130	157	159	145	134
AT4/LGTURB	0	121	129	182	189	199	196	215	204	216	172	191
AT7/LGTURB	246	263	273	313	330	308	316	354	371	368	346	364
ATP/LGTURB	239	242	237	225	252	257	262	260	267	254	249	233
ATR/LGTURB	1,355	1,160	1,163	1,148	1,177	1,212	1,236	1,175	1,212	1,170	1,282	1,302
B3C-320C/JT3D-3B	0	10	10	9	6	6	6	6	6	6	6	5
B3C-320CH/JT3D-3B	0	95	95	95	93	90	90	90	91	88	89	93
B3F-320B/JT3D	1	1	1	2	2	2	0	0	0	0	0	0

Appendix K. Daily Departures by Aircraft Type and Month

	1992	Daily Departures										
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
B3F-320B/JT3D-3B	74	71	70	66	63	53	51	49	48	46	45	29
BAC-200/RR_SPEY-506	0	0	5	5	5	6	6	8	3	3	3	3
BAC-200/RR_SPEY-511	4	7	7	9	9	9	15	11	11	10	10	12
BAC-500/RR_SPEY-512	208	212	212	203	241	239	243	231	230	208	189	174
BE1/SMTURB	1,700	1,773	1,693	1,695	1,733	1,800	1,835	1,880	1,839	1,887	1,975	1,985
BE9/SMTURB	286	268	220	216	218	248	247	238	233	247	239	236
BEK/SMTURB	0	116	125	120	104	115	109	112	111	122	122	136
CD2/SMTURB	24	38	34	29	36	36	47	26	25	18	18	18
CL4/LGTURB	0	5	5	5	5	5	5	5	6	2	2	2
CNC/SMTURB	0	4	4	4	4	4	4	4	6	6	6	5
CNJ/*	1	1	1	1	1	1	1	1	1	1	1	1
CNN/SMTURB	0	10	10	10	10	10	10	10	10	10	10	10
CONCORDE	7	7	7	7	7	7	7	5	6	7	7	4
CRJ/*	0	0	0	0	0	0	0	0	0	0	9	17
CS5/LGTURB	50	50	50	50	50	50	50	50	50	50	50	50
CV5/LGTURB	0	2	2	6	6	6	7	5	5	6	9	9
CV6/LGTURB	0	10	9	8	9	9	9	9	16	16	16	16
CVF/LGTURB	0	14	14	14	15	17	18	18	19	21	22	20
CVL-10B/JT8D-7	5	3	3	3	3	3	3	4	4	4	4	4
CVL-12/JT8D-9	5	4	4	4	5	6	3	3	2	2	1	1
D10-10/CF6-6D	701	629	646	639	629	633	652	653	613	621	627	621
D10-15/CF6-50C2F	42	21	21	19	16	20	23	23	20	16	23	23
D1C-10F/CF6-6D	0	45	45	47	50	46	49	50	49	46	47	47
D8C-33F/JT4A-11	0	260	257	269	257	262	268	268	271	266	279	281
D8F-51/JT3D	0	0	0	0	0	0	0	0	0	0	0	0
D8S-62H/JT3D-3B	8	11	11	8	8	8	8	9	7	7	7	10
D8S-62H/JT3D-7	3	5	5	5	4	5	4	4	4	5	5	4
D8S-63H/JT3D-7	1	4	4	4	4	4	4	5	3	3	4	5
D8S-73F/CFM56-2C	9	7	7	6	6	6	6	6	5	5	5	5
D9C-30C/JT8D-9A	0	7	0	0	7	7	7	7	7	7	7	7
D9C-30F/JT8D-7B	0	90	97	102	94	91	91	92	93	92	92	92

Appendix K. Daily Departures by Aircraft Type and Month

OAG Airplane/engine	1992 Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						Daily Departures						
D9M-87/JT8D-217	203	278	289	348	357	354	335	325	367	362	375	373
D9M-87/JT8D-219	0	1	1	3	3	3	4	4	4	3	9	13
D9S-30/JT8D-17	102	93	93	94	94	91	118	118	116	114	121	120
D9S-30/JT8D-7B	1,758	1,576	1,577	1,485	1,437	1,467	1,473	1,480	1,427	1,400	1,354	1,295
D9S-30/JT8D-9A	705	704	708	718	715	750	765	700	702	672	636	656
D9S-40/JT8D-11	169	164	160	165	166	168	136	151	146	140	164	145
D9S-40/JT8D-15	129	142	137	140	137	94	118	135	135	139	136	130
D9X-50/JT8D-17	0	164	164	172	170	176	174	168	156	157	162	183
D9Z-81/JT8D-209	420	415	416	390	427	432	430	430	428	430	405	396
D9Z-81/JT8D-217	349	238	248	260	255	257	232	233	260	256	269	279
D9Z-82/JT8D-217	2,117	1,886	2,129	2,081	2,178	2,266	2,253	2,317	2,270	2,264	2,296	2,259
D9Z-82/JT8D-217C	137	137	137	159	157	158	161	156	155	152	127	125
D9Z-82/JT8D-219	59	59	59	56	56	48	49	54	97	97	98	98
D9Z-83/JT8D-219	259	261	261	271	271	287	386	401	378	459	388	416
D9Z-88/JT8D-217	43	43	42	0	0	0	0	0	0	0	0	0
D9Z-88/JT8D-219	611	629	654	681	704	693	693	693	692	693	705	737
DC8/*	9	9	10	11	6	7	8	7	7	7	2	3
DC9-10/JT8D-7A	66	67	67	67	67	67	67	67	68	68	68	68
DC9-10/JT8D-7B	657	692	666	670	659	657	653	635	649	655	636	640
DC9-20/JT8D-11	35	0	0	0	0	0	0	0	0	0	0	0
DFL/*	1	2	2	2	2	1	1	1	3	3	3	3
DH1/MDTURB	0	1	1	42	52	51	51	51	49	43	43	61
DH3/MDTURB	0	113	113	132	141	141	134	138	142	144	140	146
DH7/LGTURB	428	399	414	384	387	417	403	407	394	382	374	400
DH8/MDTURB	2,015	1,883	1,913	1,901	1,982	2,042	2,134	2,144	2,167	2,097	2,130	2,019
DHB/SMTURB	24	24	24	24	58	58	76	66	54	27	27	27
DHT/SMTURB	1,622	1,656	1,640	1,619	1,576	1,585	1,612	1,643	1,632	1,581	1,504	1,546
DLR-30/CF6-50C	0	3	1	4	3	4	3	2	7	8	9	9
DLR-30/CF6-50C2	0	68	66	68	66	79	73	72	68	68	74	64
DLR-30/CF6-50C2R	0	18	22	19	17	17	22	22	17	17	17	22
DLR-40/JT9D-20	0	22	21	16	17	21	20	20	23	23	21	21

Appendix K. Daily Departures by Aircraft Type and Month

	1992				Daily Departures							
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
DO8/SMTURB	393	391	399	402	424	428	427	445	440	425	419	452
EM2/SMTURB	1,626	1,634	1,670	1,691	1,708	1,719	1,723	1,749	1,780	1,768	1,794	1,777
EMB/SMTURB	604	578	554	549	577	558	461	469	496	521	539	540
F10-100/TAY620-15	57	55	53	52	78	85	79	80	79	78	104	106
F10-100/TAY650-15	402	415	442	453	501	512	528	567	576	597	642	689
F27/LGTURB	798	830	825	771	768	761	756	759	742	708	657	628
F28-1000/RR_SPEY-MK5	111	103	105	94	95	92	101	83	77	80	84	83
F28-1000C/RR_SPEY-MK	6	5	5	5	5	5	5	5	5	5	5	5
F28-2000/RR_SPEY-MK5	19	19	15	20	20	21	22	20	19	18	19	19
F28-3000/RR_SPEY-MK5	4	5	5	5	5	5	5	5	5	5	5	6
F28-4000/RR_SPEY-MK5	831	837	846	828	852	824	796	843	812	780	801	717
F2B/LGTURB	0	8	8	9	11	11	11	8	8	8	8	8
F2E/LGTURB	0	16	16	20	20	20	20	20	20	20	11	8
F50/LGTURB	662	664	671	704	754	769	726	755	764	745	757	750
HEC/SMTURB	3	3	4	24	24	40	40	40	40	21	16	16
HS7/LGTURB	251	262	260	260	248	261	271	268	260	267	262	259
I62/SOL	72	74	73	70	81	74	77	78	67	64	56	58
I72/*	0	19	19	18	18	18	18	18	18	19	21	20
I86/KUZ	76	92	91	94	91	89	91	90	108	95	79	77
IL8/LGTURB	10	10	8	7	4	4	4	4	3	3	1	1
J31/SMTURB	1,891	1,790	1,825	1,776	1,763	1,866	1,902	1,937	1,932	1,869	1,880	1,889
L10-1/RB211-22B	294	313	309	318	311	305	313	317	300	293	255	268
L10-200/RB211-524B	76	72	75	76	76	74	78	78	78	70	80	80
L10-50/RB211-22B	8	8	8	8	8	9	10	9	11	11	12	12
L4T/SMTURB	12	11	8	9	11	11	10	7	7	8	11	17
LLR-500/RB211-524B4	70	75	75	79	80	89	94	94	91	81	83	82
LOE/LGTURB	59	45	19	6	6	6	6	6	6	6	6	6
LOF/LGTURB	0	37	37	36	44	48	45	45	44	34	37	41
LOH/LGTURB	3	10	9	7	7	7	7	7	7	7	7	6
LOM/LGTURB	2	2	3	2	2	2	2	2	2	2	1	1
LRJ/*	0	4	4	4	4	3	3	3	1	1	1	1

Appendix K. Daily Departures by Aircraft Type and Month

	1992					Daily Departures						
OAG Airplane/engine	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
M1F/*	0	8	8	8	9	9	9	9	8	8	9	9
MDL-11C/CF6-80C2	4	4	4	4	6	6	8	9	9	9	9	9
MDL-11P/CF6-80C2	6	8	12	15	18	20	21	21	21	21	29	28
MDL-11P/PW4460	34	37	41	47	61	70	75	77	76	74	84	85
MRC-100/JT8D-15	25	19	19	30	38	37	30	31	39	35	32	25
MU2/SMTURB	0	12	12	12	14	11	11	11	11	11	10	10
ND2/MDTURB	21	13	13	18	18	12	11	11	21	20	19	12
NDC/*	1	1	1	1	1	1	1	1	1	1	1	1
PA6/SMTURB	0	3	3	3	3	3	3	3	3	3	3	3
PL6/SMTURB	2	5	6	2	2	2	2	2	2	2	2	2
SF3/MDTURB	1,624	1,686	1,706	1,748	1,804	1,769	1,741	1,806	1,818	1,817	1,870	1,854
SFF/MDTURB	0	0	0	0	0	0	0	1	1	6	6	2
SH3/MDTURB	61	69	74	89	105	115	96	101	106	108	109	116
SH6/MDTURB	755	725	728	743	775	741	733	736	702	688	646	616
SWM/SMTURB	1,701	1,773	1,805	1,781	1,815	1,806	1,806	1,780	1,759	1,771	1,763	1,776
T34/SOL	259	271	270	265	269	265	261	264	202	203	204	221
T54/SOL	610	621	606	636	633	616	605	601	487	480	470	458
VC8/LGTURB	0	13	13	13	13	13	13	13	13	13	13	13
VCV/LGTURB	17	4	4	4	4	4	4	4	4	4	4	4
WWP/*	3	4	4	4	4	4	4	8	9	8	8	9
Y40/IVC	26	26	26	16	30	33	34	31	60	73	64	64
Y42/*	94	96	96	97	97	91	91	88	98	88	101	95
YN2/SMTURB	0	0	0	0	0	0	0	6	6	7	7	7
YN7/LGTURB	111	117	78	77	77	79	79	79	79	85	45	37
YS1/LGTURB	267	286	295	289	294	286	292	286	277	273	262	254
Total	52,034	53,189	53,525	53,510	54,848	55,883	56,181	56,475	56,076	55,465	55,571	55,026

Appendix L. Estimated Jet Fuel Density

World jet fuel density can be estimated from calculations utilizing geographical jet fuel densities and world volumetric data. These data assume that military jet fuel consumption is 15% of the world jet fuel consumption for all areas of the world. The total 1990 jet fuel volume is defined in the International Energy Annual for 1991 (see Table L-1). World military fuel is assumed to be 80% JP-4 and 20% JP-5/8. However, Europe's military fuel is JP-8 and Eastern Europe's & U.S.S.R.'s military jet fuel is assumed to have the same density as their commercial jet fuel. Data on world average densities is taken from Boeing Document D6-81575 "Fuel Reformulation and Jet Fuel". JP-4 density is estimated at 6.348 pounds per gallon as given in the International Energy Annual. JP-5/8 fuel density was estimated at 6.67 pounds per gallon. Eastern Europe's & U.S.S.R.'s jet fuel density of 6.615 pounds per gallon is an average taken from fuel samples analyzed by Boeing.

The resulting world average density is 6.659 pounds per gallon. This value was rounded to 6.66 for this study.

Table L-1. Average regional densities and volumes for calculating the world average jet fuel density in 1990.

Geographical Areas	Commercial Jet Fuel		Military Jet Fuel	
	Density (lbs/gal)	Volume (bbls/day)	Density (lbs/gal)	Volume (bbls/day)
USA West - PADD 5	6.810	357,000	6.415	63,000
USA East - PADD 1-4	6.750	937,000	6.415	165,000
Canada	6.750	77,000	6.415	14,000
Western Europe	6.650	530,000	6.670	94,000
Asia -Pacafic	6.630	410,000	6.415	72,000
Latin America	6.630	157,000	6.415	28,000
Middle East	6.630	152,000	6.415	27,000
Africa	6.630	94,000	6.415	17,000
Eastern Europe & U.S.S.R.	6.615	496,000	6.615	88,000
Total		3,210,000		566,000

Appendix M. Effective Global Emission Indices for 1992 Aircraft

In this appendix, the effective global emission indices for April 1992 aircraft/engine combinations have been tabulated. The table also includes the fuel burned by each aircraft/engine type, the fractional of the total fuel consumption within a given generic type, and the fraction of the global fuel use for scheduled air traffic by that generic type. Effective global emission indices, weighted by fuel use, have also been calculated for each generic type. Emission indices have been calculated by integrating the fuel burned and emissions over the 0-9 kilometer altitude band and over the 9-13 kilometer band. The fuel use in the two altitude bands is also included in the table for each aircraft type.

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
BAE-146		**1,547.8**	**0.6%**		**8.8**	**8.1**	**0.8**	**7.7**	**0.2**	**0.0**		
	146-200/ALF502R-5	1,181.8		76.4%	8.8	7.9	0.8	7.7	0.2	0.0	737.5	444.3
	146-300/ALF502R-5	212.3		13.7%	8.8	8.0	0.8	7.7	0.2	0.0	163.0	49.3
	146-200/ALF502R-3	67.0		4.3%	8.0	10.4	1.2	7.3	0.8	0.1	52.7	14.2
	146-100/ALF502R-5	45.2		2.9%	8.9	7.4	0.7	7.8	0.2	0.0	20.9	24.3
	146-100/ALF502R-3	31.1		2.0%	8.1	9.7	1.1	7.3	0.8	0.1	18.1	13.0
	146-300/LF507-1F	10.1		0.7%	9.5	8.3	0.9	8.2	0.5	0.0	4.9	5.2
	14F-300QT/ALF502R-5	0.4		0.0%	8.8	8.4	0.8	0.0	0.0	0.0	0.4	0.0
Boeing 707		**2,100.7**	**0.8%**		**15.1**	**39.1**	**44.7**	**5.9**	**8.0**	**7.9**		
	B3C-320CH/JT3D-3B	1,191.0		56.7%	15.1	38.8	44.3	5.9	7.7	7.7	372.0	819.0
	B3F-320B/JT3D-3B	746.3		35.5%	15.2	39.5	45.5	6.0	8.4	8.3	258.7	487.6
	B3C-320C/JT3D-3B	124.9		5.9%	15.0	39.5	44.4	6.0	7.9	7.9	34.8	90.2
	B3F-320B/JT3D	38.4		1.8%	14.9	38.0	43.3	5.9	7.1	7.2	9.2	29.2
Boeing 720		**28.6**	**0.0%**		**5.4**	**35.8**	**40.7**	**4.6**	**7.2**	**3.4**		
	720-000/JT3C-12	28.6		100.0%	5.4	35.8	40.7	4.6	7.2	3.4	15.7	12.9
Boeing 727-100		**3,106.8**	**1.2%**		**10.9**	**7.4**	**2.2**	**7.7**	**3.7**	**1.1**		
	727-100/JT8D-7B	1,873.5		60.3%	10.8	7.4	2.2	7.8	3.8	1.1	1,123.1	750.4
	72C-100F/JT8D-7B	908.6		29.2%	10.9	7.4	2.2	7.7	3.4	1.0	443.5	465.1
	727-100/JT8D-7A	188.4		6.1%	10.8	7.5	2.2	7.7	4.6	1.4	123.3	65.1
	727-100/JT8D-9A	91.2		2.9%	11.6	7.8	1.6	7.5	4.8	0.9	65.5	25.7
	727-100/JT8D-9	24.0		0.8%	11.7	8.2	1.6	7.6	5.4	1.0	17.7	6.3
	72C-100F/JT8D-9A	21.1		0.7%	11.7	7.7	1.6	7.5	3.4	0.6	8.3	12.8

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band EI (NOx)	0-9 km Altitude Band EI (CO)	0-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
Boeing 727-200		**21,478.4**	**8.5%**		**11.6**	**5.0**	**0.8**	**8.7**	**2.4**	**0.5**		
	72S-200/JT8D-15	14,832.4		69.1%	11.7	4.9	0.7	8.7	2.3	0.5	6,966.5	7,865.9
	72S-200/JT8D-9A	4,265.7		19.9%	11.2	5.4	1.1	8.7	2.3	0.4	2,007.2	2,258.4
	72S-200/JT8D-17R	1,643.6		7.7%	12.1	4.5	0.6	9.5	2.6	0.6	741.9	901.8
	72S-200/JT8D-17	624.8		2.9%	11.7	4.6	0.7	9.2	2.3	0.5	277.6	347.2
	72S-200/JT8D-9	82.7		0.4%	11.1	5.4	1.1	8.7	2.2	0.4	39.1	43.6
	72S-200/JT8D-7B	29.2		0.1%	11.0	5.1	1.3	9.0	2.3	0.6	15.3	13.9
Boeing 737-100		**53.7**	**0.0%**		**9.3**	**6.9**	**2.0**	**7.3**	**2.3**	**0.5**		
	737-100/JT8D-7A	53.7		100.0%	9.3	6.9	2.0	7.3	2.3	0.5	34.4	19.3
Boeing 737-200		**15,563.0**	**6.1%**		**10.2**	**6.5**	**1.4**	**7.7**	**2.9**	**0.6**		
	737-200/JT8D-15	5,322.3		34.2%	10.8	5.4	0.8	7.7	3.3	0.7	3,219.1	2,103.2
	737-200/JT8D-9A	3,248.3		20.9%	9.9	6.8	1.4	7.4	2.4	0.5	2,089.3	1,159.0
	737-200/JT8D-7B	2,573.3		16.5%	9.0	10.4	3.2	7.8	2.1	0.5	1,468.7	1,104.6
	737-200/JT8D-15A	1,848.3		11.9%	10.7	5.5	0.9	7.6	3.1	0.7	995.9	852.4
	737-200/JT8D-17	1,231.2		7.9%	10.7	5.1	0.7	8.3	3.4	0.7	812.9	418.3
	737-200/JT8D-17A	851.7		5.5%	10.5	5.4	2.6	7.5	3.1	0.9	463.6	388.0
	73C-200C/JT8D-9A	210.5		1.4%	9.9	6.8	1.4	7.4	2.4	0.5	123.0	87.5
	73C-200C/JT8D-17A	89.2		0.6%	9.5	5.3	2.5	7.1	3.3	0.9	57.1	32.1
	73C-200C/JT8D-17	88.7		0.6%	10.6	5.1	0.7	8.2	3.4	0.7	58.0	30.7
	737-200/JT8D-9	65.7		0.4%	9.8	6.9	1.5	7.4	2.4	0.5	42.9	22.8
	73C-200F/JT8D-17	18.3		0.1%	10.9	5.0	0.7	8.2	3.2	0.7	7.7	10.5
	73C-200C/JT8D-15	15.7		0.1%	10.8	5.3	0.8	7.6	3.2	0.7	7.6	8.2
Boeing 737-300		**9,826.6**	**3.9%**		**12.2**	**15.6**	**1.3**	**9.6**	**2.9**	**0.2**		
	73Y-300/CFM56-3B	9,826.6		100.0%	12.2	15.6	1.3	9.6	2.9	0.2	4,262.5	5,564.1

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
Boeing 737-400		**1,787.5**	**0.7%**		**12.2**	**15.0**	**1.1**	**9.6**	**3.5**	**0.2**		
	73Z-400/CFM56-3B	1,787.5		100.0%	12.2	15.0	1.1	9.6	3.5	0.2	933.5	854.0
Boeing 737-500		**1,497.2**	**0.6%**		**11.4**	**12.9**	**0.8**	**9.4**	**3.8**	**0.2**		
	73L-500/CFM56-3C	1,497.2		100.0%	11.4	12.9	0.8	9.4	3.8	0.2	969.3	527.9
Boeing 747-100		**22,519.1**	**8.9%**		**23.4**	**22.2**	**12.1**	**13.9**	**0.4**	**0.6**		
	747-100/JT9D-7A	15,907.8		70.6%	24.0	21.4	11.2	13.9	0.4	0.6	2,418.0	13,489.7
	74C-100F/JT9D-7A	2,992.0		13.3%	23.3	23.3	12.2	13.5	0.5	0.7	552.2	2,439.8
	747-100/JT9D-3A	1,769.8		7.9%	20.7	19.7	9.4	14.3	0.3	0.3	278.3	1,491.5
	747-100/JT9D-7AH	1,258.3		5.6%	23.4	21.6	11.3	13.5	0.4	0.6	197.4	1,060.9
	747-100B/RB211-524C2	370.4		1.6%	19.4	42.2	38.2	14.0	4.4	1.2	116.0	254.4
	747-100/JT9D-3AW	189.9		0.8%	18.6	22.4	10.6	13.5	0.3	0.3	45.7	144.2
	747-100B/JT9D-7F	30.9		0.1%	24.5	29.2	16.8	14.4	3.4	1.4	10.9	20.0
Boeing 747-200		**26,358.5**	**10.4%**		**22.8**	**22.8**	**12.8**	**14.2**	**1.4**	**0.8**		
	747-200B/CF6-50E2	6,488.6		24.6%	21.7	20.9	10.9	14.5	1.5	1.4	1,122.9	5,365.6
	747-200B/JT9D-7AW	4,043.5		15.3%	24.3	20.7	10.9	14.1	0.3	0.5	615.7	3,427.8
	747-200B/JT9D-7Q	3,855.2		14.6%	20.0	21.1	7.5	12.5	0.8	0.7	617.4	3,237.8
	74C-200F/JT9D-7Q	2,256.9		8.6%	20.2	20.5	7.3	12.2	0.8	0.7	323.9	1,933.1
	747-200B/JT9D-7J	1,907.8		7.2%	28.0	19.7	11.3	16.8	2.0	0.3	224.3	1,683.5
	74C-200F/CF6-50E2	1,211.4		4.6%	22.7	21.3	11.3	13.9	1.6	1.4	167.3	1,044.1
	747-200B/RB211-524D4	1,144.4		4.3%	27.0	34.7	29.9	15.1	3.0	0.5	152.5	991.9
	747-200B/RB211-524C2	1,118.0		4.2%	20.8	40.2	36.7	14.5	3.4	0.7	232.0	886.0
	747-200B/JT9D-7W	1,030.3		3.9%	24.3	20.5	10.8	14.0	0.3	0.5	138.8	891.5
	747-200B/JT9D-7F	895.3		3.4%	26.8	22.3	12.9	16.1	2.1	0.4	123.7	771.6
	74C-200F/JT9D-7F	721.6		2.7%	25.0	24.4	14.2	15.8	2.3	0.6	144.8	576.8
	747-200B/JT9D-7R4G2	396.5		1.5%	24.6	4.8	0.7	14.0	1.8	0.3	48.3	348.2

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
	74C-200F/JT9D-7A	350.5		1.3%	23.3	22.7	12.0	13.7	0.5	0.6	58.9	291.7
	74C-200F/RB211-524D4	342.4		1.3%	25.0	37.8	32.4	14.3	3.8	0.7	69.0	273.5
	74C-200F/JT9D-7J	276.7		1.0%	25.9	24.8	14.5	15.5	2.3	0.6	49.1	227.6
	747-200B/JT9D-7A	238.6		0.9%	23.4	24.8	13.1	13.2	0.7	0.8	52.5	186.1
	74C-200F/JT9D-7FW	63.1		0.2%	25.7	24.4	14.2	16.1	2.4	0.6	10.6	52.5
	74Q-200M/CF6-50E2	17.6		0.1%	23.3	20.4	10.8	13.8	1.5	1.3	2.1	15.5
Boeing 747-300		**5,771.8**	**2.3%**		**24.4**	**15.5**	**9.6**	**14.5**	**1.9**	**0.5**		
	74U-300/JT9D-7R4G2	2,372.6		41.1%	24.7	4.7	0.7	14.6	1.7	0.3	338.0	2,034.6
	74U-300/RB211-524D4	1,192.1		20.7%	26.6	36.4	32.1	15.8	2.6	0.6	198.3	993.8
	7UQ-300M/JT9D-7R4G2	811.0		14.1%	24.7	4.8	0.7	14.3	1.8	0.3	114.0	697.0
	7UQ-300M/CF6-50E2	650.9		11.3%	22.6	19.2	10.1	15.0	1.3	1.3	103.8	547.1
	74U-300/CF6-80C2	587.2		10.2%	20.6	18.1	5.0	12.0	1.5	0.3	76.0	511.2
	7UQ-300M/CF6-80C2	158.0		2.7%	19.6	20.7	5.8	11.5	1.8	0.4	24.4	133.6
Boeing 747-400		**14,779.0**	**5.8%**		**25.8**	**8.9**	**1.6**	**13.9**	**1.0**	**0.4**		
	74I-400/RB211-524G	4,777.3		32.3%	33.7	6.9	0.5	14.9	1.1	0.6	525.8	4,251.5
	74I-400/PW4056	4,467.7		30.2%	21.2	3.6	0.3	14.2	0.3	0.3	491.2	3,976.6
	74I-400/CF6-80C2	2,651.0		17.9%	18.9	16.8	4.3	11.6	1.5	0.3	363.4	2,287.6
	74I-400/RB211-524H	1,486.0		10.1%	35.1	5.9	0.5	16.2	1.3	0.6	198.6	1,287.5
	7IQ-400M/CF6-80C2	1,397.0		9.5%	19.1	16.8	4.3	11.5	1.5	0.3	179.6	1,217.4
Boeing 747-SP		**2,573.1**	**1.0%**		**23.2**	**30.6**	**19.9**	**14.4**	**1.1**	**0.8**		
	74P-SP/JT9D-7A	1,896.0		73.7%	22.9	29.4	18.0	14.0	0.6	0.8	254.9	1,416.3
	74P-SP/JT9D-7FW	428.6		16.7%	25.0	31.1	22.2	15.8	2.5	0.5	54.7	327.8
	74P-SP/JT9D-7F	237.5		9.2%	23.8	35.8	25.7	15.5	3.3	1.3	40.0	124.8
	74P-SP/RB211-524C2	11.1		0.4%	18.6	46.7	41.6	12.0	14.8	3.5	5.5	5.5

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
Boeing 747-SR		**673.0**	**0.3%**		**18.6**	**19.3**	**11.1**	**14.0**	**2.7**	**2.7**		
	74X-100SR/CF6-45A2	673.0		100.0%	18.6	19.3	11.1	14.0	2.7	2.7	352.9	320.1
Boeing 757-200		**8,051.6**	**3.2%**		**17.3**	**10.4**	**0.9**	**12.6**	**2.0**	**0.2**		
	757-200/PW2037	4,544.4		56.4%	17.5	8.2	0.8	13.4	1.3	0.2	1,460.3	3,084.1
	757-200/PW2040	1,650.5		20.5%	17.2	11.2	1.0	12.4	1.7	0.2	429.4	1,221.1
	757-200/RB211-535E4	830.8		10.3%	20.7	11.5	1.1	10.3	2.9	0.1	237.5	593.2
	757-200/RB211-535C	657.5		8.2%	14.7	17.1	1.1	9.8	8.7	1.3	383.8	273.7
	75F/*	368.5		4.6%	16.9	11.6	1.0	12.5	2.1	0.2	142.0	226.5
Boeing 767-200		**10,084.3**	**4.0%**		**19.6**	**6.1**	**1.3**	**12.2**	**2.6**	**0.6**		
	767-200/CF6-80A	7,637.6		75.7%	18.8	6.9	1.5	12.5	2.9	0.6	1,704.9	5,932.8
	767-200/JT9D-7R4D	1,922.0		19.1%	22.9	2.9	0.4	11.3	1.2	0.2	469.9	1,452.1
	767-200/CF6-80A2	524.7		5.2%	19.0	7.1	1.6	12.4	2.9	0.7	171.7	353.0
Boeing 767-300		**4,536.4**	**1.8%**		**18.0**	**11.7**	**3.0**	**13.4**	**2.3**	**0.6**		
	76M-300/CF6-80A2	3,923.7		86.5%	19.7	7.4	1.7	13.6	2.2	0.6	678.1	3,245.6
	76M-300/CF6-80C2	612.8		13.5%	15.1	19.5	5.3	10.6	3.4	1.1	372.8	240.0
Airbus A300		**9,745.2**	**3.8%**		**20.6**	**18.9**	**7.0**	**14.4**	**1.2**	**0.9**		
	A30B2-100/CF6-50C2R	3,274.3		33.6%	21.2	17.7	7.1	15.2	1.1	0.9	1,257.2	2,017.2
	A30B4-200/CF6-50C2	2,575.5		26.4%	21.2	19.2	7.3	14.8	1.2	1.0	929.6	1,646.0
	A30B4-100/CF6-50C2	736.2		7.6%	20.1	17.7	6.7	14.6	1.3	1.0	457.6	278.7
	A30B2-200/CF6-50C2R	668.9		6.9%	21.2	18.5	7.4	14.6	1.3	1.0	351.0	317.9
	A3L-300/PW4152	567.1		5.8%	20.1	2.6	0.3	14.3	0.3	0.2	151.6	415.5
	A30B4-200/JT9D-59A	460.6		4.7%	17.8	35.7	10.5	12.0	2.1	1.7	173.3	287.3
	A3L-300/CF6-80C2A2	373.1		3.8%	16.2	20.8	5.9	11.2	2.2	0.6	92.4	280.7

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band			9-13 km Altitude Band			Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
					EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)		
	A30B2-100/CF6-50C	351.1		3.6%	21.8	20.0	7.9	14.6	1.3	1.0	139.1	212.0
	A30B4-100/JT9D-59A	238.7		2.4%	16.0	30.0	8.5	12.1	1.5	1.2	99.6	139.1
	A30B2-200/CF6-50C2	188.7		1.9%	21.3	19.2	7.3	14.3	1.4	1.0	97.0	91.7
	A3L-300/CF6-80C2A8	132.3		1.4%	15.6	24.9	7.1	10.2	2.4	0.6	23.4	108.9
	A3L-300/JT9D-7R4E1	115.3		1.2%	25.2	4.3	0.7	14.4	1.2	0.2	21.9	93.4
	A0CC4-200/CF6-50C2	63.4		0.7%	22.3	18.6	7.0	15.5	1.0	0.9	11.6	51.8
Airbus A300-600		**1,539.0**	**0.6%**		**18.9**	**10.9**	**2.0**	**13.2**	**2.0**	**0.4**		
	A36-600/JT9D-7R4H1	756.9		49.2%	20.7	6.8	0.9	13.5	2.1	0.4	224.5	532.4
	A36-600/CF6-80C2A1	435.4		28.3%	19.0	20.5	5.8	12.8	1.9	0.5	113.9	321.5
	A36-600/PW4158	346.8		22.5%	16.0	9.7	0.9	13.1	1.7	0.2	151.8	195.0
Airbus A310		**4,682.3**	**1.8%**		**19.6**	**6.7**	**1.4**	**13.6**	**2.0**	**0.5**		
	A31-200/CF6-80A3	3,001.9		64.1%	17.6	7.4	1.7	13.0	2.4	0.6	813.0	2,188.9
	A31-200/JT9D-7R4E1	1,423.1		30.4%	25.2	4.1	0.6	14.8	1.1	0.2	254.7	1,168.4
	A31-200/JT9D-7R4D1	203.0		4.3%	21.7	4.0	0.6	11.8	1.5	0.3	102.1	100.9
	A31-200/CF6-80C2A2	54.3		1.2%	16.5	23.8	6.9	11.0	3.4	1.1	23.6	30.7
Airbus A320		**3,653.4**	**1.4%**		**16.1**	**6.8**	**0.5**	**12.1**	**2.0**	**0.4**		
	A32-200/CFM56-5A1	2,582.9		70.7%	14.9	7.1	0.7	11.1	2.2	0.5	1,149.5	1,433.4
	A32-200/V2500-A1	867.5		23.7%	19.7	6.1	0.2	15.7	1.5	0.2	384.7	482.9
	A32-100/CFM56-5A1	115.7		3.2%	14.9	7.1	0.7	11.0	2.2	0.5	48.9	66.8
	A32-200/CFM56-5A3	87.3		2.4%	15.0	6.8	0.6	11.0	2.1	0.4	32.1	55.2
BAC111		**543.9**	**0.2%**		**11.4**	**13.4**	**2.3**	**9.3**	**2.7**	**0.6**		
	BAC-500/RR_SPEY-512	513.6		94.4%	11.4	12.7	1.6	9.3	2.6	0.5	309.5	204.1
	BAC-200/RR_SPEY-511	18.0		3.3%	11.7	32.9	18.8	10.2	6.6	4.1	11.7	6.3
	BAC-200/RR_SPEY-506	12.3		2.3%	11.3	12.3	1.6	9.3	3.0	0.5	7.0	5.2

Table M-1. Effective Global Emission Indices for 1992 Aircraft

					0-9 km Altitude Band			9-13 km Altitude Band				
Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
Concorde		**403.6**	**0.2%**		**10.4**	**27.9**	**5.4**	**10.0**	**26.0**	**1.8**		
	Concorde	403.6		100.0%	10.4	27.9	5.4	10.0	26.0	1.8	76.6	20.8
Cessna Citation		**1.2**	**0.0%**		**10.5**	**5.9**	**0.5**	**9.9**	**2.1**	**0.4**		
	CNJ/*	1.2		100.0%	10.5	5.9	0.5	9.9	2.1	0.4	1.2	0.1
Caravelle		**23.9**	**0.0%**		**8.9**	**6.0**	**1.4**	**7.2**	**2.4**	**0.5**		
	CVL-12/JT8D-9	15.0		62.7%	8.9	6.1	1.3	7.2	2.5	0.5	7.1	7.8
	CVL-10B/JT8D-7	8.9		37.3%	8.9	5.9	1.6	7.4	2.3	0.5	4.6	4.3
DC-8		**4,397.3**	**1.7%**		**7.5**	**43.5**	**37.2**	**5.6**	**7.0**	**2.0**		
	D8C-33F/JT4A-11	3,855.3		87.7%	7.3	44.9	38.4	5.4	7.4	2.0	1,282.4	2,572.9
	DC8/*	131.7		3.0%	7.9	36.9	29.8	6.0	5.4	2.0	41.0	90.8
	D8S-62H/JT3D-3B	112.8		2.6%	13.7	29.4	34.0	6.1	5.7	5.6	32.3	80.5
	D8S-73F/CFM56-2C	109.8		2.5%	11.7	11.9	0.8	10.3	2.3	0.1	21.3	88.5
	D8S-62H/JT3D-7	99.7		2.3%	8.0	34.1	27.9	5.9	4.4	1.4	20.9	78.8
	D8S-63H/JT3D-7	87.9		2.0%	8.1	32.4	26.6	6.1	4.2	1.3	16.7	71.2
DC-9		**9,035.2**	**3.6%**		**9.5**	**9.6**	**2.7**	**8.1**	**2.3**	**0.5**		
	D9S-30/JT8D-7B	3,647.8		40.4%	9.4	9.5	3.0	8.1	2.1	0.5	2,336.4	1,311.3
	D9S-30/JT8D-9A	1,708.4		18.9%	9.2	9.9	2.0	7.7	2.3	0.5	1,141.0	567.4
	DC9-10/JT8D-7B	1,605.4		17.8%	9.4	9.4	3.0	8.0	2.1	0.5	1,072.8	532.6
	D9X-50/JT8D-17	533.7		5.9%	10.7	6.1	0.8	9.4	2.3	0.5	309.1	224.6
	D9S-40/JT8D-11	442.7		4.9%	10.7	18.5	6.2	8.2	4.5	1.0	297.7	145.0
	D9S-40/JT8D-15	330.8		3.7%	10.8	6.6	0.9	8.9	2.4	0.5	239.9	90.9
	D9C-30F/JT8D-7B	288.8		3.2%	9.3	9.5	3.0	8.1	2.1	0.5	165.5	123.4

Table M-1. Effective Global Emission Indices for 1992 Aircraft

					0-9 km Altitude Band			9-13 km Altitude Band				
Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
	D9S-30/JT8D-17	257.8		2.9%	9.3	6.2	0.8	8.5	2.8	0.6	162.5	95.3
	DC9-10/JT8D-7A	219.9		2.4%	9.3	9.4	2.9	8.1	2.1	0.5	106.8	113.1
DC-10		**19,140.1**	**7.5%**		**21.0**	**17.6**	**6.5**	**13.2**	**2.0**	**1.3**		
	D10-10/CF6-6D	14,281.2		74.6%	20.6	18.3	6.8	12.6	2.2	1.4	3,074.5	11,206.7
	DLR-30/CF6-50C2	2,056.2		10.7%	21.3	18.0	6.7	12.6	2.1	1.3	337.6	1,718.6
	D1C-10F/CF6-6D	1,087.7		5.7%	25.4	10.0	3.3	20.6	1.3	0.6	262.2	825.5
	DLR-40/JT9D-20	964.4		5.0%	21.2	12.1	4.9	15.3	0.1	0.2	121.2	843.2
	DLR-30/CF6-50C2R	299.4		1.6%	20.4	18.5	7.1	12.6	2.4	1.5	82.3	217.2
	D10-15/CF6-50C2F	273.6		1.4%	19.5	18.0	6.6	12.5	2.6	1.6	90.2	183.4
	DLR-30/CF6-50C	177.6		0.9%	21.9	15.9	6.1	13.1	1.7	1.1	19.4	158.2
Fokker 100		**1,003.1**	**0.4%**		**9.5**	**25.9**	**2.5**	**6.4**	**11.5**	**1.6**		
	F10-100/TAY650-15	896.6		89.4%	9.3	27.1	2.6	6.2	12.5	1.7	544.5	352.2
	F10-100/TAY620-15	106.5		10.6%	11.4	15.5	2.1	8.0	3.2	1.1	63.2	43.3
Fokker 28		**1,680.0**	**0.7%**		**10.5**	**6.0**	**0.5**	**8.5**	**1.5**	**0.4**		
	F28-4000/RR_SPEY-MK5	1,468.7		87.4%	10.5	6.0	0.5	8.5	1.5	0.4	1,118.9	349.8
	F28-1000/RR_SPEY-MK5	168.8		10.0%	10.5	6.0	0.5	8.5	1.5	0.4	124.8	44.0
	F28-2000/RR_SPEY-MK5	24.9		1.5%	10.1	6.7	0.5	8.7	1.6	0.4	22.4	2.5
	F28-3000/RR_SPEY-MK5	10.1		0.6%	10.0	5.1	0.5	8.5	1.4	0.4	7.2	2.9
	F28-1000C/RR_SPEY-MK	7.4		0.4%	10.4	6.1	0.5	8.6	1.6	0.4	5.9	1.5
Ilyushin 62		**1,974.3**	**0.8%**		**14.6**	**34.2**	**39.5**	**5.9**	**5.9**	**6.0**		
	I62/SOL	1,974.3		100.0%	14.6	34.2	39.5	5.9	5.9	6.0	323.1	1,651.2

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band EI (NOx)	0-9 km Altitude Band EI (CO)	0-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
Ilyushin 72		**248.4**	**0.1%**		**15.1**	**38.7**	**44.5**	**5.8**	**8.0**	**7.9**		
	I72/*	248.4		100.0%	15.1	38.7	44.5	5.8	8.0	7.9	72.3	176.0
Ilyushin 86		**1,263.5**	**0.5%**		**15.1**	**38.8**	**44.7**	**5.8**	**8.1**	**8.0**		
	I86/KUZ	1,263.5		100.0%	15.1	38.8	44.7	5.8	8.1	8.0	377.5	886.0
Lockheed 1011		**8,843.2**	**3.5%**		**20.1**	**19.2**	**13.5**	**15.0**	**1.9**	**0.7**		
	L10-1/RB211-22B	5,257.2		59.4%	18.2	25.4	18.8	14.7	3.1	1.0	1,625.2	3,632.1
	LLR-500/RB211-524B4	2,751.6		31.1%	26.2	4.4	0.8	15.6	0.3	0.3	382.8	2,368.8
	L10-200/RB211-524B	583.7		6.6%	22.4	4.7	0.9	14.8	0.6	0.4	325.9	257.7
	L10-50/RB211-22B	250.8		2.8%	19.6	24.7	18.5	14.7	2.7	0.8	42.9	207.9
McDonnell Douglas MD-11		**2,841.3**	**1.1%**		**19.6**	**9.7**	**1.5**	**12.4**	**1.6**	**0.2**		
	MDL-11P/PW4460	1,879.6		66.2%	19.6	7.5	0.6	13.0	1.5	0.2	225.3	1,654.3
	MDL-11P/CF6-80C2	557.0		19.6%	19.6	13.4	3.0	11.4	1.8	0.3	71.5	485.5
	M1F/*	231.4		8.1%	19.5	14.0	3.2	10.9	2.1	0.3	36.3	195.1
	MDL-11C/CF6-80C2	173.2		6.1%	20.0	12.9	2.9	11.7	1.7	0.2	19.9	153.3
McDonnell Douglas MD-80		**16,121.6**	**6.4%**		**14.3**	**5.3**	**1.5**	**10.6**	**3.3**	**1.2**		
	D9Z-82/JT8D-217	8,762.0		54.3%	14.7	5.6	1.6	10.7	3.8	1.3	3,792.6	4,969.4
	D9Z-88/JT8D-219	2,249.9		14.0%	14.0	4.3	1.2	10.6	1.4	0.5	1,287.4	962.4
	D9Z-81/JT8D-209	1,415.1		8.8%	13.0	5.2	1.6	10.4	3.1	1.1	845.1	570.0
	D9M-87/JT8D-217	1,131.5		7.0%	13.8	6.2	1.7	9.7	4.7	1.7	545.7	585.8
	D9Z-83/JT8D-219	1,081.0		6.7%	14.2	4.3	1.2	10.6	1.3	0.5	504.3	576.7
	D9Z-81/JT8D-217	799.0		5.0%	14.6	5.6	1.6	10.7	4.0	1.4	463.9	335.1
	D9Z-82/JT8D-217C	419.0		2.6%	14.6	5.6	1.6	10.8	4.2	1.4	285.3	133.6
	D9Z-82/JT8D-219	250.0		1.6%	14.5	4.3	1.2	10.6	1.3	0.5	106.8	143.2

Table M-1. Effective Global Emission Indices for 1992 Aircraft

Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	0-9 km Altitude Band EI (NOx)	0-9 km Altitude Band EI (CO)	0-9 km Altitude Band EI (HC)	9-13 km Altitude Band EI (NOx)	9-13 km Altitude Band EI (CO)	9-13 km Altitude Band EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
	D9M-87/JT8D-219	14.2		0.1%	14.1	4.9	1.3	9.7	2.1	0.8	4.8	9.4
Mercure		**70.8**	**0.0%**		**10.7**	**5.4**	**0.8**	**7.8**	**3.8**	**0.7**		
	MRC-100/JT8D-15	70.8		100.0%	10.7	5.4	0.8	7.8	3.8	0.7	52.3	18.4
Tupolev 134		**845.5**	**0.3%**		**9.4**	**9.3**	**2.9**	**8.0**	**2.1**	**0.5**		
	T34/SOL	845.5		100.0%	9.4	9.3	2.9	8.0	2.1	0.5	446.1	399.5
Tupolev 154		**5,610.2**	**2.2%**		**11.8**	**4.7**	**0.7**	**8.7**	**2.2**	**0.5**		
	T54/SOL	5,610.2		100.0%	11.8	4.7	0.7	8.7	2.2	0.5	1,950.8	3,659.4
YAK 40		**53.6**	**0.0%**		**10.8**	**7.4**	**2.2**	**7.6**	**4.1**	**1.2**		
	Y40/IVC	53.6		100.0%	10.8	7.4	2.2	7.6	4.1	1.2	35.9	17.6
YAK 42		**460.4**	**0.2%**		**10.8**	**7.4**	**2.2**	**7.6**	**3.8**	**1.1**		
	Y42/*	460.4		100.0%	10.8	7.4	2.2	7.6	3.8	1.1	236.2	224.2
Miscellaneous		**23.9**	**0.0%**		**9.9**	**4.8**	**0.4**	**8.6**	**1.3**	**0.4**		
	LRJ/*	12.9		53.8%	10.7	5.6	0.5	8.7	1.3	0.4	5.4	7.5
	DFL/*	6.6		27.6%	10.7	5.5	0.5	8.5	1.4	0.4	3.0	3.6
	WWP/*	4.2		17.7%	8.4	3.1	0.1				4.2	0.0
	NDC/*	0.2		0.9%	9.1	8.7	0.6				0.2	0.0

Table M-1. Effective Global Emission Indices for 1992 Aircraft

					0-9 km Altitude Band			9-13 km Altitude Band				
Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
Small Turboprops		**2,975.4**	**1.2%**		**8.1**	**4.0**	**0.2**					
	EM2/SMTURB	679.0		22.8%	8.2	3.9	0.2				679.0	0.0
	SWM/SMTURB	580.9		19.5%	8.2	4.0	0.2				580.9	0.0
	J31/SMTURB	564.0		19.0%	8.1	4.1	0.2				564.0	0.0
	BE1/SMTURB	504.2		16.9%	8.2	4.0	0.2				504.2	0.0
	DHT/SMTURB	261.6		8.8%	7.7	4.6	0.3				261.6	0.0
	EMB/SMTURB	167.7		5.6%	8.1	4.0	0.2				167.7	0.0
	DO8/SMTURB	94.4		3.2%	7.9	4.3	0.3				94.4	0.0
	BE9/SMTURB	53.4		1.8%	8.0	4.2	0.2				53.4	0.0
	BEK/SMTURB	42.7		1.4%	8.2	3.9	0.2				42.7	0.0
	DHB/SMTURB	5.7		0.2%	8.0	4.1	0.2				5.7	0.0
	MU2/SMTURB	5.4		0.2%	8.4	3.7	0.2				5.4	0.0
	CD2/SMTURB	4.3		0.1%	7.6	4.7	0.3				4.3	0.0
	CNN/SMTURB	3.2		0.1%	8.1	4.1	0.2				3.2	0.0
	L4T/SMTURB	3.0		0.1%	8.2	3.8	0.2				3.0	0.0
	CNC/SMTURB	2.1		0.1%	8.3	3.8	0.2				2.1	0.0
	HEC/SMTURB	2.0		0.1%	6.3	6.3	0.5				2.0	0.0
	PA6/SMTURB	1.6		0.1%	8.4	3.6	0.2				1.6	0.0
	PL6/SMTURB	0.3		0.0%	7.5	4.8	0.3				0.3	0.0
Medium Turboprops		**1,944.3**	**0.8%**		**11.8**	**5.1**	**0.6**					
	SF3/MDTURB	829.7		42.7%	11.7	5.1	0.6				829.7	0.0
	DH8/MDTURB	790.8		40.7%	11.8	5.1	0.6				790.8	0.0
	SH6/MDTURB	225.4		11.6%	12.3	5.1	0.6				225.4	0.0
	DH3/MDTURB	56.8		2.9%	11.8	5.0	0.6				56.8	0.0
	SH3/MDTURB	22.2		1.1%	12.3	5.1	0.6				22.2	0.0
	DH1/MDTURB	12.1		0.6%	12.3	5.1	0.6				12.1	0.0
	ND2/MDTURB	7.2		0.4%	12.1	5.1	0.7				7.2	0.0

Table M-1. Effective Global Emission Indices for 1992 Aircraft

					0-9 km Altitude Band			9-13 km Altitude Band				
Generic Type	OAG Airplane/engine	Fuel (1000 kg/day)	% of Global Fuel Burned	% of Total within Type	EI (NOx)	EI (CO)	EI (HC)	EI (NOx)	EI (CO)	EI (HC)	Fuel (1000 kg/day) (0-9 km)	Fuel (1000 kg/day) (9-13 km)
Large Turboprops		**2,126.2**	**0.8%**		**13.0**	**4.3**	**0.0**					
	ATR/LGTURB	522.5		24.6%	13.1	4.3	0.0				522.5	0.0
	F50/LGTURB	359.3		16.9%	13.0	4.3	0.0				359.3	0.0
	F27/LGTURB	338.5		15.9%	13.1	4.3	0.0				338.5	0.0
	DH7/LGTURB	143.8		6.8%	13.0	4.3	0.0				143.8	0.0
	AT7/LGTURB	140.0		6.6%	13.1	4.3	0.0				140.0	0.0
	HS7/LGTURB	115.7		5.4%	12.9	4.3	0.0				115.7	0.0
	YS1/LGTURB	106.1		5.0%	12.7	4.4	0.0				106.1	0.0
	ATP/LGTURB	85.9		4.0%	12.9	4.4	0.0				85.9	0.0
	AT4/LGTURB	76.1		3.6%	13.1	4.3	0.0				76.1	0.0
	AN4/LGTURB	56.9		2.7%	13.3	4.3	0.0				56.9	0.0
	YN7/LGTURB	48.7		2.3%	13.1	4.4	0.0				48.7	0.0
	LOF/LGTURB	30.0		1.4%	12.8	4.3	0.0				30.0	0.0
	CL4/LGTURB	15.3		0.7%	13.2	3.8	0.0				15.3	0.0
	CS5/LGTURB	14.6		0.7%	12.2	4.5	0.0				14.6	0.0
	CVF/LGTURB	12.2		0.6%	12.8	4.3	0.0				12.2	0.0
	VC8/LGTURB	11.3		0.5%	12.7	4.3	0.0				11.3	0.0
	LOE/LGTURB	9.7		0.5%	12.8	4.0	0.0				9.7	0.0
	F2E/LGTURB	7.2		0.3%	13.1	4.4	0.0				7.2	0.0
	IL8/LGTURB	6.1		0.3%	13.2	4.1	0.0				6.1	0.0
	VCV/LGTURB	5.6		0.3%	12.7	4.1	0.0				5.6	0.0
	LOH/LGTURB	5.5		0.3%	12.9	4.3	0.0				5.5	0.0
	F2B/LGTURB	5.1		0.2%	12.6	4.2	0.0				5.1	0.0
	CV5/LGTURB	3.9		0.2%	12.7	4.3	0.0				3.9	0.0
	LOM/LGTURB	3.3		0.2%	12.7	4.1	0.0				3.3	0.0
	CV6/LGTURB	2.9		0.1%	12.9	4.3	0.0				2.9	0.0

Appendix N. Departure and Distance Summaries for April 1992 Scheduled Air Traffic

In this appendix, the daily distance flown and the number of departures for each OAG airplane/engine combination in April 1992 are grouped by generic aircraft type and tabulated. For each airplane/engine combination, the fraction of the global totals for scheduled air traffic for both distance and departures have been calculated. The average route distance is also provided for each aircraft type.

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
BAE-146		**216,262**	**0.86%**	**744**	**1.39%**	**291**
	146-200/ALF502R-5	167,406	0.66%	549	1.03%	305
	146-300/ALF502R-5	27,233	0.11%	122	0.23%	223
	146-200/ALF502R-3	8,310	0.03%	42	0.08%	198
	146-100/ALF502R-5	7,135	0.03%	14	0.03%	510
	146-100/ALF502R-3	4,568	0.02%	13	0.02%	351
	146-300/LF507-1F	1,572	0.01%	3	0.01%	524
	14F-300QT/ALF502R-5	38	0.00%	1	0.00%	38
Boeing 707		**181,283**	**0.72%**	**172**	**0.32%**	**1,054**
	B3C-320CH/JT3D-3B	102,996	0.41%	95	0.18%	1,084
	B3F-320B/JT3D-3B	63,865	0.25%	66	0.12%	968
	B3C-320C/JT3D-3B	10,984	0.04%	9	0.02%	1,220
	B3F-320B/JT3D	3,438	0.01%	2	0.00%	1,719
Boeing 720		**2,053**	**0.01%**	**6**	**0.01%**	**342**
	720-000/JT3C-12	2,053	0.01%	6	0.01%	342
Boeing 727-100		**309,411**	**1.23%**	**778**	**1.45%**	**398**
	727-100/JT8D-7B	182,258	0.72%	492	0.92%	370
	72C-100F/JT8D-7B	97,482	0.39%	186	0.35%	524
	727-100/JT8D-7A	17,421	0.07%	56	0.10%	311
	727-100/JT8D-9A	7,770	0.03%	32	0.06%	243
	72C-100F/JT8D-9A	2,456	0.01%	3	0.01%	819
	727-100/JT8D-9	2,024	0.01%	9	0.02%	225
Boeing 727-200		**2,045,949**	**8.12%**	**3,501**	**6.54%**	**584**
	72S-200/JT8D-15	1,404,929	5.57%	2,422	4.53%	580
	72S-200/JT8D-9A	413,432	1.64%	694	1.30%	596
	72S-200/JT8D-17R	156,957	0.62%	272	0.51%	577
	72S-200/JT8D-17	59,973	0.24%	95	0.18%	631
	72S-200/JT8D-9	7,918	0.03%	13	0.02%	609
	72S-200/JT8D-7B	2,740	0.01%	5	0.01%	548
Boeing 737-100		**8,200**	**0.03%**	**20**	**0.04%**	**410**
	737-100/JT8D-7A	8,200	0.03%	20	0.04%	410

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
Boeing 737-200		**2,114,891**	**8.39%**	**5,646**	**10.55%**	**375**
	737-200/JT8D-15	709,100	2.81%	1,889	3.53%	375
	737-200/JT8D-9A	429,073	1.70%	1,289	2.41%	333
	737-200/JT8D-7B	376,407	1.49%	938	1.75%	401
	737-200/JT8D-15A	260,092	1.03%	584	1.09%	445
	737-200/JT8D-17	155,090	0.62%	492	0.92%	315
	737-200/JT8D-17A	118,691	0.47%	276	0.52%	430
	73C-200C/JT8D-9A	29,081	0.12%	75	0.14%	388
	73C-200C/JT8D-17A	12,381	0.05%	32	0.06%	387
	73C-200C/JT8D-17	11,139	0.04%	36	0.07%	309
	737-200/JT8D-9	8,704	0.03%	26	0.05%	335
	73C-200F/JT8D-17	2,825	0.01%	4	0.01%	706
	73C-200C/JT8D-15	2,308	0.01%	5	0.01%	462
Boeing 737-300		**1,596,368**	**6.33%**	**3,036**	**5.67%**	**526**
	73Y-300/CFM56-3B	1,596,368	6.33%	3,036	5.67%	526
Boeing 737-400		**274,018**	**1.09%**	**665**	**1.24%**	**412**
	73Z-400/CFM56-3B	274,018	1.09%	665	1.24%	412
Boeing 737-500		**223,671**	**0.89%**	**641**	**1.20%**	**349**
	73L-500/CFM56-3C	223,671	0.89%	641	1.20%	349
Boeing 747-100		**1,073,923**	**4.26%**	**435**	**0.81%**	**2,469**
	747-100/JT9D-7A	758,339	3.01%	287	0.54%	2,642
	74C-100F/JT9D-7A	144,965	0.58%	71	0.13%	2,042
	747-100/JT9D-3A	82,239	0.33%	28	0.05%	2,937
	747-100/JT9D-7AH	61,175	0.24%	23	0.04%	2,660
	747-100B/RB211-524C2	17,203	0.07%	18	0.03%	956
	747-100/JT9D-3AW	8,598	0.03%	6	0.01%	1,433
	747-100B/JT9D-7F	1,404	0.01%	2	0.00%	702
Boeing 747-200		**1,239,289**	**4.92%**	**545**	**1.02%**	**2,274**
	747-200B/CF6-50E2	303,941	1.21%	160	0.30%	1,900
	747-200B/JT9D-7AW	189,969	0.75%	71	0.13%	2,676
	747-200B/JT9D-7Q	174,815	0.69%	84	0.16%	2,081
	74C-200F/JT9D-7Q	105,444	0.42%	42	0.08%	2,511
	747-200B/JT9D-7J	87,462	0.35%	22	0.04%	3,976
	74C-200F/CF6-50E2	59,816	0.24%	24	0.04%	2,492
	747-200B/RB211-524D4	57,184	0.23%	21	0.04%	2,723
	747-200B/RB211-524C2	52,613	0.21%	34	0.06%	1,547
	747-200B/JT9D-7W	49,061	0.19%	16	0.03%	3,066

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
	747-200B/JT9D-7F	42,672	0.17%	14	0.03%	3,048
	74C-200F/JT9D-7F	34,223	0.14%	18	0.03%	1,901
	747-200B/JT9D-7R4G2	19,551	0.08%	7	0.01%	2,793
	74C-200F/RB211-524D4	17,026	0.07%	10	0.02%	1,703
	74C-200F/JT9D-7A	16,997	0.07%	7	0.01%	2,428
	74C-200F/JT9D-7J	13,260	0.05%	6	0.01%	2,210
	747-200B/JT9D-7A	11,304	0.04%	7	0.01%	1,615
	74C-200F/JT9D-7FW	3,076	0.01%	1	0.00%	3,076
	74Q-200M/CF6-50E2	875	0.00%	1	0.00%	875
Boeing 747-300		**276,191**	**1.10%**	**119**	**0.22%**	**2,321**
	74U-300/JT9D-7R4G2	112,551	0.45%	45	0.08%	2,501
	74U-300/RB211-524D4	57,192	0.23%	28	0.05%	2,043
	7UQ-300M/JT9D-7R4G2	39,166	0.16%	16	0.03%	2,448
	7UQ-300M/CF6-50E2	29,833	0.12%	14	0.03%	2,131
	74U-300/CF6-80C2	29,290	0.12%	12	0.02%	2,441
	7UQ-300M/CF6-80C2	8,159	0.03%	4	0.01%	2,040
Boeing 747-400		**746,632**	**2.96%**	**259**	**0.48%**	**2,883**
	74I-400/CF6-80C2	136,035	0.54%	55	0.10%	2,473
	74I-400/PW4056	224,728	0.89%	70	0.13%	3,210
	74I-400/RB211-524G	240,207	0.95%	77	0.14%	3,120
	74I-400/RB211-524H	72,868	0.29%	30	0.06%	2,429
	7IQ-400M/CF6-80C2	72,794	0.29%	27	0.05%	2,696
Boeing 747-SP		**138,519**	**0.55%**	**54**	**0.10%**	**2,565**
	74P-SP/JT9D-7A	101,526	0.40%	38	0.07%	2,672
	74P-SP/JT9D-7FW	23,098	0.09%	8	0.01%	2,887
	74P-SP/JT9D-7F	13,373	0.05%	7	0.01%	1,910
	74P-SP/RB211-524C2	522	0.00%	1	0.00%	522
Boeing 747-SR		**27,645**	**0.11%**	**54**	**0.10%**	**512**
	74X-100SR/CF6-45A2	27,645	0.11%	54	0.10%	512
Boeing 757-200		**1,064,923**	**4.23%**	**1,223**	**2.29%**	**871**
	757-200/PW2037	612,357	2.43%	690	1.29%	887
	757-200/PW2040	229,631	0.91%	206	0.38%	1,115
	757-200/RB211-535E4	108,369	0.43%	111	0.21%	976
	757-200/RB211-535C	67,039	0.27%	144	0.27%	466
	75F/*	47,527	0.19%	72	0.13%	660

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
Boeing 767-200		**1,048,039**	**4.16%**	**819**	**1.53%**	**1,280**
	767-200/CF6-80A	795,036	3.15%	600	1.12%	1,325
	767-200/JT9D-7R4D	199,739	0.79%	154	0.29%	1,297
	767-200/CF6-80A2	53,264	0.21%	65	0.12%	819
Boeing 767-300		**435,695**	**1.73%**	**342**	**0.64%**	**1,274**
	76M-300/CF6-80A2	384,994	1.53%	220	0.41%	1,750
	76M-300/CF6-80C2	50,701	0.20%	122	0.23%	416
Airbus A300		**725,512**	**2.88%**	**1,036**	**1.94%**	**700**
	A30B2-100/CF6-50C2R	234,654	0.93%	325	0.61%	722
	A30B4-200/CF6-50C2	186,589	0.74%	248	0.46%	752
	A30B4-100/CF6-50C2	47,211	0.19%	119	0.22%	397
	A3L-300/PW4152	46,392	0.18%	38	0.07%	1,221
	A30B2-200/CF6-50C2R	45,058	0.18%	93	0.17%	484
	A3L-300/CF6-80C2A2	39,587	0.16%	35	0.07%	1,131
	A30B4-200/JT9D-59A	37,563	0.15%	60	0.11%	626
	A30B2-100/CF6-50C	24,973	0.10%	39	0.07%	640
	A30B4-100/JT9D-59A	19,352	0.08%	31	0.06%	624
	A3L-300/CF6-80C2A8	14,366	0.06%	9	0.02%	1,596
	A30B2-200/CF6-50C2	12,792	0.05%	28	0.05%	457
	A3L-300/JT9D-7R4E1	12,122	0.05%	8	0.01%	1,515
	A0CC4-200/CF6-50C2	4,853	0.02%	3	0.01%	1,618
Airbus A300-600		**132,201**	**0.52%**	**163**	**0.30%**	**811**
	A36-600/JT9D-7R4H1	63,921	0.25%	73	0.14%	876
	A36-600/CF6-80C2A1	38,947	0.15%	40	0.07%	974
	A36-600/PW4158	29,333	0.12%	50	0.09%	587
Airbus A310		**469,968**	**1.86%**	**424**	**0.79%**	**1,108**
	A31-200/CF6-80A3	299,844	1.19%	287	0.54%	1,045
	A31-200/JT9D-7R4E1	146,750	0.58%	88	0.16%	1,668
	A31-200/JT9D-7R4D1	18,146	0.07%	39	0.07%	465
	A31-200/CF6-80C2A2	5,228	0.02%	10	0.02%	523
Airbus A320		**611,093**	**2.42%**	**1,082**	**2.02%**	**565**
	A32-200/CFM56-5A1	425,042	1.69%	775	1.45%	548
	A32-200/V2500-A1	151,488	0.60%	252	0.47%	601
	A32-100/CFM56-5A1	19,399	0.08%	33	0.06%	588
	A32-200/CFM56-5A3	15,164	0.06%	22	0.04%	689

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
BAC111		**79,896**	**0.32%**	**217**	**0.41%**	**368**
	BAC-500/RR_SPEY-512	75,570	0.30%	203	0.38%	372
	BAC-200/RR_SPEY-511	2,479	0.01%	9	0.02%	275
	BAC-200/RR_SPEY-506	1,847	0.01%	5	0.01%	369
Concorde		**21,024**	**0.08%**	**7**	**0.01%**	**3,003**
	Concorde	21,024	0.08%	7	0.01%	3,003
Cessna Citation		**167**	**0.00%**	**1**	**0.00%**	**167**
	CNJ/*	167	0.00%	1	0.00%	167
Caravelle		**3,459**	**0.01%**	**7**	**0.01%**	**494**
	CVL-12/JT8D-9	2,191	0.01%	4	0.01%	548
	CVL-10B/JT8D-7	1,268	0.01%	3	0.01%	423
DC-8		**296,601**	**1.18%**	**303**	**0.57%**	**979**
	D8C-33F/JT4A-11	253,771	1.01%	269	0.50%	943
	D8S-73F/CFM56-2C	10,088	0.04%	6	0.01%	1,681
	DC8/*	9,597	0.04%	11	0.02%	872
	D8S-62H/JT3D-3B	8,667	0.03%	8	0.01%	1,083
	D8S-62H/JT3D-7	7,764	0.03%	5	0.01%	1,553
	D8S-63H/JT3D-7	6,714	0.03%	4	0.01%	1,679
DC-9		**1,252,254**	**4.97%**	**3,613**	**6.75%**	**347**
	D9S-30/JT8D-7B	517,724	2.05%	1,485	2.78%	349
	D9S-30/JT8D-9A	238,532	0.95%	718	1.34%	332
	DC9-10/JT8D-7B	225,195	0.89%	670	1.25%	336
	D9X-50/JT8D-17	66,799	0.27%	172	0.32%	388
	D9S-40/JT8D-11	52,479	0.21%	165	0.31%	318
	D9C-30F/JT8D-7B	43,001	0.17%	102	0.19%	422
	D9S-40/JT8D-15	37,365	0.15%	140	0.26%	267
	D9S-30/JT8D-17	36,639	0.15%	94	0.18%	390
	DC9-10/JT8D-7A	34,520	0.14%	67	0.13%	515
DC-10		**1,287,511**	**5.11%**	**812**	**1.52%**	**1,586**
	D10-10/CF6-6D	967,730	3.84%	639	1.19%	1,514
	DLR-30/CF6-50C2	142,380	0.56%	68	0.13%	2,094
	D1C-10F/CF6-6D	70,235	0.28%	47	0.09%	1,494
	DLR-40/JT9D-20	56,284	0.22%	16	0.03%	3,518
	DLR-30/CF6-50C2R	20,523	0.08%	19	0.04%	1,080

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
	D10-15/CF6-50C2F	18,190	0.07%	19	0.04%	957
	DLR-30/CF6-50C	12,169	0.05%	4	0.01%	3,042
Fokker 100		**167,667**	**0.67%**	**505**	**0.94%**	**332**
	F10-100/TAY650-15	149,630	0.59%	453	0.85%	330
	F10-100/TAY620-15	18,037	0.07%	52	0.10%	347
Fokker 28		**255,767**	**1.01%**	**952**	**1.78%**	**269**
	F28-4000/RR_SPEY-MK555	223,802	0.89%	828	1.55%	270
	F28-1000/RR_SPEY-MK555	26,059	0.10%	94	0.18%	277
	F28-2000/RR_SPEY-MK555	3,134	0.01%	20	0.04%	157
	F28-3000/RR_SPEY-MK555	1,677	0.01%	5	0.01%	335
	/F28-1000C/RR_SPEY-MK55	1,095	0.00%	5	0.01%	219
Ilyushin 62		**178,400**	**0.71%**	**70**	**0.13%**	**2,549**
	I62/SOL	178,400	0.71%	70	0.13%	2,549
Ilyushin 72		**22,458**	**0.09%**	**18**	**0.03%**	**1,248**
	I72/*	22,458	0.09%	18	0.03%	1,248
Ilyushin 86		**113,764**	**0.45%**	**94**	**0.18%**	**1,210**
	I86/KUZ	113,764	0.45%	94	0.18%	1,210
Lockheed 1011		**585,020**	**2.32%**	**481**	**0.90%**	**1,216**
	L10-1/RB211-22B	335,962	1.33%	318	0.59%	1,056
	LLR-500/RB211-524B4	196,967	0.78%	79	0.15%	2,493
	L10-200/RB211-524B	35,145	0.14%	76	0.14%	462
	L10-50/RB211-22B	16,946	0.07%	8	0.01%	2,118
McDonnell Douglas MD-11		**198,364**	**0.79%**	**74**	**0.14%**	**2,681**
	MDL-11P/PW4460	131,692	0.52%	47	0.09%	2,802
	MDL-11P/CF6-80C2	38,392	0.15%	15	0.03%	2,559
	M1F/*	16,602	0.07%	8	0.01%	2,075
	MDL-11C/CF6-80C2	11,678	0.05%	4	0.01%	2,920

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
McDonnell Douglas MD-80		**2,131,002**	**8.46%**	**4,249**	**7.94%**	**502**
	D9Z-82/JT8D-217	1,176,645	4.67%	2,081	3.89%	565
	D9Z-88/JT8D-219	284,405	1.13%	681	1.27%	418
	D9Z-81/JT8D-209	181,334	0.72%	390	0.73%	465
	D9M-87/JT8D-217	162,148	0.64%	348	0.65%	466
	D9Z-83/JT8D-219	145,411	0.58%	271	0.51%	537
	D9Z-81/JT8D-217	96,946	0.38%	260	0.49%	373
	D9Z-82/JT8D-217C	47,077	0.19%	159	0.30%	296
	D9Z-82/JT8D-219	34,778	0.14%	56	0.10%	621
	D9M-87/JT8D-219	2,258	0.01%	3	0.01%	753
Mercure		**8,411**	**0.03%**	**30**	**0.06%**	**280**
	MRC-100/JT8D-15	8,411	0.03%	30	0.06%	280
Tupolev 134		**130,207**	**0.52%**	**265**	**0.50%**	**491**
	T34/SOL	130,207	0.52%	265	0.50%	491
Tupolev 154		**574,728**	**2.28%**	**636**	**1.19%**	**904**
	T54/SOL	574,728	2.28%	636	1.19%	904
YAK 40		**4,796**	**0.02%**	**16**	**0.03%**	**300**
	Y40/IVC	4,796	0.02%	16	0.03%	300
YAK 42		**49,147**	**0.20%**	**97**	**0.18%**	**507**
	Y42/*	49,147	0.20%	97	0.18%	507
Miscellaneous		**5,853**	**0.02%**	**11**	**0.02%**	**532**
	LRJ/*	2,402	0.01%	4	0.01%	601
	WWP/*	2,206	0.01%	4	0.01%	552
	DFL/*	1,227	0.00%	2	0.00%	614
	NDC/*	18	0.00%	1	0.00%	18
Small Turboprops		**1,357,333**	**5.39%**	**9,966**	**18.62%**	**136**
	EM2/SMTURB	323,771	1.28%	1,691	3.16%	191
	SWM/SMTURB	268,737	1.07%	1,781	3.33%	151
	J31/SMTURB	259,269	1.03%	1,776	3.32%	146
	BE1/SMTURB	229,159	0.91%	1,695	3.17%	135
	DHT/SMTURB	103,191	0.41%	1,619	3.03%	64

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
	EMB/SMTURB	76,581	0.30%	549	1.03%	139
	DO8/SMTURB	40,993	0.16%	402	0.75%	102
	BE9/SMTURB	23,520	0.09%	216	0.40%	109
	BEK/SMTURB	19,988	0.08%	120	0.22%	167
	MU2/SMTURB	2,629	0.01%	12	0.02%	219
	DHB/SMTURB	2,492	0.01%	24	0.04%	104
	CD2/SMTURB	1,637	0.01%	29	0.05%	56
	CNN/SMTURB	1,456	0.01%	10	0.02%	146
	L4T/SMTURB	1,440	0.01%	9	0.02%	160
	CNC/SMTURB	1,042	0.00%	4	0.01%	261
	PA6/SMTURB	773	0.00%	3	0.01%	258
	HEC/SMTURB	554	0.00%	24	0.04%	23
	PL6/SMTURB	101	0.00%	2	0.00%	51
Medium Turboprops		**748,067**	**2.97%**	**4,673**	**8.73%**	**160**
	SF3/MDTURB	331,788	1.32%	1,748	3.27%	190
	DH8/MDTURB	303,549	1.20%	1,901	3.55%	160
	SH6/MDTURB	76,756	0.30%	743	1.39%	103
	DH3/MDTURB	22,212	0.09%	132	0.25%	168
	SH3/MDTURB	7,057	0.03%	89	0.17%	79
	DH1/MDTURB	4,028	0.02%	42	0.08%	96
	ND2/MDTURB	2,677	0.01%	18	0.03%	149
Large Turboprops		**768,648**	**3.05%**	**4,649**	**8.69%**	**165**
	ATR/LGTURB	187,684	0.74%	1,148	2.15%	163
	F50/LGTURB	132,624	0.53%	704	1.32%	188
	F27/LGTURB	120,937	0.48%	771	1.44%	157
	AT7/LGTURB	49,932	0.20%	313	0.58%	160
	DH7/LGTURB	49,751	0.20%	384	0.72%	130
	HS7/LGTURB	41,964	0.17%	260	0.49%	161
	YS1/LGTURB	36,883	0.15%	289	0.54%	128
	ATP/LGTURB	29,758	0.12%	225	0.42%	132
	AT4/LGTURB	26,887	0.11%	182	0.34%	148
	AN4/LGTURB	20,770	0.08%	109	0.20%	191
	YN7/LGTURB	18,541	0.07%	77	0.14%	241
	LOF/LGTURB	12,138	0.05%	36	0.07%	337
	CL4/LGTURB	6,830	0.03%	5	0.01%	1,366
	CVF/LGTURB	4,927	0.02%	14	0.03%	352
	CS5/LGTURB	4,843	0.02%	50	0.09%	97
	VC8/LGTURB	4,563	0.02%	13	0.02%	351
	LOE/LGTURB	4,196	0.02%	6	0.01%	699
	F2E/LGTURB	2,461	0.01%	20	0.04%	123
	IL8/LGTURB	2,444	0.01%	7	0.01%	349
	VCV/LGTURB	2,382	0.01%	4	0.01%	596
	LOH/LGTURB	2,200	0.01%	7	0.01%	314
	F2B/LGTURB	1,989	0.01%	9	0.02%	221

Table N-1. Departure and distance summaries for April 1992 scheduled air traffic

Generic Type	OAG Airplane/engine	Distance (nm/day)	% of Global Distance	Daily Departures	% of Global Departures	Average Route Distance (nm)
	CV5/LGTURB	1,534	0.01%	6	0.01%	256
	LOM/LGTURB	1,412	0.01%	2	0.00%	706
	CV6/LGTURB	998	0.00%	8	0.01%	125
TOTAL		**25,202,280**		**53,510**		

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13. ABSTRACT *(Maximum 200 words)*

This report describes the development of a three-dimensional database of aircraft fuel burn and emissions (fuel burned, NOx, CO, and hydrocarbons) from scheduled commercial aircraft for each month of 1992. The seasonal variation in aircraft emissions was calculated for selected regions (global, North America, Europe, North Atlantic, and North Pacific).

A series of parametric calculations were done to quantify the possible errors introduced from making approximations necessary to calculate the global emission inventory. The effects of wind, temperature, load factor, payload, and fuel tankering on fuel burn were evaluated to identify how they might affect the accuracy of aircraft emission inventories.

These emissions inventories are available for use by atmospheric scientists conducting the Atmospheric Effects of Aviation Project (AEAP) modeling studies. Fuel burned and emissions of nitrogen oxides (NOx as NO2), carbon monoxide, and hydrocarbons have been calculated on a 1 degree latitude x 1 degree longitude x 1 kilometer altitude grid and delivered to NASA as electronic files.

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