APPENDIX B - OVERVIEW PAPERS

In-Flight Measurements

Porter J. Perkins
NASA Lewis Research Center

There are two sources of in-flight ozone measurements; they are the NASA Globlal Atmospheric Sampling Program (GASP) and the carry-on ozone monitors used by other organizations. GASP consists of continuous daily measurements of ambient data since March 1975 and in-cabin data since March 1977. The in-cabin data are taken at one location in the cabins of a 747-100 and a 747SP. This program is scheduled to terminate in June 1979. The carry-on ozone monitors used by the FAA, the airlines, and other organizations measure ozone at several locations in the cabin. Only GASP data are presented here.

The objectives of the GASP ozone measurements are to establish the characteristics of ambient (outside) ozone concentrations during routine operations, and to determine the attenuation of ambient concentrations of cabin air systems from simultaneous ambient and in-cabin measurements. Characteristics of ambient ozone include:

(1) Maximum concentrations
(2) Duration of ozone encounters
(3) Frequency of ozone encounters
(4) Variability of ozone during a flight
(5) The above characteristics in relation to routes, altitude, and metorological conditions.

Ozone is measured at only one point in the cabin (fig. 1).

Ambient or atmospheric ozone concentrations can on some occasions vary widely along the flight path of a high altitude commercial airliner, ranging from less than 100 parts per billion by volume (ppbv) to over 1200 ppbv (fig. 2). Large and rapid (within 5 min) excursions of ozone concentrations can occur during high ozone encounters.

Simultaneous measurements of atmospheric and in-cabin ozone reveal an average attenuation factor of 62 percent (retention of ozone in the cabin of 38 percent of the atmospheric concentration) for the B747-100 airliner (figs. 3 and 4 and table I). However, the B747-SP type airliner showed a retention in the cabin averaging 80 percent of the atmospheric ozone (fig. 5 and table I). This was reduced to 5 percent on this aircraft when charcoal filters were installed in the cabin air system to destroy ozone (fig. 6 and table I).

Similar ozone measurements in a Gates Learjet Business jet conducted by NASA showed ozone retention in the cabin to range from 41 to 75 percent depending upon the load in the cabin (fig. 7 and table II).

Atmospheric ozone measurements from GASP-equipped airliners can establish the susceptibility of these aircraft on their specific route structures to high cabin ozone concentrations. A full year of data from the B747-100 airliner disclosed that, statistically, ozone concentrations are highest in the second quarter and peak during April (figs. 8 to 10).

TABLE I. - CORRELATIONS BETWEEN ATMOSPHERIC OZONE CONCENTRATIONS AND IN-CABIN OZONE LEVELS FOR B 747 AIRLINERS (SELECTIVE SAMPLE FLIGHTS WITH AND WITHOUT OZONE DESTRUCTION TECHNIQUES USED IN CABIN AIR SYSTEM)

Aircraft type	Added technique for reducing ozone	Ozone retention in cabin, percent of atmospheric level
B-747-100	None	38
B-747-SP	None	80
	Modified cabin air circulation	58
	15th-stage compressor bleed	19
	Charcoal filter	5

TABLE II. - CORRELATIONS BETWEEN ATMOSPHERIC OZONE CONCENTRATIONS AND IN-CABIN OZONE LEVELS FOR GATES LEARJET

Flight	Aircraft cabin configuration	Ozone retention in cabin, percent of atmospheric level
1	Relatively empty	75
2	↓	65
3	↓	61
4	↓	52
	Average	63
5	Relatively full	43
6	Relatively full	41
	Average	42

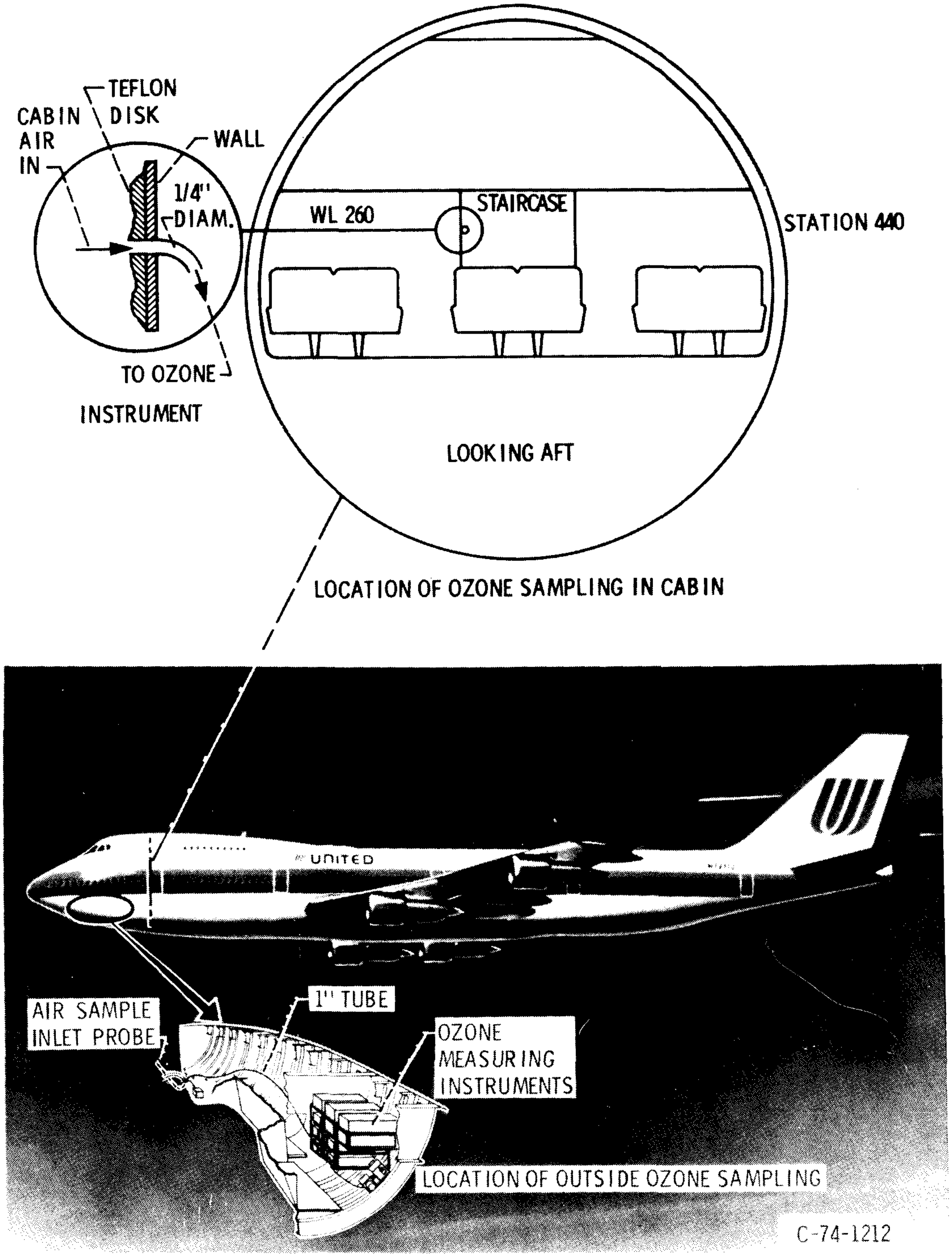

Figure 1. - Ozone measurement locations on B747 airliner.

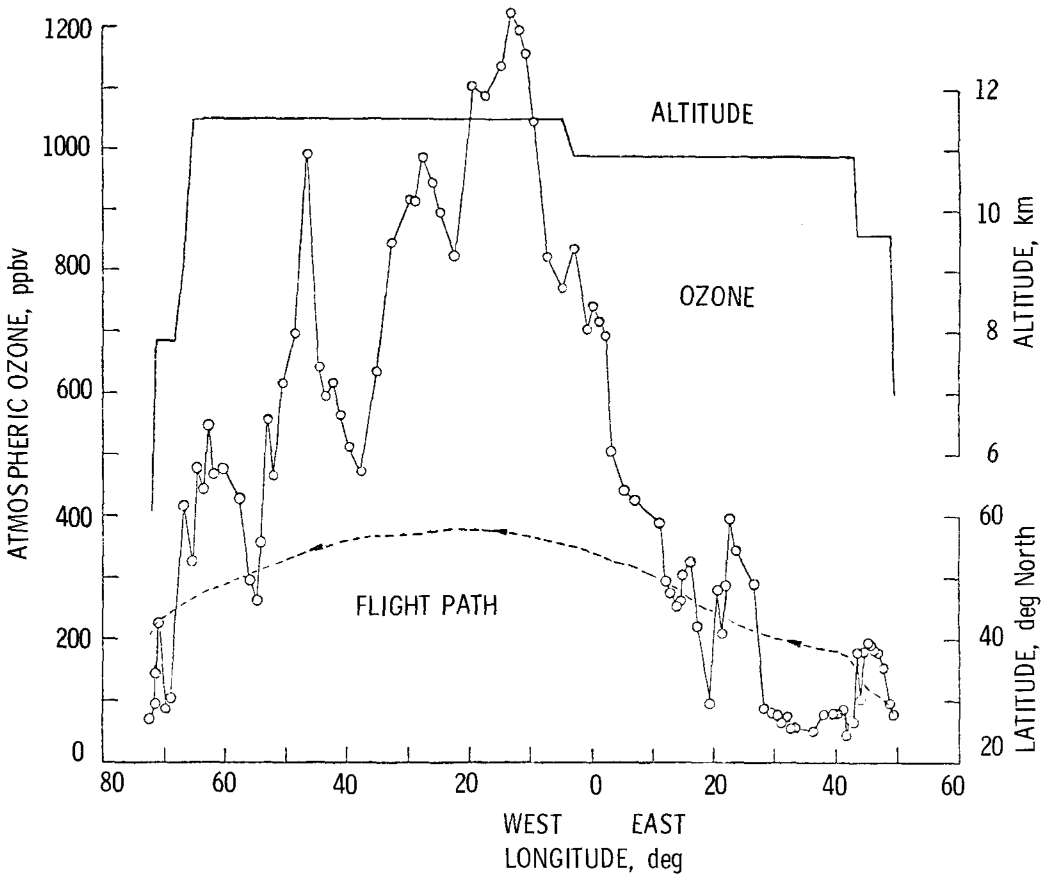

Figure 2. - Example of a high ozone concentration encounter.

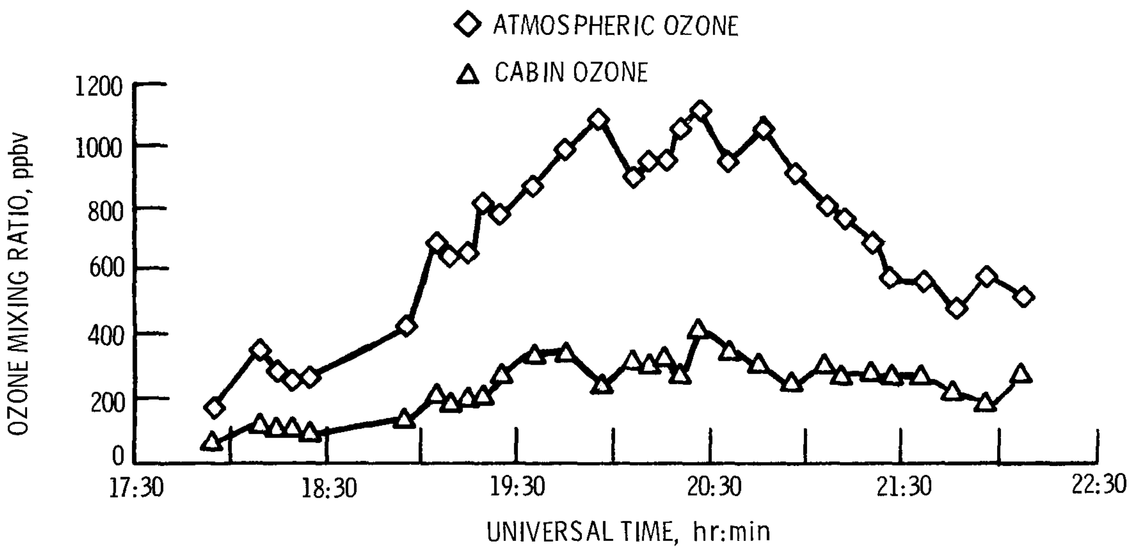

Figure 3. - Time history of ambient and cabin ozone levels for B747-100 airliner flying from New York to Los Angeles on April 3, 1977.

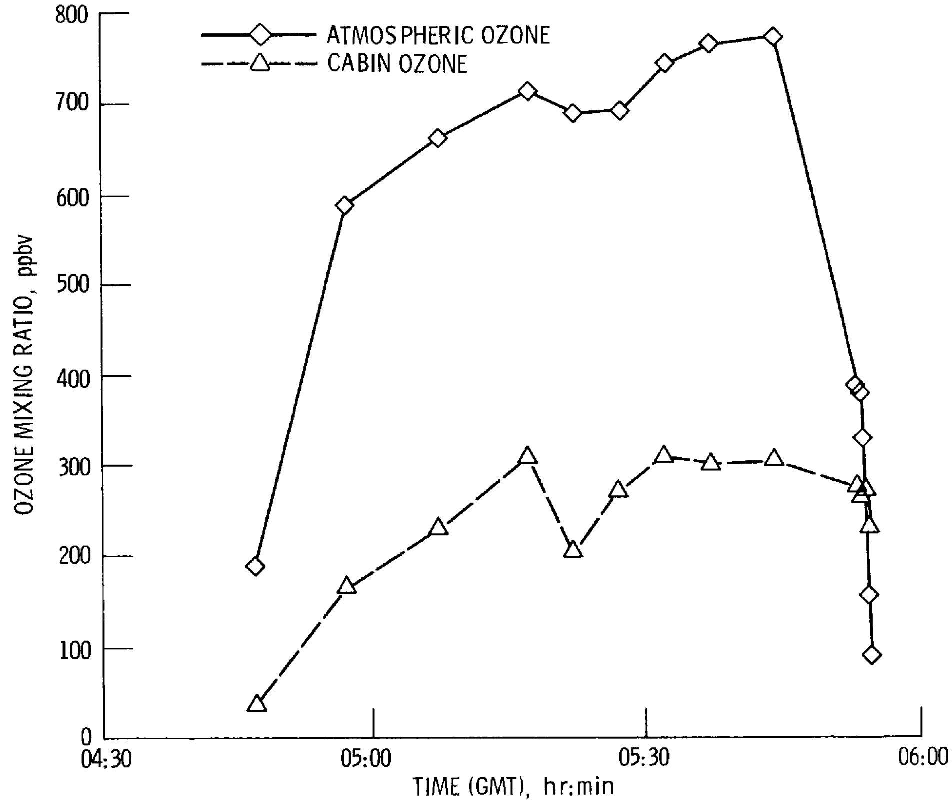

Figure 4. - Time history of atmospheric and cabin ozone levels for B-747 airliner flying from Denver to Chicago on March 8, 1978.

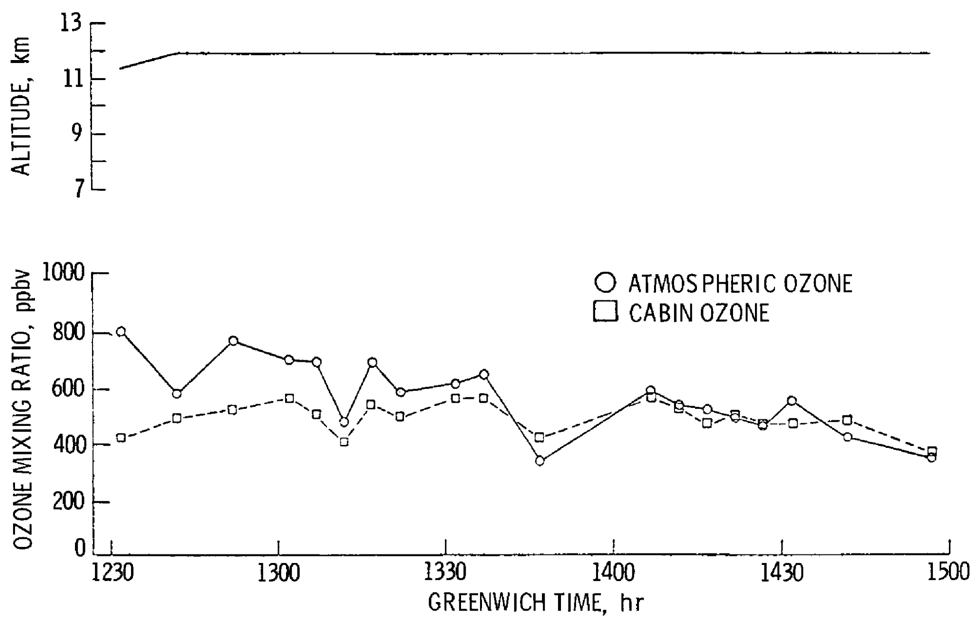

Figure 5. - Time history of cabin and atmospheric ozone mixing ratio levels for B747-SP airliner.

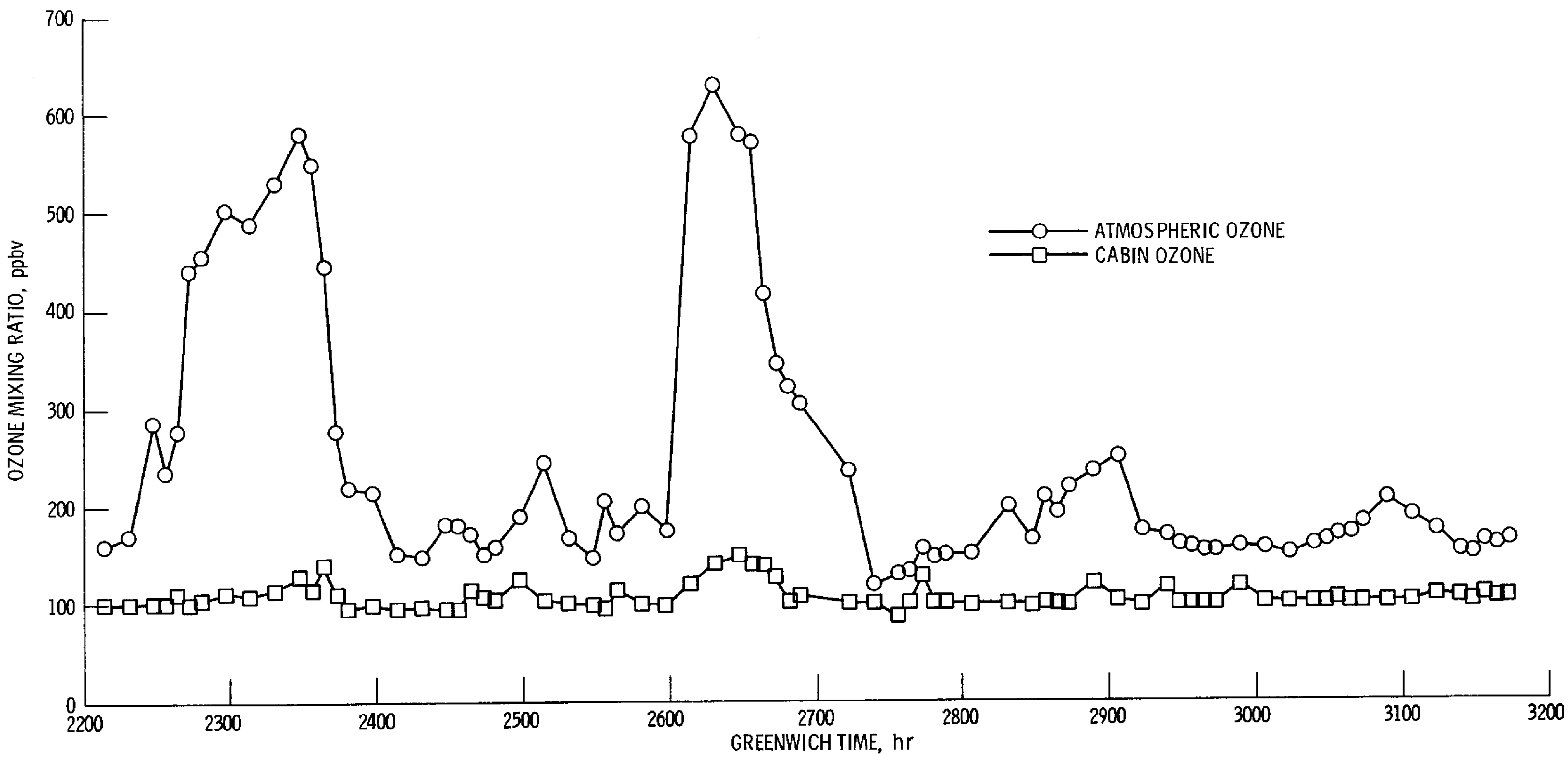

Figure 6. - Time history of ozone concentrations with charcoal filter on aircraft 533 Pa (B747-SP).

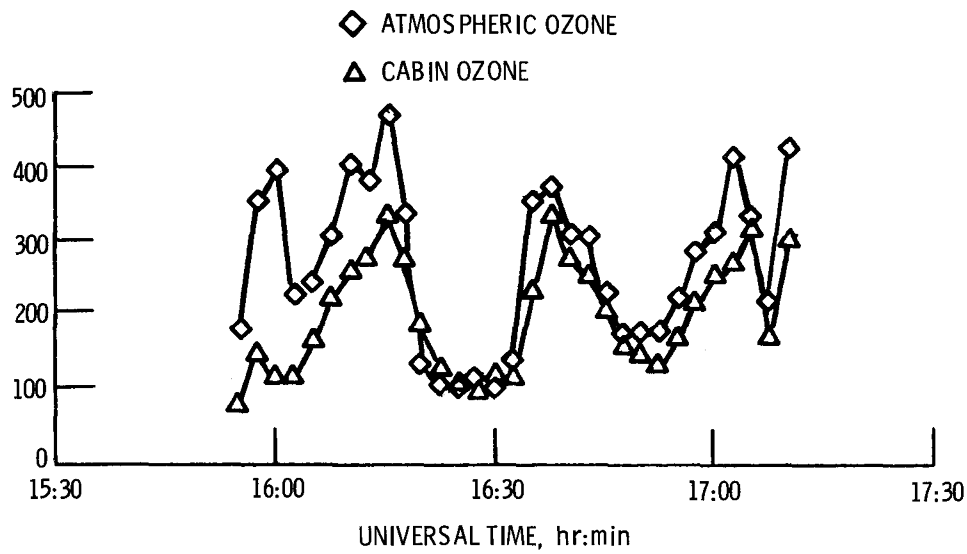

Figure 7. - Comparison of ambient and cabin ozone for Gates Learjet.

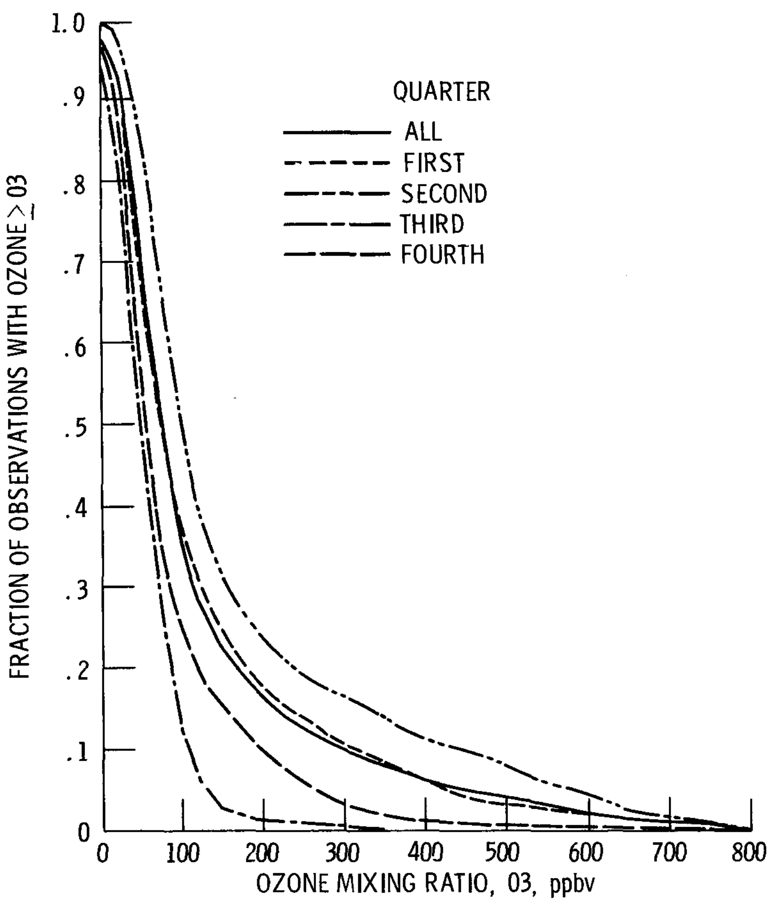

Figure 8. - Cumulative ambient ozone frequency distribution for B747-100 for one year.

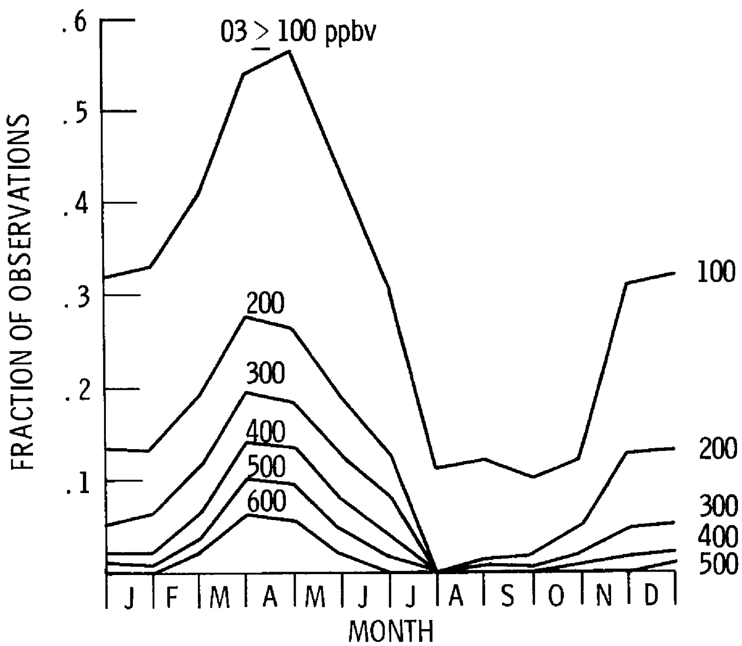

Figure 9. - Bimonthly variation of encounter frequencies for B747-100 for one year.

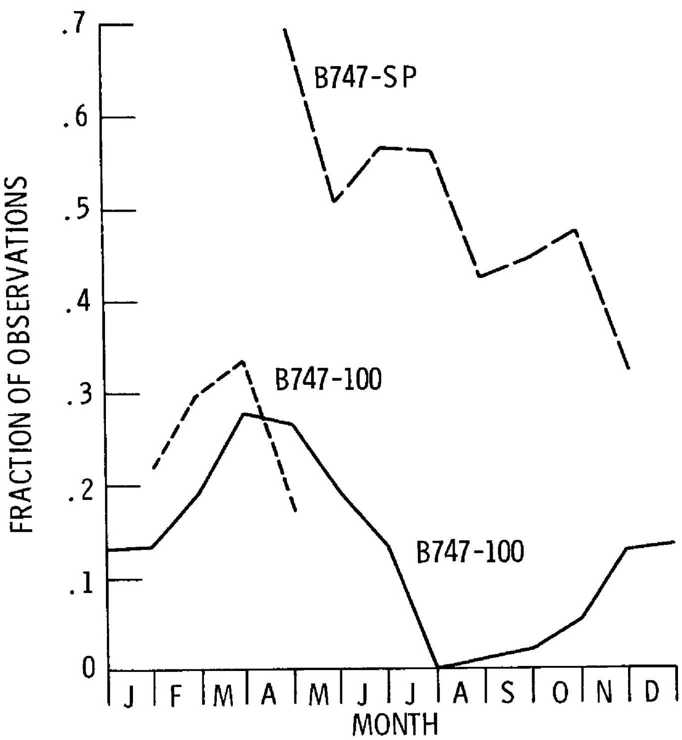

Figure 10. - Bimonthly variation of encounter frequencies for $O_3 \geq 200$ ppbv.