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The Capability of Satellite Borne Remote Sensors to Measure Stratospheric Trace Constituents

Volume III: Supporting Material

Edwin L. Keitz

Metrek Division of the Mitre Corporation
McLean, VA 22101

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REMOTE SENSING OF THE STRATOSPHERE Vol. III: Supporting Material
The Mitre Corporation/Metrek Division

ABSTRACT

This document is Volume III of a three volume report issued as MITRE/METREK Technical Report, MTR-7519. The three volumes cover the following principal subjects:

Volume I contains a synthesis of the results of two previous MITRE/METREK studies {1,2} and an update of the information contained in them. The update was made during the Summer and Fall of 1977. These studies deal with a comprehensive review of stratospheric trace constituent measurement requirements. The scope of the study was restricted to those constituents which fall into the general category of "air pollutants."

Volume II separates stratospheric trace constituent measurement requirements into two somewhat overlapping areas. In the first area, it is assumed that the only problem of interest is ozone; its chemistry chain, environmental effects and measurement requirements. In like manner, in the second area it is assumed that the only problem of interest is stratospheric aerosols; their chemistry, effects and measurement requirements.

Volume III contains material of a supportive nature not considered to be of sufficient importance to be included in the other two volumes. This material is of two types:

- Information and numerical evaluations used in the development of mission evaluations for stratospheric trace constituent measurement.
- Various spatial and temporal distributions for those stratospheric trace species having sufficient measurements available to warrant their presentation.

The reader is advised to note that the results and conclusions presented here are based on the specific combination of remote sensors, Shuttle orbits and analysis values selected to exemplify the technique presented. Although these sensors and orbits are typical, extension of the study to include all available sensors and many orbits, or to another specific small combination could result in different results and conclusions.

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LIST OF CHEMICAL SYMBOLS*

Symbol	Name
A	Argon
Al^{++++}	Aluminum ion
nAl_2O_3	Aluminum oxide aerosol
Br	Atomic bromine
Br^-	Bromide ion aerosol
BrO	Bromine oxide
Ca^{++}	Calcium ion aerosol
CBr_4	Tetrabromomethane (carbon tetrabromide)
$CCl_2{=}CHCl$	Trichloroethylene
CCl_4	Tetrachloromethane (carbon tetrachloride)
$CFCl_2^+$	Dichlorofluoromethane radical
$CFCl_3$	Trichlorofluomethane (F-11)
CF_2Cl^+	Chlorodifluoromethane radical
$CF_2ClCFCl_2$	Trichlorotrifluoroethane (F-113)
CF_2Cl_2	Dichlorodifluoromethane (F-12)
$CHClF_2$	Chlorodifluoromethane (F-22)
$CHCl_2F$	Dichlorofluoromethane
$CHCl_3$	Trichloromethane (chloroform)
$CH_2{:}CHCl$	Vinyl chloride
CH_2Cl_2	Dichloromethane (methyl dichloride)

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*Common name given in parentheses where appropriate. Unless specifically stated, species is assumed to be in gaseous state.

LIST OF CHEMICAL SYMBOLS (Continued)

Symbol	Name
CH_2O	Methanal (formaldehyde)
CH_3	Methyl radical
CH_3Br	Bromomethane (methyl bromide)
CH_3CCl_3	Trichloroethane (methyl chloroform)
CH_3Cl	Chloromethane (methyl chloride)
CH_3O	Methyl oxy radical
CH_3O_2	Methyl peroxy radical
$(CH_3)_2S$	Methyl sulfide
CH_4	Methane
CO	Carbon monoxide
$COCl$	Carbonyl monochloride
COS	Carbonyl sulfide
CO_2	Carbon dioxide
nCO_2	Carbon dioxide in cluster formation; quasi aerosol
CS_2	Carbon disulfide
$C_2H_4Cl_2$	Dichloroethane
C_2H_5Cl	Chloroethane (ethyl chloride)
C_xH_y	Non-methane hydrocarbons (NMHC)
Cl	Atomic chlorine
Cl^-	Chloride ion aerosol
$Cl_2C{:}CCl_2$	Tetrachloroethene (perchloroethylene)
$ClFCO$	Fluoroformyl chloride

LIST OF CHEMICAL SYMBOLS (Continued)

Symbol	Name
ClO	Chlorine monoxide
$ClONO_2$	Chlorine nitrate
ClO_2	Chlorine dioxide
ClO_x	"Odd" chlorine
Cu^{++}	Copper ion aerosol
F_2CO	Carbonyl fluoride
Fe^{++} or Fe^{+++}	Iron ion aerosol
H	Atomic hydrogen
HBr	Hydrogen bromide
HCl	Hydrogen chloride
HF	Hydrogen fluoride
HNO_2	Nitrous acid
HNO_3	Nitric acid
$nHNO_3$	Nitric acid aerosol
HO or OH	Hydroxyl
HO_2	Hydroperoxyl
HSO_3^-	Bisulfite radical
H_2	Molecular hydrogen
H_2O	Water vapor
nH_2O	Liquid water or ice (as aerosol or in cluster formation)
H_2O_2	Hydrogen peroxide

LIST OF CHEMICAL SYMBOLS (Continued)

Symbol	Name
H_2S	Hydrogen sulfide
H_2SO_4	Sulfuric acid
$H_2SO_4 \cdot nH_2O$	Sulfuric acid aerosol
$H_xC_yO_z$	Unspecified organic compound
I^-	Iodide ion aerosol
K^+	Potassium ion aerosol
M	Unspecified third body
Mg	Magnesium aerosol
Mn^{++} or Mn^{+++}	Manganese ion aerosol
N	Atomic nitrogen
N_2	Molecular nitrogen
nN_2	Molecular nitrogen in cluster formation; quasi aerosol
NH_3	Ammonia
NH_4^+	Ammonium ion
nNH_4^+	Ammonium ion aerosol
$NH_4HSO_4 \cdot nH_2O$	Ammonium bisulfate aerosol
$(NH_4)_2SO_4$	Ammonium sulfate aerosol
$(NH_4)_2S_2O_8$	Ammonium peroxydisulfate aerosol
NO	Nitric oxide
nNO	Nitric oxide in cluster formation; quasi aerosol
NO_2	Nitrogen dioxide

LIST OF CHEMICAL SYMBOLS (Continued)

Symbol	Name
NO_2^-	Nitrite ion aerosol
NO_3	Nitrogen trioxide
NO_3^-	Nitrate ion aerosol
NO_x	"Odd" nitrogen (nitrogen oxides)
N_2O	Nitrous oxide
N_2O_5	Nitrogen pentoxide
Na^+	Sodium ion aerosol
O	Atomic oxygen, unspecified
$O(^1D)$	Atomic oxygen, excited state ^1D
$O(^3P)$	Atomic oxygen, normal state
$O(^1S)$	Atomic oxygen, excited state ^1S
O_2	Molecular oxygen
$O_2(^1\Delta)$	Molecular oxygen, excited state $^1\Delta$
O_3	Ozone
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
nSO_2	Sulfur dioxide in cluster formation; quasi aerosol
SO_3	Sulfur trioxide
$SO_4^=$	Sulfate ion aerosol
Si^{++++}	Silicon ion aerosol

1.0 INTRODUCTION

This volume presents several appendices of supporting material used in preparation of Volumes I and II. Brief descriptions of these appendices are given below.

1.1 Appendix A

This appendix presents the two basic information sets used in the evaluation of the individual stratospheric constituents. The first set consists of the value matrices for all species contained in groups 1 and 2 of the prioritized list of constituents contained in Volume I plus the matrices for all those other constituents for which evaluations were planned or completed.

The second information set gives the evaluations of the various species for present knowledge and required knowledge. Also shown are the weighting functions for the various performance parameters along with the rationale for selecting these weightings.

1.2 Appendix B

The twenty-nine figures presented show various distributions for those species having sufficient measurements to warrant their presentation. References to the principal sources of the information are shown in the caption for each figure. Table 1-I presents a compilation of the distributions given in this appendix.

In all cases, the information is intended to show typical rather than precise data. These figures are presented for purposes of mission planning and not necessarily for precise scientific study.

TABLE 1-I

SPECIFIC DISTRIBUTIONS INCLUDED IN APPENDIX B

	Vertical	Latitude	Global	Seasonal
H_2O Vapor	x			
O_3	x	x	x	x
Aerosols	x	x		
CO_2	x			
NO	x	x		x
NO_2	x			
H_2	x			
N_2O	x			
HNO_3	x	x		x
CO	x			
CH_4	x			
HCl	x			
Freon 11	x	x		x
Sulfates	x	x		
Bromides	x	x		

All vertical profiles for gases are presented on identical base charts for interspecies comparisons at a glance. The profiles show both the number density and the volume mixing ratio of each gas. The other distributions shown are presented in the units used in the original references.

1.3 Appendix C

This appendix presents the references used in all three volumes. For the convenience of the user, the same set of reference numbers was used in all volumes. Therefore, the text of any one volume does not cite all the references.

APPENDIX A

INFORMATION SETS USED IN THE EVALUATIONS

APPENDIX A: INFORMATION SETS USED IN THE EVALUATIONS

A.1 INTRODUCTION

This appendix presents the evaluation matrices used during the mission evaluations discussed in Volumes I and II. The use of these matrices and of the evaluation method has been discussed in Appendix A of both Volumes I and II.

For each species evaluated six matrices and a summary table are presented. The matrices for the seventh parameter, launch time, are not presented since in the present evluations no case occurred where the time of launch was of any significance. Therefore every species was given equal value for this parameter. This common matrix is shown as Table A-I.

The summary table gives the total value for present knowledge and required knowledge for each species. Also included are the parameter weighting functions and the rationale for assignment of these.

TABLE A-I

EVALUATION MATRIX, TIME OF LAUNCH, ALL SPECIES

DATA STATUS	270°	180°	90°	None or DNA
Good				DNA 10
Med				
Sparse				
None				

SEASONAL PHASE DEVIATION*

90° - Launch is one season prior to desires season.
180° - Launch is two seasons prior to desires season.
270° - Launch is three seasons prior to desired season.
DNA - Launch time is not important.

A.2 INFORMATION SETS

The following pages present the evaluation matrices (left side of page) and the summary table (right side of page) for each of the eighteen species in the study.

TABLE A-II

EVALUATION MATRICES, WATER VAPOR, H_2O

Latitude Coverage

DATA STATUS				
Good		6	8	10
Med		5	7	$^{R}9$
Sparse		2	$^{P}6$	7
None	0			
	None	60°	120°	180°

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS				
Good		3	9	10
Med		2	7	$^{R}9$
Sparse		1	$^{P}5$	7
None	0			
	None	Short Survey	>One Year	Decades

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS						
Good		3	5	7	9	10
Med		2	4	6	8	9
Sparse		1	2	3	$^{P}7$	$^{R}8$
None	0					
	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS				
Good		3	7	$^{R}10$
Med		2	6	9
Sparse		1	$^{P}5$	7
None	0			
	None	<10%	50%	100%

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS					
Good		0	3	5	$^{R}10$
Med		0	2	4	9
Sparse		0	1	3	$^{P}7$
None	0				
	None	<1	1	10	>40

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS				
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			
	None	0-° 90°	90°- 180°	180°- 360°

LONGITUDE BAND COVERED

TABLE A-III

EVALUATION SUMMATION, WATER VAPOR, H_2O

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.3	6	1.8	9	2.7
Duration of Program	.2	5	1.0	9	1.8
Diurnal Coverage	.1	7	0.7	8	0.8
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	5	0.75	10	1.5
Vertical Profile Resolution	.15	7	1.05	10	1.5
Longitude	.1	0	0	8	0.8
	1.0		5.3		9.1
Rounded Off Total		5		9	

Rationale for weighting functions:
All parameters known to some extent. Increased knowledge of Latitudinal and Vertical profiles desirable. Diurnal change considered to be negligible.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-IV

EVALUATION MATRICES, OZONE, O_3

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		4	6	$^{P}10^{R}$
Med		3	5	9
Sparse		2	4	8
None	0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		2	6	$^{R}10$
Med		2	5	$^{P}7$
Sparse		1	4	6
None	0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good			5	6	9	10
Med			4	5	$^{R}8$	9
Sparse			$^{P}2$	3	6	7
None	0					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		2	7	$^{R}10$
Med		1	6	8
Sparse		0	5	$^{P}7$
None				

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	3	7	$^{R}10$
Med		0	2	5	7
Sparse		0	1	3	$^{P}5$
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		3	5	$^{P}10^{R}$
Med		2	4	9
Sparse		1	3	6
None				

LONGITUDE BAND COVERED

TABLE A-V

EVALUATION SUMMATION, OZONE, O_3

Parameter	WF 0-1	Present Knowledge		Required Knowledge	
		V	VXWF	V	VXWF
Latitude	.25	10	2.5	10	2.5
Duration of Program	.25	7	1.75	10	2.5
Diurnal Coverage	.15	2	.3	8	1.2
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.1	7	.7	10	1
Vertical Profile Resolution	.15	5	.75	10	1.5
Longitude	.1	10	1	10	1
	1.0		7.0		9.7
Rounded Off Total		7		10	

Rationale for weighting functions:

Latitude coverage very important due to desirability of polar zone measurements.

Total ozone has to be measured for several decades.

Diurnal coverage: Ozone shows little diurnal change extensive measurement not warranted.

Vertical profiles rather well understood some improvement desirable.

Longitudinal distribution of total ozone reasonably well measured.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-VI

EVALUATION MATRICES, AEROSOLS

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		4	6	R10
Med		3	5	P9
Sparse		2	4	5
None				

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		5	R9	10
Med		3	P8	9
Sparse		1	5	7
None				

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		8	8	8	9	10
Med		7	7	7	P9R	9
Sparse		6	6	6	8	8
None						

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		2	7	R10
Med		1	6	P8
Sparse		0	5	7
None				

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	2	7	R10
Med		0	1	5	P7
Sparse		0	0	2	4
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	R10
Med		7	8	9
Sparse		P6	7	8
None				

LONGITUDE BAND COVERED

TABLE A-VII

EVALUATION SUMMATION, AEROSOLS

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.15	9	1.35	10	1.5
Duration of Program	.15	8	1.2	9	1.35
Diurnal Coverage	.05	9	0.45	9	0.45
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.25	8	2.0	10	2.5
Vertical Profile Pesolution	.15	7	1.05	10	1.5
Longitude	.25	6	1.5	10	2.5
	1.0		7.55		9.8
Rounded Off Total		8		10	

Rationale for weighting functions:
Latitude already well covered
Measurements taken over many year period.
Diurnal change small and negligible.
Launch time unimportant except for volcanic activity.
Vertical coverage: More data needed in upper stratosphere current data resolution acceptable.
Longitudinal coverage needs improvement.

Note: SAM II is scheduled for NIMBUS G, 1 Km resolution, polar orbit (aerosols)

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-VIII

EVALUATION MATRICES, CARBON DIOXIDE, CO_2

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		3	7	10
Med		2	5	9
Sparse		1	2	$^{P}8^{R}$
None	0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		3	7	10
Med		2	5	9
Sparse		1	3	$^{P}8^{R}$
None	0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	3	4	9	10
Med		1	2	3	8	9
Sparse		0	1	2	$^{P}8^{R}$	8
None	0					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		2	5	$^{P}10^{R}$
Med		1	3	9
Sparse		0	1	8
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	6	$^{R}9$	10
Med		0	4	8	9
Sparse		0	2	7	$^{P}8$
None	0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		3	7	10
Med		2	5	9
Sparse		1	2	$^{P}8^{R}$
None	0			

LONGITUDE BAND COVERED

TABLE A-IX

EVALUATION SUMMATION, CARBON DIOXIDE, CO_2

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	0.1	8	0.8	8	0.8
Duration of Program	0.3	8	2.4	8	2.4
Diurnal Coverage	0.1	8	0.8	8	0.8
Launch Time	0	10	0	10	0
Vertical Profile Coverage	0.2	10	2.0	10	2.0
Vertical Profile Resolution	0.2	8	1.6	9	1.8
Longitude	0.1	8	0.8	8	0.8
	1.0		8.4		8.6
Rounded Off Total		8		9	

Rationale for weighting functions:

CO_2 distributions are nearly constant except for long-term buildup. Vertical profile needs some additional verification particularly at higher altitudes.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-X

EVALUATION MATRICES, HYDROXYL, HO

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		8	9	10
Med		7	$^{R}8$	9
Sparse		6	7	8
None	P_0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		8	9	10
Med		$^{R}7$	8	9
Sparse		5	7	8
None	P_0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		1	4	5	9	10
Med		1	4	5	$^{R}8$	9
Sparse		1	3	4	7	8
None	P_0					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		4	8	10
Med		3	$^{R}7$	9
Sparse		2	6	7
None	P_0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		2	3	8	10
Med		1	2	$^{R}7$	9
Sparse		1	2	5	7
None	P_0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	P_0			

LONGITUDE BAND COVERED

TABLE A-XI

EVALUATION SUMMATION, HYDROXYL, HO

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.15	0	0	8	1.2
Duration of Program	.1	0	0	7	.7
Diurnal Coverage	.3	0	0	8	2.4
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.2	0	0	7	1.4
Vertical Profile Resolution	.2	0	0	7	1.4
Longitude	.05	0	0	8	0.4
	1.0		0		7.5
Rounded Off Total		0		8	

Rationale for weighting functions:
Primary requirements at present are for initial measurements of hydroxyl stressing vertical profile and diurnal change. Theoretical models indicate a strong diurnal change.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XII

EVALUATION MATRICES, ATOMIC OXYGEN, $O(^3P)$

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		8	9	10
Med		7	8	$^{R}9$
Sparse		6	7	8
None	$^{P}0$			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		8	9	10
Med		$^{R}7$	8	9
Sparse		5	7	8
None	$^{P}0$			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		1	4	5	9	10
Med		1	4	5	8	$^{R}9$
Sparse		1	3	4	7	8
None	$^{P}0$					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		4	5	10
Med		3	4	$^{R}9$
Sparse		$^{P}2$	3	7
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		2	3	6	10
Med		1	2	5	$^{R}9$
Sparse		1	2	$^{P}4$	6
None	0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XIII

EVALUATION SUMMATION, ATOMIC OXYGEN, O(^{3}P)

Parameter	WF 0-1	Present Knowledge		Required Knowledge	
		V	VXWF	V	VXWF
Latitude	.15	0	0	9	1.35
Duration of Program	.1	0	0	7	0.7
Diurnal Coverage	.3	0	0	9	2.7
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.2	0	0	9	1.8
Vertical Profile Resolution	.2	0	0	9	1.8
Longitude	.05	0	0	8	0.4
	1.0		0		8.75
Rounded Off Total		0		9	

Rationale for weighting functions:
Primary requirements at present are for initial measurements of atomic oxygen stressing vertical profile and diurnal change.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XIV

EVALUATION MATRICES, ATOMIC OXYGEN, $O(^1D)$

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		8	9	10
Med		7	8	$^R9$
Sparse		6	7	8
None	P_0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		8	9	10
Med		$^R7$	8	9
Sparse		5	7	8
None	P_0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		1	4	5	9	10
Med		1	4	5	8	$^R9$
Sparse		1	3	4	7	8
None	P_0					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		4	5	10
Med		3	4	$^R9$
Sparse		2	3	7
None	P_0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		2	3	6	10
Med		1	2	5	$^R9$
Sparse		1	2	4	6
None	P_0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-90°	90°-180°	180°-360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^R8$
None	P_0			

LONGITUDE BAND COVERED

TABLE A-XV

EVALUATION SUMMATION, ATOMIC OXYGEN, $O(^1D)$

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.15	0	0	9	1.35
Duration of Program	.1	0	0	7	0.7
Diurnal Coverage	.3	0	0	9	2.7
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.2	0	0	9	1.8
Vertical Profile Resolution	.2	0	0	9	1.8
Longitude	.05	0	0	8	0.4
	1.0		0		8.75
Rounded Off Total		0		9	

Rationale for weighting functions:
Primary requirements at present are for initial measurements of atomic oxygen stressing vertical profile and diurnal change.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XVI

EVALUATION MATRICES, AMMONIA, NH_3

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		8	9	10
Med		7	8	9
Sparse		6	$^{R}7$	8
None	P_0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		8	9	10
Med.		7	8	9
Sparse		$^{R}6$	7	8
None	P_0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		3	7	8	9	10
Med		2	$^{R}6$	7	8	9
Sparse		1	4	6	7	8
None	P_0					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		4	8	10
Med		3	$^{R}7$	9
Sparse		2	6	7
None	P_0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		2	3	8	10
Med		1	2	$^{R}7$	9
Sparse		1	2	5	7
None	P_0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	P_0			

LONGITUDE BAND COVERED

TABLE A-XVII

EVALUATION SUMMATION, AMMONIA, NH_3

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.2	0	0	7	1.4
Duration of Program	.1	0	0	6	0.6
Diurnal Coverage	.15	0	0	6	0.9
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.25	0	0	7	1.75
Vertical Profile Resolution	.25	0	0	7	1.75
Longitude	.05	0	0	8	0.4
	1.0		0		6.8
Rounded Off Total		0		7	

Rationale for weighting functions:
Primary requirements at present are for initial measurements of ammonia stressing vertical profile.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XVIII

EVALUATION MATRICES, NITRIC OXIDE, NO

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	9	^{R}10
Med		5	8	9
Sparse		^{P}4	6	8
None	0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		5	^{R}9	10
Med		2	^{P}8	9
Sparse		0	2	8
None				

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	3	6	9	10
Med		1	2	5	8	^{R}9
Sparse		0	1	4	^{P}5	8
None						

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		2	8	^{R}10
Med		1	^{P}7	9
Sparse		0	3	8
None				

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	2	8	^{R}10
Med		0	1	^{P}7	9
Sparse		0	0	0	6
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-90°	90°-180°	180°-360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	^{R}8
None	^{P}0			

LONGITUDE BAND COVERED

TABLE A-XIX

EVALUATION SUMMATION, NITRIC OXIDE, NO

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.25	4	1.0	10	2.5
Duration of Program	.2	8	1.6	9	1.8
Diurnal Coverage	.3	5	1.5	9	2.7
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.1	7	0.7	10	1.0
Vertical Profile Resolution	.1	7	0.7	10	1.0
Longitude	.05	0	0	8	0.4
	1.0		5.5		9.4
Rounded Off Total		6		9	

Rationale for weighting functions:

Vertical profile has been measured to some extent. Most important need lies in understanding diurnal change. Also important are the latitudinal and seasonal changes. Theoretically diurnal and seasonal changes are large.

Legend:
WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XX

EVALUATION MATRICES, NITROGEN DIOXIDE, NO_2

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	9	$^{R}10$
Med		5	8	9
Sparse		$^{P}4$	6	8
None				

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		6	$^{R}9$	10
Med		6	8	9
Sparse		$^{P}5$	7	8
None				

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	3	6	9	10
Med		1	2	5	8	$^{R}9$
Sparse		0	1	4	$^{P}5$	8
None						

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		2	8	$^{R}10$
Med		1	7	9
Sparse		0	$^{P}6$	8
None				

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	2	8	$^{R}10$
Med		0	1	7	9
Sparse		0	0	$^{P}4$	6
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXI

EVALUATION SUMMATION, NITROGEN DIOXIDE, NO_2

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.15	4	.6	10	1.5
Duration of Program	.15	5	.75	9	1.35
Diurnal Coverage	.35	5	1.75	9	3.15
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	6	0.9	10	1.5
Vertical Profile Resolution	.15	4	0.6	10	1.5
Longitude	.05	0	0	8	0.4
	1.0		4.6		9.4
Rounded Off Total		5		9	

Rationale for weighting functions:

Critical need lies in diurnal measurements to clarify contradiction between theoretical and measured diurnal changes. Also needed are better vertical profiles, latitudinal and seasonal changes.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXII

EVALUATION MATRICES, ATOMIC CHLORINE, Cl

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	8	10
Med		5	7	9
Sparse		4	6	$^{R}8$
None	$^{P}0$			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		7	9	10
Med		6	$^{R}8$	10
Sparse		5	7	9
None	$^{P}0$			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	5	7	9	10
Med		1	4	6	8	10
Sparse		0	3	5	$^{R}7$	9
None	$^{P}0$					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		5	9	10
Med		4	$^{R}8$	9
Sparse		$^{P}3$	7	8
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	3	9	10
Med		0	2	$^{R}8$	9
Sparse		0	1	$^{P}2$	8
None	0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXIII

EVALUATION SUMMATION, ATOMIC CHLORINE, Cl

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.2	0	0	8	1.6
Duration of Program	.1	0	0	8	.8
Diurnal Coverage	.35	0	0	7	2.45
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	0	0	8	1.2
Vertical Profile Resolution	.15	0	0	8	1.2
Longitude	.05	0	0	8	.4
	1.0		0		7.65
Rounded Off Total		0		8	

Rationale for weighting functions:

No measurements of stratospheric atomic Cl exist. Since atomic Cl is formed by various UV reactions and atomic Cl reacts almost immediately with O_3 diurnal variation is very important. Other important initial measurements are vertical profile and latitudinal distribution.

Legend:
WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXIV

EVALUATION MATRICES, CHLORINE MONOXIDE, ClO

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	8	10
Med		5	7	9
Sparse		4	6	$^{R}8$
None	$^{P}0$			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		7	9	10
Med		6	$^{R}8$	10
Sparse		5	7	9
None	$^{P}0$			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	5	7	9	10
Med		1	4	6	8	10
Sparse		0	3	5	$^{R}7$	9
None	$^{P}0$					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		5	9	10
Med		4	$^{R}8$	9
Sparse		$^{P}3$	7	8
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	3	9	10
Med		0	2	$^{R}8$	9
Sparse		0	1	$^{P}2$	8
None	0				

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXV

EVALUATION SUMMATION, CHLORINE MONOXIDE, ClO

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.2	0	0	8	1.6
Duration of Program	.1	0	0	8	0.8
Diurnal Coverage	.35	0	0	7	2.45
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	0	0	8	1.2
Vertical Profile Resolution	.15	0	0	8	1.2
Longitude	.05	0	0	8	0.4
	1.0		4.8		9.35
Rounded Off Total			5		9

Rationale for weighting functions:

No measurements of stratospheric ClO exist. Reactions of ClO are closely linked to atomic Cl reactions. Also ClO photodissociates in presence of UV. Diurnal change important. Therefore, same weighting functions as Atomic Cl are used.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF.

TABLE A-XXVI

EVALUATION MATRICES, NITROUS OXIDE, N_2O

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	9	$^{R}10$
Med		5	8	9
Sparse		$^{P}4$	6	8
None				

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		6	$^{R}9$	10
Med		6	8	9
Sparse		$^{P}5$	7	8
None				

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	3	6	9	10
Med		1	2	4	9	10
Sparse		0	1	4	$^{P}8^{R}$	9
None						

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		2	8	$^{R}10$
Med		1	7	9
Sparse		0	$^{P}6$	8
None				

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	2	8	$^{R}10$
Med		0	1	7	9
Sparse		0	0	$^{P}4$	6
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXVII

EVALUATION SUMMATION, NITROUS OXIDE, N_2O

Parameter	WF 0-1	Present Knowledge		Required Knowledge	
		V	VXWF	V	VXWF
Latitude	.25	4	1.0	10	2.5
Duration of Program	.15	5	0.75	9	1.35
Diurnal Coverage	.1	8	0.8	8	0.8
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	6	0.9	10	1.5
Vertical Profile Resolution	.15	4	0.6	10	1.5
Longitude	.05	0	0	8	0.4
	1.0		4.05		8.05
Rounded Off Total		4		8	

Rationale for weighting functions:

Very few measurements exist. Primary need is for increased vertical profile data and latitudinal distributions. Theoretically there is no diurnal change.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXVIII

EVALUATION MATRICES, NITRIC ACID VAPOR, HNO_3

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	9	$^{R}10$
Med		4	8	9
Sparse		2	$^{P}5$	7
None				

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		5	$^{R}9$	10
Med		4	7	9
Sparse		3	$^{P}3$	7
None	0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	4	7	9	10
Med		1	3	7	$^{R}8$	9
Sparse		0	2	4	$^{P}7$	8
None						

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		3	8	$^{R}10$
Med		2	$^{P}7$	9
Sparse		1	3	5
None				

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	3	9	$^{R}10$
Med		0	1	$^{P}8$	9
Sparse		0	0	4	7
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-90°	90°-180°	180°-360°
Good		6	8	10
Med		5	7	9
Sparse		4	6	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXIX

EVALUATION SUMMATION, NITRIC ACID VAPOR, HNO_3

Parameter	WF 0-1	Present Knowledge		Required Knowledge	
		V	VXWF	V	VXWF
Latitude	.3	5	1.5	10	3.0
Duration of Program	.25	3	.75	9	2.25
Diurnal Coverage	.1	7	.7	8	.8
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	7	1.05	10	1.5
Vertical Profile Resolution	.1	8	.8	10	1.0
Longitude	.1	0	0	8	.8
	1.0		4.8		9.35
Rounded Off Total			5		9

Rationale for weighting functions:

Latitudinal variations and seasonal variations are large and require additional measurement. Vertical profile should be extended to top of stratosphere. Diurnal variation appears to be small.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXX

EVALUATION MATRICES, CARBON MONOXIDE, CO

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		8	9	10
Med		7	8	9
Sparse		$^{R}6$	7	8
None	$^{P}0$			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		3	7	8	9	10
Med		2	$^{R}6$	7	8	9
Sparse		1	4	6	7	8
None	$^{P}0$					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		4	8	10
Med		3	7	$^{R}9$
Sparse		2	$^{P}5$	6
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		2	3	8	10
Med		1	2	7	$^{R}9$
Sparse		0	1	$^{P}3$	7
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-90°	90°-180°	180°-360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXXI

EVALUATION SUMMATION, CARBON MONOXIDE, CO

Parameter	WF 0-1	Present Knowledge		Required Knowledge	
		V	VXWF	V	VXWF
Latitude	.4	0	0	8	3.2
Duration of Program	.1	0	0	6	0.6
Diurnal Coverage	.15	0	0	6	0.9
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	5	.75	9	1.35
Vertical Profile Resolution	.15	3	.45	9	1.35
Longitude	.05	0	0	8	0.4
	1.0		1.2		7.8
Rounded Off Total			1		8

Rationale for weighting functions:
Distribution mostly unknown except for a few vertical profiles. Additional vertical profiles and latitudinal measurements of first priority.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXXII

EVALUATION MATRICES, METHANE, CH_4

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		8	9	10
Med		7	8	9
Sparse		6	7	R8
None	P0			

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		8	9	10
Med		7	8	9
Sparse		R6	7	8
None	P0			

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		3	7	8	9	10
Med		2	R6	7	8	9
Sparse		1	4	6	7	8
None	P0					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		4	8	10
Med		3	7	R8
Sparse		2	5	P6
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		2	3	8	10
Med		1	2	7	R9
Sparse		0	1	P3	7
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	R8
None	P0			

LONGITUDE BAND COVERED

TABLE A-XXXIII

EVALUATION SUMMATION, METHANE, CH_4

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.4	0	0	8	3.2
Duration of Program	.1	0	0	6	0.6
Diurnal Coverage	.15	0	0	6	0.9
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.15	6	0.9	8	1.2
Vertical Profile Resolution	.15	3	0.45	9	1.35
Longitude	.05	0	0	8	0.4
	1.0		1.35		7.65
Rounded Off Total			1		8

Rationale for weighting functions:
Distribution mostly unknown except for a few vertical profiles. Additional vertical profiles and latitudinal measurements of first priority.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXXIV

EVALUATION MATRICES, HYDROGEN CHLORIDE, HCl

Latitude Coverage

DATA STATUS	None	60°	120°	180°
Good		6	8	10
Med		5	7	$^{R}9$
Sparse		$^{P}4$	6	8
None				

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS	None	Short Survey	>One Year	Decades
Good		7	9	10
Med		6	$^{R}8$	10
Sparse		$^{P}5$	7	9
None				

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal
Good		2	5	7	9	10
Med		1	4	6	8	10
Sparse		0	3	5	$^{R}7$	9
None	$^{P}0$					

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS	None	<10%	50%	100%
Good		5	8	10
Med		4	7	$^{R}9$
Sparse		3	$^{P}6$	8
None	0			

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS	None	<1	1	10	>40
Good		0	3	9	10
Med		0	2	8	$^{R}9$
Sparse		0	1	$^{P}7$	8
None					

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS	None	0-° 90°	90°- 180°	180°- 360°
Good		8	9	10
Med		7	8	9
Sparse		6	7	$^{R}8$
None	$^{P}0$			

LONGITUDE BAND COVERED

TABLE A-XXXV

EVALUATION SUMMATION, HYDROGEN CHLORIDE, HCl

Parameter	WF 0-1	Present Knowledge V	Present Knowledge VXWF	Required Knowledge V	Required Knowledge VXWF
Latitude	.35	4	1.4	9	3.15
Duration of Program	.1	5	.5	8	.8
Diurnal Coverage	.1	0	0	7	.7
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.2	6	1.2	9	1.8
Vertical Profile Resolution	.2	7	1.4	9	1.8
Longitude	.05	0	0	8	.4
	1.0		4.5		8.65
Rounded Off Total		5		9	

Rationale for weighting functions:
Very few measurements of stratospheric HCl exist. Basic need is for better and more extensive measurements of the vertical and latitudinal profiles. Since the reaction rates for the basic HCl formation and decomposition reactions are at least an order of magnitude slower than the rates for the principal Cl and ClO reactions, diurnal changes in HCl should be small.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

TABLE A-XXXVI

EVALUATION MATRICES, HYDROGEN FLUORIDE, HF

Latitude Coverage

DATA STATUS				
Good		8	9	10
Med		7	8	9
Sparse		6	R 7	8
None	P 0			
	None	60°	120°	180°

LATITUDE BAND COVERED

Duration of Measurement Program

DATA STATUS				
Good		8	9	10
Med		7	8	9
Sparse		R 6	7	8
None	P 0			
	None	Short Survey	>One Year	Decades

DURATION OF MEASUREMENT PROGRAM

Diurnal Coverage

DATA STATUS						
Good		3	7	8	9	10
Med		2	R 6	7	8	9
Sparse		1	4	6	7	8
None	P 0					
	None	Fixed Time	Partial Day	Full Day	Part Day/ Night	Full Diurnal

DIURNAL COVERAGE

Vertical Coverage

DATA STATUS				
Good		4	8	10
Med		3	R 7	9
Sparse		2	6	7
None	P 0			
	None	<10%	50%	100%

STRATOSPHERIC VERTICAL COVERAGE

Vertical Resolution

DATA STATUS					
Good		2	3	8	10
Med		1	2	R 7	9
Sparse		1	2	5	7
None	P 0				
	None	<1	1	10	>40

NUMBER OF DATA POINTS OBTAINED

Longitude Coverage

DATA STATUS				
Good		8	9	10
Med		7	8	9
Sparse		6	7	R 8
None	P 0			
	None	0-° 90°	90°- 180°	180°- 360°

LONGITUDE BAND COVERED

TABLE A-XXXVII

EVALUATION SUMMATION, HYDROGEN FLUORIDE, HF

Parameter	WF 0-1	Present Knowledge		Required Knowledge	
		V	VXWF	V	VXWF
Latitude	.2	0	0	7	1.4
Duration of Program	.1	0	0	6	0.6
Diurnal Coverage	.15	0	0	6	0.9
Launch Time	0	10	0	10	0
Vertical Profile Coverage	.25	0	0	7	1.75
Vertical Profile Resolution	.25	0	0	7	1.75
Longitude	.05	0	0	8	0.4
	1.0		0		6.8
Rounded Off Total		0		7	

Rationale For Weighting Functions:

Primary requirements at present are for initial measurements of hydrogen fluoride stressing vertical profile.

Legend: WF = Weighting Function
V = Value to user taken from value matrices
VXWF = Product of V and WF

APPENDIX B

SPECIFIC SPECIES DISTRIBUTIONS

APPENDIX B: SPECIFIC SPECIES DISTRIBUTIONS

This appendix contains twenty-nine figures presented to show various distributions for those species having sufficient measurements to warrant their presentation. In all cases, the information is intended to show typical rather than precise data. These figures are presented for purposes of mission planning and not necessarily for precise scientific study.

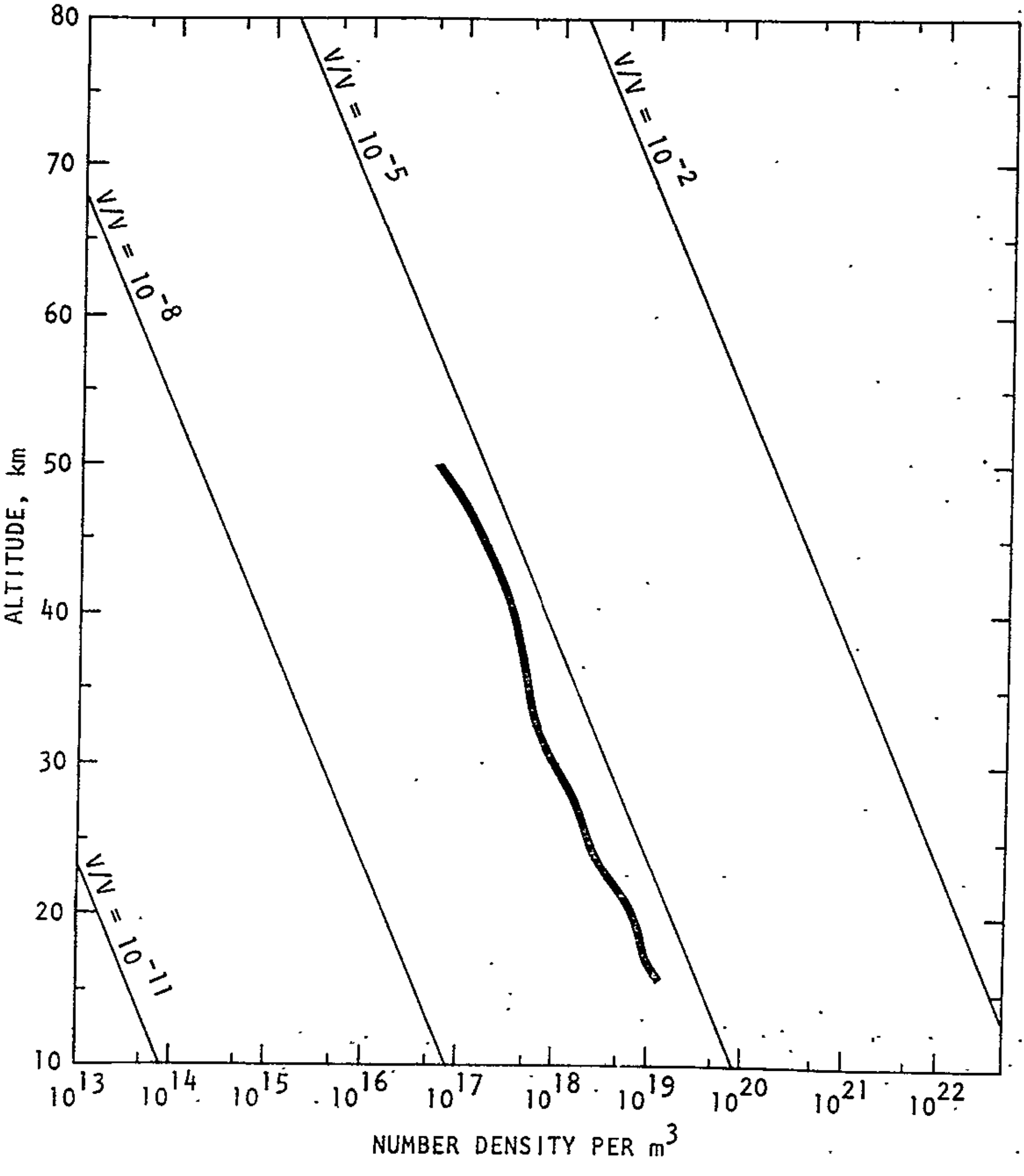


FIGURE B-1
VERTICAL DISTRIBUTION OF WATER VAPOR,
H_2O, MID-LATITUDE [84, 85, 86, 87]

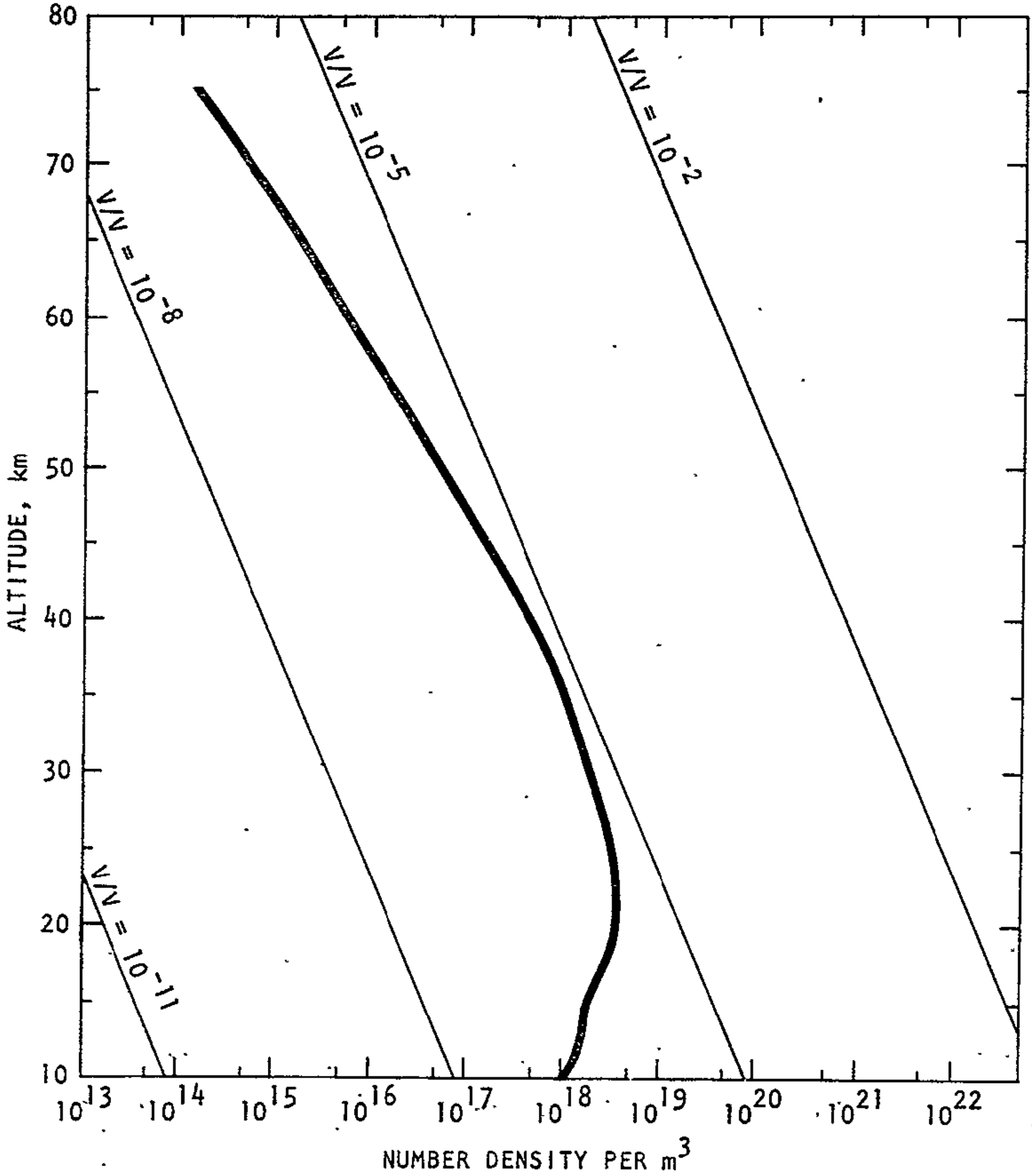


FIGURE B-2
VERTICAL DISTRIBUTION OF OZONE, O_3
MID-LATITUDE [88]

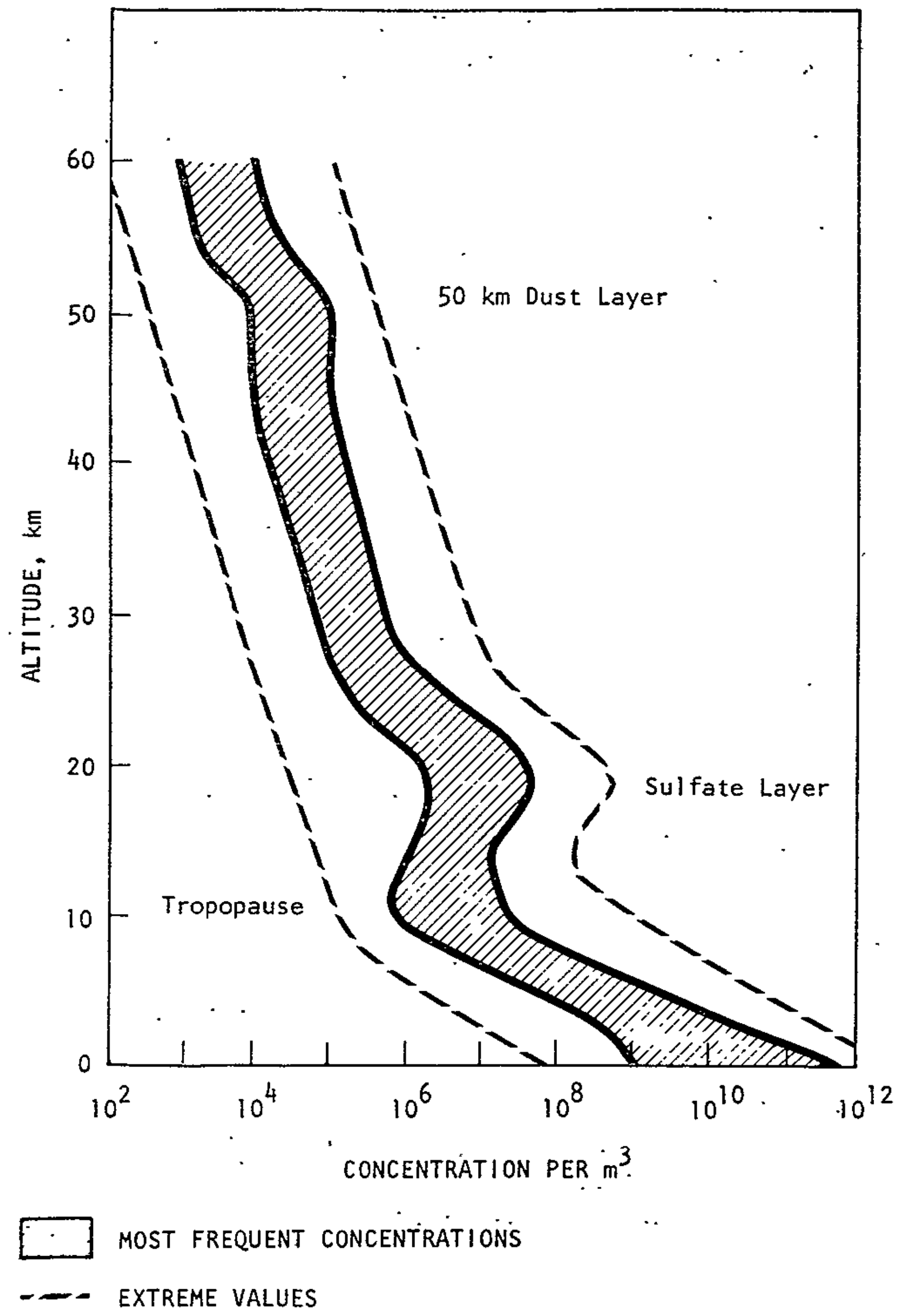


FIGURE B-3
VERTICAL DISTRIBUTION OF AEROSOLS [66]

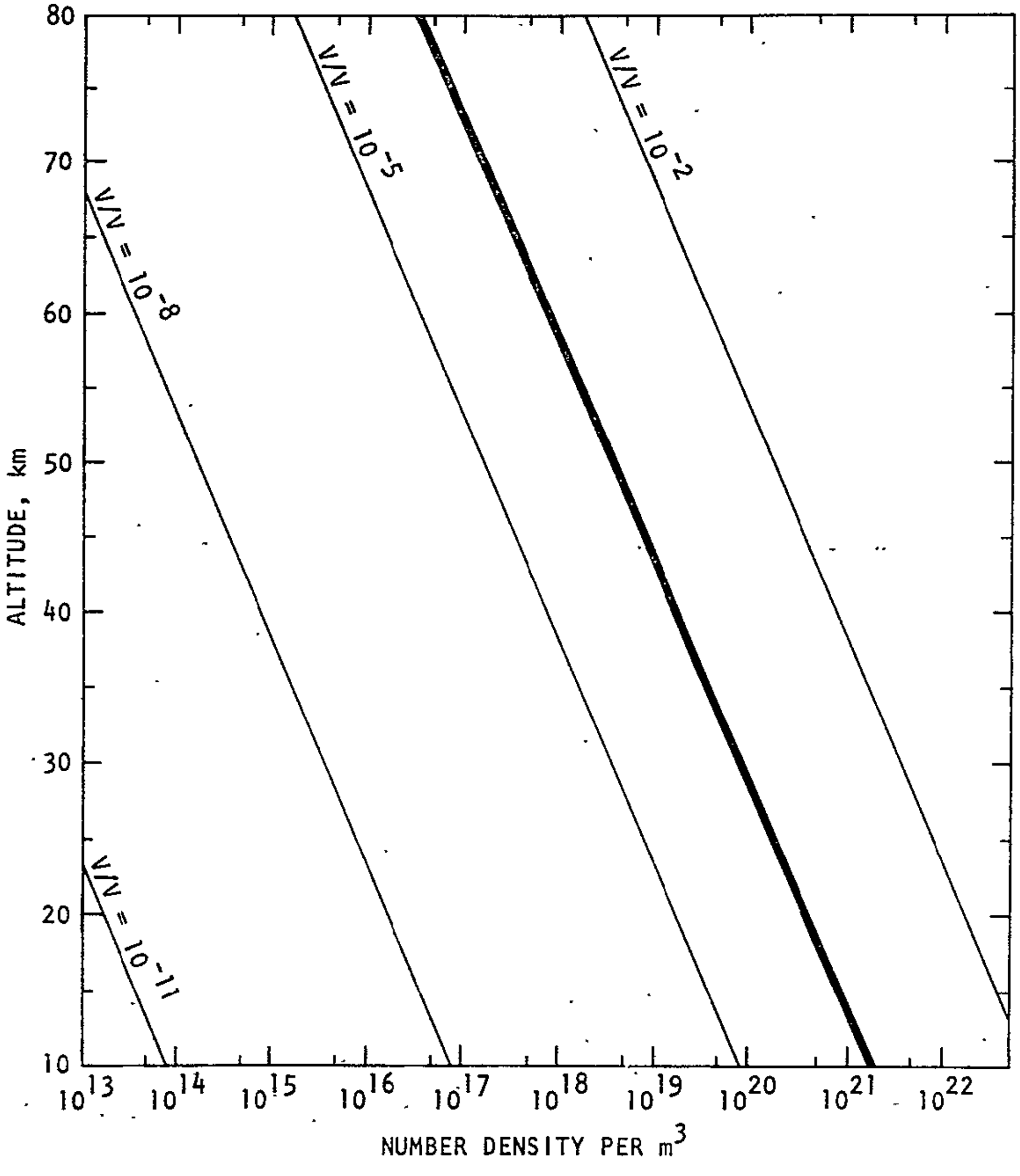


FIGURE B-4
VERTICAL DISTRIBUTION OF CARBON DIOXIDE, CO_2
ALL LATITUDES, ALL SEASONS [89]

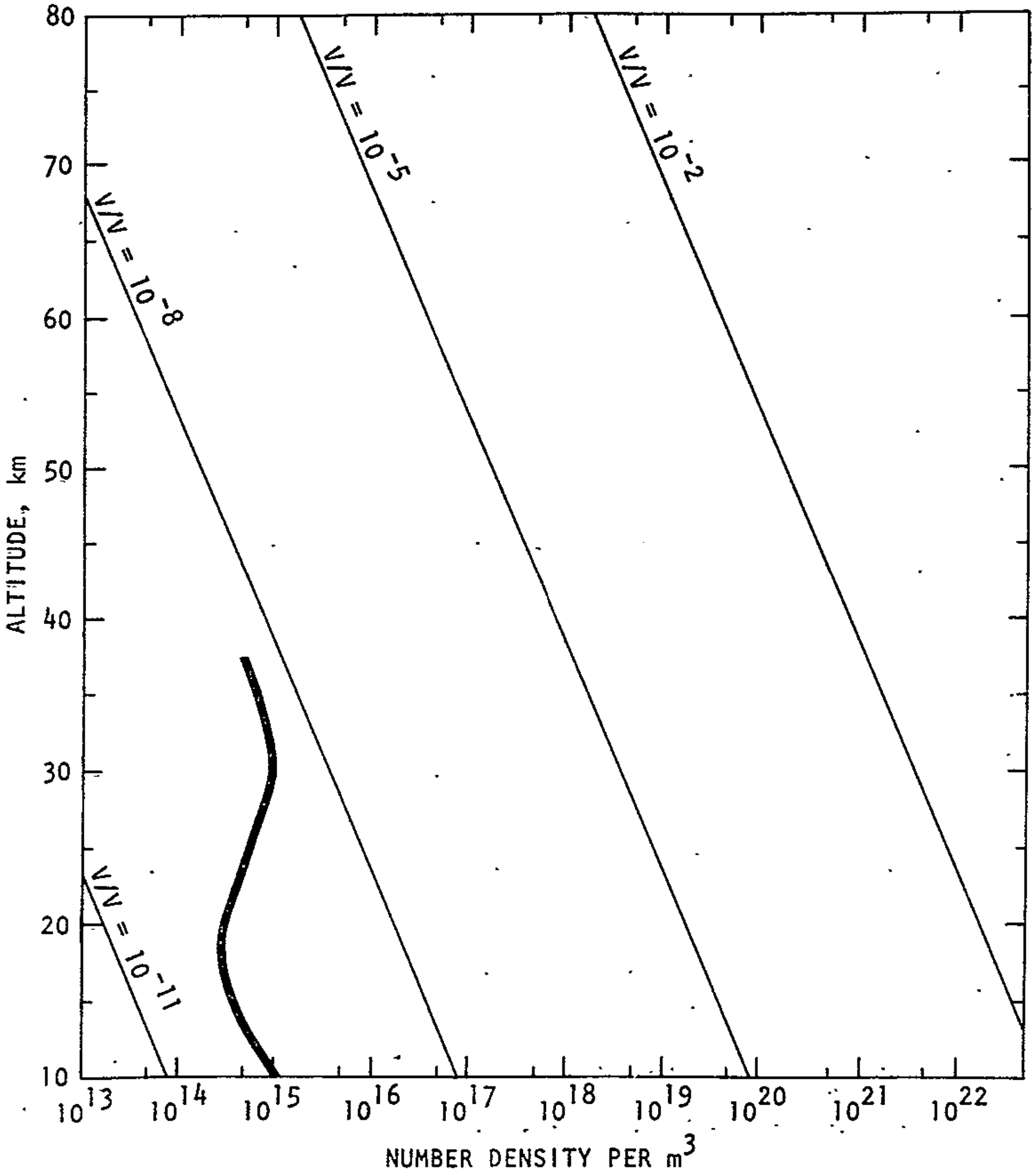


FIGURE B-5
VERTICAL DISTRIBUTION OF NITRIC OXIDE, NO
MID-LATITUDE[89]

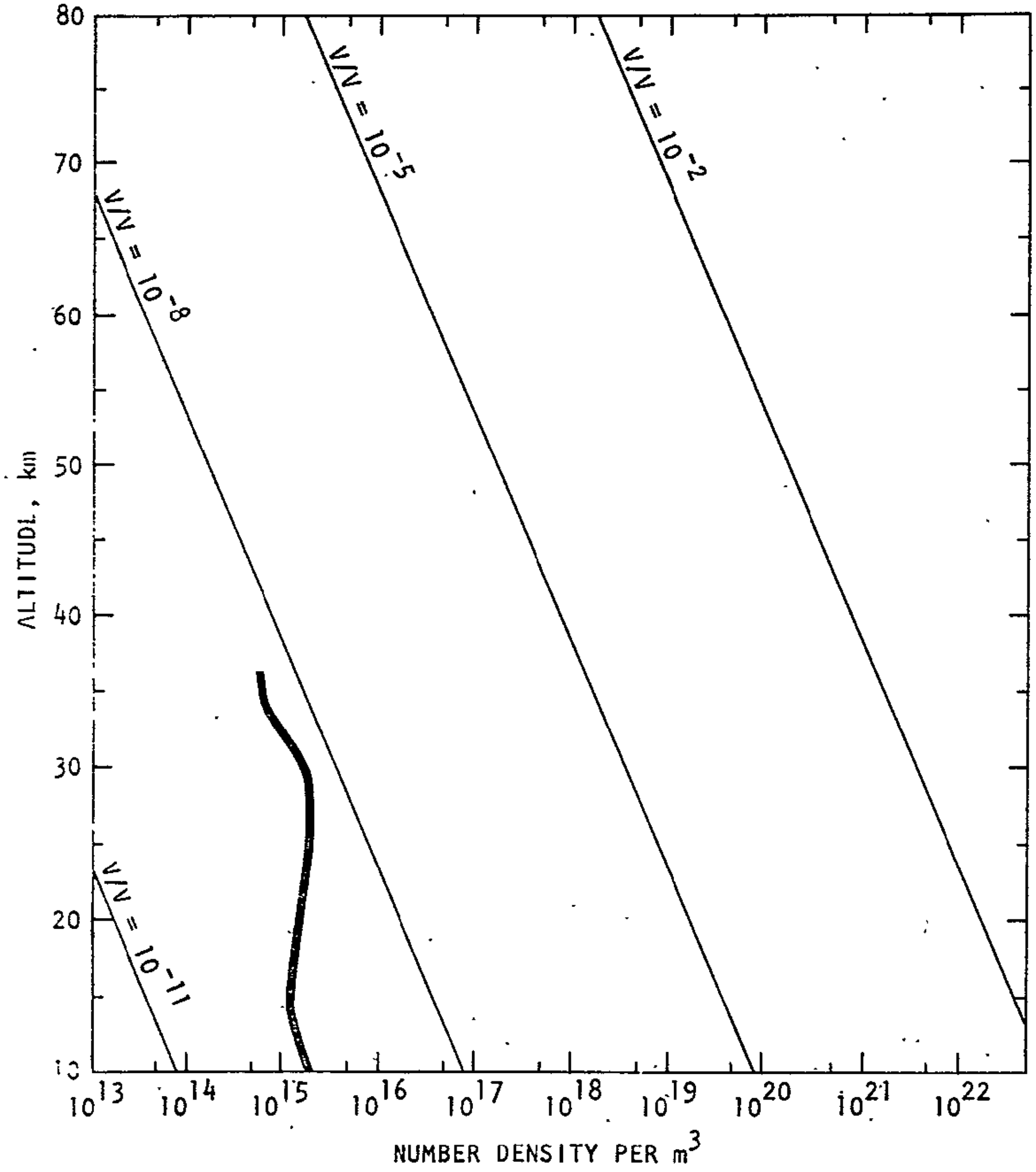


FIGURE B-6
VERTICAL DISTRIBUTION OF NITROGEN DIOXIDE, NO_2
MID-LATITUDE [89]

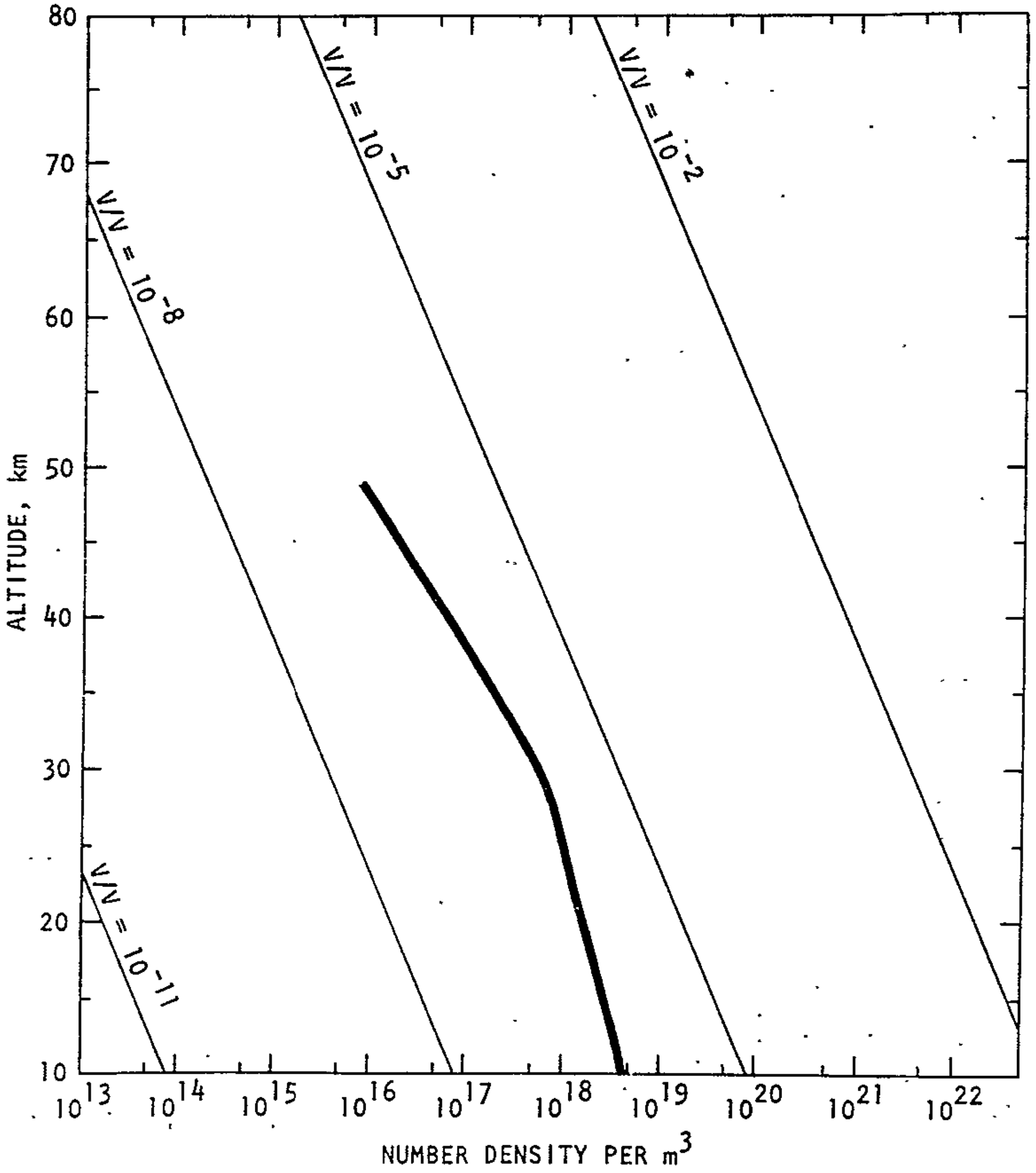


FIGURE B-7
VERTICAL DISTRIBUTION OF HYDROGEN, H_2
MID-LATITUDE[63]

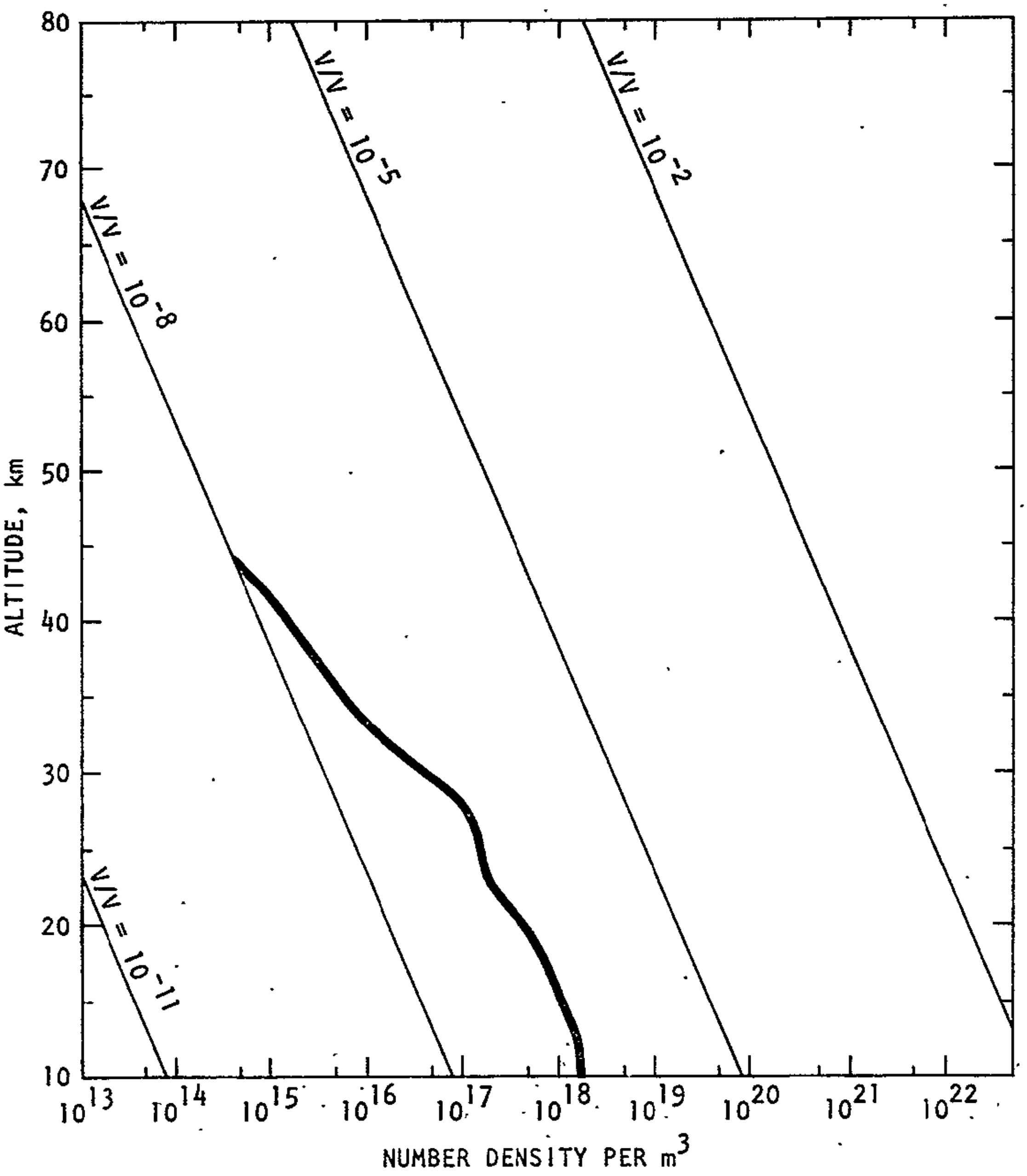


FIGURE B-8
VERTICAL DISTRIBUTION OF NITROUS OXIDE, N_2O
MID-LATITUDE[90]

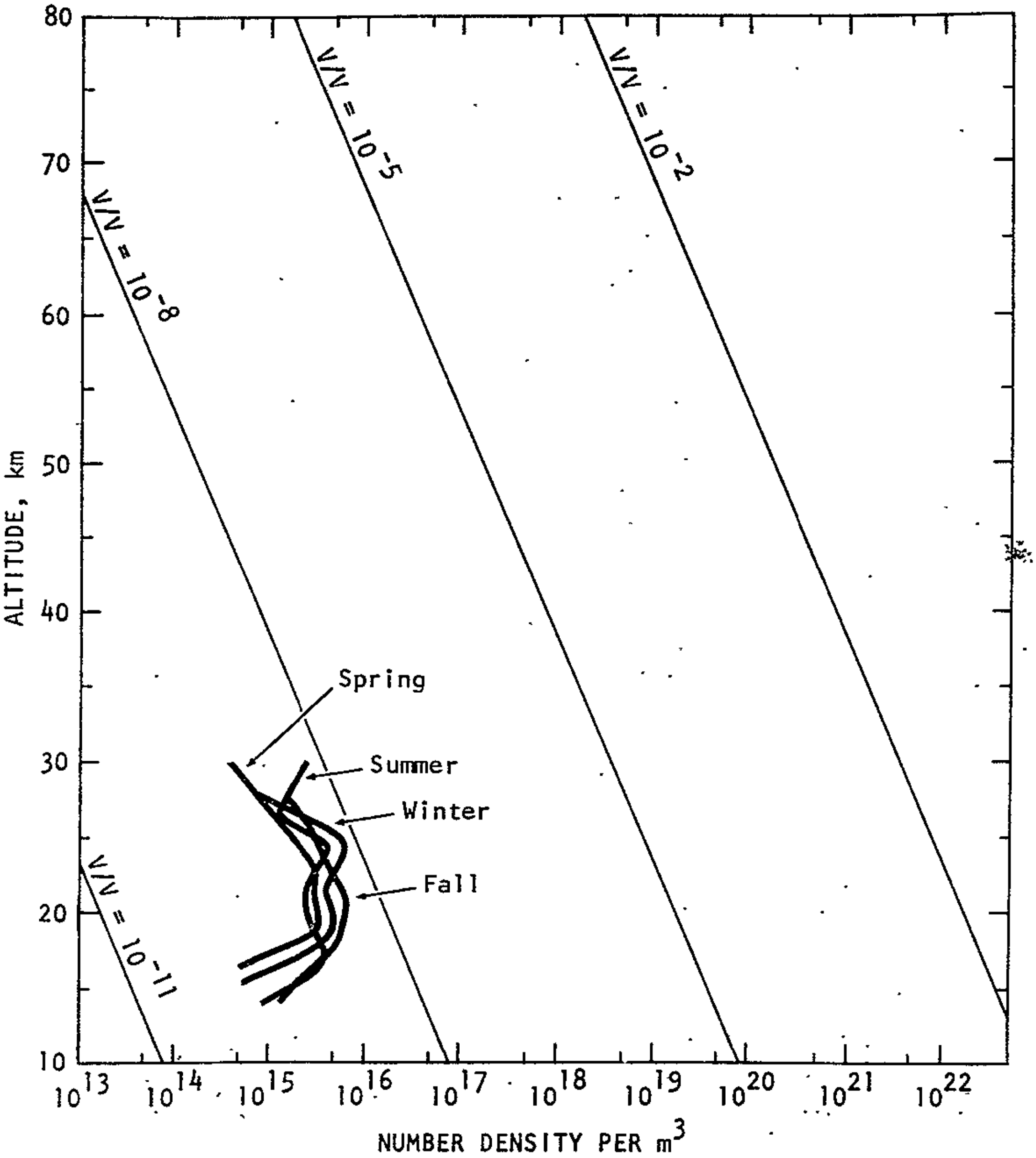


FIGURE B-9
VERTICAL DISTRIBUTION OF NITRIC ACID, HNO_3
MID-LATITUDE [91]

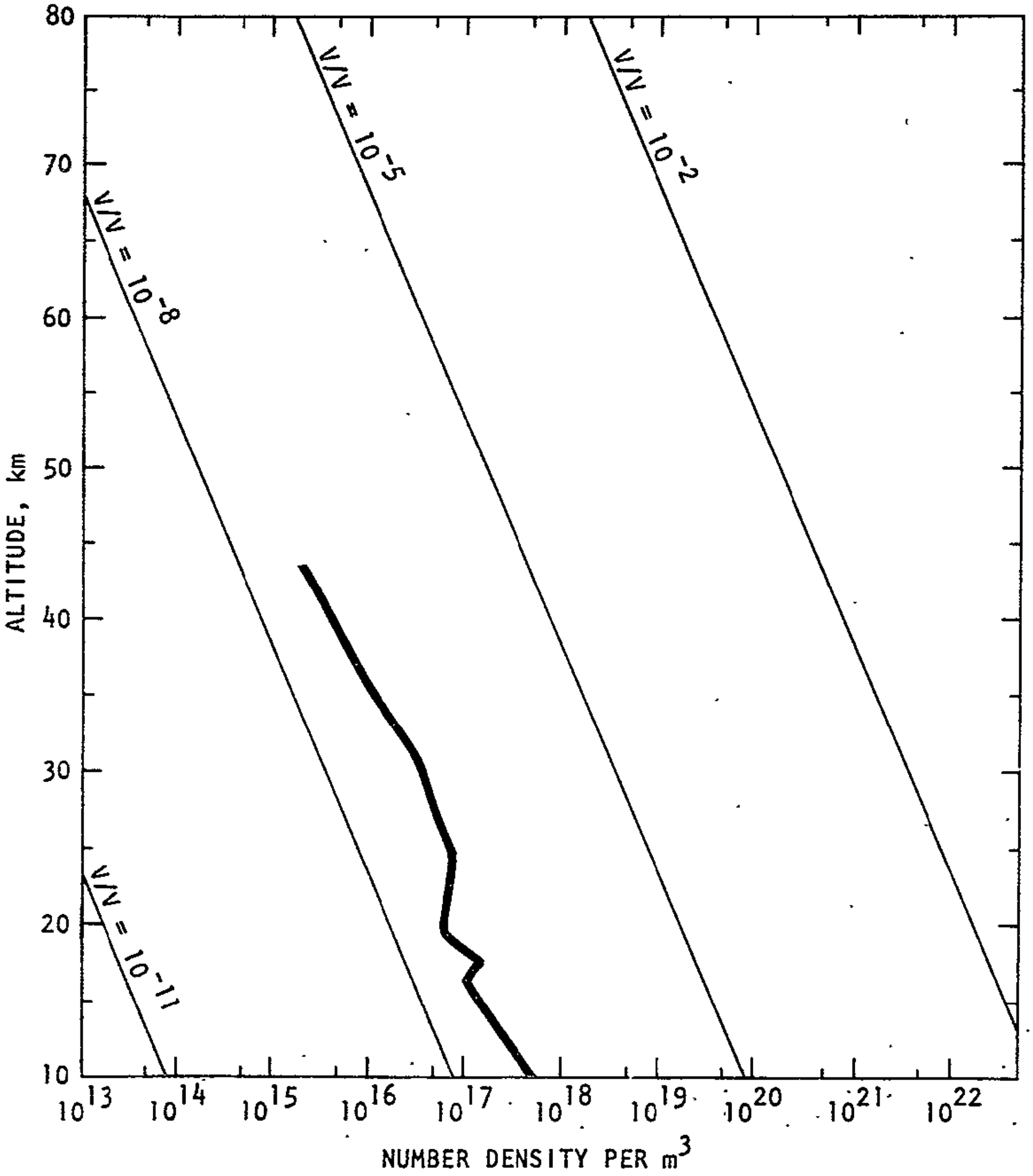


FIGURE B-10
VERTICAL DISTRIBUTION OF CARBON MONOXIDE, CO
MID-LATITUDE [90]

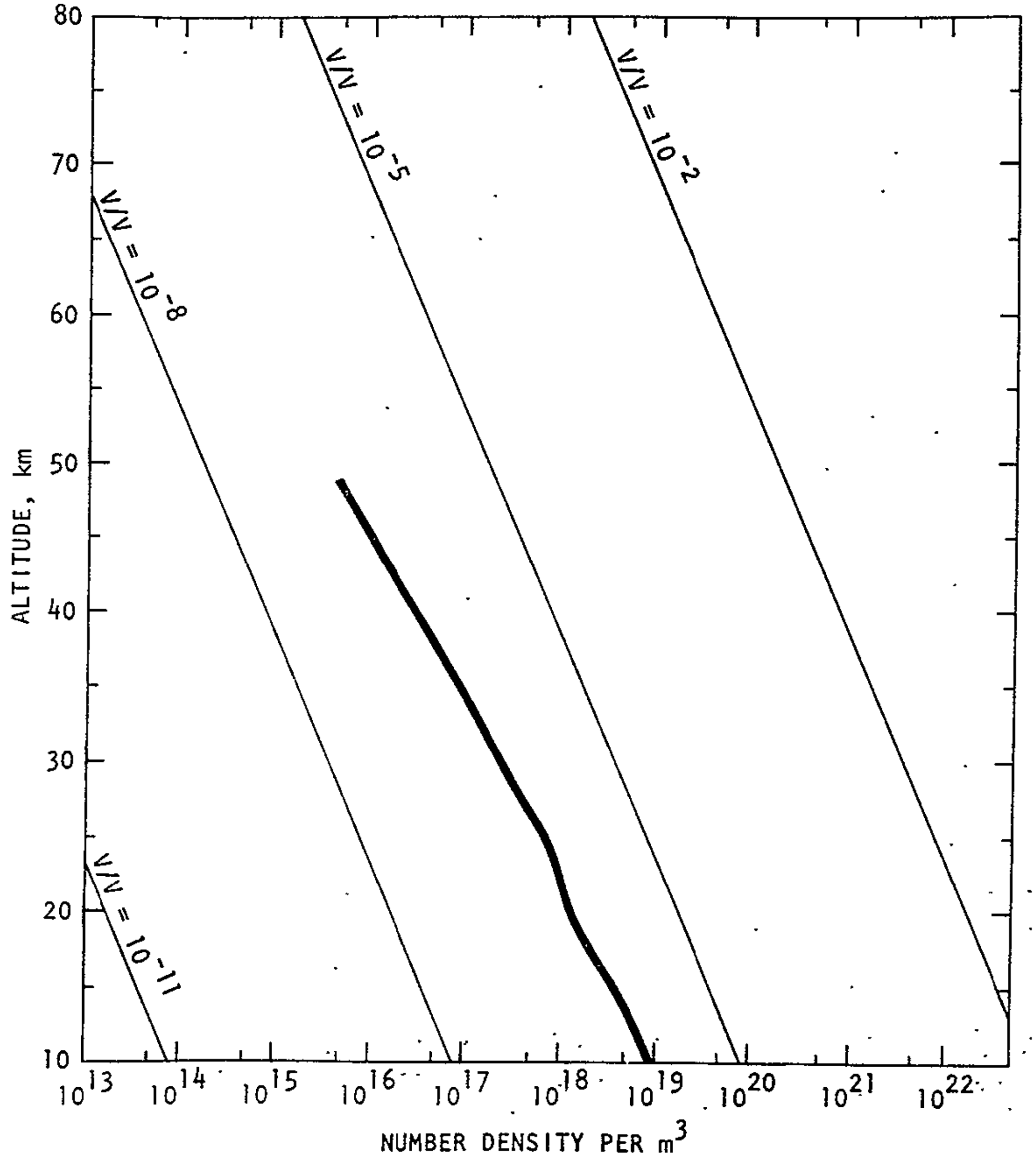


FIGURE B-11
VERTICAL DISTRIBUTION OF METHANE, CH_4
MID-LATITUDE[90]

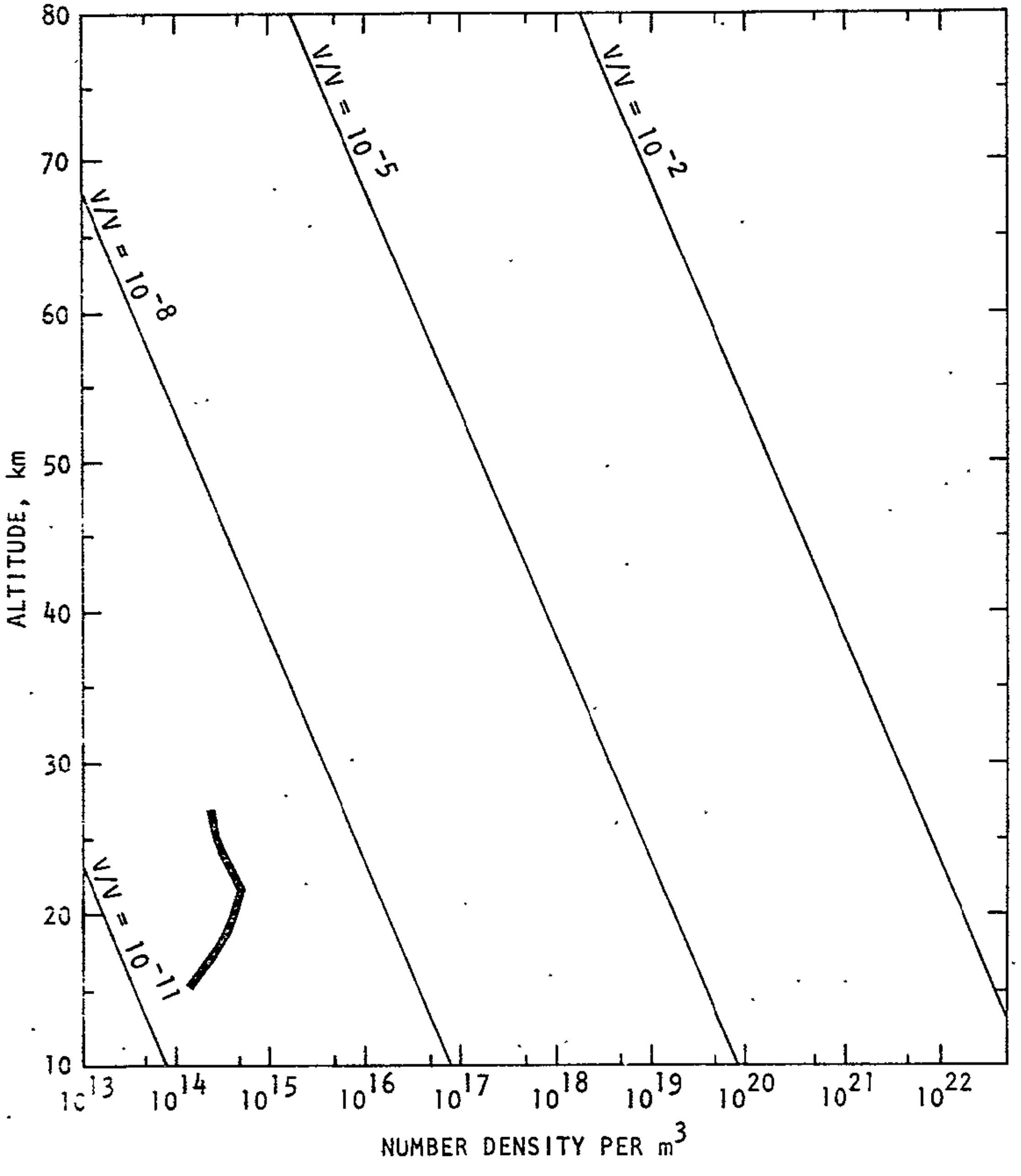


FIGURE B-12
VERTICAL DISTRIBUTION OF HYDROGEN CHLORIDE, HCL
MID-LATITUDE [40]

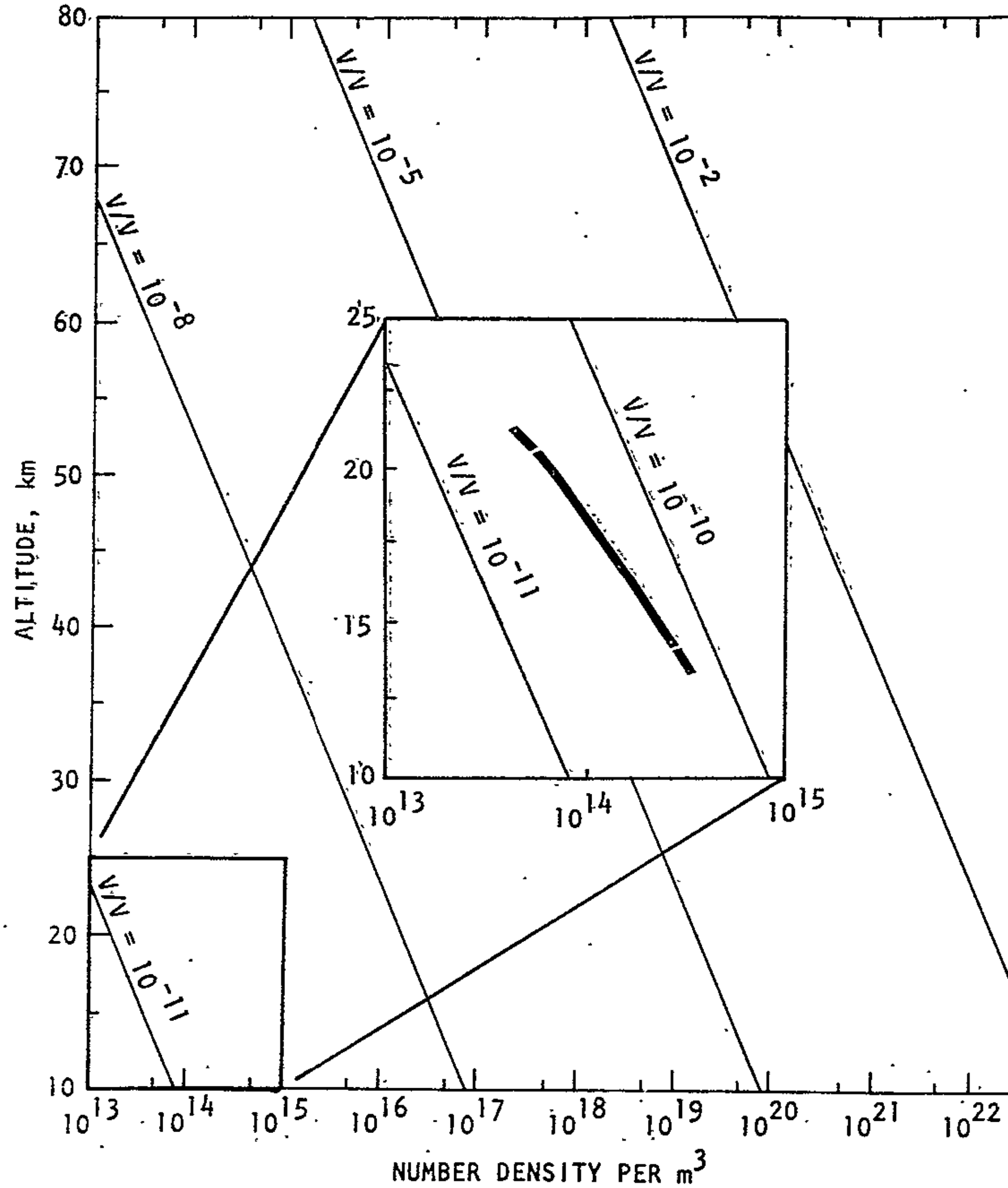


FIGURE B-13
VERTICAL DISTRIBUTION OF FREON 11, SPRING, EQUATOR [40]

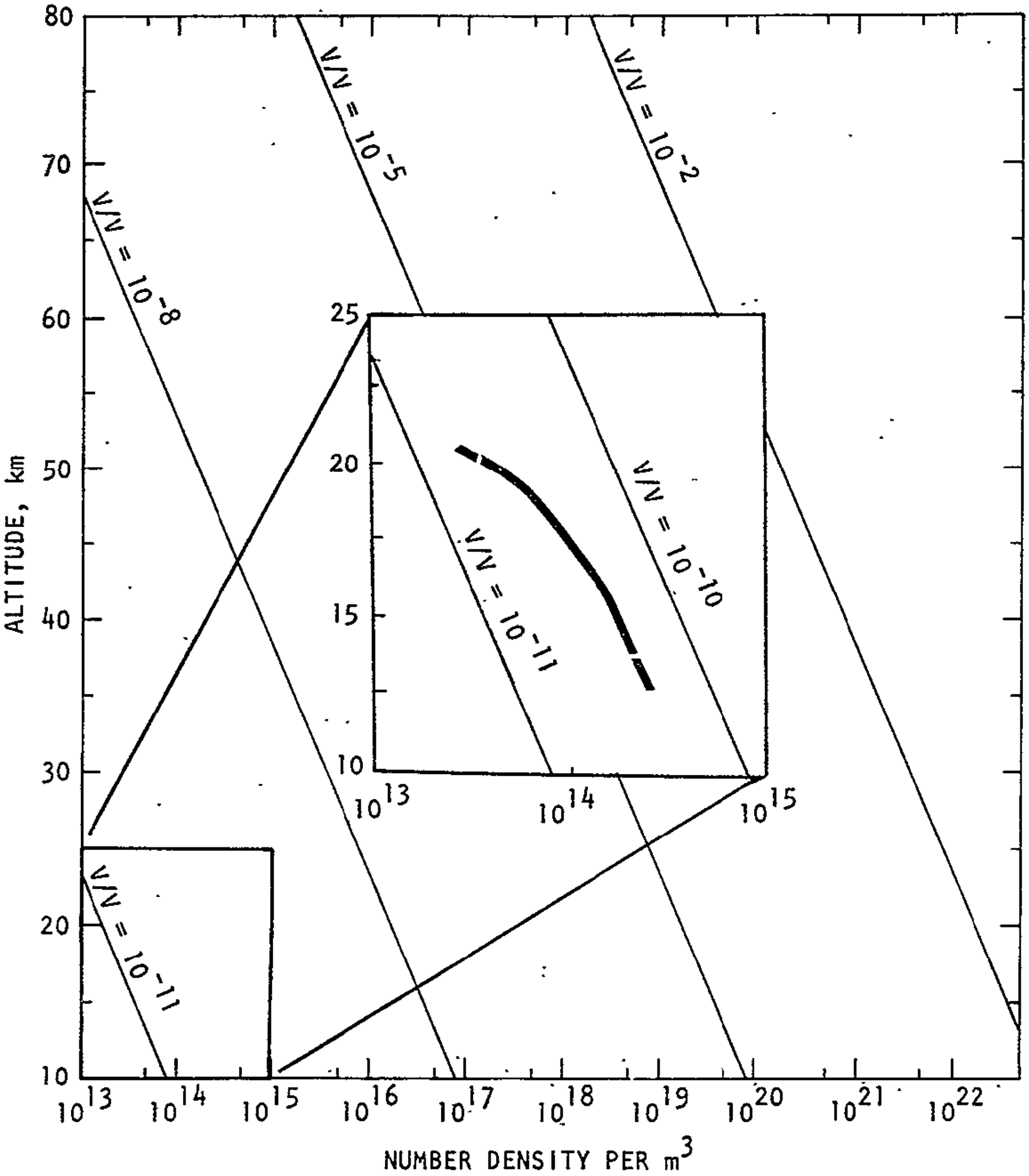


FIGURE B-14
VERTICAL DISTRIBUTION OF FREON 11, SPRING,
MID-LATITUDE[40]

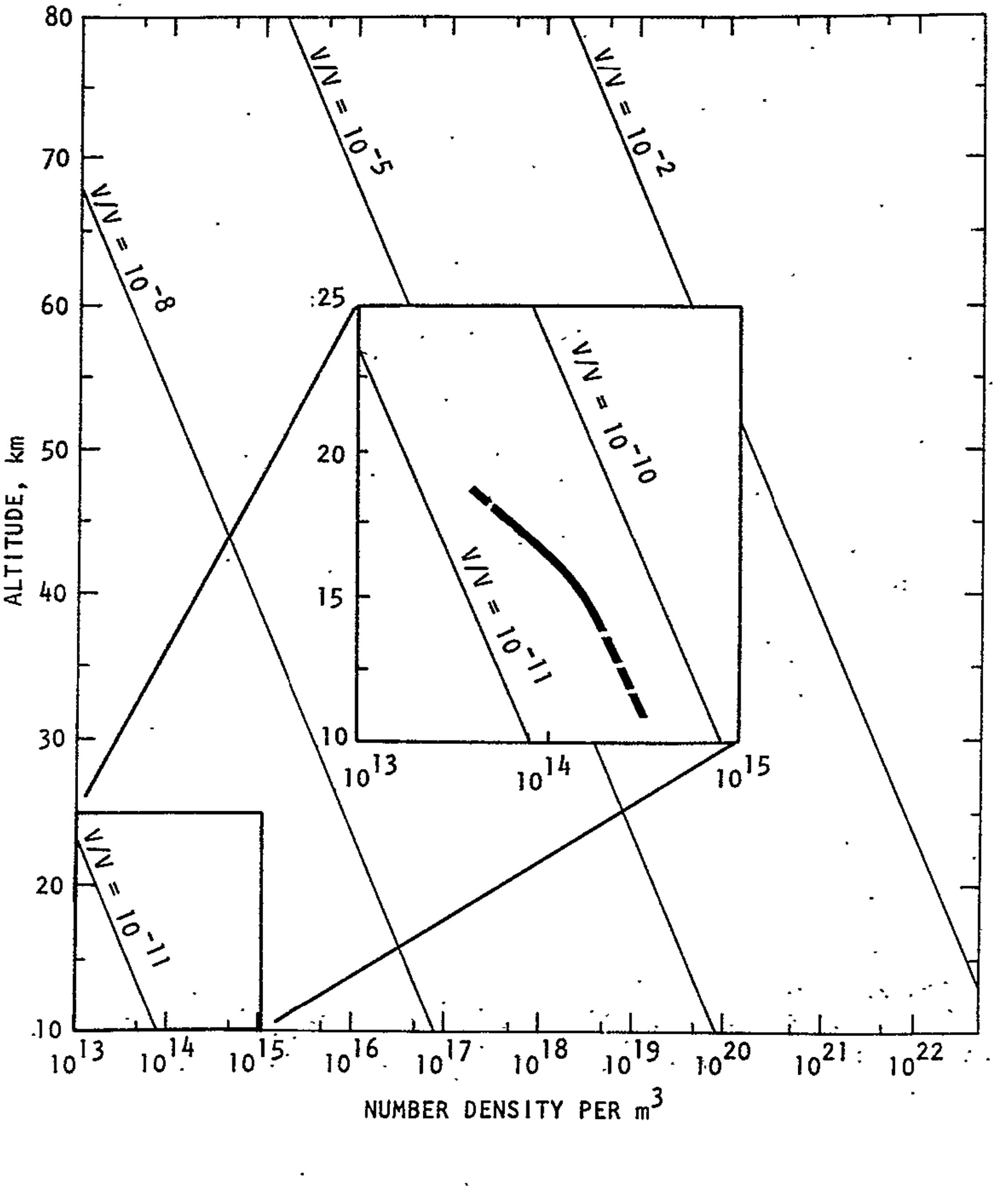


FIGURE B-15
VERTICAL DISTRIBUTION OF FREON 11, SPRING, 70°N[40]

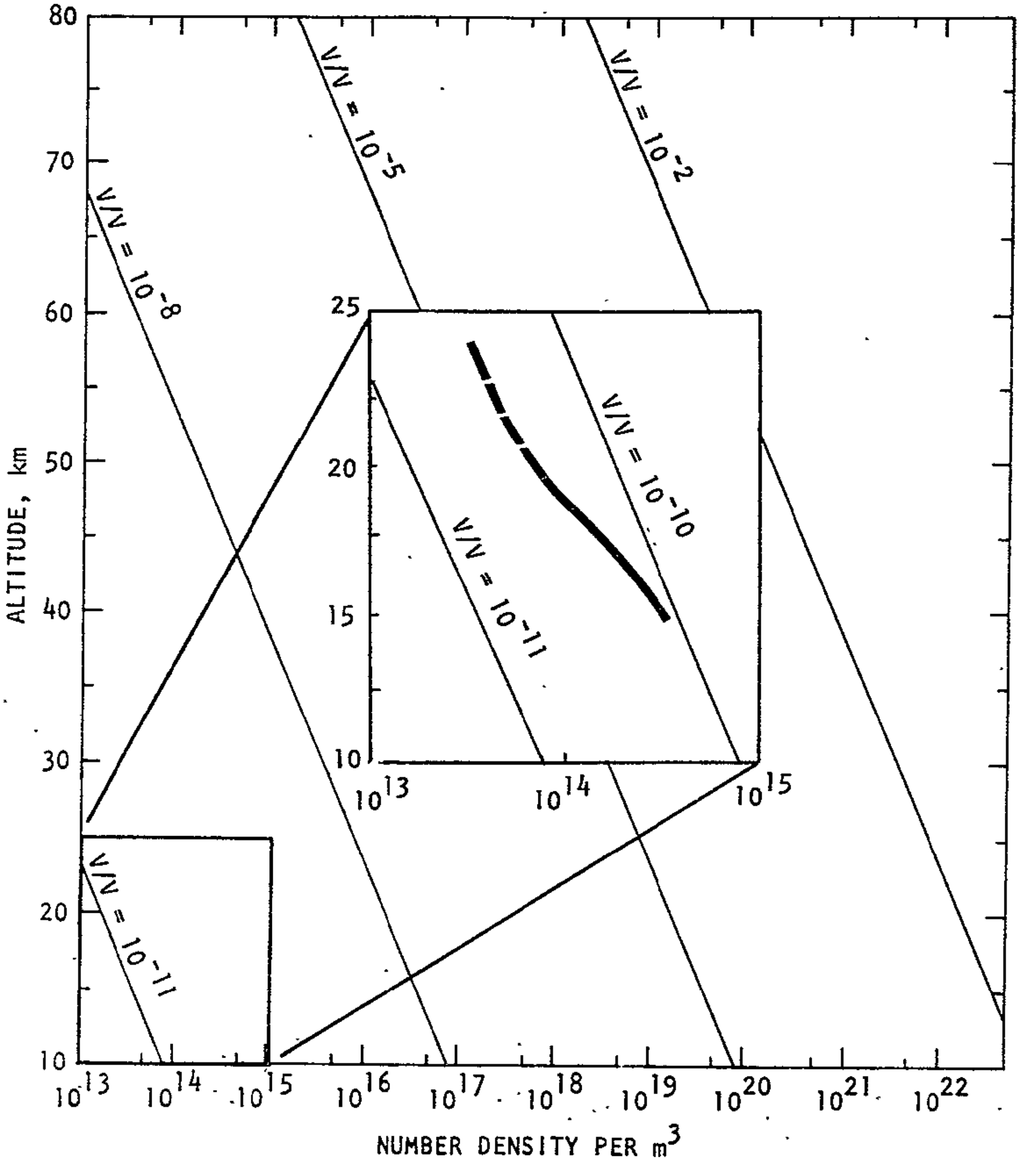


FIGURE B-16
VERTICAL DISTRIBUTION OF FREON 11, AUTUMN, EQUATOR[40]

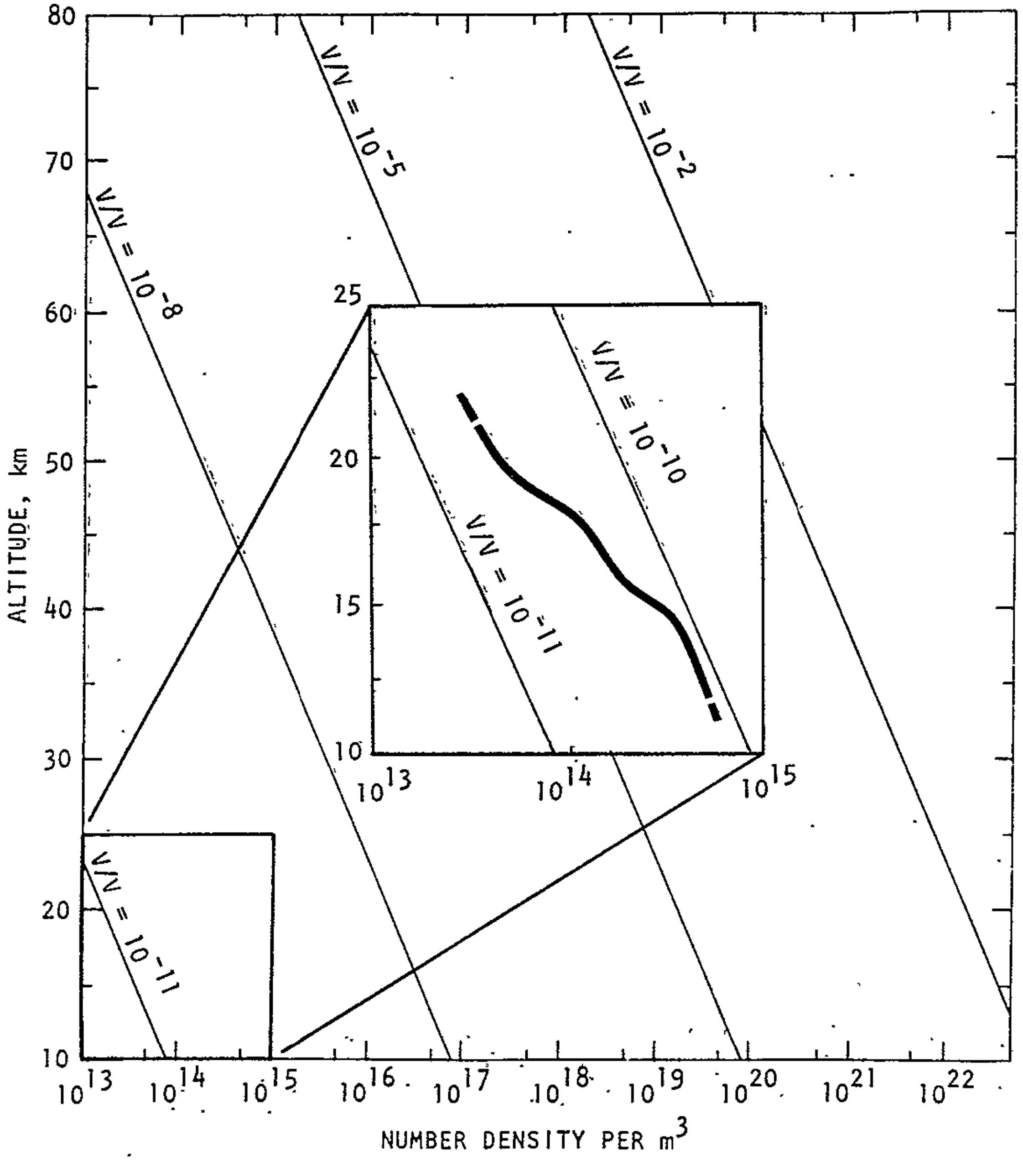


FIGURE B-17
VERTICAL DISTRIBUTION OF FREON 11, AUTUMN, MID-LATITUDE [40]

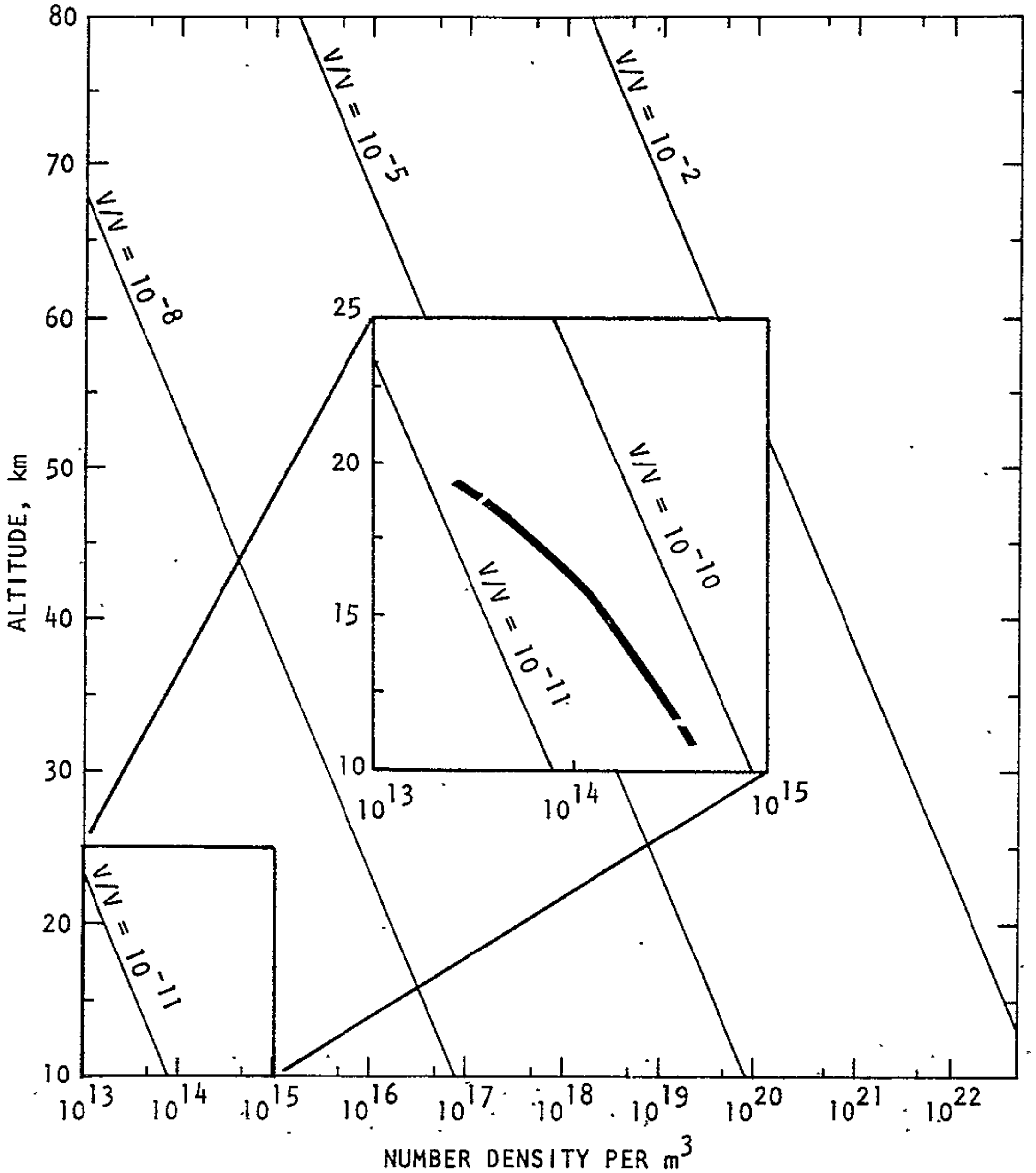


FIGURE B-18
VERTICAL DISTRIBUTION OF FREON 11, AUTUMN, 70°N [40]

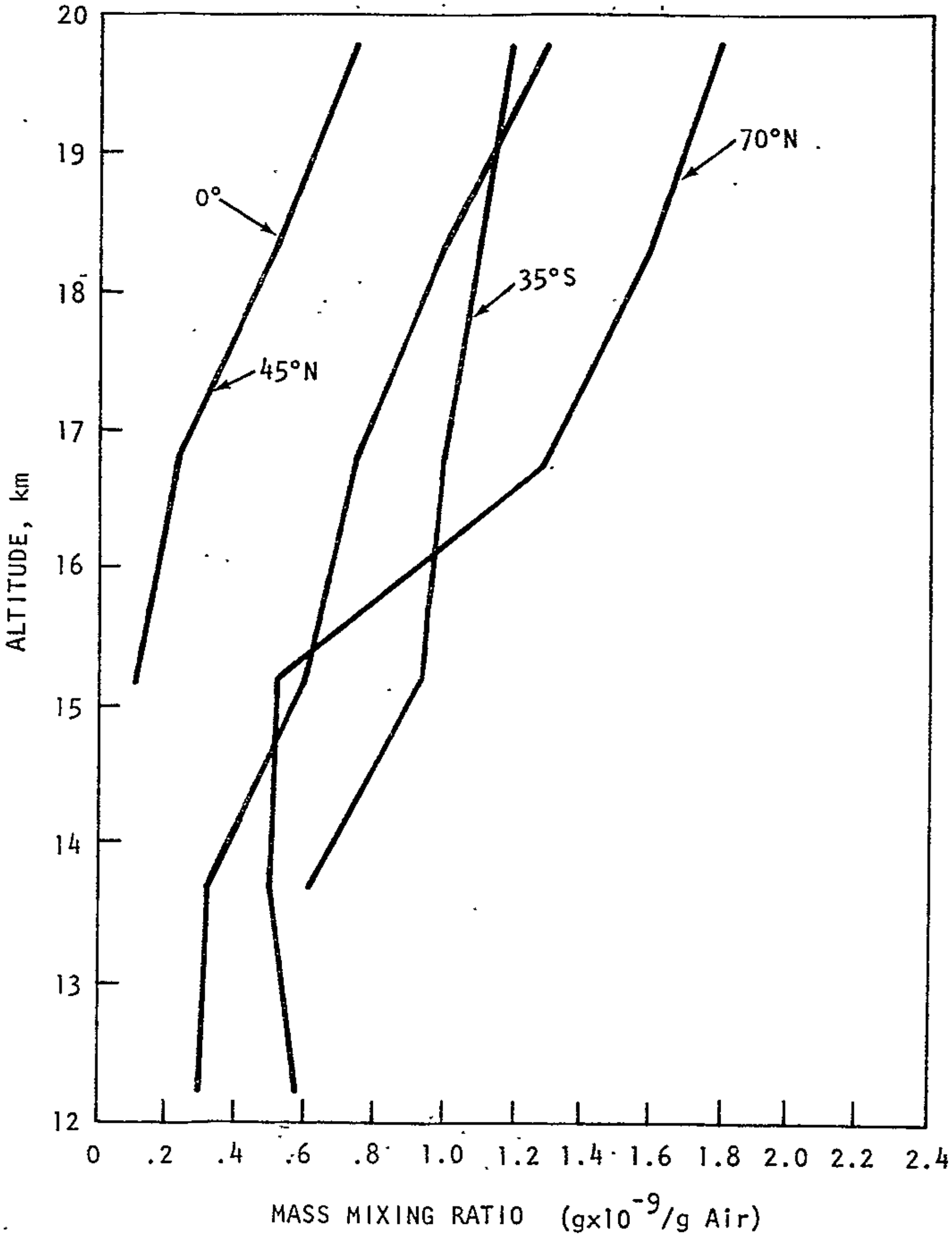


FIGURE B-19
VERTICAL DISTRIBUTION OF SULFATES [81]

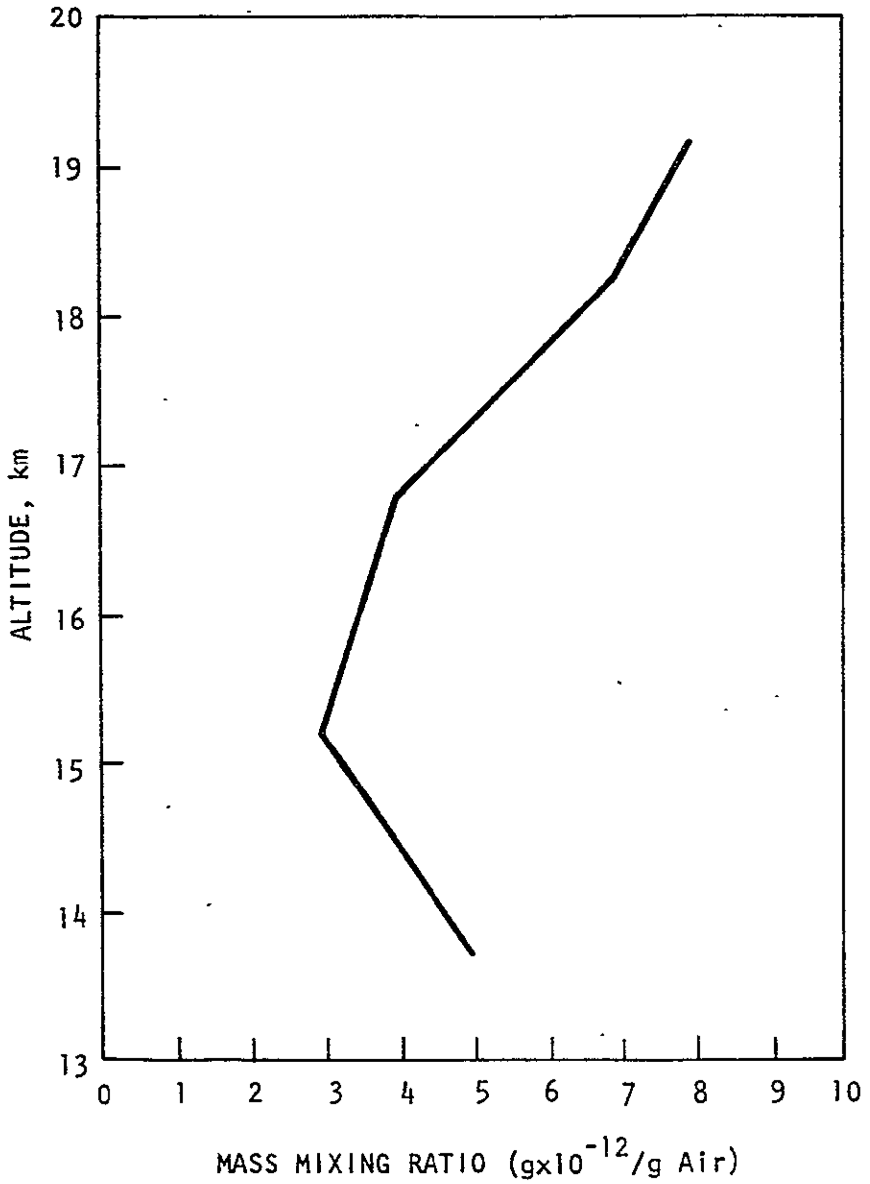
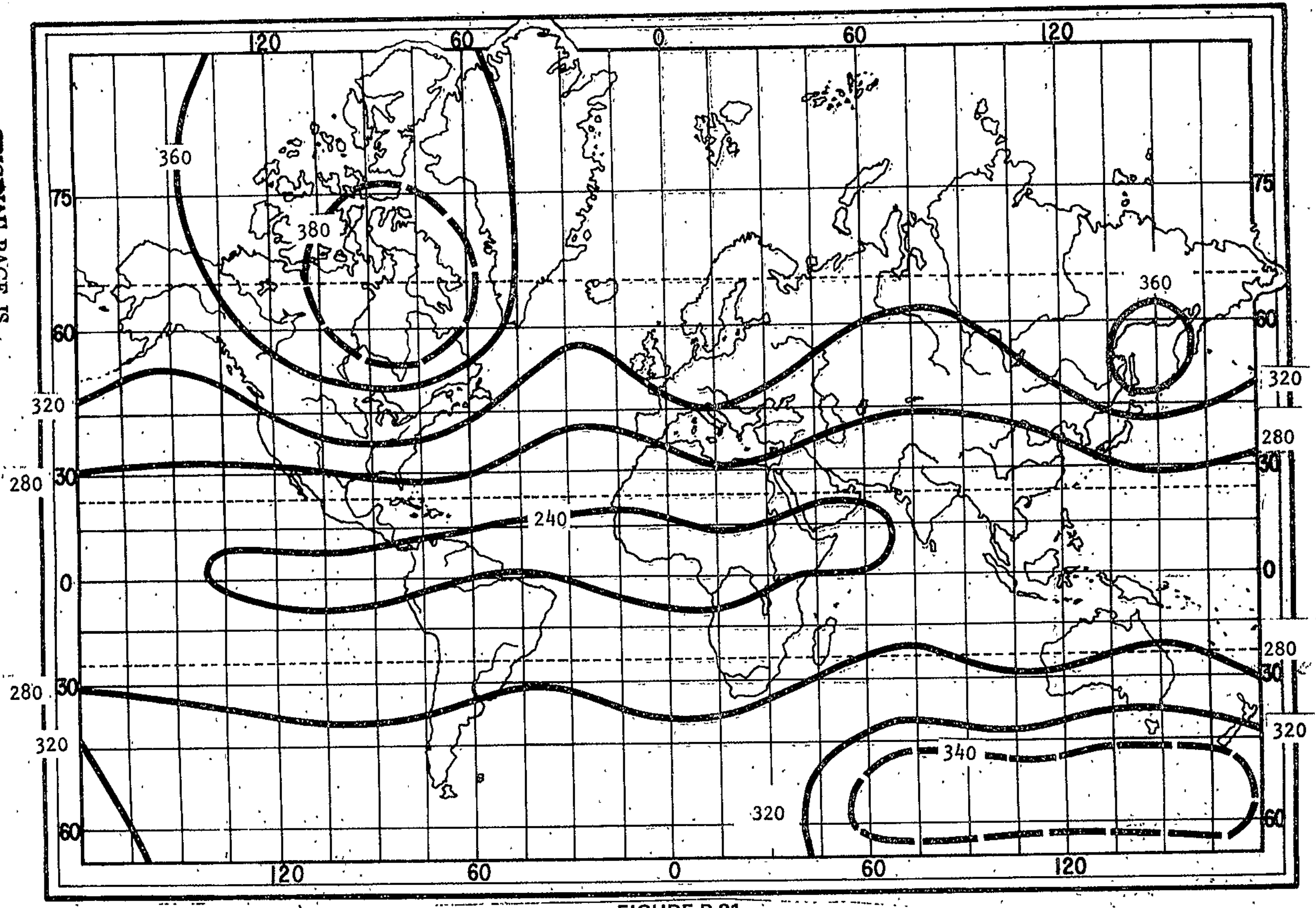
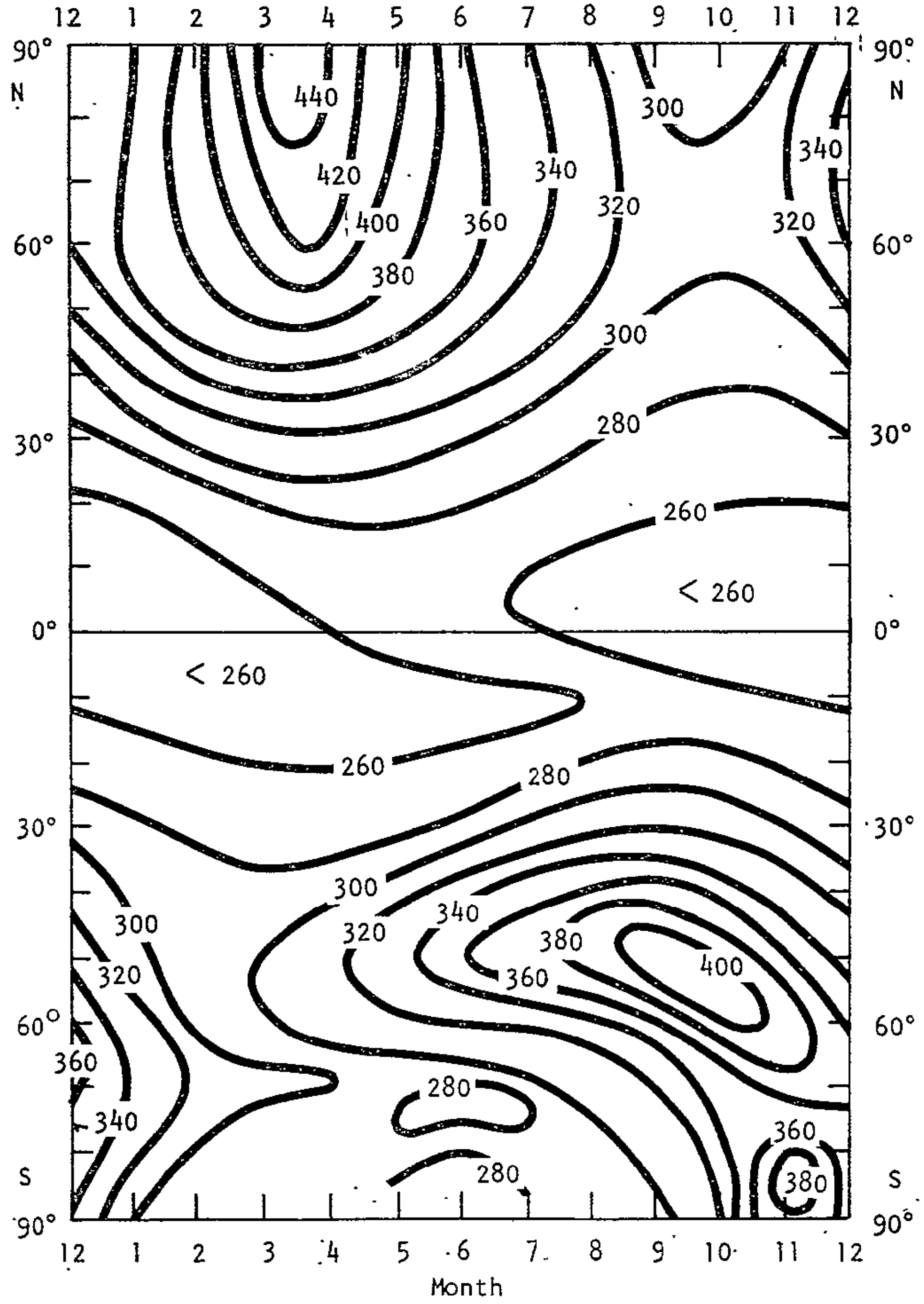


FIGURE B-20
ESTIMATED MID-LATITUDE VERTICAL PROFILE FOR BROMIDES[80]



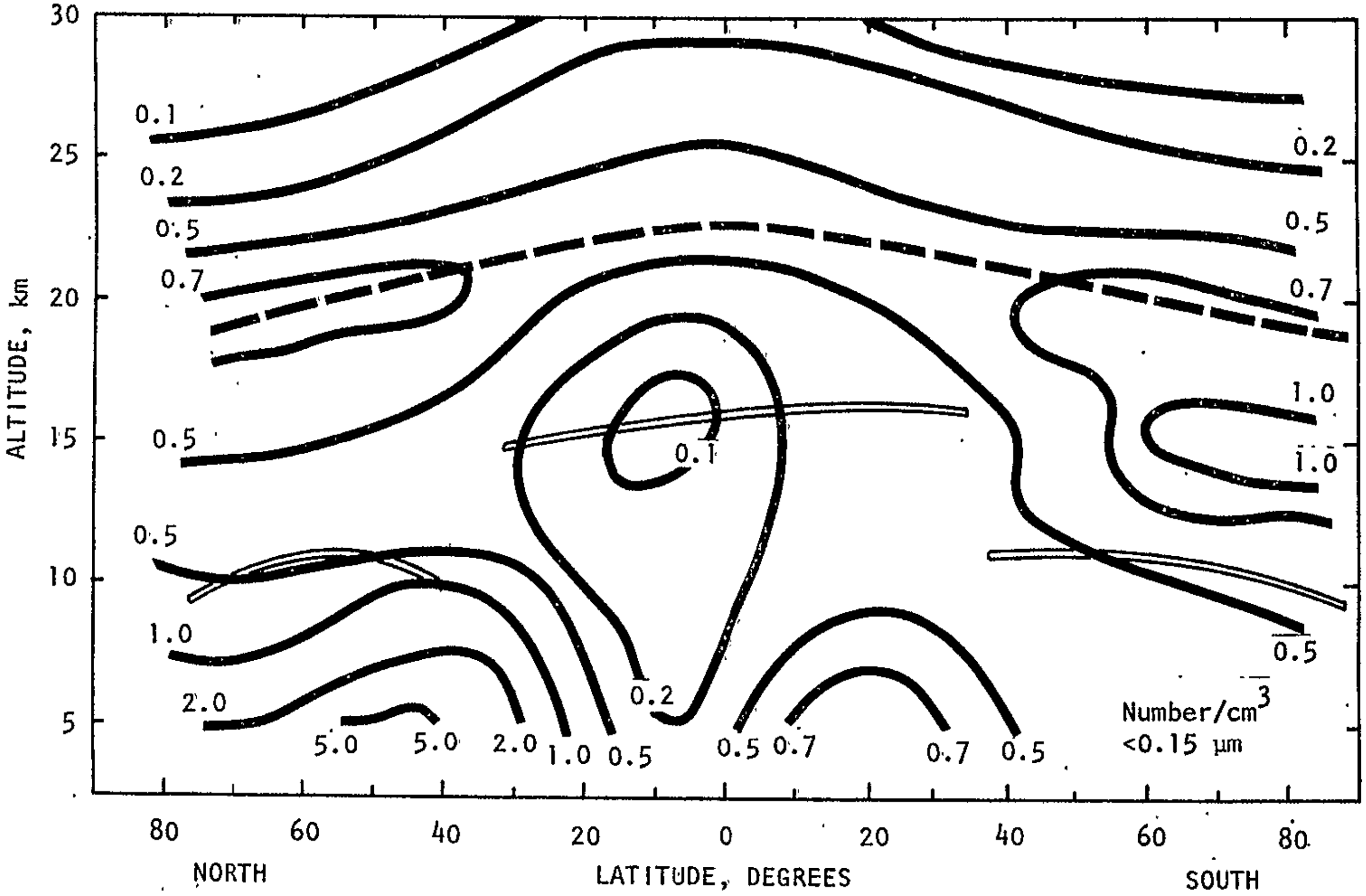
(Units: milli atm.-cm.)

FIGURE B-21
GLOBAL DISTRIBUTION OF TOTAL OZONE[40]



(The numbers are total amounts in the conventional units of 10^{-3} atm-cm STP.)

FIGURE B-22
WORLDWIDE TOTAL OZONE AS A FUNCTION OF SEASON AND LATITUDE [63]



(Solid lines are lines of constant aerosol concentrations [number cm^{-3}]; open lines indicate the altitude of the tropopause.)

FIGURE B-23
LATITUDINAL DISTRIBUTION OF AEROSOLS[66]

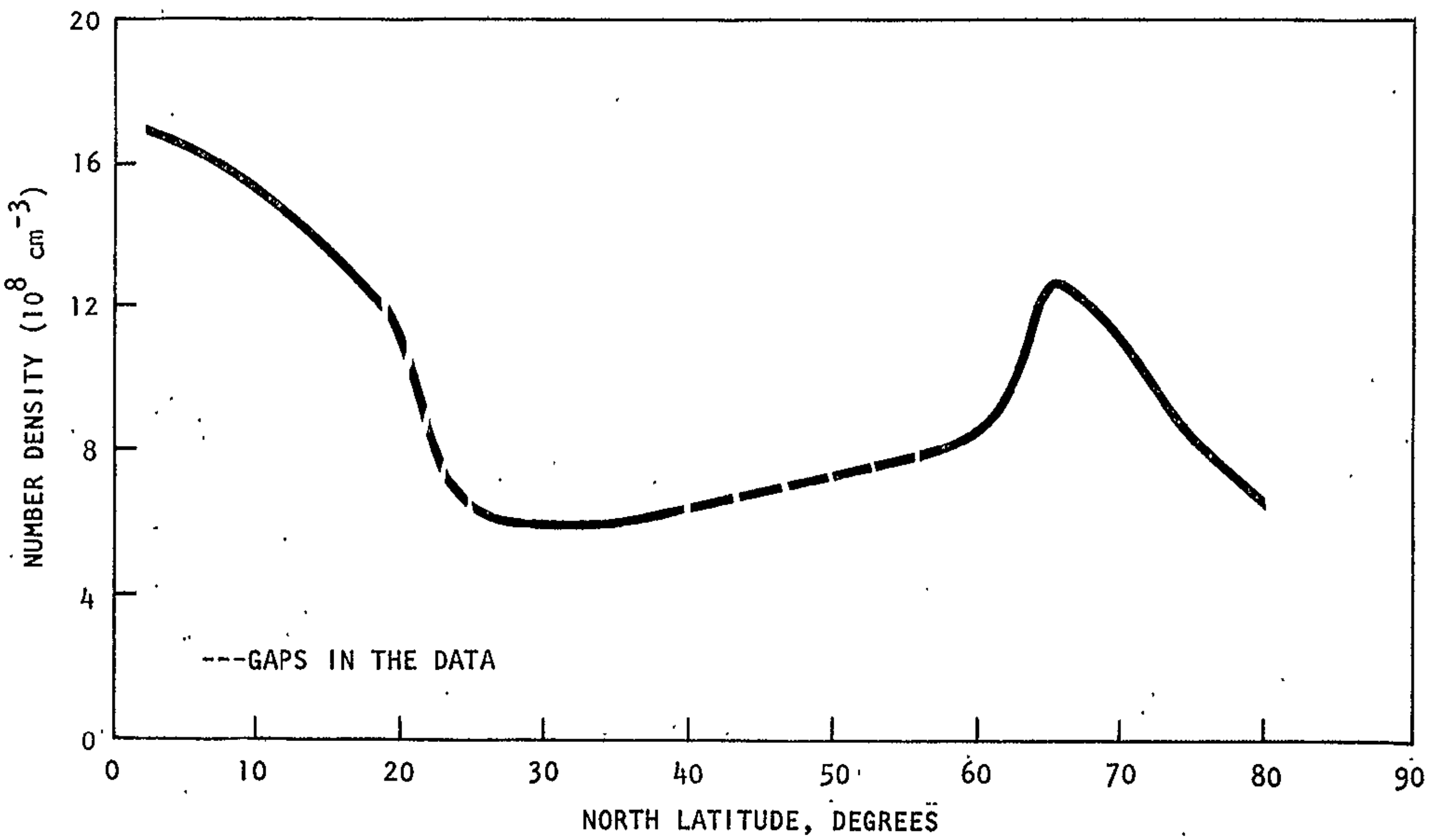


FIGURE B-24
AVERAGE LATITUDINAL DISTRIBUTION OF NITRIC OXIDE, NO, AT 18.3 km[82]

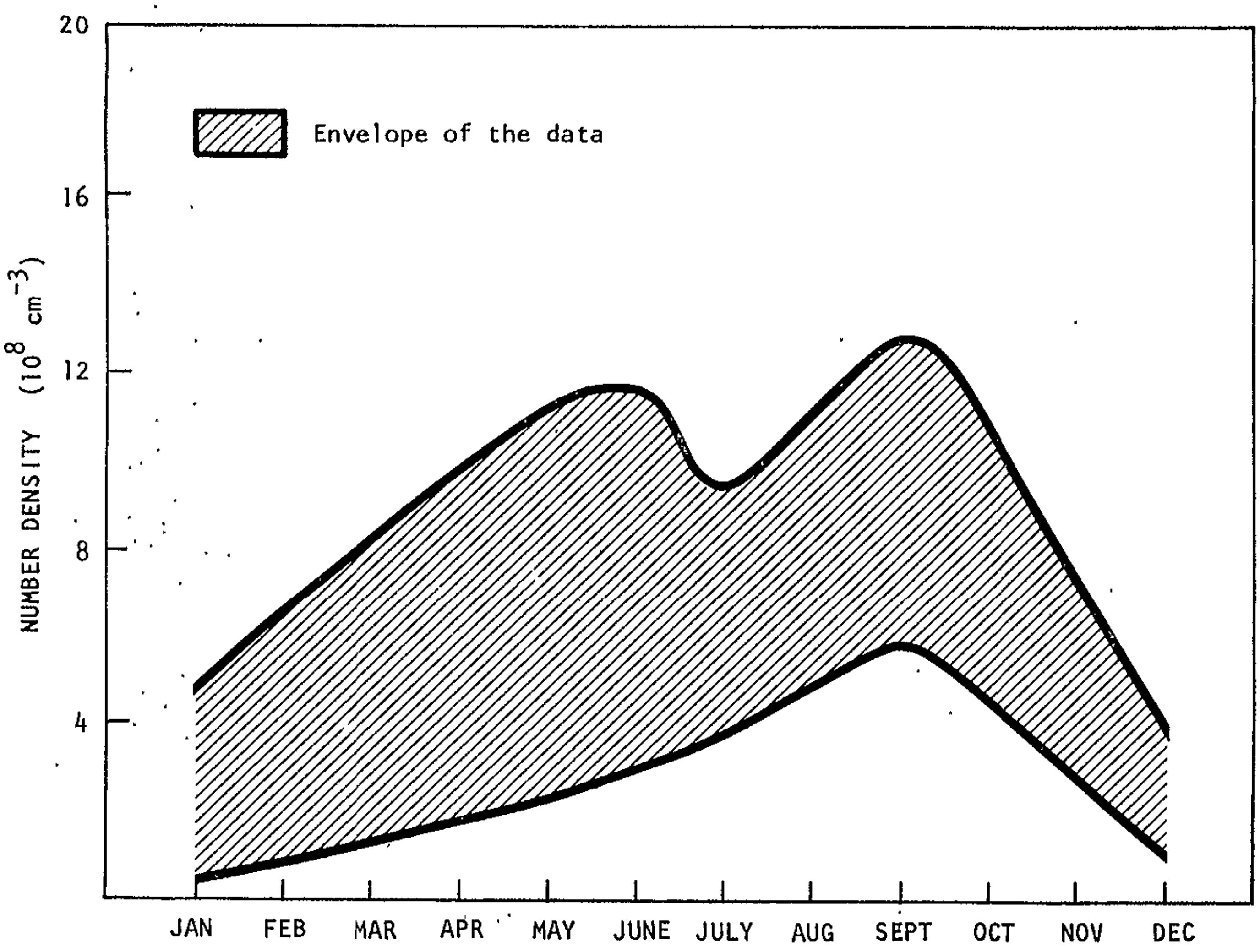


FIGURE B-25
SEASONAL DISTRIBUTION OF NO AT 21.3 km [82]

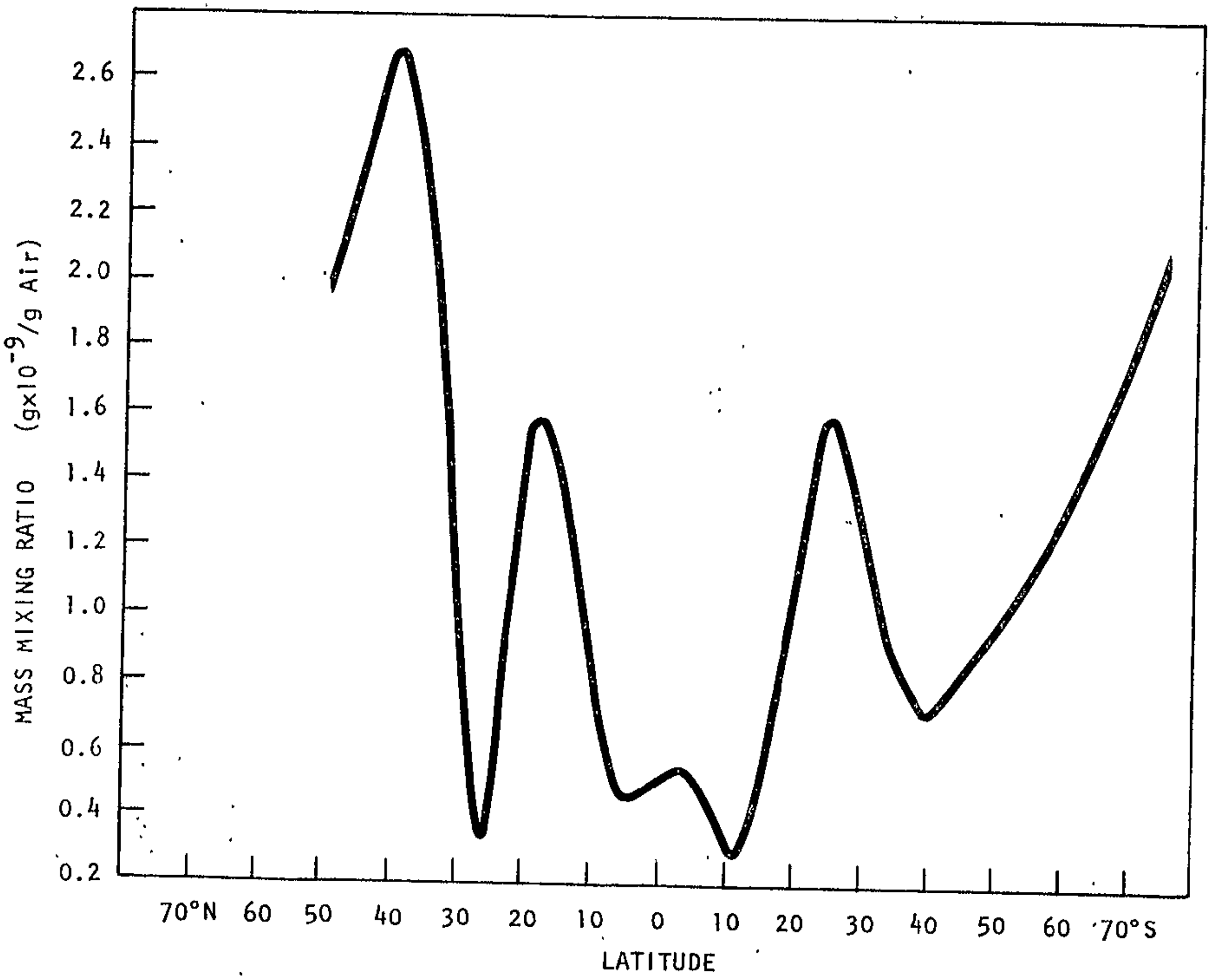


FIGURE B-26
LATITUDINAL DISTRIBUTION OF HNO_3 VAPOR AT 19 km [81]

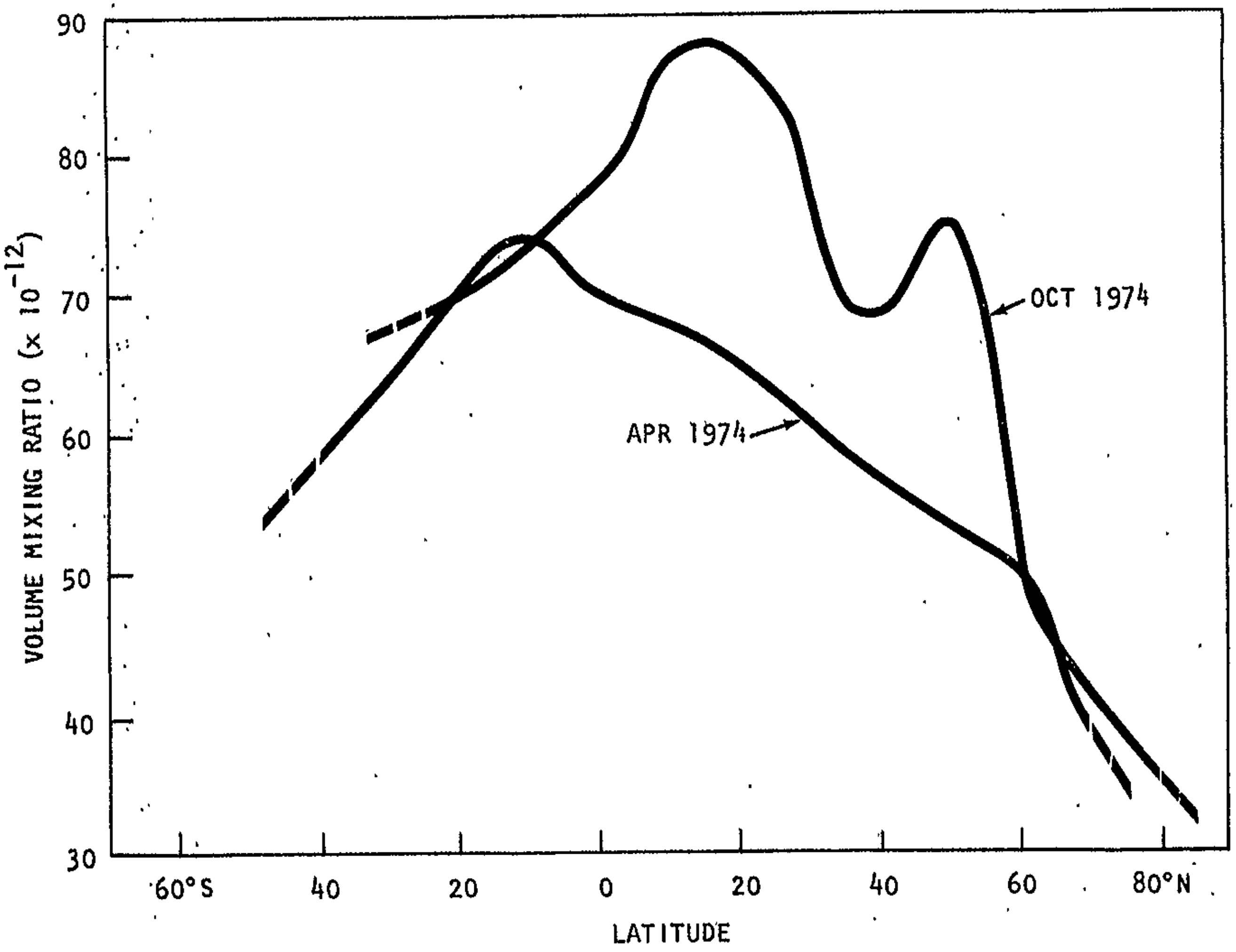


FIGURE B-27
LATITUDINAL VARIATION OF FREON 11 AT 17 km [83]

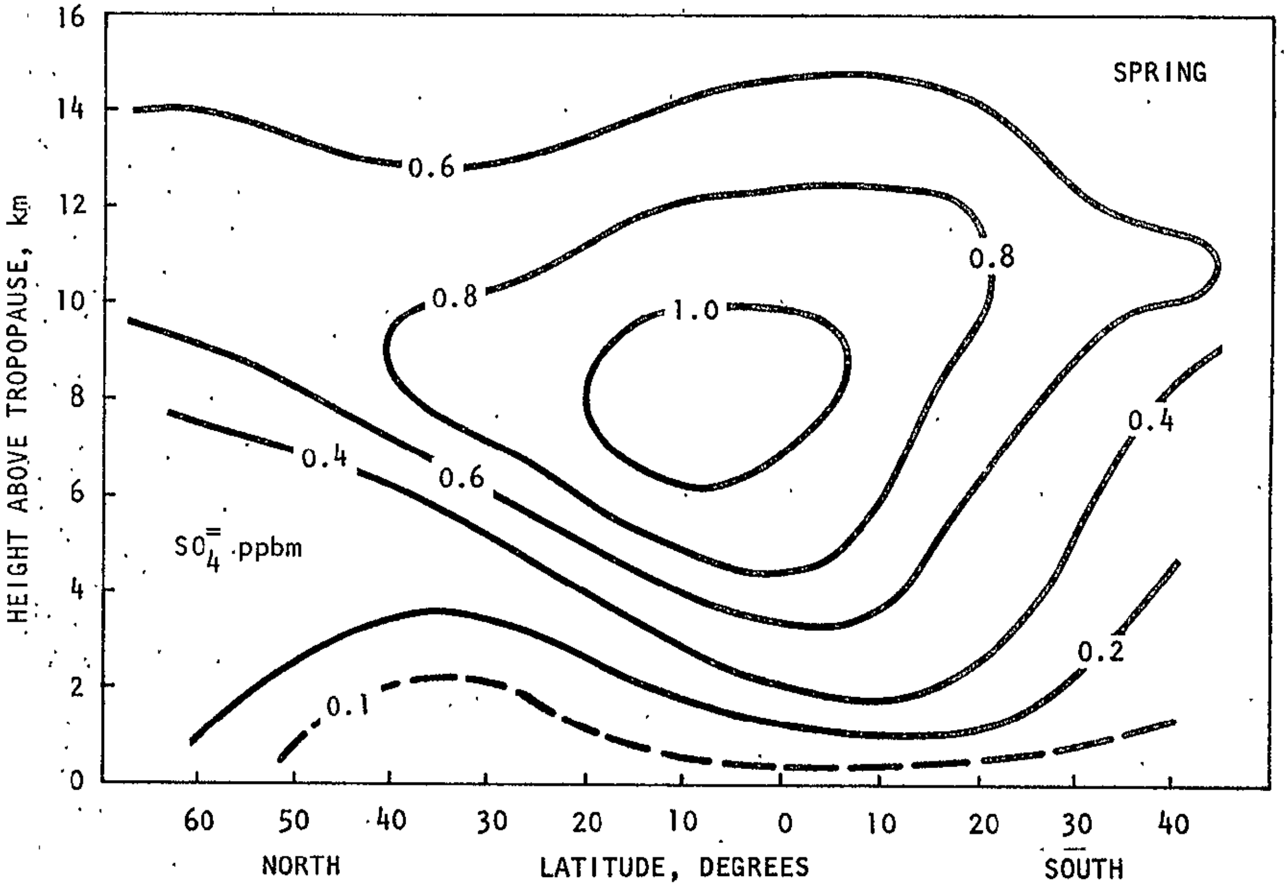


FIGURE B-28
LATITUDINAL DISTRIBUTION OF SULFATE [66]

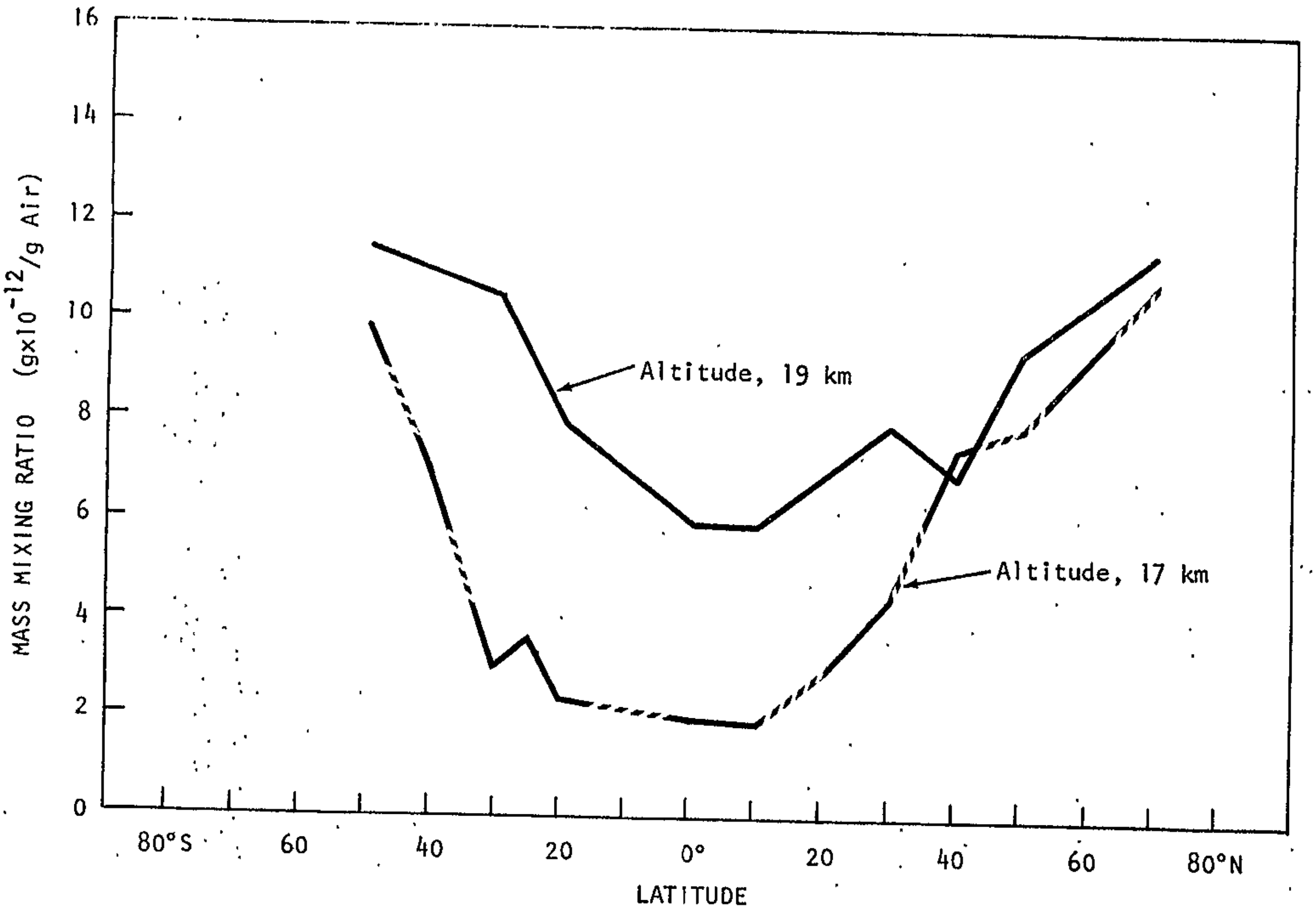


FIGURE B-29
ESTIMATED LATITUDINAL PROFILES FOR BROMIDES[80]

APPENDIX C

REFERENCES

NOTE: For the convenience of the user, the same set of references is presented in Volumes I, II and III of this report. Therefore, in any one volume, all references are not cited in the text.

APPENDIX C

REFERENCES

1. J.J. Carmichael et. al., "Stratospheric Measurement Requirements and Satellite-Borne Remote Sensing Capabilities," MTR-7007, The MITRE Corporation, NASA CR-144911, February 1976.

2. J.J. Carmichael et. al., "Evaluation of Satellites and Remote Sensors for Atmosphere Pollution Measurements," MTR-7170, The MITRE Corporation, NASA CR-144970, September 1976.

3. R.E. Newell, "Radioactive Contamination of the Upper Atmosphere", Progress in Nuclear Energy, Series 12, Health Physics, 2:538, Pergamon Press, Inc., Elmsford, N.Y., 1969.

4. A.J. Grobecker, et. al., (eds.), Report of Findings: The Effects of Stratospheric Pollution by Aircraft, DOT-TST-75-50, December 1974.

5. E.R. Reiter, "Mean and Eddy Motions in the Atmosphere," Monthly Weather Review, 97:200-204, 1969.

6. S. Teweles, "Stratospheric-Mesospheric Circulation," in Research in Geophysics, Vol. 2, edited by H. Odishaw, pp. 509-528, MIT Press, Cambridge, Mass., 1964.

7. R.J. Murgatroyd and F. Singleton, "Possible Meridional Circulation in the Stratosphere and Mesosphere", Quart. J. Roy. Meteor. Soc., 87:125-136, 1961.

8. H.S. Johnston, "Reduction of Stratospheric Ozone by Nitrogen Oxide Catalysts from SST Exhaust," Science, 173:517-522, 1971.

9. P.J. Crutzen, "SST's--A Threat to the Earth's Ozone Shield," Ambio, 1:41-51, 1972.

10. P.J. Crutzen, "A Review of Upper Atmospheric Photochemistry," Can. J. Chem., 52:1569-1581, 1974.

11. J.S. Chang, "Global Transport and Kinetics Model," in First Annual Report, DPT-CIAP Program, UCRL-51336, Lawrence Livermore Laboratory, Livermore, Calif., 1973.

12. J.S. Chang et. al., "Simulation of Chemical Kinetics Transport in the Stratosphere," UCRL-74823, Lawrence Livermore Laboratory, Livermore, Calif., 1973.

13. R.W. Stewart, "Response of Stratospheric Ozone to the Simulated Injection of Nitric Oxide," presented at the Fall AGU meeting, San Francisco, Calif., 1973.

14. R.W. Stewart and M.I. Hoffert, "Stratospheric Contamination Experiments with a One-dimensional Atmospheric Model," AIAA Paper No. 73-531, presented at the AIAA/AMS International Conference on the Environmental Impact of Aerospace Operations in the High Atmosphere, Denver, Colo., June, 1973.

15. M.B. McElroy et. al., "Atmospheric Ozone: Possible Impact of Stratospheric Aviation," J. Atmos. Sci., 31:287-303, 1974.

16. R.C. Whitten and R.P. Turco, "A Model for Studying the Effects of Injecting Contaminents into the Stratosphere and Mesosphere," AIAA Paper No. 73-539, presented at the AIAA/AMS International Conference on the Environmental Impact of Aerospace Operations in the High Atmosphere, Denver, Colo. June, 1973.

17. R.C. Whitten and R.P. Turco, "The Effect of SST Emissions on the Earth's Ozone Layer," Proceedings Int. Conf. on Struct., Compos. Anthropogenic Perturbations, 905-932, 1974.

18. T. Shimazaki and T. Ogawa, "Theoretical Models of Minor Constituents' Distributions in the Stratosphere and the Impacts of the SST Exhaust Gases," Proc. Int. Conf. on Struct., Compos., and Gen. Circ. of the Upper and Lower Atmos., and Possible Anthropogenic Perturbations, 1062-1092, 1974.

19. Deleted.

20. E. Hessvedt, "Effect of Supersonic Transport upon the Ozone Layer, Studies in a Two-dimensional Photochemical Model with Transport," AGARD Conf. Proc. No. 125 on Atmospheric Pollution by Aircraft Engines, 6-1..6-8, 1973.

21. E. Hessvedt, "Reduction of Stratospheric Ozone from High-flying Aircraft, Studied in a Two-dimensional Photochemical Model with Transport," Can. J. Chem., 52:1592-1598, 1974.

22. Deleted.

23. G.F. Widhopf and T.D. Taylor, "Numerical Experiments on Stratospheric Meridional Ozone Distributions Using A Parameterized Two-dimensional Model," *Proceedings of the Third Conference on the Climatic Impact Assessment Program*, DOT-TSC-OST-74-15, 1974.

24. Deleted.

25. D.M. Cunnold et. al., "First Results of a General Circulation Model Applied to the SST-NO_x Problem," presented at the Second AIAA/AMS International Conference on the Environmental Impact of Aerospace Operations in the High Atmosphere, San Diego, Calif., July 1974.

26. S.C. Coroniti and A.J. Broderick, "Atmospheric Monitoring and Experiments: A Summary of Ongoing Projects," pp 13-21, *Proceedings of the Second Conference on the Climatic Impact Assessment Program*, Department of Transportation, DOT-TSC-OST-73-4, 1973.

27. D.J. Hofmann et al., "Global Measurement of Stratospheric Aerosol, Ozone, and Water Vapor by Balloon-Borne Sensors," pp 23-33, *Proceedings of the Second Conference on the Climatic Impact Assessment Program*, Department of Transportation, DOT-TSC-OST-73-4, 1973.

28. S.H. Melfi, "Standard Methods for Analysis and Interpretation of LIDAR Data for Environmental Monitoring," *Proceedings of Second Joint Conference on Sensing of Environmental Pollutants*, Washington, D.C., 1973.

29. H. Kildal and R. Byer, "Comparisons of Laser Methods for the Remote Detection of Atmospheric Pollutants," *Proc. IEEE*, *59*., 1644, 1971.

30. E.L. Keitz et al., "The Capability of Remote Sensing for Regional Atmospheric Pollution Studies," MTR-7267, The MITRE Corporation, January, 1977.

31. M.H. Bortner et al., "Carbon Monoxide Pollution Experiment - Final Report," General Electric Company, Space Sciences Laboratory, Valley Forge, Pennsylvania; January 1975.

32. H.W. Goldstein, "Development of the Correlation Interferometer (CIMATS) Experiment," presented at NASA Environmental Quality Monitoring Program Basic Research Review, December 1975.

33. A.J. Broderick (ed.), *Proceedings of the Second Conference on the Climatic Impact Assessment Program, November 14-17, 1972*, Department of Transportation, Report DOT-TSC-OST-73-4.

34. A.J. Broderick and T.M. Hard (eds.), *"Proceedings of the Third Conference on the Climate Impact Assessment Program, February 26 - March 1, 1974*, Department of Transportation, Report DOT-TSC-OST-74-15.

35. W.H. Mathews, W.W. Kellogg and G.D. Robinson (eds.), *Man's Impact on Climate*, MIT Press, Cambridge, Mass., 1971.

36. K.C. Smith and P.C. Hanawalt, *Molecular Photobiology: Inactivation and Recovery*, Academic Press, New York, 1969.

37. M.J. Peak et al., "Synergism Between Different Near-UV Wavelengths in the Inactivation of Transforming DNA," *Phys. Chem.-Phys. Biol.*, 21:129-131, 1975.

38. L. Musajo and G. Rodighiero, "Mode of Sensitizing Actions of Furocoumarins," *Photophysiology* VII:12,146, 1972.

39. National Academy of Sciences, *Environmental Impact of Stratospheric Flight, Biological and Climatic Effects of Aircraft Emissions in the Stratosphere*, Climatic Impact Committee, NRC, NAS, NAE, 1975.

40. Council on Environmental Quality, *Fluorocarbons and the Environment*, Report of Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS), Federal Council for Science and Technology, June 1975.

41. H.F. Blum, *Carcinogenesis by Ultraviolet Light*, Princeton University Press, 1959.

42. F. Urbach (ed.), *The Biologic Effects of Ultraviolet Radiation with Emphasis on the Skin*, Pergamon Press, New York, 1969.

43. F. Urbach (ed.), *Environment and Cancer: A Collection of Papers*, Williams and Wilkons, Baltimore, 1972.

44. E.C. Pollard, "Cellular and Molecular Effects of Solar UV Radiation," Report on Conference Sponsored by CIAP, May 7-8, 1973 at Univ. of Florida, Gainsville, Fla., in *Photochemistry and Photobiology*, 20:301-308, 1974.

45. D.C. Fork and J. Amesz, "Spectrophotometric Studies of the Mechanism of Photosynthesis," *Photophysiology*, V:97-126, 1970.

46. M.B. Allen, "Absorption Spectra, Spectrophotometry, and Action Spectra," Photophysiology, I, 1964.

47. WMO-ICSU, The Physical Basis of Climate and Climate Modeling, GARP Publications, Series No. 16, April 1975.

48. National Academy of Sciences, Weather and Climate Modification; Problems and Progress, Committee on Atmospheric Sciences, National Academy of Sciences, National Research Council, Washington, D.C., 1973.

49. V. Ramanathan, "Greenhouse Effect Due to Chlorofluorocarbons: Climatic Implications" Science, 190:50, 1975.

50. National Academy of Sciences, Understanding Climate Change, A Program for Action, Washington, D.C., 1975.

51. WMO-ICSU, The First GARP Global Experiment: Objective and Plans, GARP Publications Series No. 11, Geneva, March 1973.

52. NASA-GSFC, U.S. Plan for Participation in FGGE (First GARP Global Experiment), Greenbelts, Md., August, 1, 1975.

53. H.J. Sheetz and E.J. Friedman, "Earth Energy Experiment Evaluation," The MITRE Corporation, MTR-7008, September 1975.

54. Deleted.

55. Deleted.

56. C.L. Wilson and W.H. Mathews (eds.), Study of Critical Environmental Problems (SCEP), MIT Press, Cambridge, Mass. 197

57. S. Katzoff (ed.), Remote Measurement of Pollution, NASA SP-285, National Aeronautics and Space Administration, Langley Research Center, 1971.

58. M.J. Molina and F.S. Rowland, "Stratospheric Sink for Chlorofluoromethanes: Chlorine Atom - Catalysed Destruction of Ozone," Nature, 249(5460):810, 1974.

59. D. Ehhalt et.al., "Heterogeneous Chemical Reactions in the Stratosphere," Journal of Geophysical Research, 80:1653-1655, 1975.

in the Troposphere and Stratosphere," Journal of Geophysical Research, 80:1650-1652, 1975.

61. R.F. Fleagle and J.A. Businger, An Introduction to Atmospheric Physics, p. 153., Academic Press, New York, 1963.

62. A.J. Grobecker (ed.), The Natural and Radiatively Perturbed Troposphere, CIAP Monograph 4, DOT-TST-75-54, September, 1975.

63. A.J. Grobecker (ed.), The Natural Stratosphere of 1974, CIAP Monograph 1, DOT-TST-75-51, September, 1975.

64. R.J. Massa, et. al., USDOT CIAP Atmospheric Monitoring and Experiments, The Program and Results, DOT-TST-75-106, Dynatrend, Inc., Burlington, Mass., June 1975.

65. National Academy of Sciences, Atmospheric Chemistry; Problems and Scope, 1975.

66. R.G. Eldridge, The Size Distribution and Composition of Stratospheric Aerosols, The MITRE Corp., WP-11282, October 1975.

67. National Academy of Sciences, Halocarbons: Environmental Effects of Chlorofluromethane Release, NAS Committee on Impacts of Stratospheric Change, National Research Council, Washington, D.C., 1976.

68. National Academy of Science, Halocarbons: Effects on Stratospheric Ozone, NAS Panel on Atmospheric Chemistry, National Research Council, Washington, D.C., 1976.

69. Interdepartmental Committee for Atmospheric Sciences (ICAS), The Possible Impact of Fluorocarbons and Halocarbons on Ozone, ICAS 18a-FY75, Federal Council for Science and Technology, National Science Foundation, May 1975.

70. U.S. DOT, High-Altitude Pollution Program, Initial Planning Documentation, Office of Environmental Quality, FAA, DOT, June 16, 1975.

71. NASA, The NASA Program on Upper Atmospheric Research, Upper Atmospheric Research Office, Office of Space Science, Washington, D.C., June 1976.

72. European Space Agency, Sun-Earth Observatory and Climatology Study (SEOCS), Report on the Mission Definition Study, DP/PS (76)13, Neuilly, France, June 15, 1976.

73. Interdepartmental Committee for Atmospheric Sciences (ICAS), *Instrumentation and Measuring Systems for Stratospheric Research (Draft)*, ICAS Subcommittee on Instrumentation and Measuring Systems, November 29, 1976.

74. J.C. Fontanelle et.al., "Vertical Distribution of NO, NO_2, and HNO_3 as Derived from Stratospheric Absorption Infrared Spectra," *Applied Optics*, 14(4):825-839, April 1975.

75. M. Nicolet, "Stratospheric Ozone: An Introduction to Its Study," *Reviews of Geophysics and Space Physics*, 13(5): 593-636, November 1975.

76. H.S. Johnston, "Global Ozone Balance in the Natural Stratosphere," *Reviews of Geophysics and Space Physics*, 13(5): 637-649, November 1975.

77. G.B. Lubkin, "Fluorocarbons and the Stratosphere" *Physics Today*, 28(10):34-39, October 1975.

78. O.B. Toon, and J.B. Pollack, "Physical Properties of the Stratospheric Aerosols," *Journal of Geophysical Research*, 78(30):7051-7056, October 1973.

79. J.A. Ryan, and N.R. Mukherjee, "Sources of Stratospheric Gaseous Chlorine," *Reviews of Geophysics and Space Physics*, 13(5):650-658, November 1973.

80. J.P. Shedlovsky, "Neutron-Activation Analysis of Project Airstream Collections," National Center for Atmospheric Research, Boulder, Colorado, June 1973.

81. A.L. Lazrus and B.W. Gandrud, *Progress Report on Systematic Study of Stratospheric Aerosols*, National Center for Atmospheric Research, Boulder, Colorado, June 1973.

82. M. Loewenstein, et al., "Seasonal Variations of NO and O_3 at Altitudes 18.3 and 21.3 km," *Proceedings of the Fourth Conference on CIAP*, Transportation Systems Center, Cambridge, Massachusetts, February-March 1975.

83. P.W. Krey and R.J. Lagomarsino, "Stratospheric Concentrations of SF_6 and CCl_3F," *Health and Safety Laboratory Environmental Quarterly*, HASL-194, 1975.

84. H.J. Mastenbrook, "The Variability of Water Vapor in the Stratosphere," *Journal of Atmospheric Science*, 28:1495-1501, 1971.

85. H.J. Mastenbrook, "Water Vapor Distribution in the Stratosphere and High Troposphere," *Journal of Atmospheric Science*, 25:299-311, 1968.

86. H.J. Mastenbrook, "Stratospheric Water Vapor Distribution and Variability," *Proceeding International Conference on Structure, Composition and General Circulation of the Upper and Lower Atmosphere and Possible Anthropogenic Perturbations*, 1:233-248, 1974.

87. W.F. Evans, "Rocket Measurements of Water Vapor in the Stratosphere," *Proceedings International Conference on Structure, Composition and General Circulation of the Upper and Lower Atmosphere and Possible Anthropogenic Perturbations*, 1:249-256, 1974.

88. A.J. Krueger and R.A. Minzner, "A Proposed Mid-Latitude Ozone Model for the U.S. Standard Atmosphere," National Aeronautics and Space Administration, NASA X-651-73-22, 1973.

89. T.M. Hard, "Summary of Recent Reports of Stratospheric Trace-Gas Profiles," CIAP Monograph 1, Chapter 3.7, September 1975.

90. D.H. Ehhalt, et. al., "Vertical Profiles of CH_4, H_2, CO, N_2O and CO_2 in the Stratosphere," *Proceedings of the Third Conference on CIAP*, pp. 153-160, 1974.

91. D.G. Murcray, et al., "Recent Results of Stratospheric Trace-Gas Measurements from Balloon-Borne Spectrometers," *Proceedings of the Third Conference on CIAP*, pp. 184-192, 1974.

92. P. Cutchis, "Stratospheric Ozone Depletion and Solar Ultraviolet Radiation on Earth," *Science*, 14(4132):13-19, 5 April 1974.

93. P.R. Wakeling, "Fragility of the Earth's Ozone Shield and You and Me," *Applied Optics*, 14(9):2034-2035, September 1975.

94. M. Ackerman, "NO, NO_2, and HNO_3 below 35 km in the Atmosphere," *Journal Atmospheric Sciences*, 32(9):1649-1657, September 1975.

95. K. Telegadas and G.J. Ferber, "Atmospheric Concentrations and Inventory of Krypton-85 in 1973," *Science*, 190:882-883, 28 November 1975.

96. R.A. Reck, "Aerosols and Polar Temperature Changes," *Science*, 188:728-730, 16 May 1975.

97. D.H. Hunt (Chairman), Proceedings of the Meeting of the Ad Hoc Group on Monitoring the Stratosphere, April 6, 1976, AHG/MS Memorandum 1/76, Federal Coordinator for Meteorological Services and Supporting Research, NOAA, DOC Rockville, Md., April 20, 1976.

98. Deleted.

99. K. Beltzner (ed.), Living With Climatic Change, Proceedings of the Toronto Conference Workshop, November 17-22, 1975, Science Council of Canada, Ottawa, March 1976.

100. E. Keitz and D. Berks (eds.), Living With Climatic Change, Phase II, Summary Report of Symposium and Workshop, November 9-11, 1976, The MITRE Corporation, MTR 7443, January 1977.

101. E. Keitz (ed.), Proceedings of the Symposium: Living With Climatic Change, Phase II, November 9-11, 1976, The MITRE Corporation, MTR 7443, Vol., II, Sept. 1977.

102. R.G. Prinn et. al., "The Impact of Stratospheric Variability on Measurement Programs for Minor Constituents," Bull Amer. Meteor Soc. 57:686-694, June 1976.

103. Deleted.

104. Deleted.

105. Deleted.

106. Deleted.

107. Deleted.

108. J. Willis, et. al., "Report of Trade-Off Analysis on SESAME System Candidates," MTR-7013, The MITRE Corporation, February, 1969.

109. W.D. Rowe, "The Application of Structured Value Analysis to Models Using Value Judgments as a Data Source," M70-14, The MITRE Corporation, March 1970.

110. E.L. Keitz, "Application of Structured Value Analysis in Determining the Value vs. Performance of Air Quality Monitoring Networks," M70-27, The MITRE Corporation, April 1970.

111. J. Dukowitz, et. al., "Advanced Automotive Power System Structured Value Analysis Model," MTR-6085, The MITRE Corporation, October 1971.

112. J. Stone and E. Keitz, "A Method for the Evaluation of Advanced Automotive Power Systems," M72-151, The MITRE Corporation, presented at the International Conference on Automobile Pollution, Toronto, Canada, June 1972.

113. R.C. Oliver et al., "Aircraft Emissions: Potential Effects on Ozone and Climate" Final Report No. FAA-EQ-77-3 prepared for High Altitude Pollution Program, U.S. D.O.T. March, 1977.

114. N.D. Sze and M.F.W , "Measurement of Fluorocarbons 11 and 12 and Model Valitation: An Assessment," Atmospheric Environment, 10 (12): 1117-1125, December 1976.

115. R.E. Huschke (ed.), Glossary of Meteorology, American Meteorological Society, Boston, MA, 1959.

116. W.E. Wilson et al., "Sulfates in the Atmosphere", EPA-600/7-77-021, Environmental Protection Agency, March 1977.

117. J.P. Friend et al., "On the Formation of Stratospheric Aerosols," Journal of Atmospheric Sciences, 30:465-479, 1973 (cited in reference 66).

118. World Meterological Organization, International Cloud Atlas, WMO, Geneva, 1956.

119. R.D. Hudson, ed., Chlorofluoromethanes and the Stratosphere, NASA Reference Publication 1010, NASA Goddard Space Flight Center, August 1977.

120. NASA, Effects of Chlorofluoromethanes on Stratospheric Ozone, Assessment Report, September, 1977.

121. U.S. House of Representatives, The National Climate Program Act, Hearings before the Subcommittee on the Environment and the Atmosphere, Ninety-Fourth Congress, Second Session, May, 1976.

122. NASA, Proposed NASA Contribution to the Climate Program, NASA Goddard Space Flight Center, July, 1977.