7

X-622-73-305
PREPRINT

NASA TM X 70504

MARINER 9 INFRARED INTERFEROMETER SPECTROMETER (IRIS) REDUCED DATA RECORDS DOCUMENTATION

(NASA-TM-X-70504) MARINER 9 INFRARED INTERFEROMETER SPECTROMETER (IRIS) REDUCED DATA RECORDS DOCUMENTATION (NASA) 48 p HC $4.50 CSCL 14B N74-10430 Unclas G3/14 21642

OCTOBER 1973

GSFC

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

X-622-73-305

MARINER 9 INFRARED INTERFEROMETER SPECTROMETER (IRIS)

REDUCED DATA RECORDS DOCUMENTATION

October 1973

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

i

FOREWORD

This document has been assembled by the Mariner 9 IRIS staff, code 622, Goddard Space Flight Center, Greenbelt, Maryland, 20771. Further questions concerning the IRIS data or instrumentation should be addressed to one of the following:

R. A. Hanel, PI
V. G. Kunde, Co-I
B. J. Conrath, Co-I
J. C. Pearl, Co-I

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (Continued)

TABLE

MARINER 9 INFRARED INTERFEROMETER SPECTROMETER (IRIS) REDUCED DATA RECORDS DOCUMENTATION

INTRODUCTION

On 14 November 1971, the Mariner 9 spacecraft was successfully inserted into orbit around Mars. One of the five instruments on board, an infrared interferometer spectrometer (IRIS) is used to record the thermal emission spectrum of Mars between 200 and 2000 cm^{-1} (50 - 5 μm) with a spectral resolution of 2.4 cm^{-1} in the apodized mode. The spatial resolution for vertical viewing, corresponding to a field of view of $\sim 4.5°$, is a circular area of approximately 110 km diameter for a periapsis height of 1400 km. The total number of calibrated spectra included in the final data set is 21167.

The purpose of this report is to document the final calibrated thermal emission spectra contained in the reduced data records (RDR). Magnetic tapes with these data records are available to the scientific community through the National Space Science Data Center, Goddard Space Flight Center, Greenbelt, Maryland 20771. The design and performance of the instrument has been published by Hanel, et al., (1972a), and science results are discussed in Hanel, et al., (1972b), Hanel, et al., (1972c), Conrath, et al., (1973), and Curran, et al., (1973).

CALIBRATION

Calibration spectra were periodically recorded while observing either deep space or an on-board warm blackbody ($T \approx 296$ K). One pair of calibration spectra is generated for every 14 spectra of Mars. Scaling of the raw Martian spectra to the calibration spectra specifies the Martian spectra in absolute radiometric units. The calibration procedure for the Mariner 9 spectra is similar to that previously described for Nimbus 4 (Hanel, et al., 1972d). The equation for the calibration of the Martian spectra is

$$I_\nu = \frac{C_{t_\nu} - C_{c_\nu}}{\alpha_\nu C_{w_\nu} - C_{c_\nu}} B_\nu (T_w) \tag{1}$$

where C_{t_ν}, C_{c_ν} and C_{w_ν} are the instantaneous spectral amplitudes for the target (Mars), the cold calibration source (deep space), and the warm calibration source (on-board reference blackbody), respectively. B_ν is the Planck function, T_w is the temperature of the warm reference blackbody, and α_ν is discussed below.

The excellent thermal stability of the Mariner 9 IRIS has permitted the entire ensemble of 1766 calibration pairs acquired during the Mariner mission to be averaged to provide a single set of calibration parameters. The final calibration equation is

$$I_\nu = \frac{C_{t_\nu} - < C_{c_\nu} >}{\alpha_\nu < C_{w_\nu} > - < C_{c_\nu} >} B_\nu (\overline{T}_w) \tag{2}$$

Consequently, the random error introduced into the individual target spectra from the calibration spectra is extremely small. The temperature $\overline{T}_w$ of the warm blackbody is an average of eight transducer measurements made immediately before and after each interferogram.

The factor α_ν is the reciprocal value of the emissivity ϵ_ν of the black paint used in the warm calibration source, an aluminum plate with 30° V-shaped grooves painted with 3M 401-C10 Black Velvet paint. While this paint is relatively black over most of the instrument spectral range, small glass beads contained in it give rise to emittance variations of a few percent near 480 cm^{-1} and 1100 cm^{-1} which are characteristic wave numbers of SiO_2. The correction factor was derived from laboratory reflectance measurements on a duplicate blackbody, from similar measurements on the same type of paint, kindly made available by James Aronson (private communication), and finally from comparisons of the warm and cold calibrations on the interferometer while in orbit around Mars. All three methods were in agreement and, consequently, the emissivity correction of the warm calibration source has been applied to all spectra. The emissivity of the reference "blackbody" is shown in Figure 1 and is listed in Table 1.

The responsivity of the instrument and a spectral instrument temperature may also be derived from each calibration pair. The noise equivalent radiance (NER), a measure of the random errors in the measurements, is calculated from the standard deviation of the individual instantaneous responsivities. The derivation and description of all the instrumental parameters are discussed in detail in Hanel, et al., 1972d.

The average instrumental parameters are illustrated in Figures 2-6. Several spikes are observable in the instrument NER (Figure 5). The locations of these spikes are:

Number	ν (cm^{-1})	f(Hz)	Probable Source
1	356.	8.36	8-1/3 bps - telemetry rate
2	713.	16.76	2 (8-1/3)

Number	$\nu(cm^{-1})$	f(Hz)	Probable Source
3	1069.	25.12	3 (8-1/3)
4	1203.	28.27	?
5	1426.	33.52	4 (8-1/3) & 33-1/3
6	1782.	41.88	5 (8-1/3)

The most probable source of these spikes are transients caused by the engineering telemetry channels which have characteristic frequencies of 8-1/3 and 33-1/3 bps. The source of the interference at 28.27 Hz is unknown.

In addition to the radiometric calibration, a wave number correction has been applied to the data. The finite solid angles of the primary and reference interferometers cause a small wave number shift and a distortion of the true wave number scale. This well known effect, caused by the interference of on-axis and off-axis rays, has been corrected for empirically. A numerical fit of a Lorentzian function was made to determine the center wave number position ν_m and ν_t of the strongest CO_2 features in a measured and in a theoretical spectrum respectively. The difference, $\nu_t - \nu_m$, is shown as a function of ν_t in Figure 7. The adopted correction is a linear least squares fit

$$\nu_t = \frac{(0.016187 + \nu_m)}{1.0010602} . \tag{3}$$

The above constants are contained in the RDR type 1 records (words 96 and 97). The ν_t wave number mesh for the calibrated radiances is also contained in the type 1 records (words 101 through 1600).

The general characteristics of a spectrum are exhibited in terms of radiance and brightness temperature in Figures 8 and 9, respectively. This spectrum is an average of 1842 spectra from the RDR records with surface temperature in the 260—280 K range, viewing angle in the 0—90° range, and for revolutions later than 100. Absorption by water vapor occurs in the 200—500 and 1400—1800 cm^{-1} regions with CO_2 absorption most evident in the 600—750 cm^{-1} region. Weak CO_2 bands occur at 961, 1064, 1260, 1366, and 1932 cm^{-1}. The broad feature in the 900—1200 cm^{-1} region is attributed to Martian silicate dust.

ORBITAL INFORMATION

Each IRIS spectrum was obtained in a 21 second frame which is equivalent to 18 DAS counts of the spacecraft clock. Orbital data for the spectra were obtained from the Supplementary Experimenter Data Records (SEDR) produced by the Jet

Propulsion Laboratory (JPL). The content of these records is described in Appendix C. Three SEDR records were generated for each IRIS frame, keyed to the IRIS frame starting DAS time. They are spaced to represent the IRIS orbital parameters at the starting DAS time plus 3, 9 and 15 counts. The orbital information contained in the IRIS Reduced Data Record (RDR) was extracted from the SEDR record which most closely corresponded to the center of the IRIS frame (count 9). In some instances, a matching SEDR record could not be found. In these cases, some of the orbital data were estimated according to the following procedure:

a. If the IRIS record was located between two records for which orbital data were available, the data points were interpolated based upon DAS time, or

b. If the IRIS record was located at the start or end of an orbit, the data were extrapolated by DAS time, using the best available orbital information. Word 93 of each IRIS RDR was set to 1.0 when the orbital data were estimated and to zero otherwise. Only the following types of data were estimated; all other orbital data were zeroed out:

Orbit number

Latitude and longitude of the center of the viewed area

Solar lighting angle

Viewing angle

Ten latitude and longitude points defining the field-of-view (each pair is set equal to the center latitude and longitude)

Mars local time

All latitude and longitude values have been corrected to conform to the new Mars pole and prime meridian. The correction was done using the algorithm developed by JPL and described in TM-33-585, "MM 71 TV Picture Catalog". The original (uncorrected) "center of the field-of-view latitude and longitude" were retained in Words 89 and 90 of RDR.

Appendix A contains a summary of event day, calendar date and GMT time of periapsis and DAS time at periapsis for each revolution during the orbital mission when data were obtained.

RDR DATA FORMAT

Magnetic Tape Format:

9 track, 1 file, no label

Density: 1600 BPI (DEN=3)

Record Format: Variable Length, Scanned (RECFM=VS)

Longest Record Length: 6404 Bytes (LRECL=6404)

Blocksize: 6408 Bytes (BLKSIZE=6408)

I/O Method: All records were written to tape using a FORTRAN unformatted WRITE statement, i.e.

WRITE (unit) (RDR(I), I=1, 1600)

Record Format: Each tape contains seven types of RDR's (one each of types 1 through 6, followed by a string of type 7):

Record Type	Name
1	Tape Summary
2	Cold Reference Calibration
3	Warm Reference Calibration
4	Average Normalized Responsivity
5	Noise Equivalent Radiance
6	Average Instrument Temperature
7	Calibrated Martian Spectrum

Appendix B describes the content of each type RDR. Each RDR consists of 100 words of header information followed by 1500 words of data. All words are full-word floating point binary values. The following table lists the content of each tape by revolution number and DAS time.

Tape	No. Records	Revolution Range	DAS Time Range
IRIS-1	4946	1—42	1672865—3109687
IRIS-2	5198	43—100	3139524—5169569
IRIS-3	3675	101—138	5236507—6536827
IRIS-4	4441	139—178	6571914—7976867
IRIS-5	2907	179—676	8043122—13507967
TOTAL	21167	1—676	1672865—13507967

ACKNOWLEDGEMENT

The following people contributed substantially to the development of the Mariner 9 IRIS reduced data records: F. Rockwell, R. Long, R. Bevacqua, J. Frost and P. Corbin of Consultants and Designers, Inc.; L. Herath of Goddard Space Flight Center; T. Burke of Jet Propulsion Laboratory.

REFERENCES

Conrath, B., R. Curran, R. Hanel, V. Kunde, W. Maguire, J. Pearl, J. Pirraglia, J. Welker, and T. Burke, Atmospheric and Surface Properties of Mars Obtained by Infrared Spectroscopy on Mariner 9, JGR, 78, 4267, 1973.

Curran, R. J., B. J. Conrath, R. A. Hanel, V. G. Kunde, and J. C. Pearl, Mars: Mariner 9 Spectroscopic Evidence for H_2O Ice Clouds, to be published in Science, 1973.

Hanel, R., B. Schlachman, E. Breihan, R. Bywaters, F. Chapman, M. Rhodes, D. Rodgers, and D. Vanous, Mariner 9 Michelson Interferometer, Appl. Opt., 11, 2625, 1972a.

Hanel, R. A., B. J. Conrath, W. A. Hovis, V. G. Kunde, P. D. Lowman, J. C. Pearl, C. Prabhakara, B. Schlachman, and G. V. Levin, Infrared Spectroscopy Experiment on the Mariner 9 Mission: Preliminary Results, Science, 175, 305, 1972b.

Hanel, R., B. Conrath, W. Hovis, V. Kunde, P. Lowman, W. Maguire, J. Pearl, J. Pirraglia, C. Prabhakara, B. Schlachman, G. Levin, P. Straat, and T. Burke, Investigation of the Martian Environment by Infrared Spectroscopy on Mariner 9, Icarus, 17, 423, 1972c.

Hanel, R. A., B. J. Conrath, V. G. Kunde, C. Prabhakara, I. Revah, V. V. Salomonson, and G. Wolford, The Nimbus 4 Infrared Spectroscopy Experiment 1. Calibrated Thermal Emission Spectra, JGR, 77, 2629, 1972d.

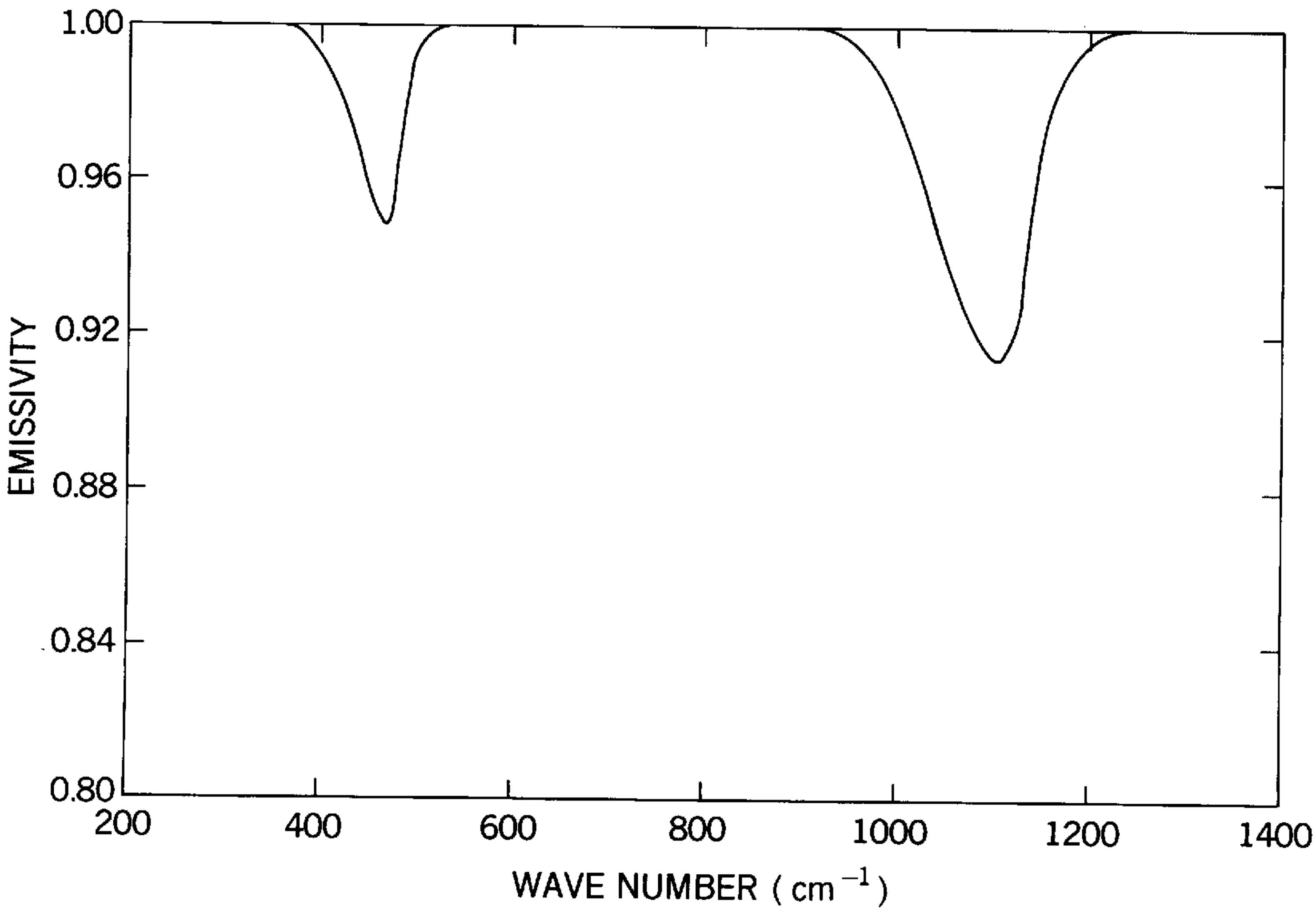

Figure 1. Emissivity of the Warm Calibration Source

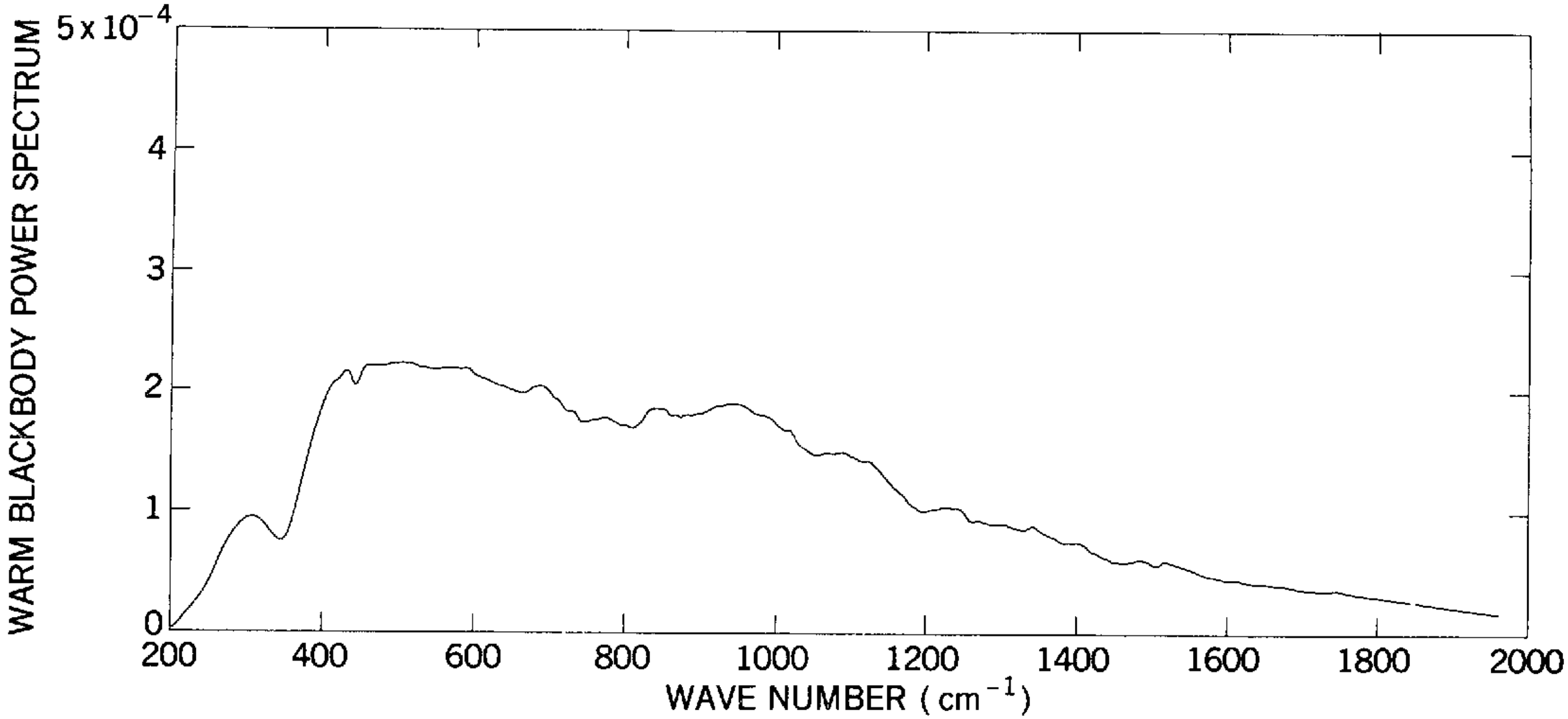

Figure 2. Average Spectral Amplitude of 1766 Warm Calibration Spectra

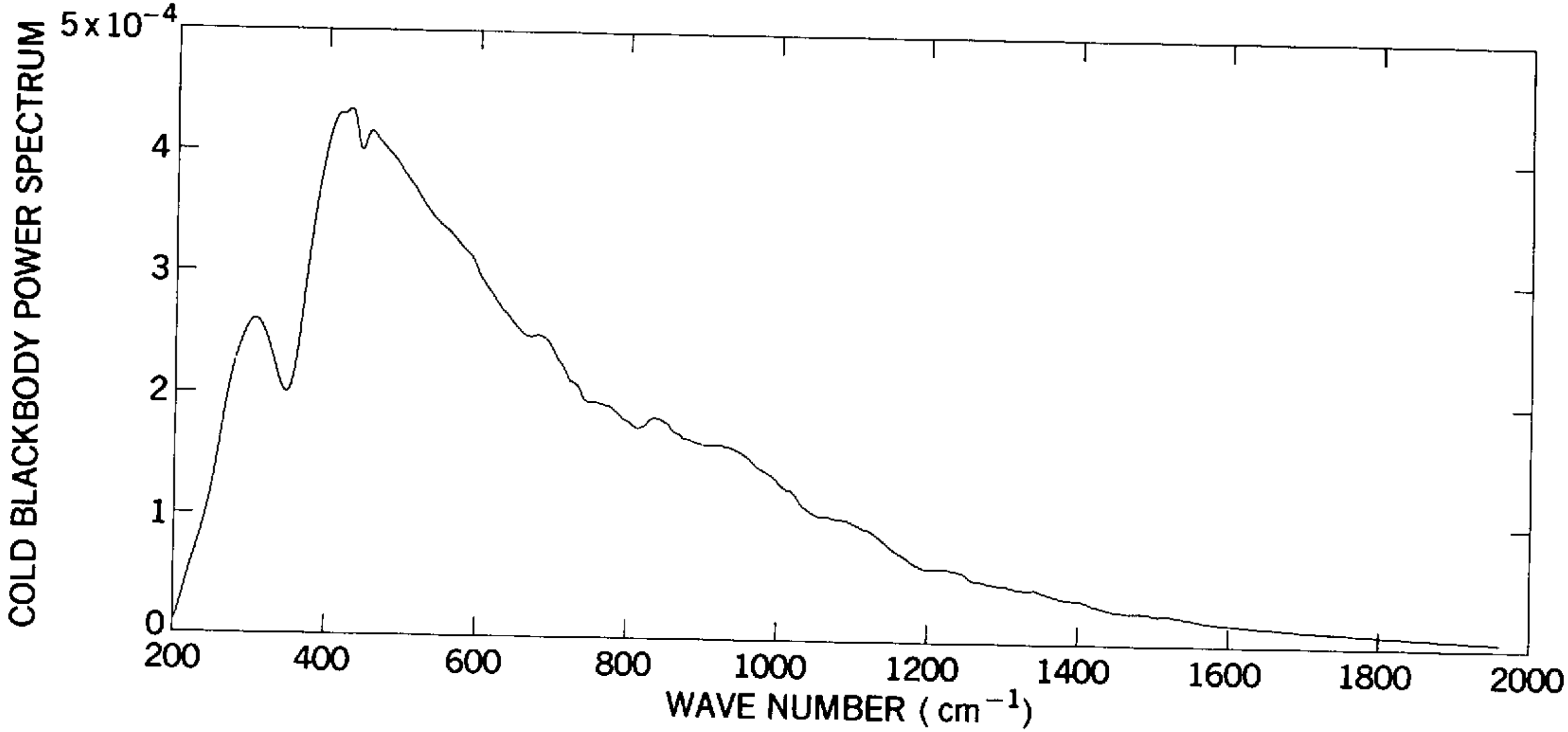

Figure 3. Average Spectral Amplitude of 1766 Cold Calibration Spectra

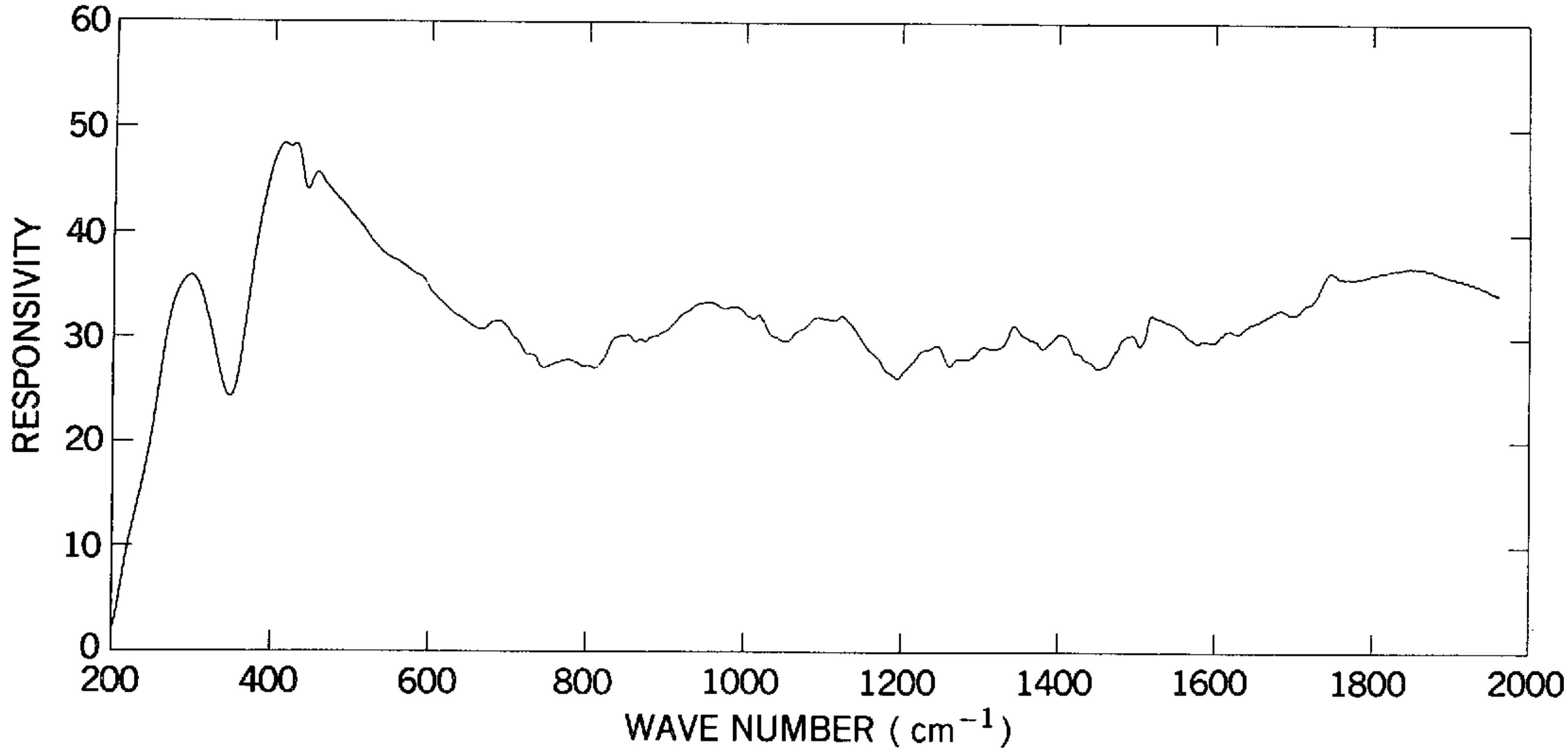

Figure 4. Average Instrument Spectral Responsivity Based on 1766 Calibration Pairs

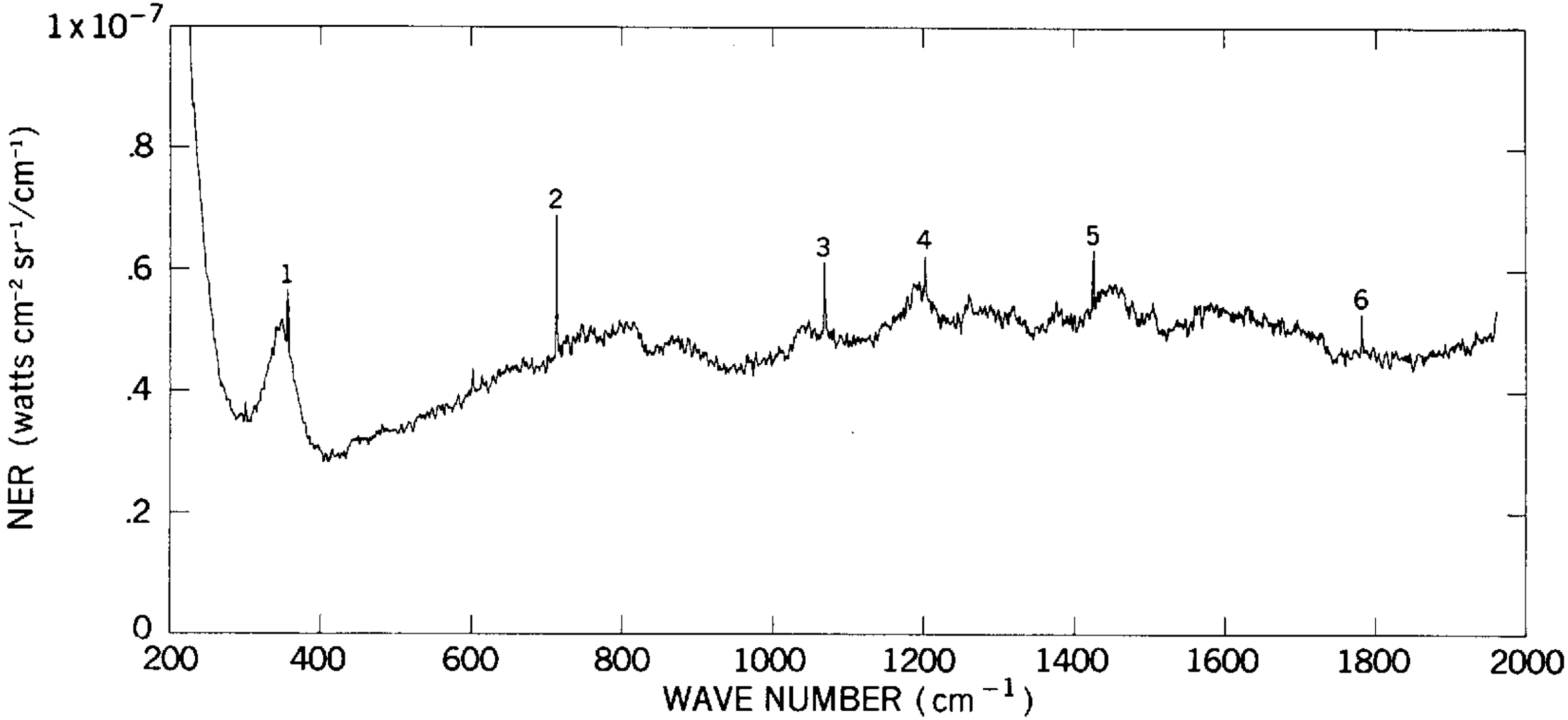

Figure 5. Instrumental NER determined from standard deviation of responsivity. The sharp numbered spikes are due to interference from the spacecraft or other experiments.

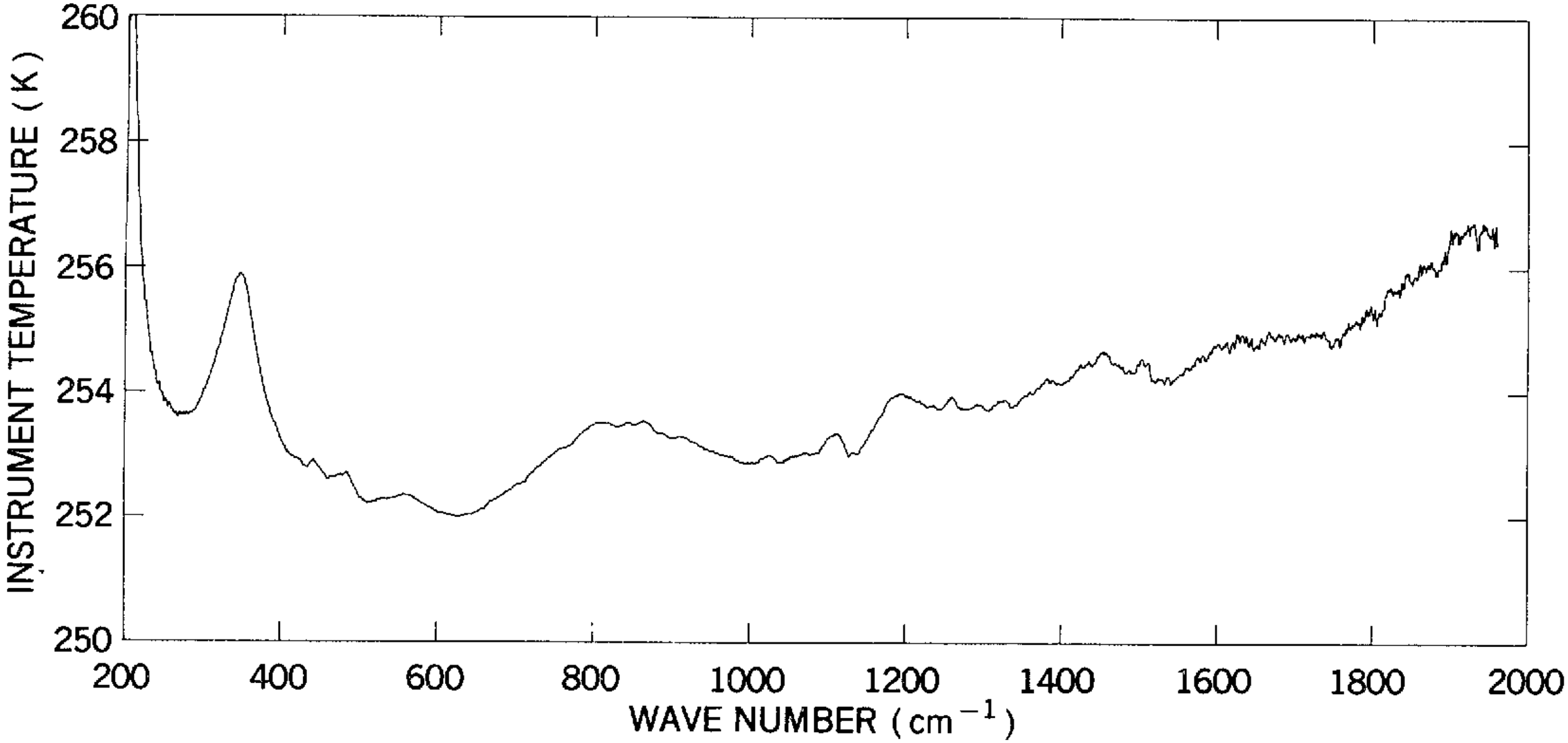

Figure 6. Instrument Temperature as Derived From Calibration Equations

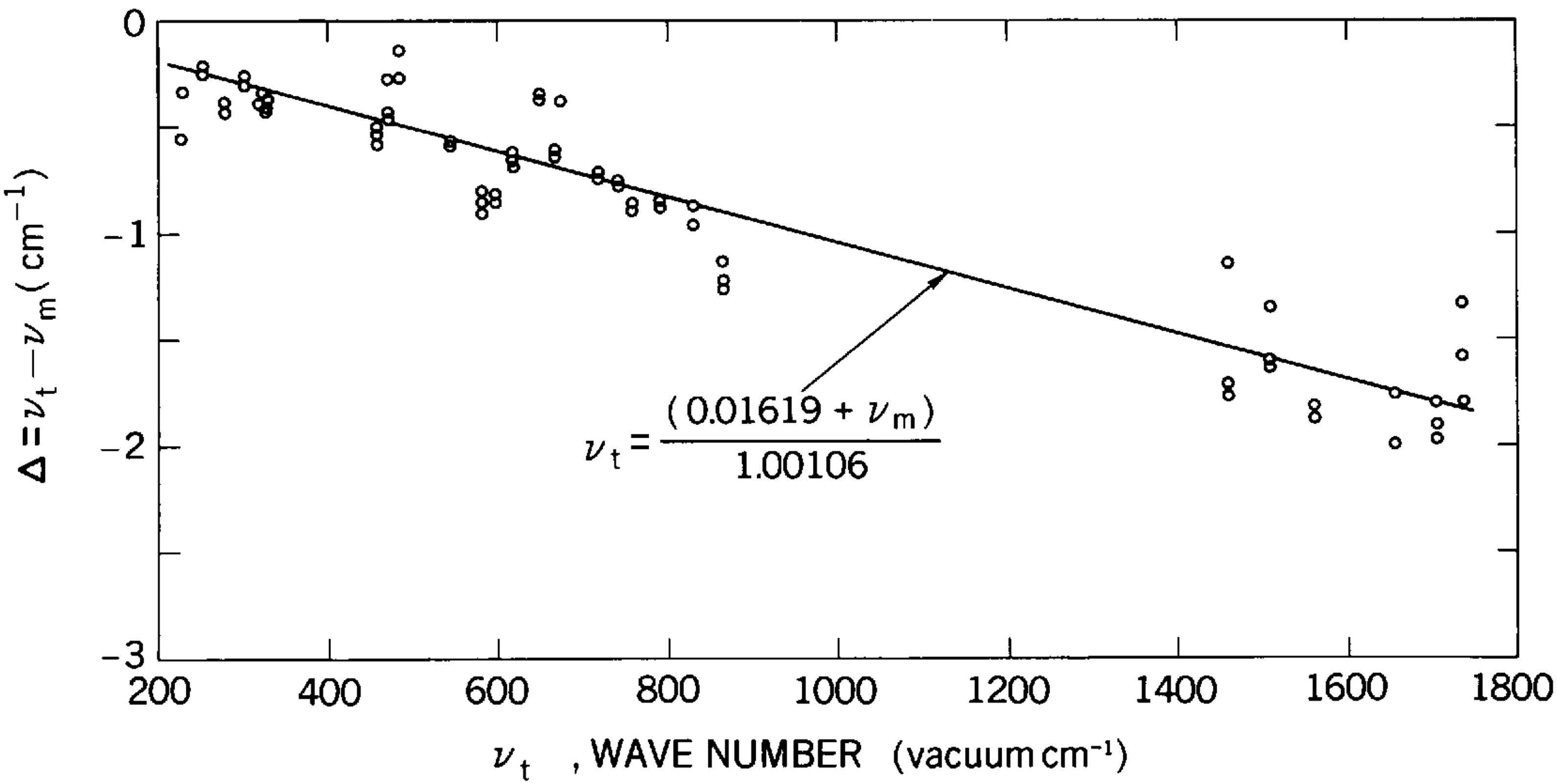

Figure 7. Wave Number Transfer Function to Correct Observed Wave Number for Finite Field-of-View Effects

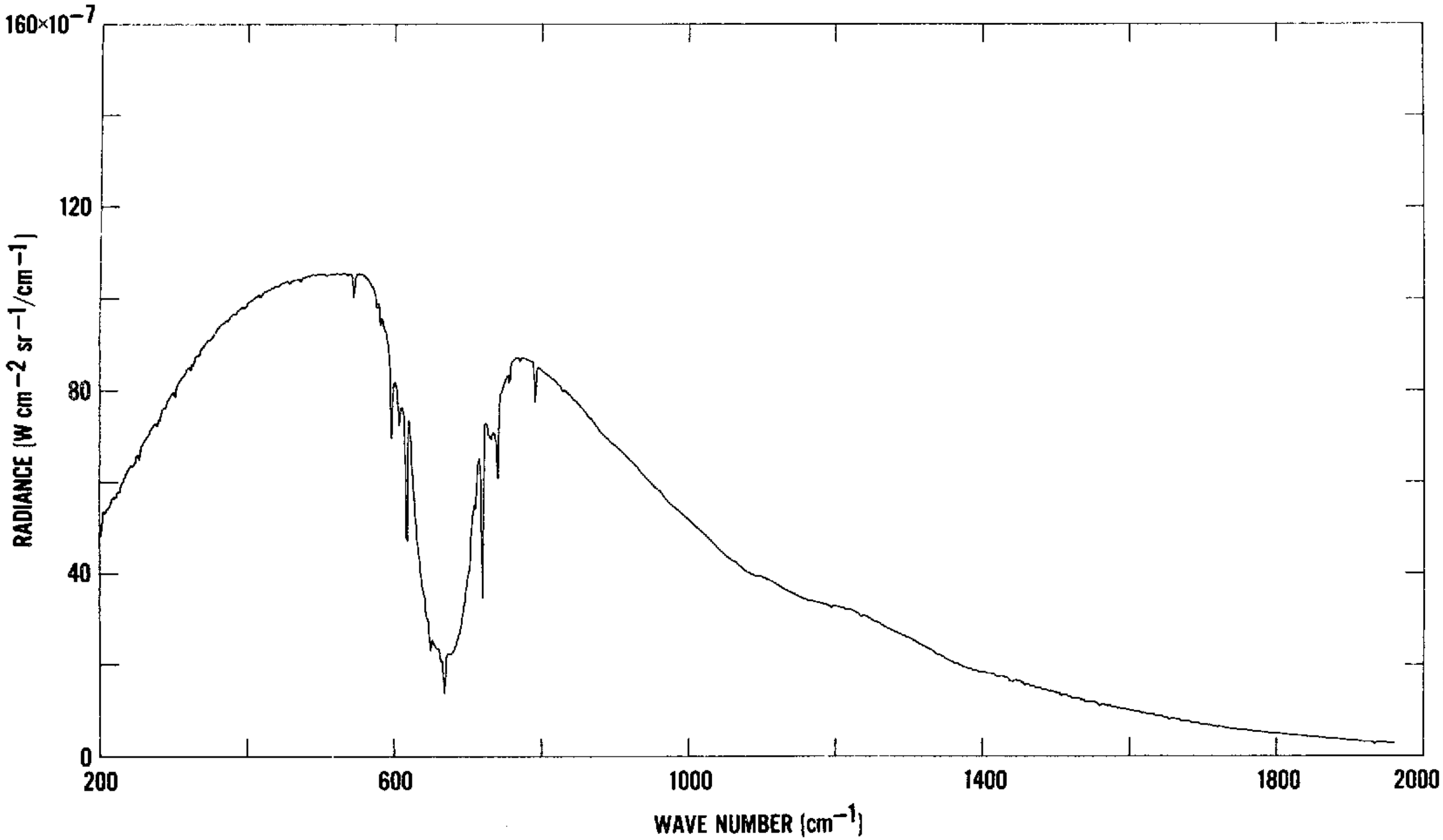

Figure 8. Average Radiance Spectrum

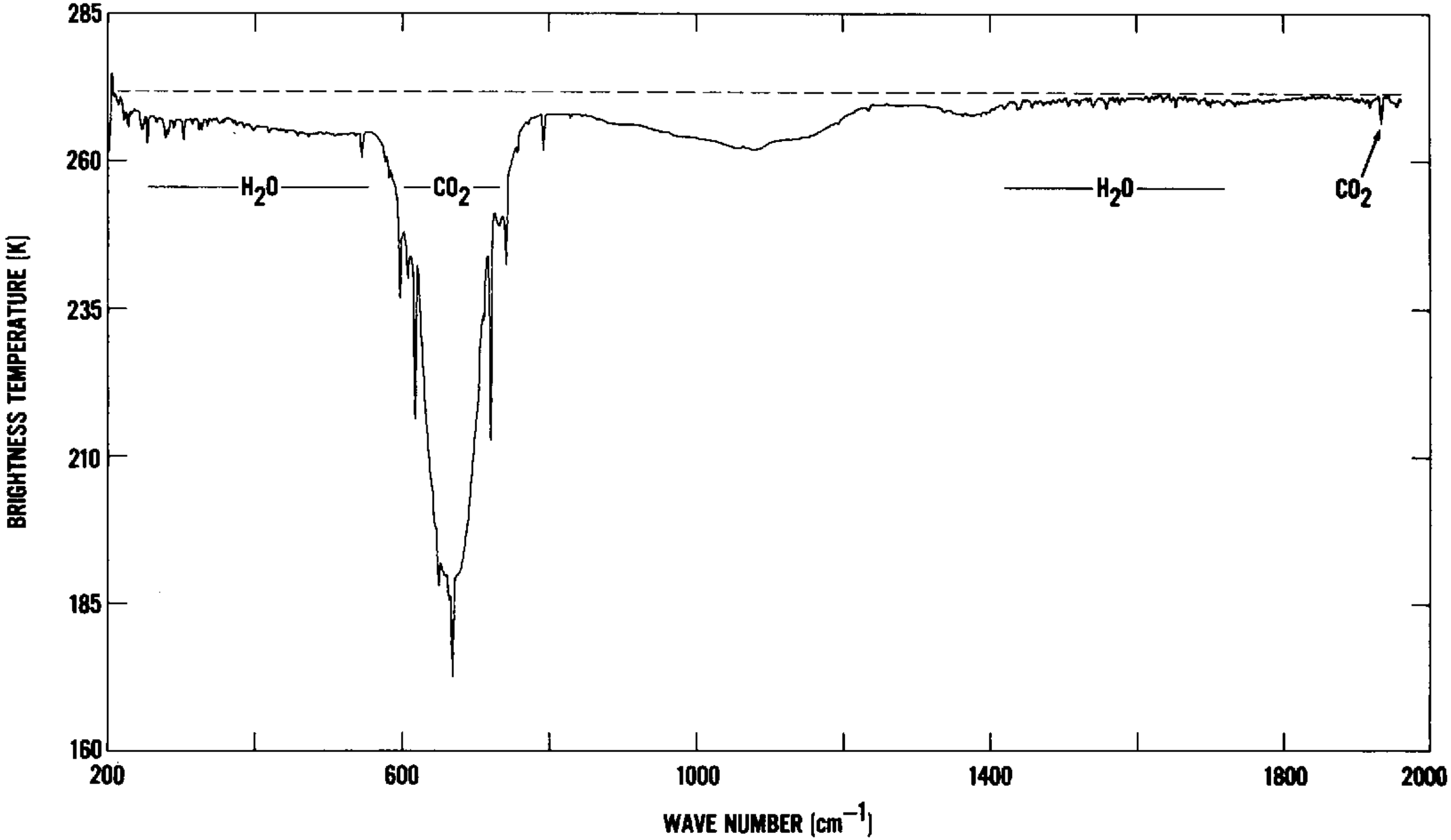

Figure 9. Average Brightness Temperature Spectrum

Table 1

Spectral Emissivity of the Warm Calibration Source

Wave Number (cm^{-1})	Emissivity	Wave Number (cm^{-1})	Emissivity
370	1.00	.	.
375	1.00	920	1.00
380	1.00	925	1.00
385	1.00	930	1.00
390	1.00	935	1.00
395	0.99	940	1.00
400	0.99	945	1.00
405	0.99	950	1.00
410	0.99	955	1.00
415	0.99	960	0.99
420	0.98	965	0.99
425	0.98	970	0.99
430	0.98	975	0.99
435	0.97	980	0.99
440	0.97	985	0.99
445	0.96	990	0.98
450	0.96	995	0.98
455	0.95	1000	0.98
460	0.95	1005	0.98
465	0.95	1010	0.97
470	0.95	1015	0.97
475	0.95	1020	0.96
480	0.96	1025	0.96
485	0.97	1030	0.96
490	0.98	1035	0.95
495	0.99	1040	0.95
500	0.99	1045	0.94
505	0.99	1050	0.94
510	1.00	1055	0.94
515	1.00	1060	0.94
520	1.00	1065	0.93
525	1.00	1070	0.93
530	1.00	1075	0.93
.	.	1080	0.92
.	.	1085	0.92
.	.	1090	0.92

Table 1 (Continued)

Wave Number (cm^{-1})	Emissivity	Wave Number (cm^{-1})	Emissivity
1095	0.92	1160	0.98
1100	0.91	1165	0.98
1105	0.91	1170	0.98
1110	0.91	1175	0.99
1115	0.92	1180	0.99
1120	0.92	1185	0.99
1125	0.92	1190	0.99
1130	0.93	1195	0.99
1135	0.94	1200	0.99
1140	0.95	1205	1.00
1145	0.96	1210	1.00
1150	0.96	1215	1.00
1155	0.97	1220	1.00

APPENDIX A

REVOLUTION SUMMARY

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
2	319	15 NOV 71	1	49	49	1711903
3	319	15 NOV 71	14	23	41	1749596
5	320	16 NOV 71	14	56	38	1780490
6	321	17 NOV 71	2	55	23	1816428
7	321	17 NOV 71	14	54	5	1852363
8	322	18 NOV 71	2	52	43	1888295
9	322	18 NOV 71	14	51	12	1924219
10	323	19 NOV 71	2	49	38	1960141
11	323	19 NOV 71	14	47	56	1996056
12	324	20 NOV 71	2	46	9	2031967
13	324	20 NOV 71	14	44	12	2067870
14	325	21 NOV 71	2	42	13	2103770
15	325	21 NOV 71	14	40	4	2139663
16	326	22 NOV 71	2	37	53	2175554
17	326	22 NOV 71	14	35	36	2211440
18	327	23 NOV 71	2	33	15	2247323
19	327	23 NOV 71	14	30	52	2283204
20	328	24 NOV 71	2	28	26	2319082
21	328	24 NOV 71	14	26	2	2354962
22	329	25 NOV 71	2	23	35	2390840
23	329	25 NOV 71	14	21	13	2426721
24	330	26 NOV 71	2	18	49	2462602
25	330	26 NOV 71	14	16	29	2498485
26	331	27 NOV 71	2	14	12	2534371
27	331	27 NOV 71	14	12	2	2570263
28	332	28 NOV 71	2	9	56	2606158
29	332	28 NOV 71	14	7	56	2642058
30	333	29 NOV 71	2	6	3	2677964
31	333	29 NOV 71	14	4	15	2713874
32	334	30 NOV 71	2	2	34	2749790
33	334	30 NOV 71	14	0	59	2785711
34	335	1 DEC 71	1	59	32	2821639
35	335	1 DEC 71	13	58	8	2857569
36	336	2 DEC 71	1	56	51	2893505
37	336	2 DEC 71	13	55	36	2929442
38	337	3 DEC 71	1	54	25	2965384
39	337	3 CEC 71	13	53	15	3001325
40	338	4 DEC 71	1	52	7	3037269

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
41	338	4 DEC 71	13	50	58	3073211
42	339	5 DEC 71	1	49	46	3109151
43	339	5 DEC 71	13	48	32	3145090
44	340	6 DEC 71	1	47	11	3181022
45	340	6 DEC 71	13	45	47	3216953
46	341	7 DEC 71	1	44	15	3252876
47	341	7 DEC 71	13	42	39	3288796
48	342	8 DEC 71	1	40	54	3324709
49	342	8 DEC 71	13	39	5	3360618
50	343	9 DEC 71	1	37	7	3396520
51	343	9 DEC 71	13	35	5	3432418
52	344	10 DEC 71	1	32	54	3468310
53	344	10 DEC 71	13	30	40	3504198
54	345	11 DEC 71	1	28	22	3540083
55	345	11 DEC 71	13	26	0	3575965
56	346	12 DEC 71	1	23	37	3611845
57	346	12 DEC 71	13	21	10	3647723
58	347	13 DEC 71	1	18	46	3683603
59	347	13 DEC 71	13	16	18	3719480
60	348	14 DEC 71	1	13	55	3755361
61	348	14 DEC 71	13	11	32	3791242
62	349	15 DEC 71	1	9	15	3827128
63	349	15 DEC 71	13	7	0	3863016
64	350	16 DEC 71	1	4	52	3898909
65	350	16 DEC 71	13	2	47	3934805
66	351	17 DEC 71	1	0	49	3970707
67	351	17 DEC 71	12	58	58	4006614
68	352	18 DEC 71	0	57	12	4042526
69	352	18 DEC 71	12	55	35	4078446
70	353	19 DEC 71	0	54	2	4114368
71	353	19 DEC 71	12	52	36	4150297
72	354	20 DEC 71	0	51	14	4186228
73	354	20 DEC 71	12	49	59	4222166
74	355	21 DEC 71	0	48	45	4258105
75	355	21 DEC 71	12	47	36	4294047
76	356	22 DEC 71	0	46	26	4329989
77	356	22 DEC 71	12	45	18	4365933
78	357	23 DEC 71	0	44	8	4401874

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
79	357	23 DEC 71	12	42	55	4437813
80	358	24 DEC 71	0	41	38	4473750
81	358	24 DEC 71	12	40	17	4509682
82	359	25 DEC 71	0	38	51	4545610
83	359	25 DEC 71	12	37	16	4581532
84	360	26 DEC 71	0	35	39	4617450
85	360	26 DEC 71	12	33	50	4653360
86	361	27 DEC 71	0	32	0	4689268
87	361	27 DEC 71	12	29	59	4725168
88	362	28 DEC 71	0	27	54	4761064
89	362	28 DEC 71	12	25	43	4796954
90	363	29 DEC 71	0	23	27	4832841
91	363	29 DEC 71	12	21	7	4868725
92	364	30 DEC 71	0	18	45	4904606
93	364	30 DEC 71	12	16	20	4940485
95	365	31 DEC 71	12	16	16	4987981
96	1	1 JAN 71	0	15	5	5023921
97	1	1 JAN 72	12	13	59	5059866
98	2	2 JAN 72	0	12	53	5095811
99	2	2 JAN 72	12	11	52	5131761
100	3	3 JAN 72	0	10	52	5167711
101	3	3 JAN 72	12	9	59	5203667
102	4	4 JAN 72	0	9	10	5239626
103	4	4 JAN 72	12	8	27	5275591
104	5	5 JAN 72	0	7	50	5311559
105	5	5 JAN 72	12	7	17	5347533
106	6	6 JAN 72	0	6	52	5383512
107	6	6 JAN 72	12	6	32	5419495
108	7	7 JAN 72	0	6	18	5455483
109	7	7 JAN 72	12	6	8	5491475
110	8	8 JAN 72	0	6	5	5527473
111	8	8 JAN 72	12	6	3	5563471
112	9	9 JAN 72	0	6	7	5599474
113	9	9 JAN 72	12	6	11	5635478
114	10	10 JAN 72	0	6	17	5671483
115	10	10 JAN 72	12	6	22	5707488
116	11	11 JAN 72	0	6	28	5743493
117	11	11 JAN 72	12	6	31	5779495

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
118	12	12 JAN 72	0	6	31	5815495
119	12	12 JAN 72	12	6	27	5851492
120	13	13 JAN 72	0	6	16	5887483
121	13	13 JAN 72	12	6	3	5923473
122	14	14 JAN 72	0	5	41	5959454
123	14	14 JAN 72	12	5	15	5995433
124	15	15 JAN 72	0	4	41	6031404
125	15	15 JAN 72	12	4	4	6067373
126	16	16 JAN 72	0	3	18	6103335
127	16	16 JAN 72	12	2	28	6139294
128	17	17 JAN 72	0	1	32	6175248
129	17	17 JAN 72	12	0	32	6211198
130	17	17 JAN 72	23	59	29	6247145
131	18	18 JAN 72	11	58	22	6283089
132	18	18 JAN 72	23	57	15	6319033
133	19	19 JAN 72	11	56	4	6354974
134	19	19 JAN 72	23	54	55	6390918
135	20	20 JAN 72	11	53	44	6426858
136	20	20 JAN 72	23	52	38	6462803
137	21	21 JAN 72	11	51	31	6498748
138	21	21 JAN 72	23	50	31	6534698
139	22	22 JAN 72	11	49	31	6570648
140	22	22 JAN 72	23	48	38	6606603
141	23	23 JAN 72	11	47	47	6642562
142	23	23 JAN 72	23	47	4	6678526
143	24	24 JAN 72	11	46	27	6714495
144	24	24 JAN 72	23	45	54	6750468
145	25	25 JAN 72	11	45	28	6786446
146	25	25 JAN 72	23	45	8	6822429
147	26	26 JAN 72	11	44	54	6858418
148	26	26 JAN 72	23	44	44	6894410
149	27	27 JAN 72	11	44	40	6930407
150	27	27 JAN 72	23	44	38	6966405
151	28	28 JAN 72	11	44	42	7002409
152	28	28 JAN 72	23	44	46	7038412
153	29	29 JAN 72	11	44	53	7074418
154	29	29 JAN 72	23	44	59	7110423
155	30	30 JAN 72	11	45	4	7146427

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
156	30	30 JAN 72	23	45	7	7182430
157	31	31 JAN 72	11	45	7	7218430
158	31	31 JAN 72	23	45	3	7254427
159	32	1 FEB 72	11	44	53	7290419
160	32	1 FEB 72	23	44	41	7326408
161	33	2 FEB 72	11	44	20	7362391
162	33	2 FEB 72	23	43	54	7398370
163	34	3 FEB 72	11	43	21	7434342
164	34	3 FEB 72	23	42	43	7470311
165	35	4 FEB 72	11	41	57	7506273
166	35	4 FEB 72	23	41	9	7542233
167	36	5 FEB 72	11	40	13	7578186
168	36	5 FEB 72	23	39	14	7614137
169	37	6 FEB 72	11	38	11	7650085
170	37	6 FEB 72	23	37	4	7686029
171	38	7 FEB 72	11	35	56	7721972
172	38	7 FEB 72	23	34	45	7757913
173	39	8 FEB 72	11	33	36	7793856
174	39	8 FEB 72	23	32	26	7829798
175	40	9 FEB 72	11	31	20	7865743
176	40	9 FEB 72	23	30	12	7901687
177	41	10 FEB 72	11	29	12	7937636
178	41	10 FEB 72	23	28	11	7973586
179	42	11 FEB 72	11	27	18	8009542
180	42	11 FEB 72	23	26	28	8045500
181	43	12 FEB 72	11	25	44	8081463
182	43	12 FEB 72	23	25	5	8117431
183	44	13 FEB 72	11	24	32	8153404
184	44	13 FEB 72	23	24	6	8189383
185	45	14 FEB 72	11	23	45	8225365
186	45	14 FEB 72	23	23	31	8261354
187	46	15 FEB 72	11	23	20	8297344
188	46	15 FEB 72	23	23	17	8333342
189	47	16 FEB 72	11	23	15	8369340
190	47	16 FEB 72	23	23	19	8405344
191	48	17 FEB 72	11	23	22	8441347
192	48	17 FEB 72	23	23	28	8477352
193	49	18 FEB 72	11	23	35	8513358

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
194	49	18 FEB 72	23	23	41	8549363
195	50	19 FEB 72	11	23	45	8585366
196	50	19 FEB 72	23	23	45	8621366
197	51	20 FEB 72	11	23	42	8657364
198	51	20 FEB 72	23	23	33	8693356
199	52	21 FEB 72	11	23	20	8729346
200	52	21 FEB 72	23	22	59	8765329
201	53	22 FEB 72	11	22	35	8801309
202	53	22 FEB 72	23	22	2	8837281
203	54	23 FEB 72	11	21	25	8873250
204	54	23 FEB 72	23	20	40	8909213
205	55	24 FEB 72	11	19	50	8945172
206	55	24 FEB 72	23	18	55	8981126
207	56	25 FEB 72	11	17	57	9017078
208	56	25 FEB 72	23	16	54	9053025
209	57	26 FEB 72	11	15	48	9088970
210	57	26 FEB 72	23	14	40	9124914
211	58	27 FEB 72	11	13	29	9160854
212	58	27 FEB 72	23	12	21	9196798
213	59	28 FEB 72	11	11	9	9232739
214	59	28 FEB 72	23	10	2	9268683
215	60	29 FEB 72	11	8	55	9304627
216	60	29 FEB 72	23	7	54	9340576
217	61	1 MAR 72	11	6	54	9376526
218	61	1 MAR 72	23	6	0	9412481
219	62	2 MAR 72	11	5	9	9448439
220	62	2 MAR 72	23	4	25	9484403
221	63	3 MAR 72	11	3	47	9520371
222	63	3 MAR 72	23	3	13	9556343
223	64	4 MAR 72	11	2	47	9592321
224	64	4 MAR 72	23	2	25	9628303
225	65	5 MAR 72	11	2	11	9664292
226	65	5 MAR 72	23	2	0	9700282
227	66	6 MAR 72	11	1	56	9736279
228	66	6 MAR 72	23	1	53	9772277
229	67	7 MAR 72	11	1	57	9808280
230	67	7 MAR 72	23	2	1	9844284
231	68	8 MAR 72	11	2	8	9880289

REVOLUTION	EVENT DAY	DATE	HOUR	MINUTE	SECOND	DAS TIME
232	68	8 MAR 72	23	2	14	9916295
233	69	9 MAR 72	11	2	20	9952300
234	69	9 MAR 72	23	2	23	9988303
235	70	10 MAR 72	11	2	25	10024304
236	70	10 MAR 72	23	2	21	10060302
237	71	11 MAR 72	11	2	13	10096295
238	71	11 MAR 72	23	2	1	10132285
239	72	12 MAR 72	11	1	41	10168268
240	72	12 MAR 72	23	1	17	10204248
241	73	13 MAR 72	11	0	44	10240221
242	73	13 MAR 72	23	0	7	10276190
243	74	14 MAR 72	10	59	23	10312153
244	74	14 MAR 72	22	58	34	10348113
246	75	15 MAR 72	22	56	41	10420019
247	76	16 MAR 72	10	55	38	10455967
248	76	16 MAR 72	22	54	32	10491912
259	82	22 MAR 72	10	43	7	10613827
260	82	22 MAR 72	22	42	28	10649794
261	83	23 MAR 72	10	41	55	10685767
262	83	23 MAR 72	22	41	27	10721744
270	87	27 MAR 72	22	40	48	11009712
276	157	5 JUN 72	21	23	26	11227610
416	160	8 JUN 72	21	18	10	11443347
423	164	12 JUN 72	9	16	9	11656145
437	171	19 JUN 72	9	14	51	12010179
445	175	23 JUN 72	9	7	14	12186047
451	178	26 JUN 72	9	0	36	12361565
459	182	30 JUN 72	8	55	37	12535415
479	192	10 JUL 72	8	51	44	12901273
668	286	12 OCT 72	19	11	20	13348239
676	290	16 OCT 72	19	6	7	13494477

APPENDIX B

REDUCED DATA RECORD (RDR) FORMAT

IRIS REDUCED DATA RECORD

TYPE 1 — Summary Record

Word No.	Content
1	Record Type Identification (1.0 = Summary)
2	Spacecraft Identification (always = 2.0)
3	Receiving Station Identification
4	Number of Calibrated Martian Spectra on this Tape
5	Apodization (0.0 = Unapodized, 1.0 = Apodized)
6	Phase Angle Correction Type (always = 1.0)
7	IFM Spike Peak Rejection Value (always = 0.02)
8-29	Spare (always = 0.0)
30	DAS Time of First Calibrated Martian Spectrum on this Tape
31	DAS Time of Last Calibrated Martian Spectrum on this Tape
32	Number of Warm-Cold Calibration Pairs Used to Calibrate the Martian Spectra
33-51	Spare (always 0.0)
52	Warm Blackbody Temperature ($\approx$ 296 K)
53	Cold Blackbody Temperature ($\approx$ 0.0 K)
54-95	Spare (always = 0.0)
96 (Note 1)	"A" Value of Wave Number Table Correction (always = 0.016087)
97 (Note 1)	"B" Value of Wave Number Table Correction (always = 0.0010602)
98	Observed Wave Number at First Mesh Point (ν_1^{obs} always = 199.92 cm^{-1})
99	Wave Number Mesh Increment (always = 1.176 cm^{-1})
100	Number of Words in Wave Number Table (always = 1500.0)
101-1600	Wave Number Table Corrected for Finite Field-of-View (ν_i^{corr} (cm^{-1}))

Note 1: $\nu_i^{obs} = 199.92 + (i - 1) * 1.176, i = 1, \ldots, 1500$

$$\nu_i^{corr} = (A + \nu_i^{obs})/(1.0 + B)$$

IRIS REDUCED DATA RECORD

TYPE 2 — Cold Reference Calibration Spectrum (Blackbody)

Word No.	Content
1	Record Type Identification (2.0 = Cold Blackbody)
2	Number of Cold Blackbody Spectra Used in Average Calculation
3-100	Spares (always = 0.0)
101-1600	Average Cold Reference Calibration Power Spectrum

IRIS REDUCED DATA RECORD

TYPE 3 — Warm Reference Calibration Spectrum (Blackbody)

Word No.	Contents
1	Record Type Identification (3.0 = Warm Blackbody)
2	Number of Warm Blackbody Spectra Used in Average Calculation
3-100	Spares (always = 0.0)
101-1600	Average Warm Reference Calibration Power Spectrum

IRIS REDUCED DATA RECORD

TYPE 4 — Average Normalized Responsivity

Word No.	Contents
1	Record Type Identification (4.0 = Responsivity)
2	Number of Calibration Warm-Cold Blackbody Pair Used in Responsivity Calculation
3-100	Spares (always = 0.0)
101-1600	Average Spectral Responsivity

IRIS REDUCED DATA RECORD

TYPE 5 — Noise Equivalent Radiance

Word No.	Contents
1	Record Type Identification (5.0 = NER)
2-100	Spares (always = 0.0)
101-1600	Noise Equivalent Radiance Spectrum ($W cm^{-2}$ sr^{-1} $/cm^{-1}$)

IRIS REDUCED DATA RECORD

TYPE 6 — Average Instrument Temperatures

Word No.	Contents
1	Record Type Identification (6.0 = Instrument Temperature)
2-100	Spares (always = 0.0)
101-1600	Average Instrument Temperatures Spectrum (K)

IRIS REDUCED DATA RECORD

TYPE 7 — Calibrated Martian Spectrum

Word No.	POGASIS Variable*	Contents
1		Record Type Identification (7.0 = Calibrated Martian Spectrum)
2	ON	Orbit Number (Range from 1.0 to 676.0)
3		Spectrum Number; the Sequence Number of the Spectrum on this Tape
4		Day } Earth Receipt Time (GMT)
5		Hour } Earth Receipt Time (GMT)
6		Minute } Earth Receipt Time (GMT)
7		Second } Earth Receipt Time (GMT)
8	LATP5	Latitude of the Center of the Viewed Area (+ = North Latitude, - = South Latitude)
9	LONP5	Longitude of the Center of the Viewed Area (0.0 to 360.0)
10		Spare (always = 0.0)
11		Bolometer Temperature (K); Average of the Readings Before and After Interferogram (IFM)
12		Bolometer Temperature Redundant Sensor (K)
13		Blackbody Temperature (K); Average of the Readings Before and After IFM
14		Blackbody Temperature Redundant Sensor (K)
15		Beamsplitter Temperature (K); Average of the Readings Before and After IFM
16		Michelson Mirror Drive Motor Temperature (K); Average of the Readings Before and After IFM
17		Temperature (K) of 45° Calibration Mirror: Average of the Readings Before and After IFM
18		Radiating Surface Temperature (K); Average of the Readings Before and After IFM

Word No.	POGASIS Variable*	Contents
19		Year — Measurement Time (GMT)
20		Day — Measurement Time (GMT)
21		Hour — Measurement Time (GMT)
22		Minute — Measurement Time (GMT)
23		Second — Measurement Time (GMT)
24	TFP	Time Before/After Periapsis (minutes; - = Before, + = After)
25-29		Spare (always = 0.0)
30		DAS Time
31	HSC	Spacecraft Altitude (kilometers)
32		Clock — Scan Platform Angles (degrees)
33		Cone — Scan Platform Angles (degrees)
34		Twist — Scan Platform Angles (degrees)
35		Scan Platform In-Motion Flag (1.0 = yes, 0.0 = no)
36	TA	Spacecraft True Anomaly (degrees)
37	VT	Spacecraft Tangential Velocity (km/sec)
38	RT	Spacecraft Radial Velocity (km/sec)
39		Telemetry Received Flag (always = 1.0. . .yes)
40	LA5	Solar Lighting — Angles at Center of the Field-of-View (degrees)
41	PHA5	Phase — Angles at Center of the Field-of-View (degrees)
42	VA5	Viewing — Angles at Center of the Field-of-View (degrees)
43	SRP5	Slant Range to the Center of the Field-of-View (kilometers)
44-53	LATQ	Ten Latitude Points Defining the Field-of-View
54-63	LONQ	Ten Corresponding Longitude Points Defining the Field-of-View
64	PST5	Angle at Spacecraft Between LOS and Center of Mars (degrees)

Word No.	POGASIS Variable*	Contents
65	ASDT	Angular Semi-Diameter of Mars (degrees)
66	TPCA	Cone Angle of Center of Mars (degrees)
67	TPKA	Clock Angle of Center of Mars (degrees)
68	RMAG	Range to Center of Mars (kilometers)
69	MCA1	Cone } Phobos Angles (degrees)
70	MKA1	Clock } Phobos Angles (degrees)
71	SMN1	Distance to Phobos (kilometers)
72	MCA2	Cone } Deimos Angles (degrees)
73	MKA2	Clock } Deimos Angles (degrees)
74	SMN2	Distance to Deimos (kilometers)
75	ZLAT	Sub-Solar Point Latitude (degrees)
76	ZLON	Sub-Solar Point Longitude (degrees)
77	MHA	Mars Local Time (hours)
78		Scan Enabled Flag
79-81		Spare (always = 0.0)
82	PIVILT	Percent of Target Illumination
83		Subspacecraft Latitude (degrees)
84		Subspacecraft Longitude (degrees)
85	LTO	Evening Terminator Longitude at Equator (degrees)
86	LTP45	Evening Terminator Longitude at 45N (degrees)
87	LTM45	Evening Terminator Longitude at 45S (degrees)
88	PSL5	Angle Between LOS and Nearest Limb of Mars (degrees)
89-90		Latitude and longitude, respectively, of the center of the viewed area with respect to pre-Mariner 9 Mars pole direction and prime meridian (Icarus, 3, 236, (1964))
91		Proportion of Field-of-View Filled by Mars

Word No.	POGASIS Variable*	Contents
92		Paint Emissivity Correction Applied to Data (always = 1.0 . . . yes)
93		Navigation Data Estimated (1.0 = yes, 0.0 = no)
94-95		Spare (always = 0.0)
96		"A" Part of Wave Number Correction (See Type 1 Summary Record)
97		"B" Part of Wave Number Correction (See Type 1 Summary Record)
98		Observed Wave Number at First Mesh Point (See Type 1 Summary Record)
99		Wave Number Mesh Increment (See Type 1 Summary Record)
100		Number of Data Points (always = 1500.0)
101-1600		Specific Intensity ($W cm^{-2}$ sr^{-1} $/cm^{-1}$)

*The POGASIS variable is the name of the program variable used to calculate the data by the Jet Propulsion Laboratory (JPL). Questions concerning the methods of their calculation should be addressed to JPL.

APPENDIX C

SUPPLEMENTARY EXPERIMENTER DATA RECORD (SEDR) FORMAT

APPENDIX C

This Appendix describes the content of the SEDR information provided by JPL. An asterisk (*) preceding the field number indicates that the field was merged into the header of the IRIS RDR.

RECORD LENGTH = 424 BYTES

TAPE CHARACTER CODE EXTENDED BINARY CODED DECIMAL INTERCHANGE CODE (EBCDIC)

C = CHARACTER STRING F = BINARY (FIXED POINT)

FIELD NO.	FIELD LENGTH	CONTENT	DATA TYPE	DECIMALS	NOTES
1	6	MEASUREMENT ID	C	-	SCISIM VARIABLE, ALPHA NUMERIC
2	2	INSTRUMENT NO.	F	0	SCISIM VARIABLE
*3	2	MEASUREMENT TIME, YEAR	F	0	
*4	2	MEASUREMENT TIME, DAY OF YEAR	F	0	
*5	2	MEASUREMENT TIME, HOUR OF DAY	F	0	
*6	2	MEASUREMENT TIME, MINUTE OF HOUR	F	0	
*7	2	MEASUREMENT TIME, SECOND OF MINUTE	F	0	
8	2	MEASUREMENT TIME, MILLISECONDS	F	0	
9	4	DAS TIME	F	0	
*10	2	EARTH RECEIVED TIME, YEAR	F	0	ERT FROM TELEMETRY, GMT
*11	2	ERT, DAY	F	0	
*12	2	ERT, HOUR	F	0	
*13	2	ERT, MINUTE	F	0	
*14	2	ERT, SECOND	F	0	
15	2	ERT, MILLISECOND	F	0	

FIELD NO.	FIELD LENGTH	CONTENT	DATA TYPE	DECIMALS	NOTES
*16	4	TIME BEFORE PERIAPSIS, SECONDS	F	0	POGASIS VARIABLE TFP
17	4	SPACECRAFT ID,	C	-	ALPHA NUMERIC
18	2	SAS SERIAL NO.	F	0	
*19	2	ORBIT NO.	F	0	POGASIS VARIABLE ON
20	6	ORBIT SOLUTION NO.	C	-	POGASIS VARIABLE ODSN, ALPHA NUMERIC
21	2	DATE OF SOLUTION, YEAR	F	0	DATE OF ORBIT SOLUTION
22	2	DATE OF SOLUTION, MONTH OF YEAR	F	0	
23	2	DATE OF SOLUTION, DAY OF MONTH	F	0	
24	2	DATE OF SOLUTION, HOUR OF DAY	F	0	
25	2	DATE OF SOLUTION, MINUTE OF HOUR	F	0	
26	4	DATE OF SOLUTION, SECOND OF MINUTE	F	0	
27	12	MDR REEL NO.	C	-	ALPHA NUMERIC
28	12	EDR REEL NO.	C	-	ALPHA NUMERIC
*29	4	SPACECRAFT ALTITUDE, KM	F	0	POGASIS VARIABLE HSC
*30	4	SCAN PLATFORM CLOCK ANGLE	F	2	
*31	4	SCAN PLATFORM CONE ANGLE	F	2	
*32	4	SCAN PLATFORM TWIST ANGLE	F	2	
*33	4	SCAN PLATFORM IN MOTION FLAG	F	0	

FIELD NO.	FIELD LENGTH	CONTENT	DATA TYPE	DECI-MALS	NOTES
*34	4	SPACECRAFT TRUE ANOMALLY, DEG	F	2	POGASIS VARIABLE TA
*35	2	SPACECRAFT TAN-GENTIAL VELOCITY, KM/SEC	F	1	POGASIS VARIABLE VT
*36	2	SPACECRAFT RADIAL VELOCITY, KM/SEC	F	1	POGASIS VARIABLE VR
*37	4	TELEMETRY RE-CEIVED FLAG	F	0	
*38	4	SOLAR LIGHTING ANGLE FOR RETICLE 5	F	2	POGASIS VARIABLE LA5
*39	4	PHASE ANGLE FOR RETICLE 5	F	2	POGASIS VARIABLE PHA5
*40	4	VIEWING ANGLE FOR RETICLE 5	F	2	POGASIS VARIABLE VA5
*41	4	LATITUDE OF RETICLE 5	F	2	POGASIS VARIABLE LATP5
*42	4	LONGITUDE OF RETICLE 5	F	2	POGASIS VARIABLE LONP5
*43	4	SLANT RANGE TO RETICLE 5, KM	F	0	POGASIS VARIABLE SRP5
*44	4	LATITUDE OF POINT Q(1)	F	2	POGASIS VARIABLE LATQ(1)
45	4	LATQ(2)	F	2	
*46	4	LATQ(3)	F	2	
47	4	LATQ(4)	F	2	
*48	4	LATQ(5)	F	2	
49	4	LATQ(6)	F	2	
*50	4	LATQ(7)	F	2	
51	4	LATQ(8)	F	2	
*52	4	LATQ(9)	F	2	

FIELD NO.	FIELD LENGTH	CONTENT	DATA TYPE	DECI-MALS	NOTES
53	4	LATQ(10)	F	2	
*54	4	LATQ(11)	F	2	
55	4	LATQ(12)	F	2	
*56	4	LATQ(13)	F	2	
57	4	LATQ(14)	F	2	
*58	4	LATQ(15)	F	2	
59	4	LATQ(16)	F	2	
*60	4	LATQ(17)	F	2	
61	4	LATQ(18)	F	2	
*62	4	LATQ(19)	F	2	
63	4	LATQ(20)	F	2	
*64	4	LONGITUDE OF POINT Q(1)	F	2	POGASIS VARIABLE LONQ(1)
65	4	LONQ(2)	F	2	
*66	4	LONQ(3)	F	2	
67	4	LONQ(4)	F	2	
*68	4	LONQ(5)	F	2	
69	4	LONQ(6)	F	2	
*70	4	LONQ(7)	F	2	
71	4	LONQ(8)	F	2	
*72	4	LONQ(9)	F	2	
73	4	LONQ(10)	F	2	
*74	4	LONQ(11)	F	2	
75	4	LONQ(12)	F	2	
*76	4	LONQ(13)	F	2	
77	4	LONQ(14)	F	2	
*78	4	LONQ(15)	F	2	
79	4	LONQ(16)	F	2	

FIELD NO.	FIELD LENGTH	CONTENT	DATA TYPE	DECI-MALS	NOTES
*80	4	LONQ(17)	F	2	
81	4	LONQ(18)	F	2	
*82	4	LONQ(19)	F	2	
83	4	LONQ(20)	F	2	
*84	4	ANGLE AT SPACE-CRAFT BETWEEN LOS AND CENTER OF MARS	F	2	POGASIS VARIABLE PST 5
*85	4	ANGULAR SEMIDIA-METER OF MARS	F	2	POGASIS VARIABLE ASDT
*86	4	CONE ANGLE OF CENTER OF MARS	F	2	POGASIS VARIABLE TPCA
*87	4	CLOCK ANGLE OF CENTER OF MARS	F	2	POGASIS VARIABLE TPKA
*88	4	RANGE TO CENTER OF MARS, KM	F	0	POGASIS VARIABLE RMAG
*89	4	CONE ANGLE OF PHOBOS	F	2	POGASIS VARIABLE MCA1
*90	4	CLOCK ANGLE OF PHOBOS	F	2	POGASIS VARIABLE MKA1
*91	4	RANGE TO PHOBOS, KM	F	2	POGASIS VARIABLE SMN1
*92	4	CONE ANGLE OF DEIMOS	F	2	POGASIS VARIABLE MCA2
*93	4	CLOCK ANGLE OF DEIMOS	F	2	POGASIS VARIABLE MKA2
*94	4	RANGE TO DEIMOS, KM	F	2	POGASIS VARIABLE SMN2
*95	4	LATITUDE OF SUB-SOLAR POINT	F	2	POGASIS VARIABLE ZLAT
*96	4	LONGITUDE OF SUB-SOLAR POINT	F	2	POGASIS VARIABLE ZLON
*97	4	MARS LOCAL TIME (HOUR ANGLE FROM SUBSOLAR POINT), HRS	F	2	POGASIS VARIABLE MHA

FIELD NO.	FIELD LENGTH	CONTENT	DATA TYPE	DECI-MALS	NOTES
98	2	IMCC POSITION	F	0	FROM TELEMETRY
*99	2	SCAN ENABLED FLAG	F	0	FROM TELEMETRY
100	2	BLACKBODY TEMPER-ATURE, DN	F	0	FROM TELEMETRY
101	2	DETECTOR TEMPER-ATURE, DN	F	0	FROM TELEMETRY
102	2	RADIATING SURFACE TEMPERATURE, DN	F	0	FROM TELEMETRY
*103	2	PERCENT OF TARGET PLANET IN VIEW WHICH IS ILLUMINATED	F	0	POGASIS VARIABLE PIVILT
*104	4	LATITUDE OF SUB-SPACECRAFT POINT	F	2	POGASIS VARIABLE
*105	4	LONGITUDE OF SUB-SPACECRAFT POINT	F	2	POGASIS VARIABLE
*106	4	LONGITUDE OF TER-MINATOR AT 0 DEG LATITUDE	F	2	POGASIS VARIABLE LTO
*107	4	LONGITUDE OF TER-MINATOR AT +45 DEG LATITUDE	F	2	POGASIS VARIABLE LTP45
*108	4	LONGITUDE OF TER-MINATOR AT -45 DEG LATITUDE	F	2	POGASIS VARIABLE LTM45
*109	4	ANGLE BETWEEN LOS AND PLANETS NEAR-EST LIMB, NEGATIVE FOR INTERCEPTING PATHS	F	2	POGASIS VARIABLE PSL5
110	2	MARTIAN DATE (EQUI-VALENT EARTH DATE), MONTH	F	0	POGASIS VARIABLE
111	2	MARTIAN DATE, DAY	F	0	POGASIS VARIABLE
112	2	RESERVED AREA FOR ANNOTATION	C	-	