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Offshore transport and diffusion in the Los Angeles Bight - 2 NPS data summary

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

OFFSHORE TRANSPORT AND DIFFUSION IN THE LOS ANGELES BIGHT - II, NPS DATA SUMMARY

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The second in a series of tracer measurements of overwater transport and diffusion has been completed. This report includes the meteorological data obtained aboard the RV/Acania. Analyses of radiosonde data to yield mixed layer parameters for mixed layer assessment is also included.

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I. Introduction

During January of 1981 the Environmental Physics Group of the Naval Postgraduate School (NPS) and Aerovironment, Inc. conducted the second of two transport and dispersion experiments in the Santa Barbara Channel area of the California coast. The purpose of these operations was to perform offshore tracer experiments in order to parameterize dispersion models that are in current use and to build a data base for future model development. The purpose of this and the previous data report is to present the pertinent meteorological and source data for use by those who will be involved in the modeling effort. In the previous report only the basic data, reduced to engineering units, was presented. This report presents the second operations data in the same format and, in addition, includes mixed layer parameters for both operations. Application of these results to the models will be the subject of a future joint report by Aerovironment and NPS. A great deal of the discussion of the data in this report is the same as the first report and is included for the sake of completeness.

Although the data gathered in this experiment has much wider application, it was collected for the specific purpose of parameterizing models that will be used to assess the onshore impact of offshore oil exploration and production sites. Such impact currently has great importance since many coastal areas are near the legal air pollution limit and any significant additional loading could push them over the limit. Air pollution models in current use have not been adequately validated for the overwater regime. The results of this study should remedy the inadequacy of the models.

During the tracer experiments SF_6 gas was released from the ship RV/Acania and tracked by an aircraft, a small boat, and one mobile and fixed stations on shore. Meteorological data was gathered on the ship and on the shore. This report contains shipboard meteorological data and gas source strength. Shore meteorological data and tracer results can be found in a report by Aerovironment.

II. Ship Operation Scenario

Since the impact of offshore sources on the shore is the purpose of these investigations the experiments must be performed during periods of onshore winds. These winds must be of a fairly long duration since it takes a minimum of 6 hours to gather enough data during any one experiment. The preliminary decision to release the tracer gas on any given day must be made on the previous day due to the time needed to prepare all of the sampling sites. Thus, the following schedule was used.

All Days

1. 0800-1200-2000: radio shipboard meteorological data to shore.
2. 1000: Shore obtains weather forecast from Point Mugu.
3. 1200: shore command center makes a go/no-go decision for a release on the following day.

Release Day

4. 0700: begin hourly wind reports to shore.
5. 1000: decision on release made by ship-shore communication, final decision made on shore.
6. Final positioning of ship.
7. 1100: start tracer gas release.
8. 1800: end tracer gas release and hourly wind reports.

Due to the variability of the wind during the period it was normally not possible to start the release by 1100.

Because of difficulty in moving the shore stations, targeting of the plume was accomplished by moving the ship. This had to be done before the release was begun because moving the ship would introduce wander into the plume trajectory and contaminate the results. In order to hold the ship stationary to the degree needed it was anchored during a release.

Significant Events:

At times, the ship was peforming tasks not directly associated with this study or was in port. As an aid in interpreting the data we list times of "significant shipboard events" in Table 1.

1/5	0940	Underway from Monterey
1/6	1250	Arrive off Ventura
1/9	1820	Underway for Port Hueneme
	1955	Dock
1/13	0500	Underway
	0610	Arrive at operation area
1/15	1723	Underway for Port Hueneme, operation completed

Table 1 - Significant Shipboard Events

III. Shipboard Equipment

We give here a brief description of the meteorological measurements that were made on the ship. Details of the equipment and calibration procedures can be found in a previous report. Two meteorological stations at heights of 7 m and 20.5 m above mean sea level were used. At each level the following parameters were measured:

relative wind speed

relative wind direction (upper level only)

air temperature

dew point

wind speed fluctuation

The following parameters were also measured:

sea surface temperature

ship roll

ship location

inversion height

temperature and humidity profiles to 5,000 ft.

sky cloud cover

The temperature and humidity profiles were obtained by shipboard radiosonde launch and were taken every 12 hours. The temperature inversion height was determined by an acoustic sounder which gave a continuous strip chart record. Most data listed above was averaged for one half hour intervals. The exceptions were relative wind direction and ships roll. For both, 10 sec averages were obtained and recorded for the full period of a gas release.

IV. Tracer Release Data

Four separate experiments were performed. For each the gas was released through the exhaust of one of the ship's motor generator sets. The exhaust is inclined at an angle of 45° above the horizontal. The motor is a 2 cycle diesel so exhaust flow rate is obtained by multiplying 2/3 times the displacement times the revolutions per minute. The pertinent exhaust outlet data to characterize plum rise are:

rpm	displacement (Cu in)	Stack Temp. (°F)	Flow Rate (cu in/sec)	Diameter (in)
1500	426	250	7.13×10^3	4.5

Table 2. Characteristics of exhaust used during tracer gas releases.

For a release, 4 tanks of SF_6 were connected to a single manifold. The manifold has a pressure gauge and two rotometers, one supplied by the manufacturer and one calibrated and supplied by Aerovironment. The second meter was used to set the flow rate the first to monitor it since it was less subject to fluctuations. The gas pressure to the rotometers was maintained at 25 lbs/in·

Using the data found in Table 4 the flow rates for the four releases were

Release 1	48.35	lbs/hr
Release 2	48.06	lbs/hr
Release 3	44.45	lbs/hr
Release 4	46.21	lbs/hr

During the releases the ship was anchored approximately 5 Nmi SWW of Ventura. As stated above the releases started at approximately 1100 and ended at approximately 1800. The exact times and locations are given in Table 3.

Release	Date	Latitude	Longitude	Start Time	End Time
1	1/6	34°15.0'N	119°20.0'W	1322	1800
2	1/9	34°14.4'N	119°20.3'W	1123	1800
3	1/13	34°14.4'N	119°20.3'W	1134	1702
4	1/15	34°11.4'N	119°19.4'W	1406	1700

Table 3. Exact locations and start and end times for each release. Times are local, Pacific Daylight Time.

Bottle Number	Initial Weight (lbs)	Release 1	Release 2	Weight after Release 3	Release 4
8	252				186
9	256				188
10	259	148			
11	252	139			
12	251		140		
13	254		142		
14	252		157		
15	260			185	
16	278			185	
17	250			175	
Total Weight		224	318	243	134
Total Release Time		4:38	6:37	5:28	2:54

Table 4. SF_6 bottle weights before and after the four releases. The total times for each release and the total weights of SF_6 used are also given.

V. Wind Histories

Hourly average wind histories taken aboard the RV/Acania are shown in Figures 1. The winds were recorded at least every hour and every half hour immediately before and during each release. These visual presentations were kept up to date on the ship and aided in the go/no-go decisions on release days.

If one compares these histories with those for the first operation during September 1980, it is immediately apparent that the wind was much less predictable during January. During the fall a well established land-sea breeze cycle existed. During the winter the sea breeze during the afternoon was not at all reliable in magnitude nor direction and, on some days, never became established at all.

Figure 1a

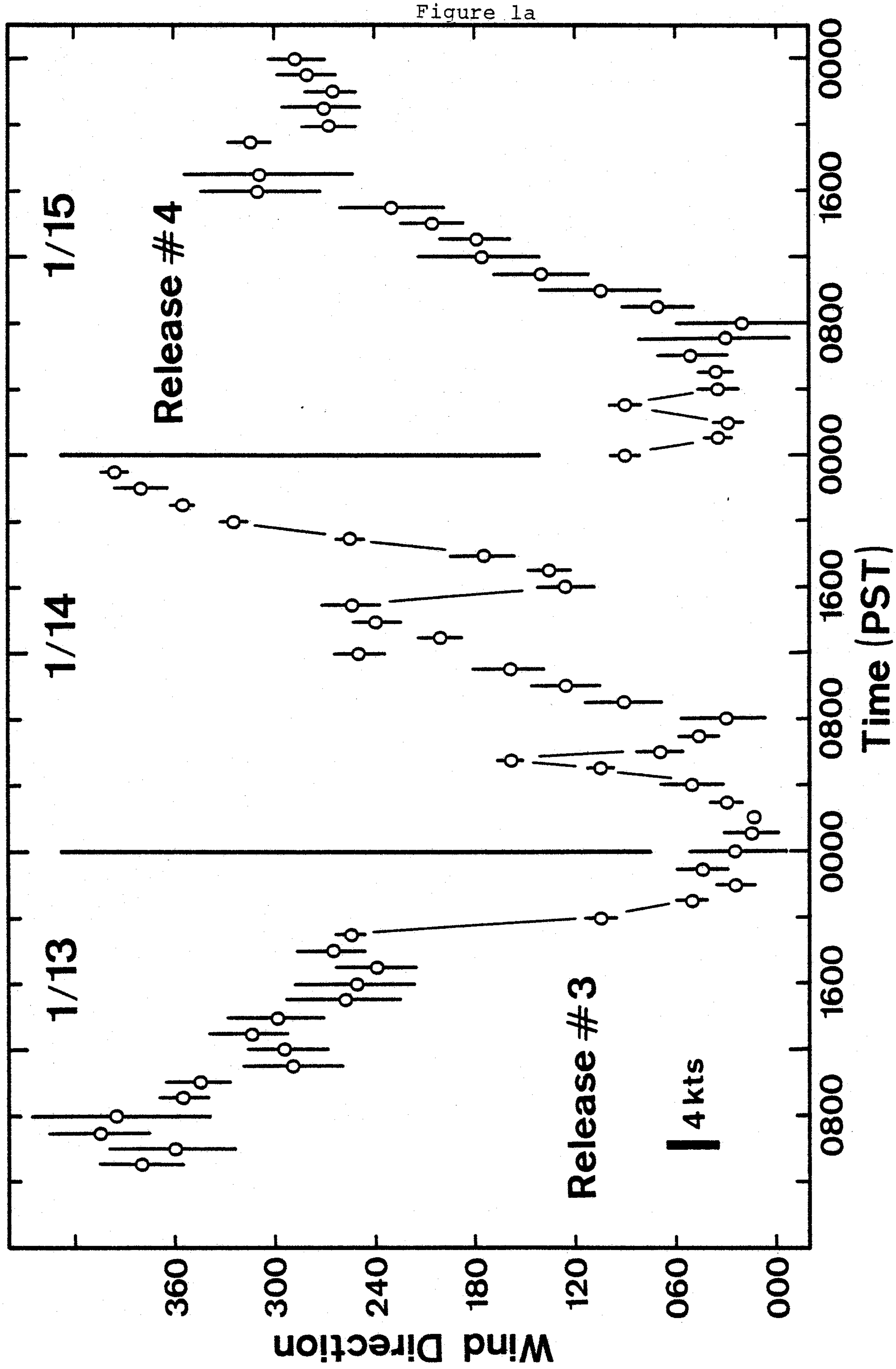

1/13
1/14
1/15
Release # 3
Release # 4
4 kts
Time (PST)
Wind Direction
000
060
120
180
240
300
360
0800
1600
0000

Figure 1b

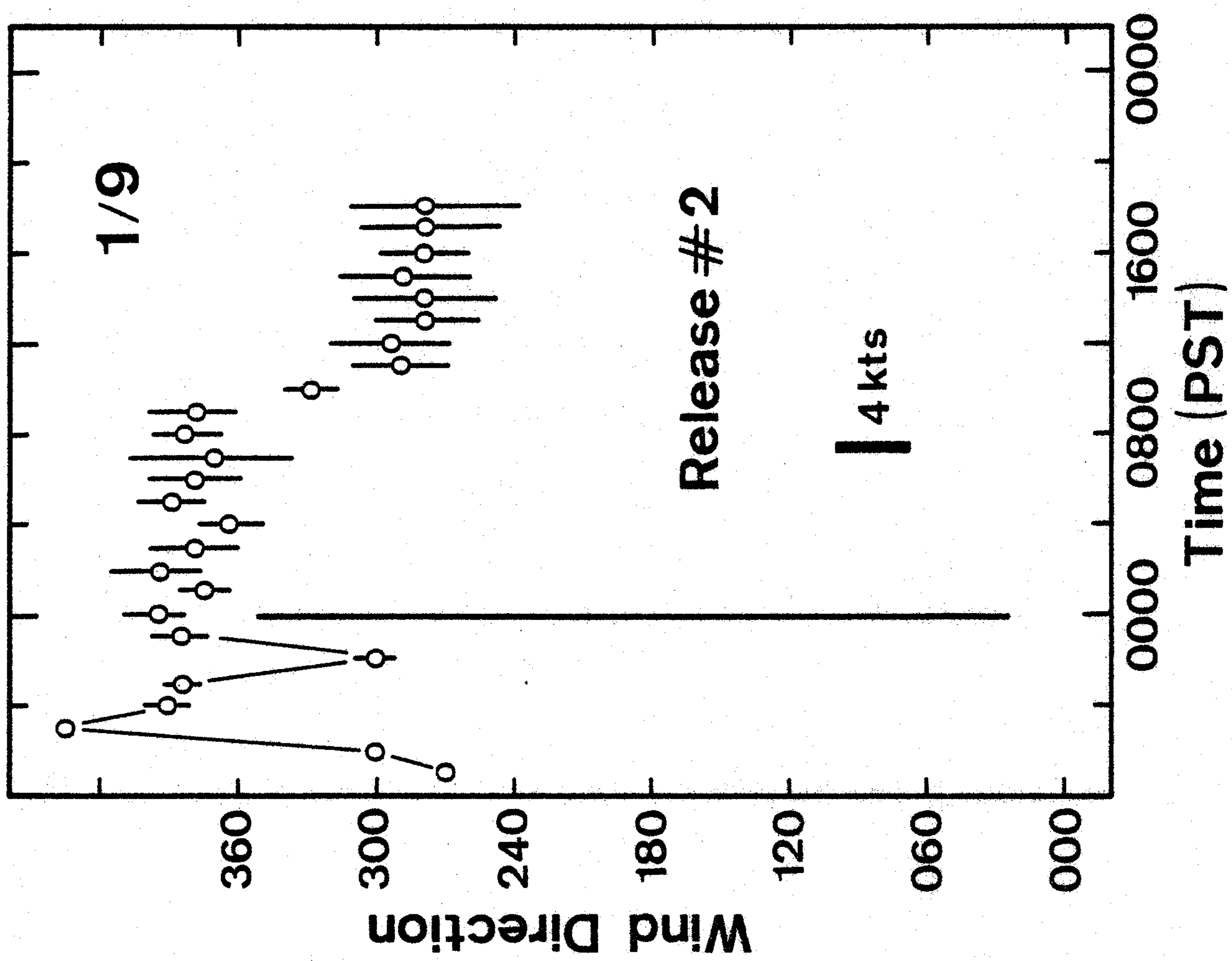
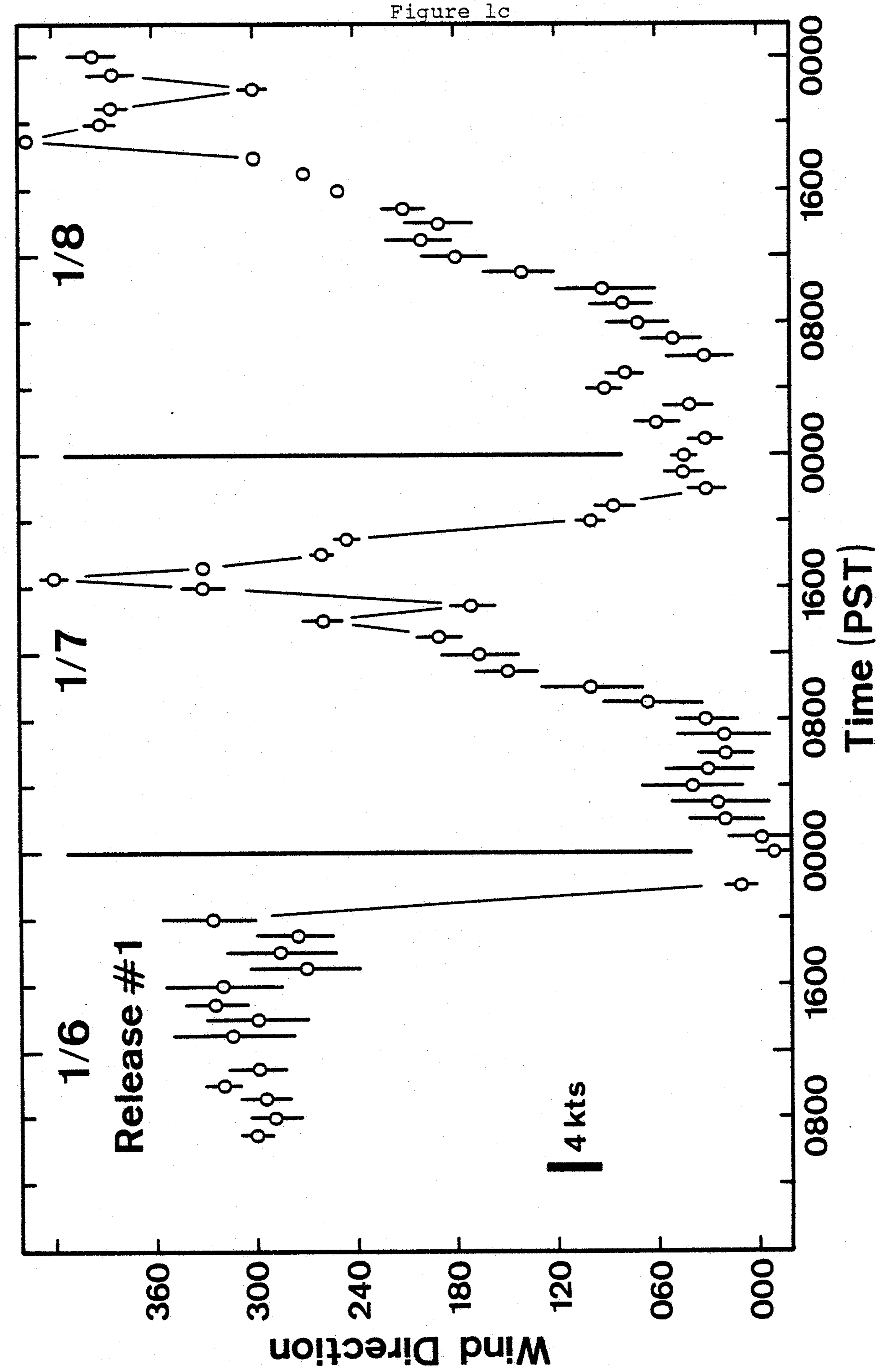

1/9
Release #2
4 kts
Time (PST)
Wind Direction
0000
1600
0800
0000
360
300
240
180
120
060
000

Figure 1c



1/6
1/7
1/8
Release #1
4 kts
Wind Direction
360
300
240
180
120
060
000
0800
1600
0000
0800
1600
0000
0800
1600
0000
Time (PST)

VI. Radiosonde Results

Radiosondes were released from the ship twice in each 24-hour period, generally at 0700 and 1900 PDT. Releases were made and interpreted by a Navy radiosonde team. Temperature and humidity were determined at standard levels and significant points. Since we are interested in the detailed structure of the boundary layer such a treatment is too coarse. Thus, the original strip chart output and the met team determined calibration points were used to construct fine scale graphs, which are presented in Figures 2.

There are two apparent sources of error in these radiosonde results. The lowest height reading, which is obtained at the ship, is subject to ships influence and should not be used. Thus, it is not possible to use the radiosonde to determine properties of the surface layer. The radiosonde humidity system was not capable of measuring a relative humidity below 20%. This is especially apparent in Figure 2i.

Figure 2a

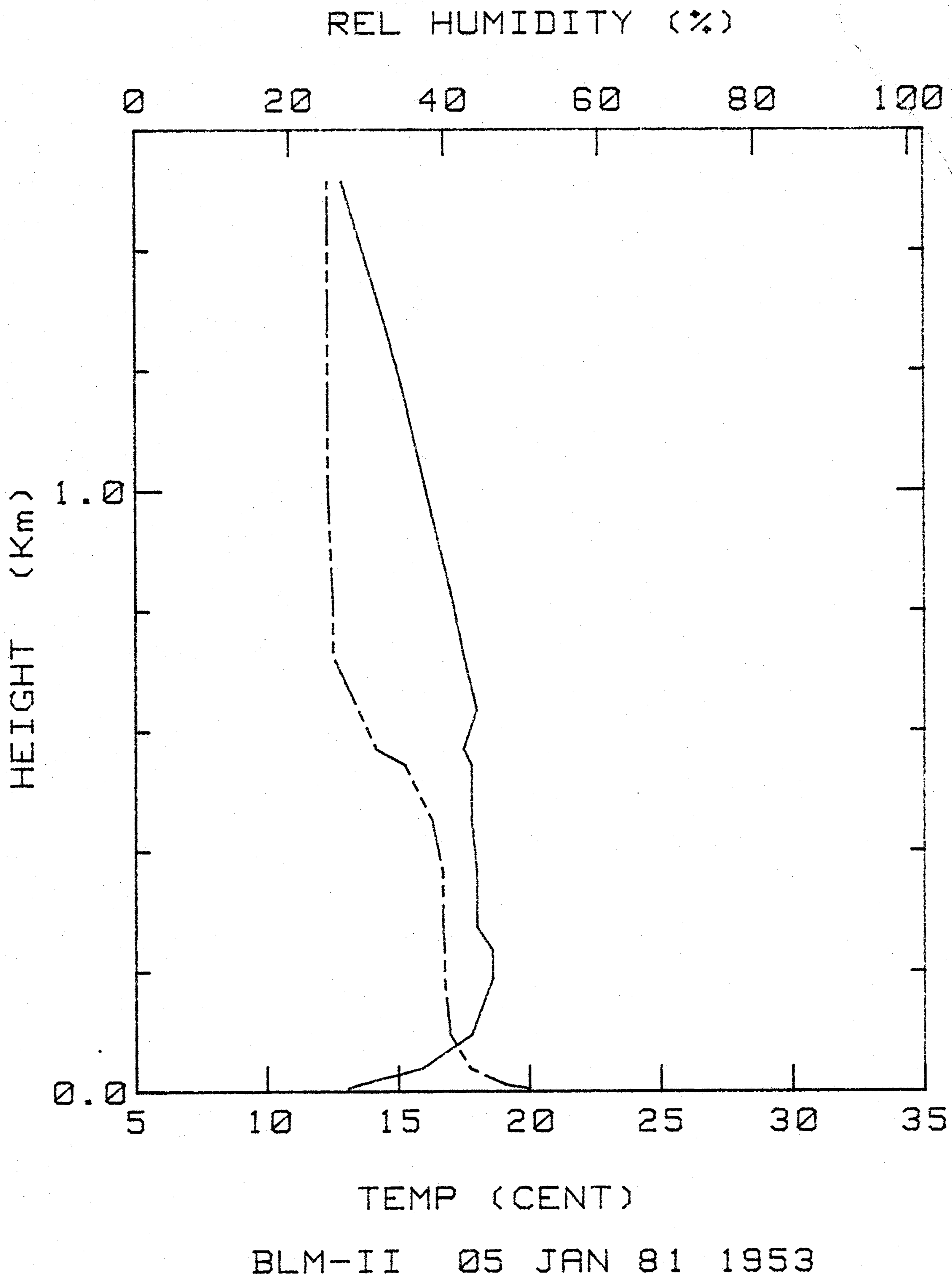

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 05 JAN 81 1953

Figure 2b

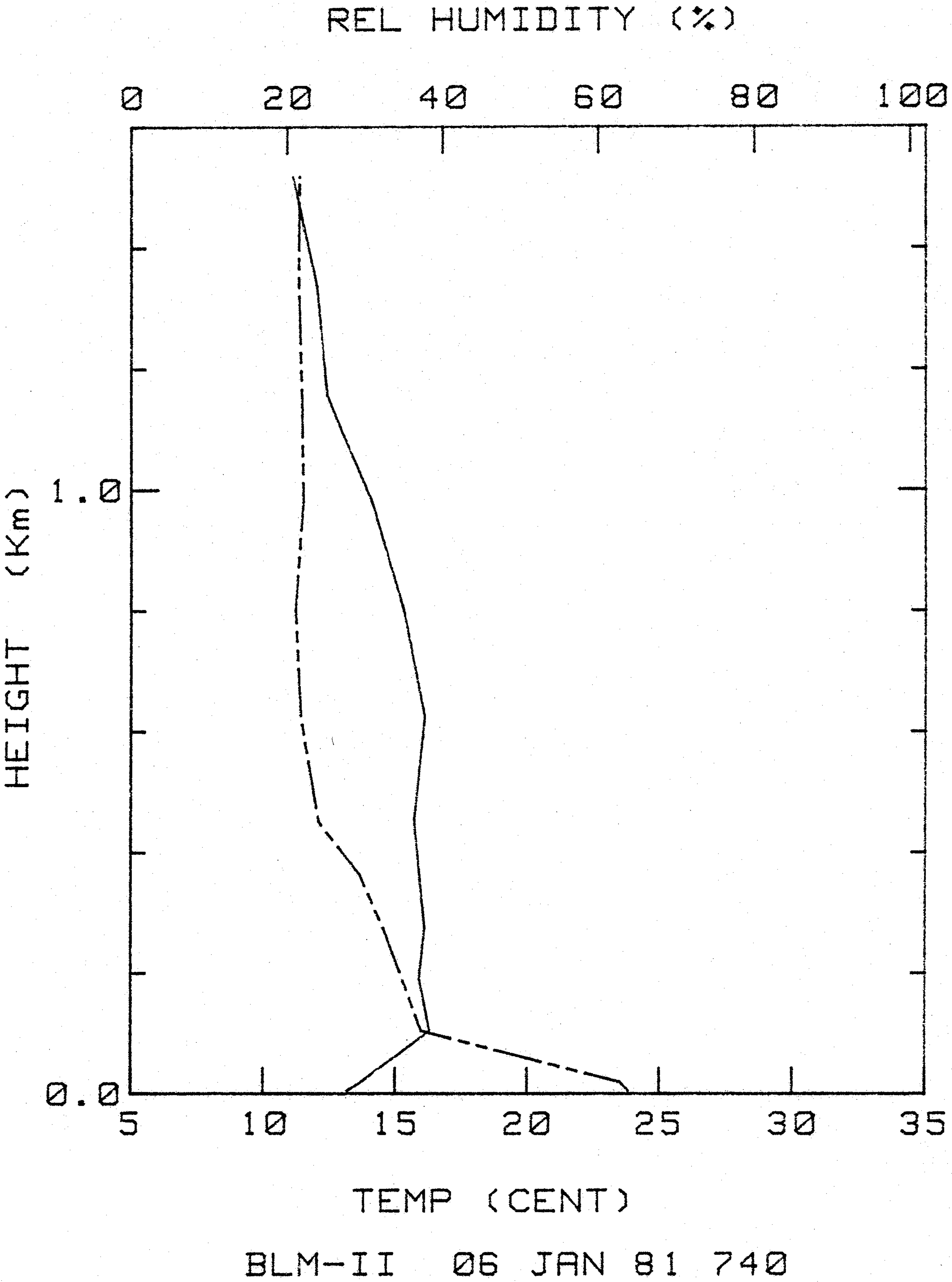

REL HUMIDITY (%)
0 20 40 60 80 100
HEIGHT (Km)
1.0
0.0
5 10 15 20 25 30 35
TEMP (CENT)
BLM-II 06 JAN 81 740

Figure 2c

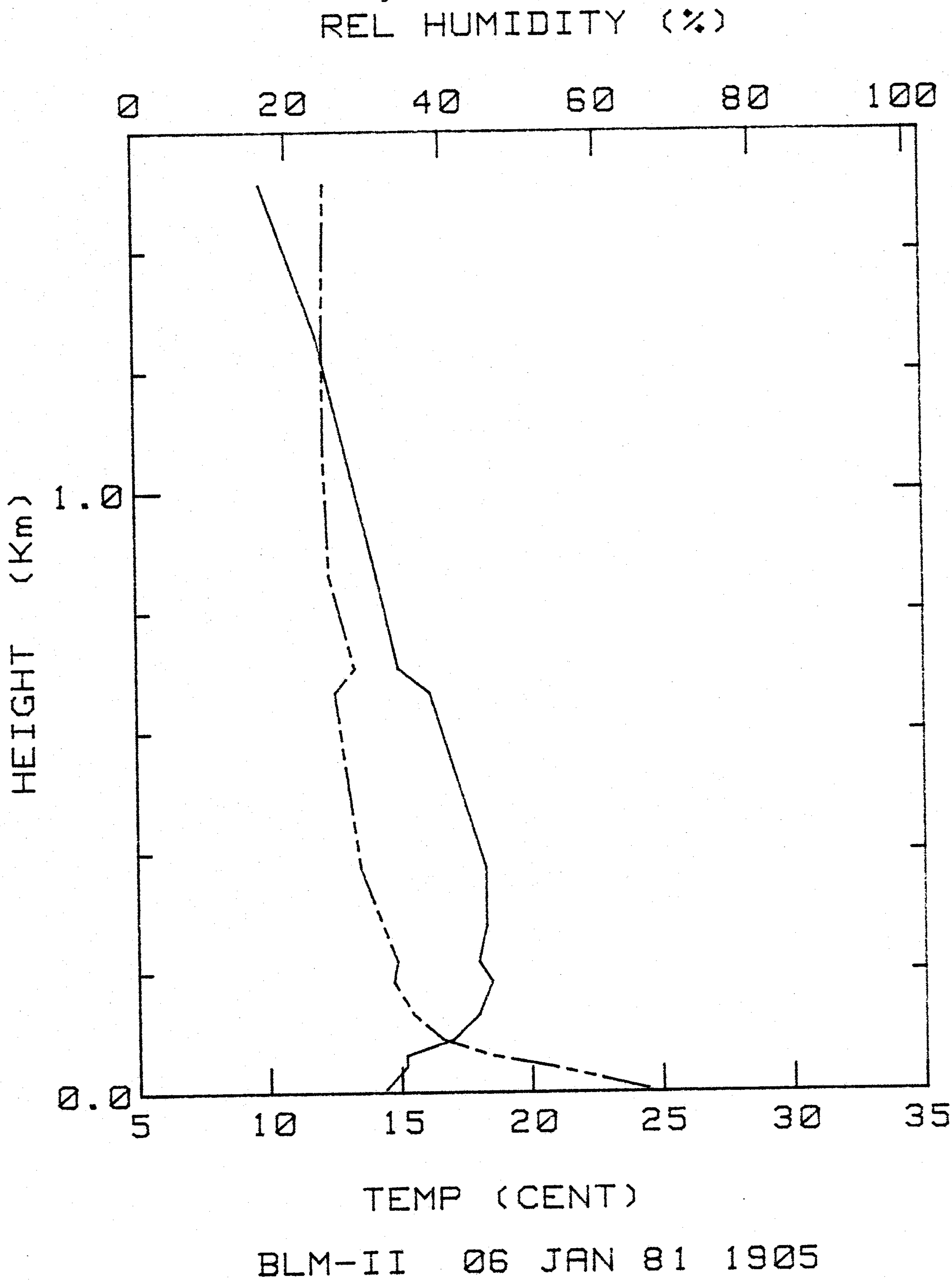

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 06 JAN 81 1905

Figure 2d

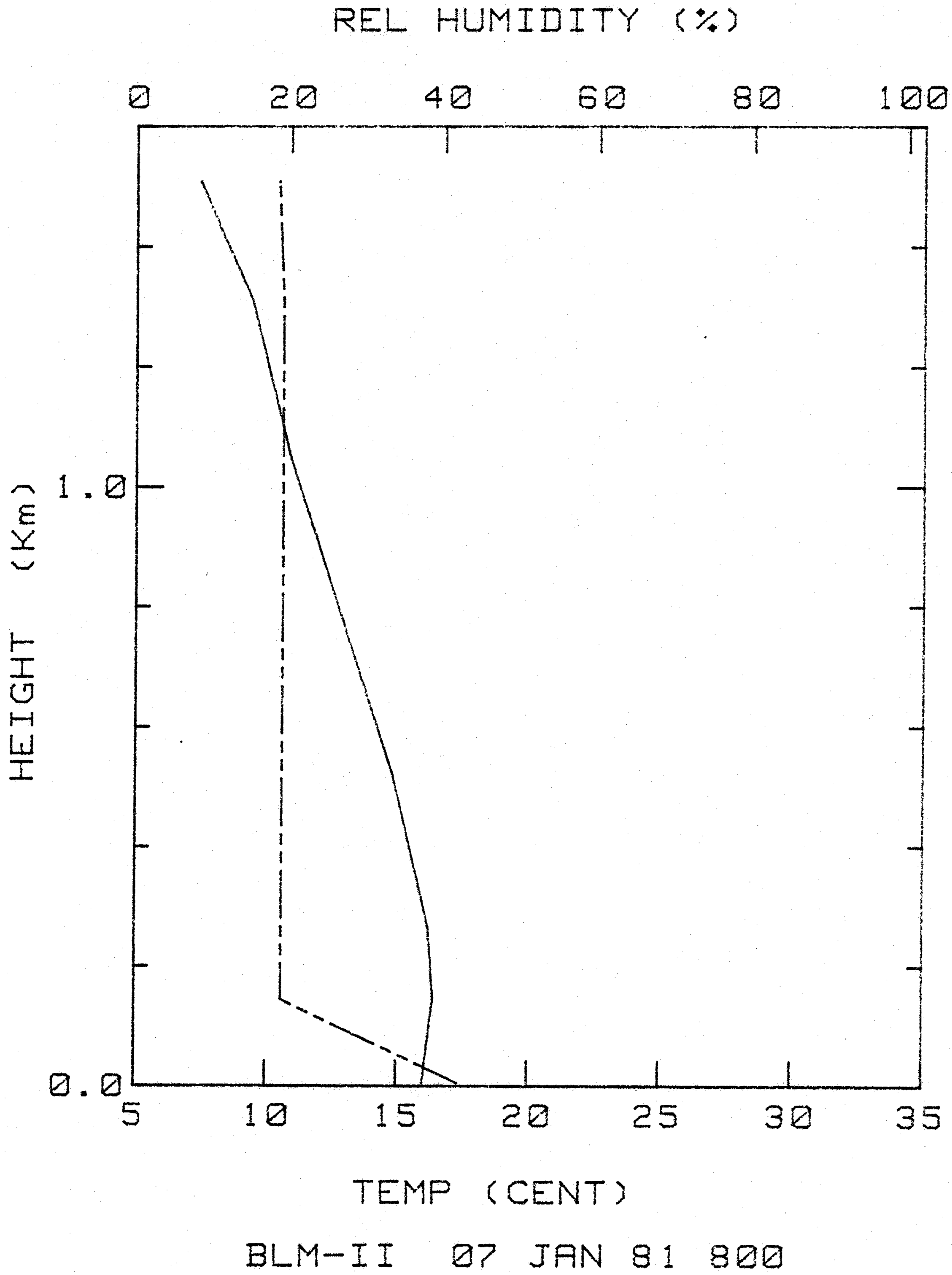
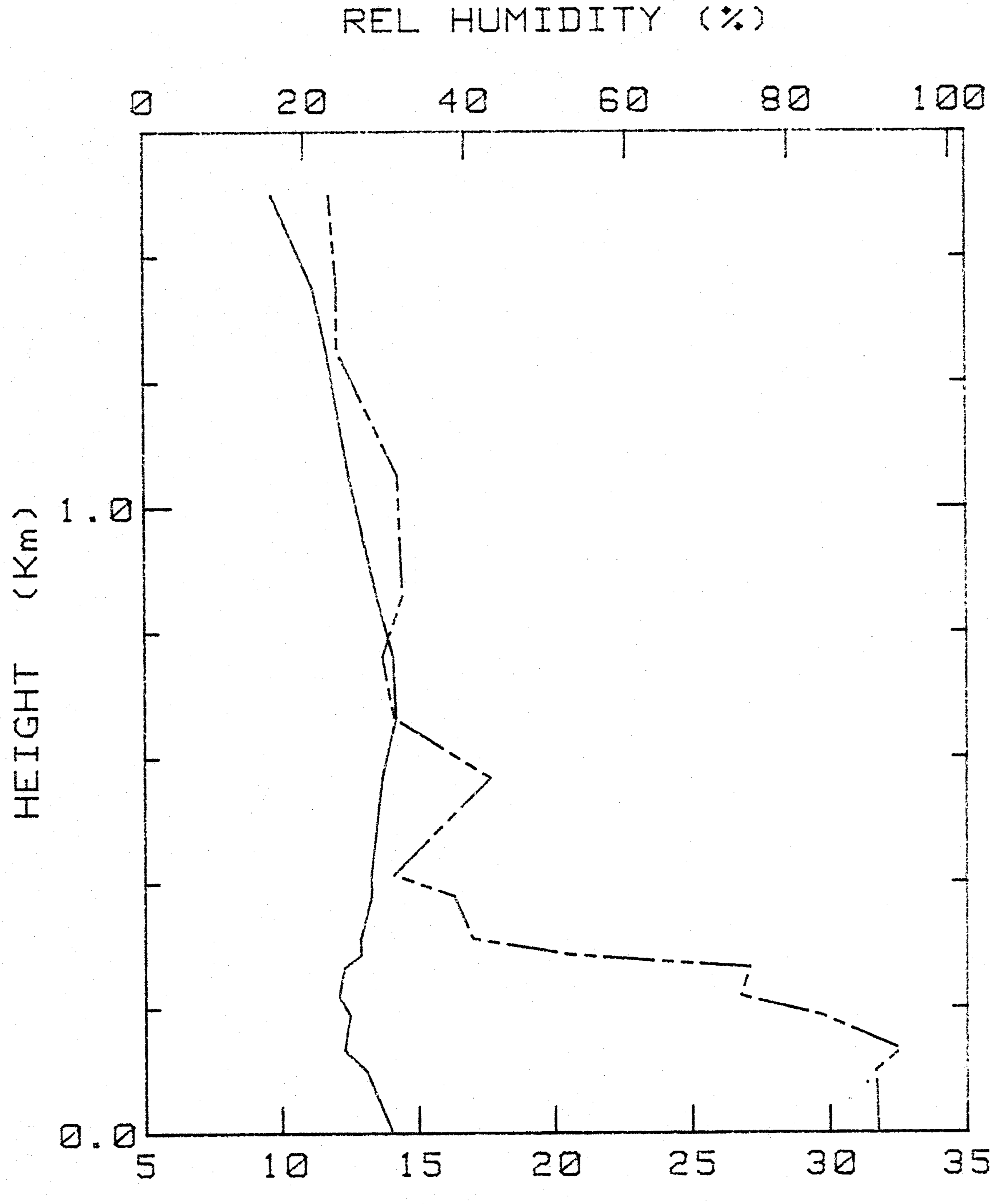

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 07 JAN 81 800

Figure 2e



BLM-II 07 JAN 81 1850

Figure 2f

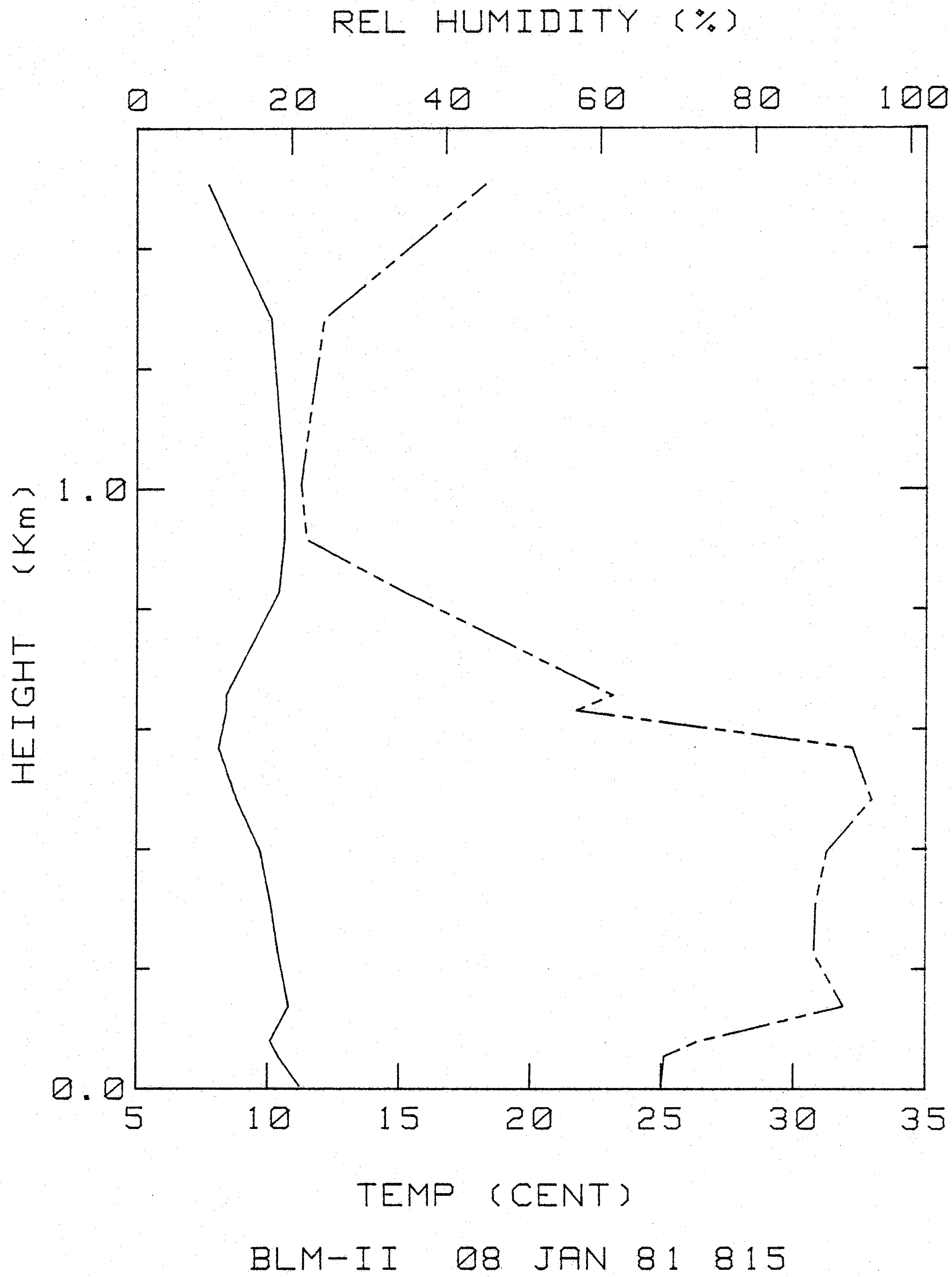

REL HUMIDITY (%)
0
20
40
60
80
100
1.0
0.0
HEIGHT (Km)
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 08 JAN 81 815

Figure 2g

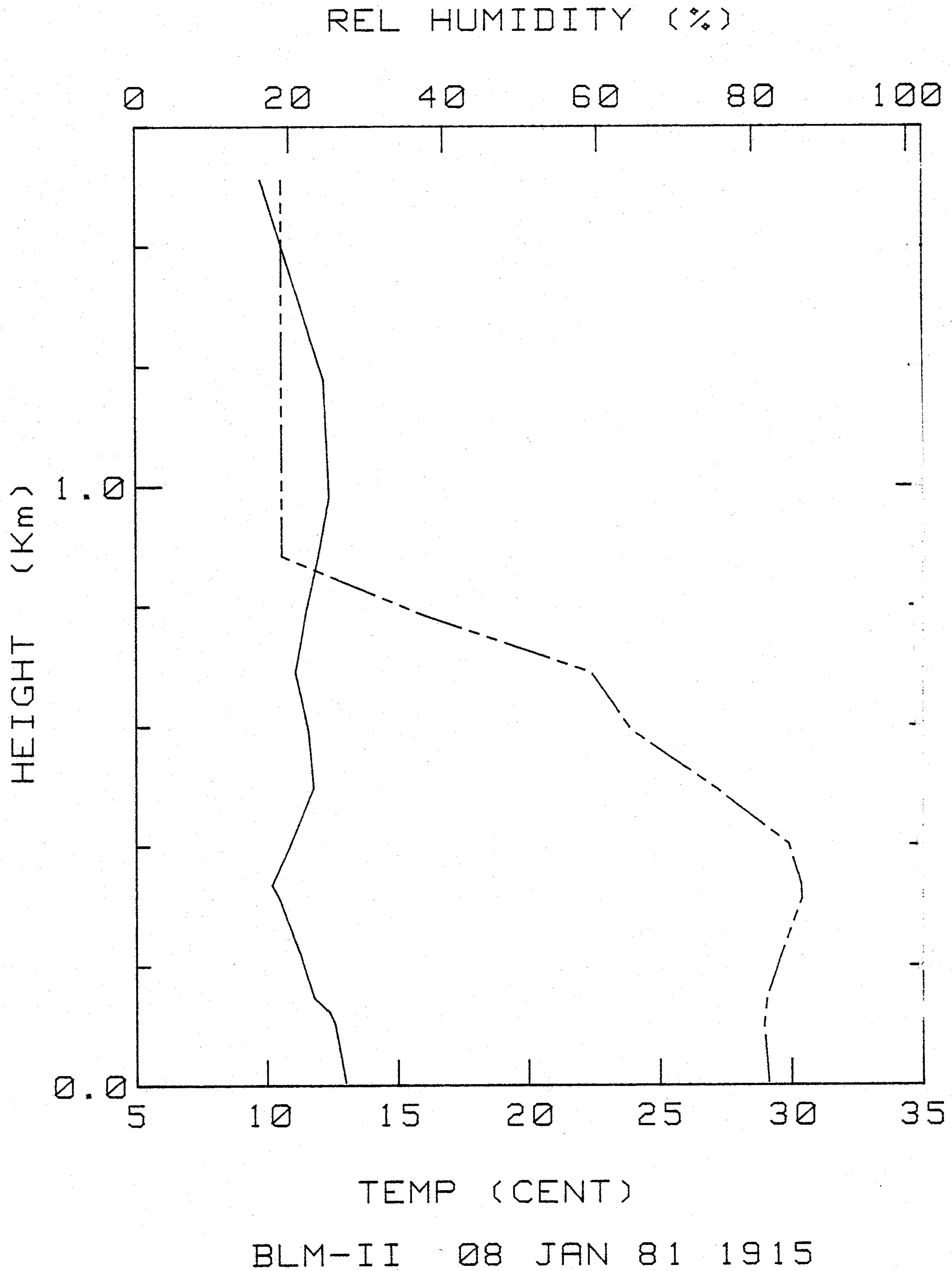

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 08 JAN 81 1915

Figure 2h

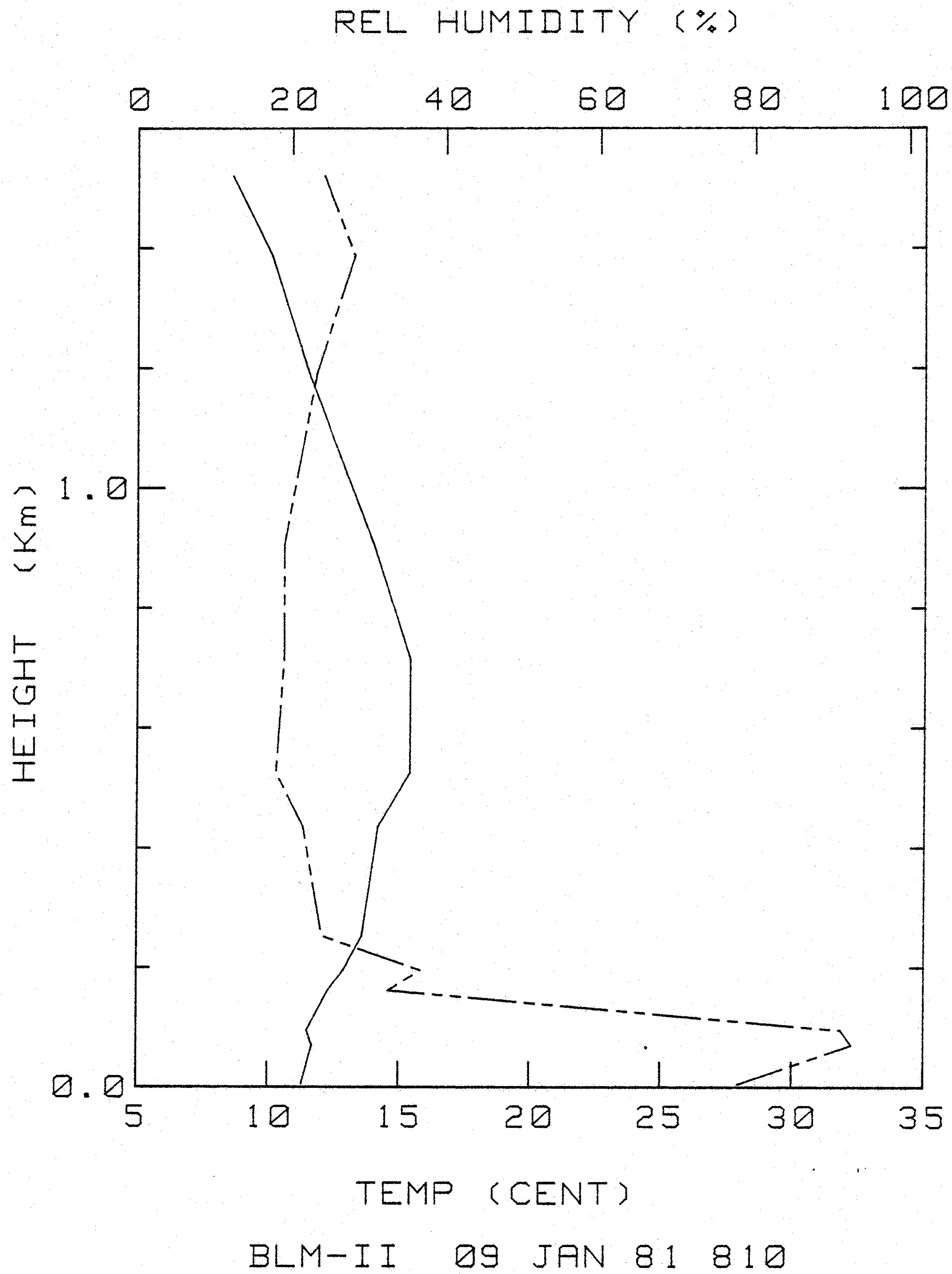

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 09 JAN 81 810

Figure 2i

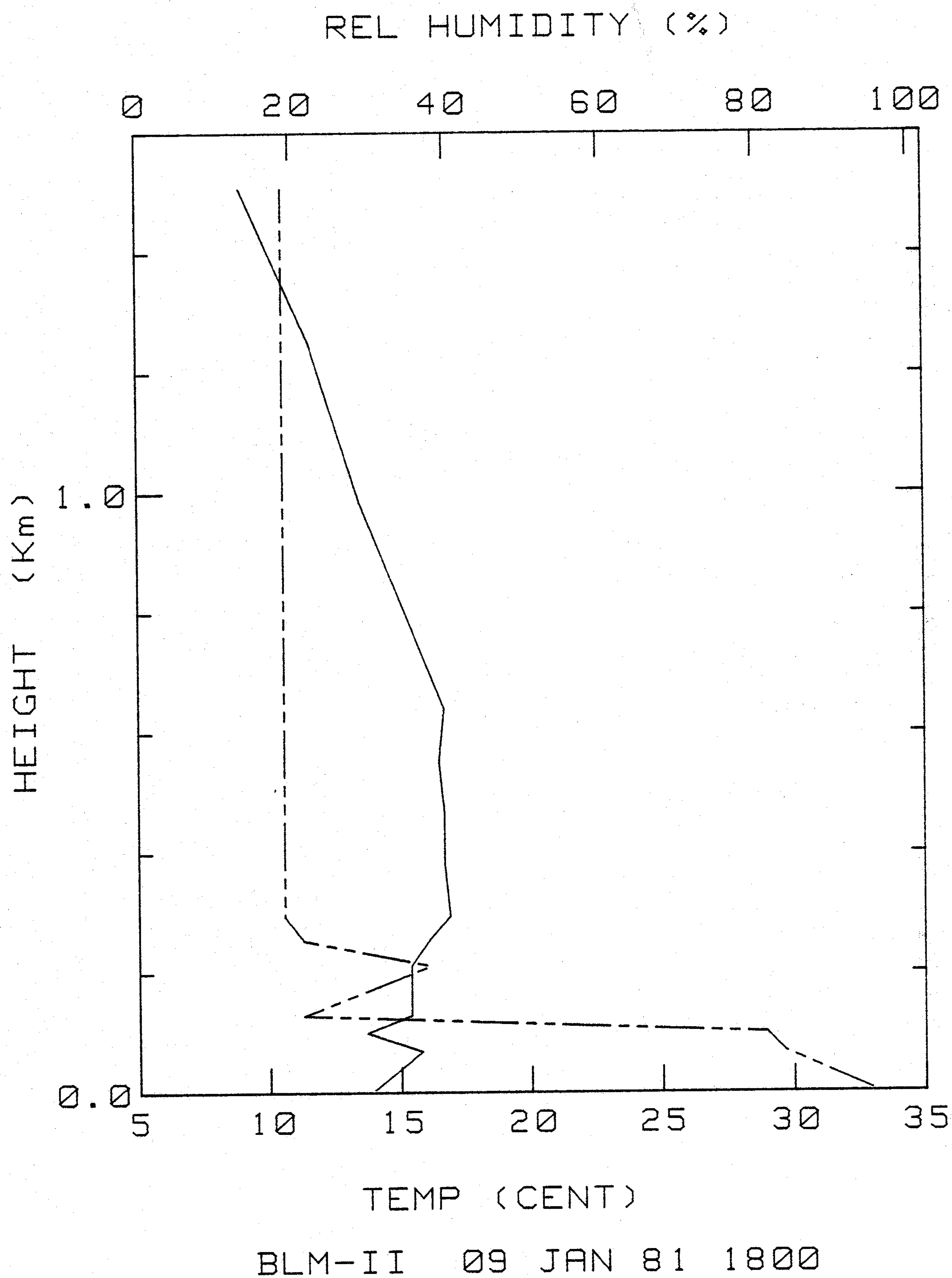

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 09 JAN 81 1800

Figure 2j

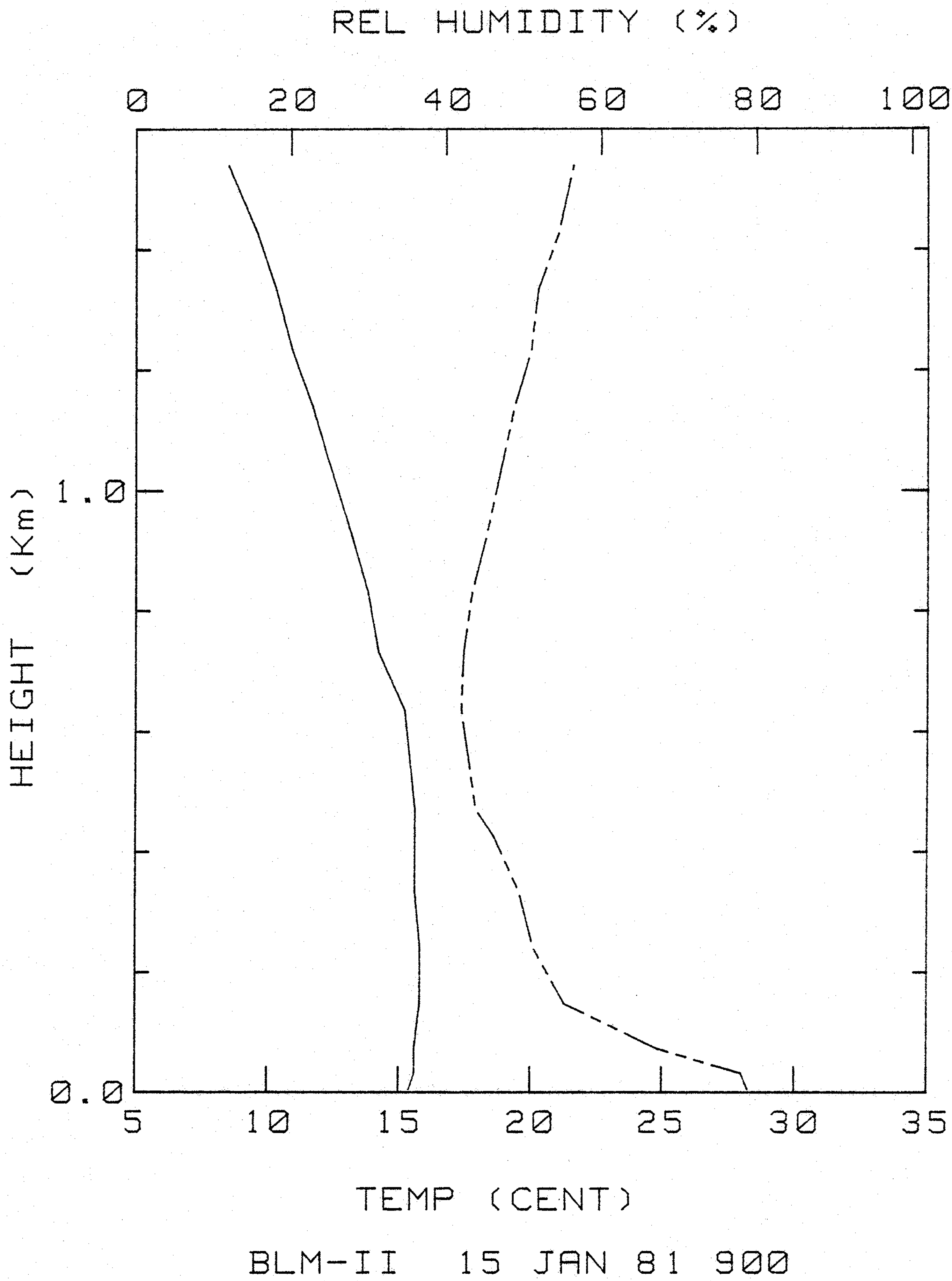

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 15 JAN 81 900

Figure 2k

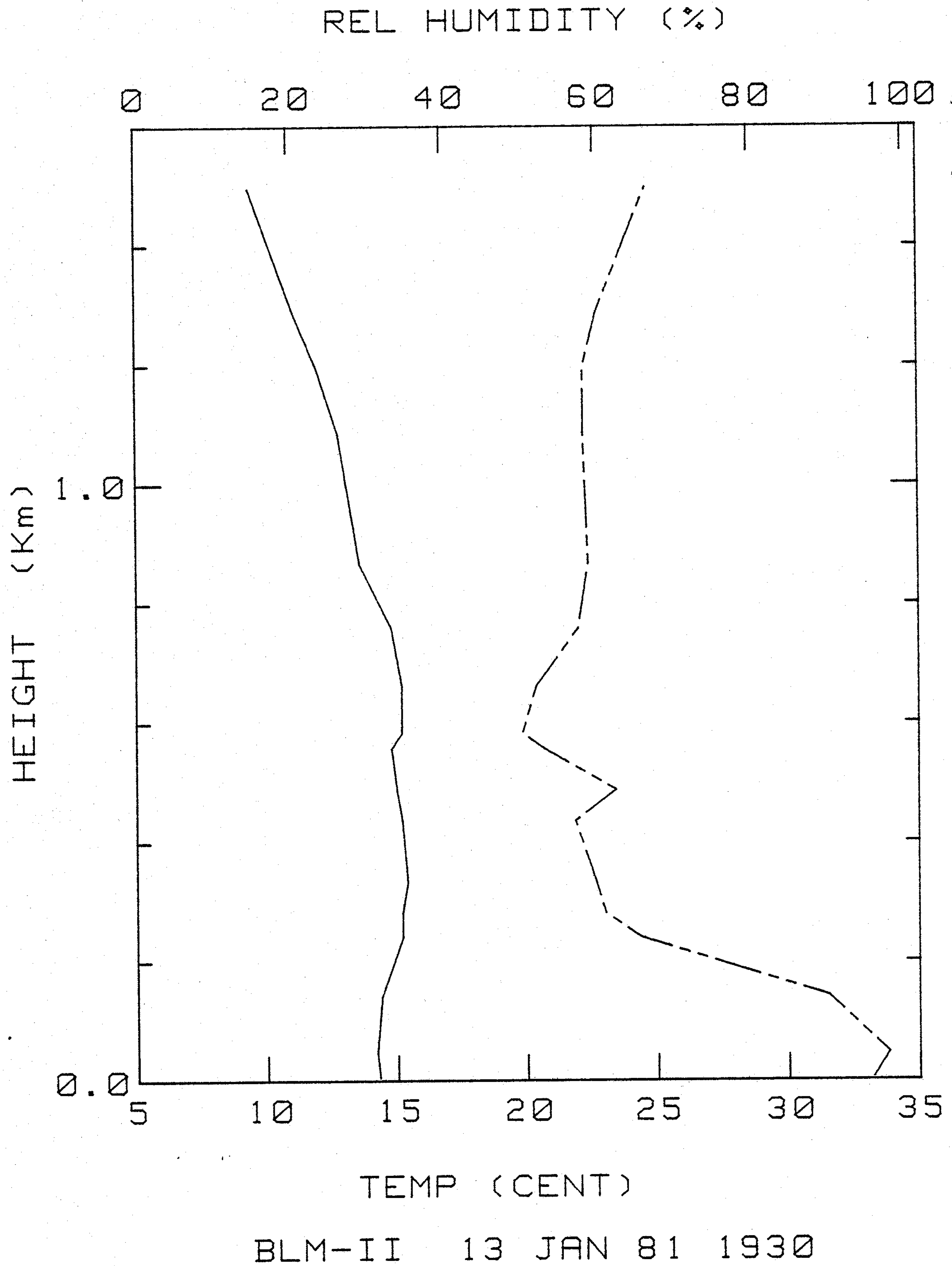

REL HUMIDITY (%)
0 20 40 60 80 100
HEIGHT (Km)
1.0
0.0
5 10 15 20 25 30 35
TEMP (CENT)
BLM-II 13 JAN 81 1930

Figure 21

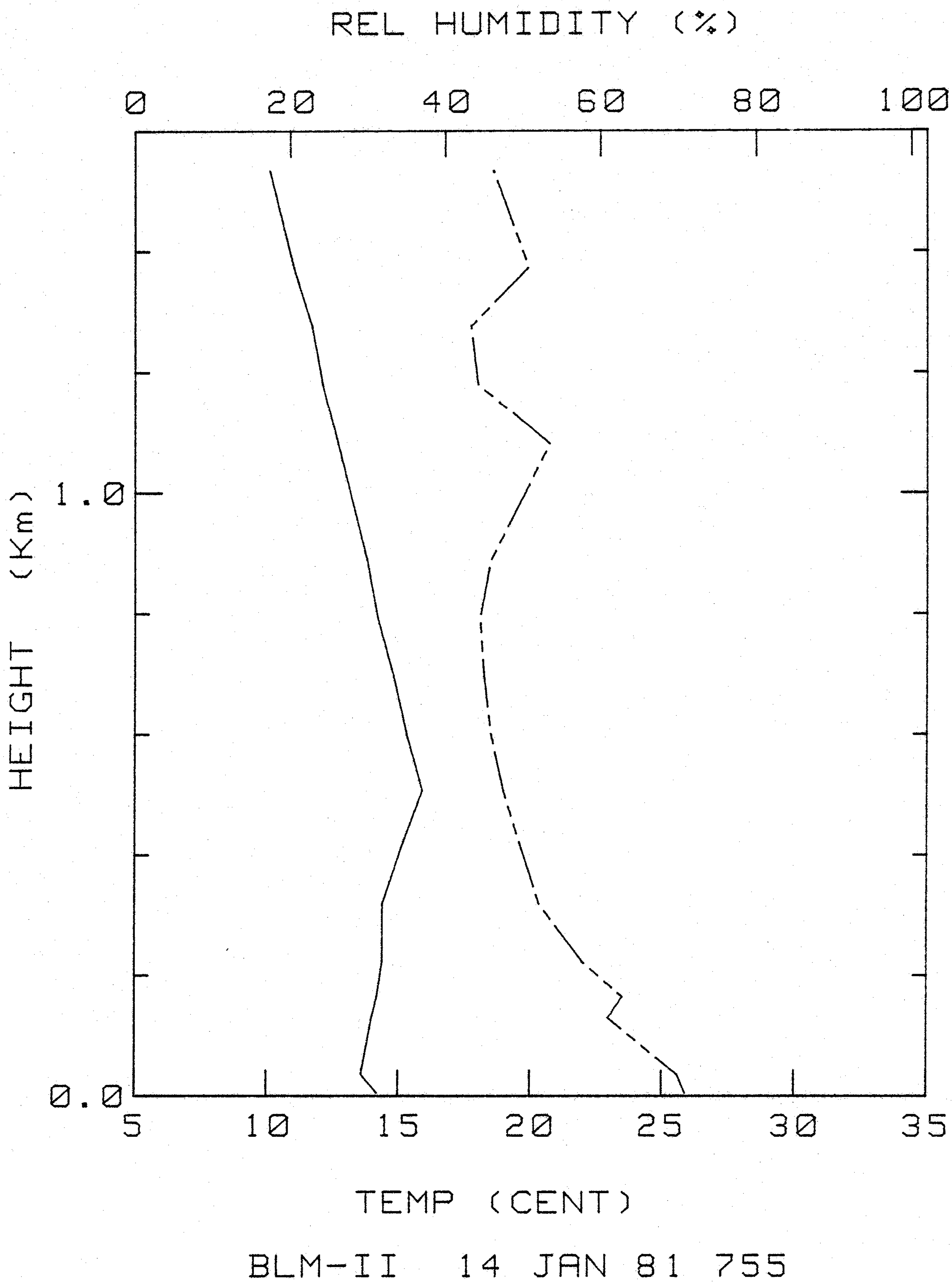

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 14 JAN 81 755

Figure 2m

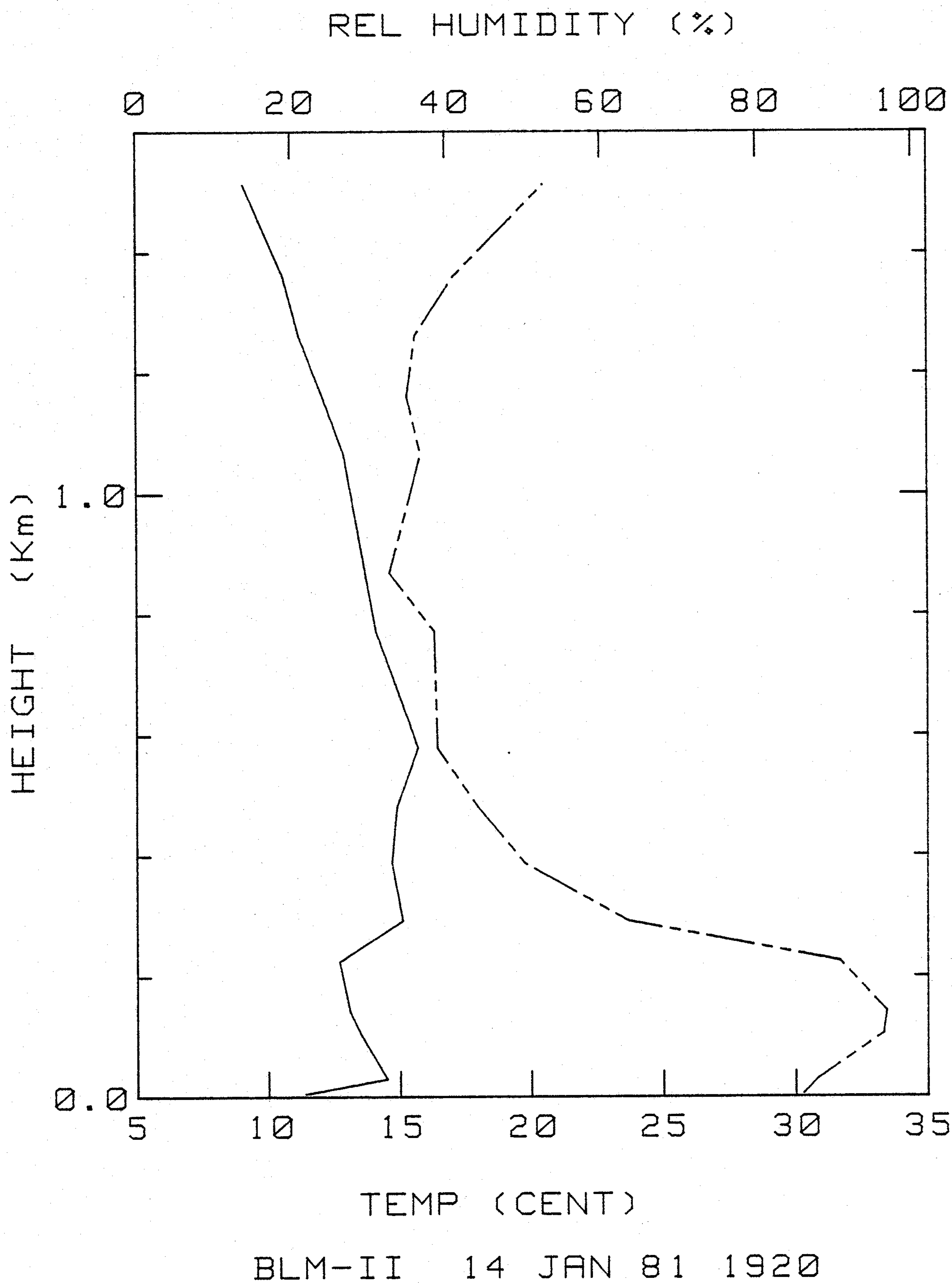

REL HUMIDITY (%)
0 20 40 60 80 100
HEIGHT (Km)
1.0
0.0
5 10 15 20 25 30 35
TEMP (CENT)
BLM-II 14 JAN 81 1920

Figure 2n

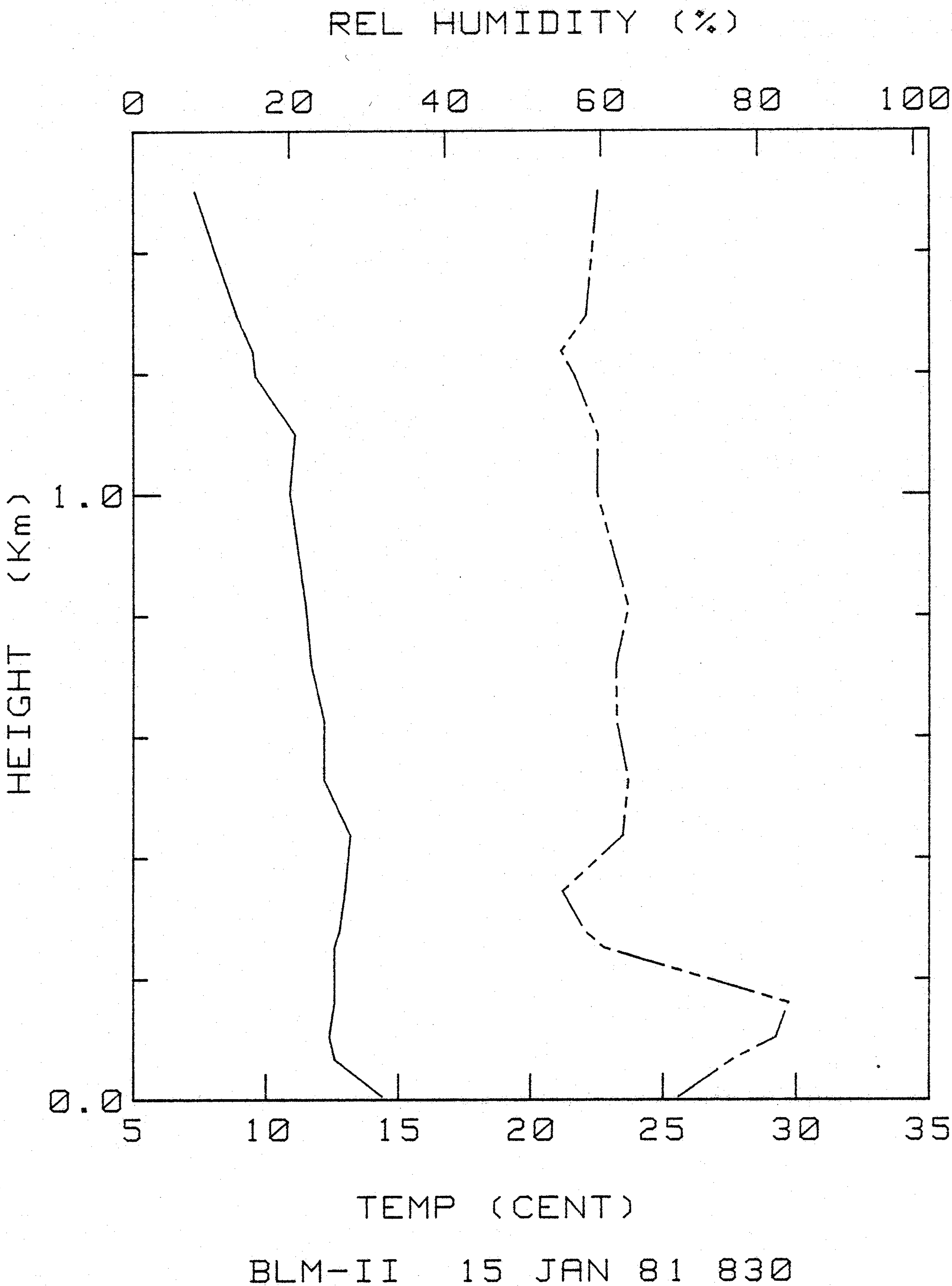

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 15 JAN 81 830

Figure 2o

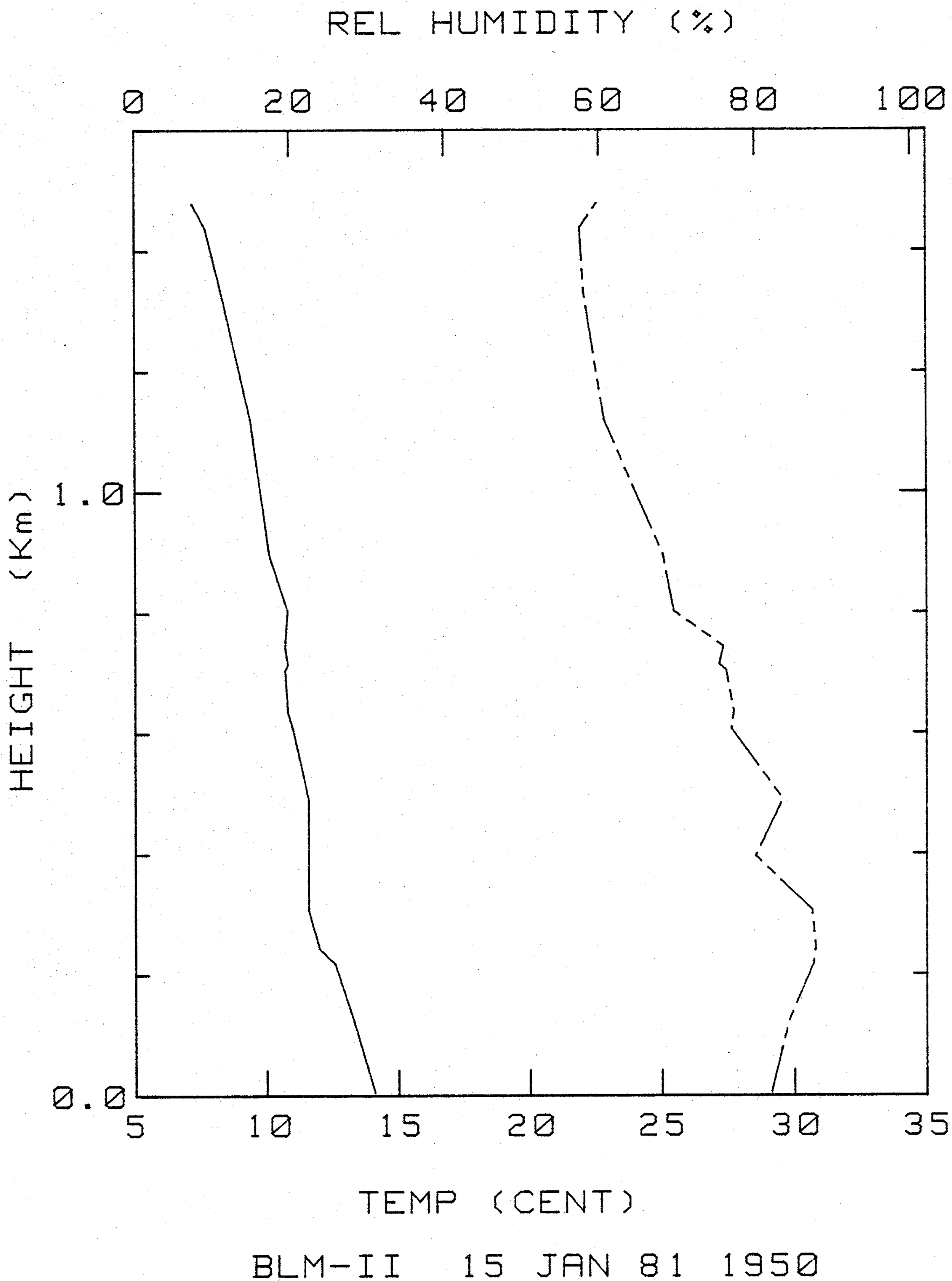
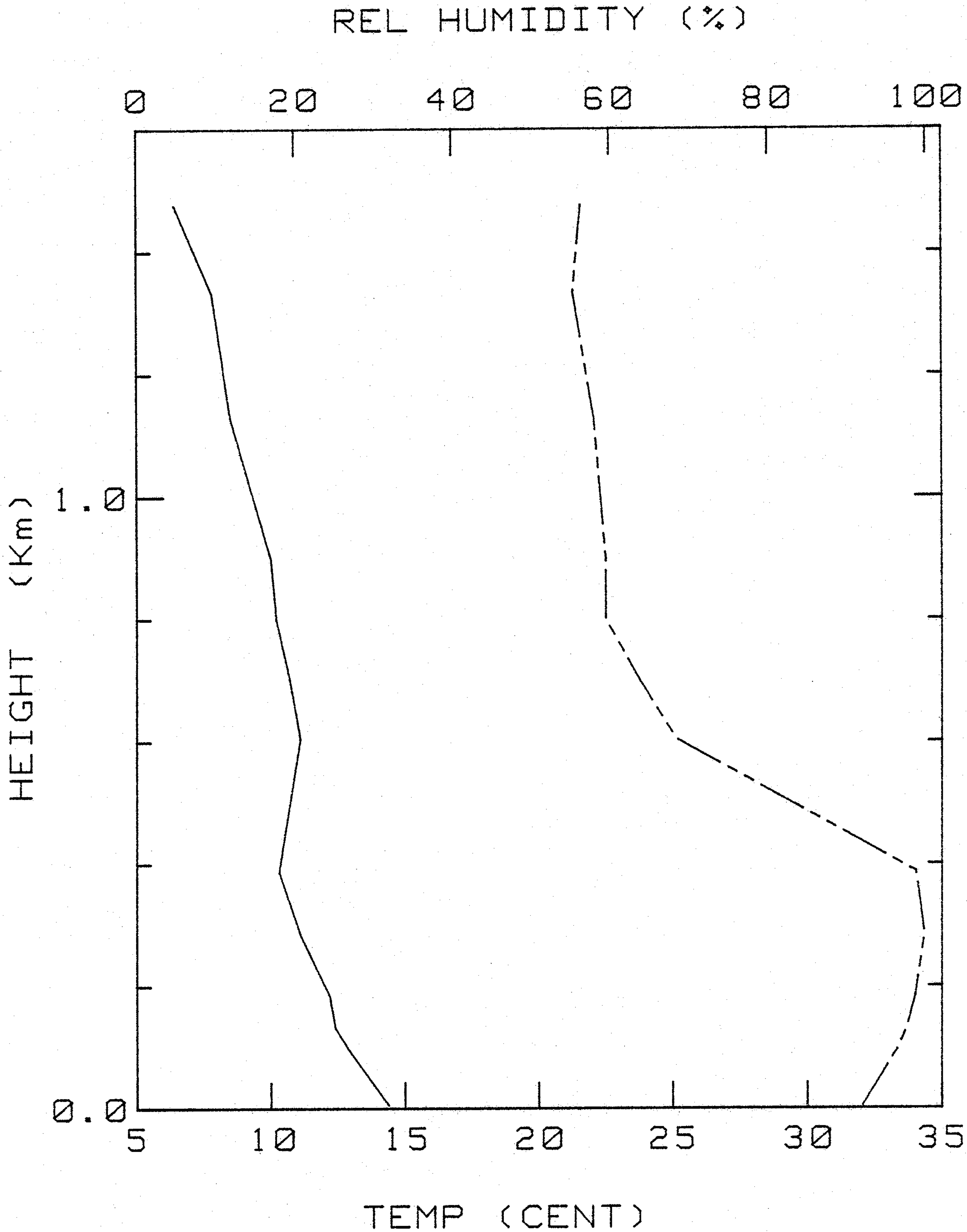
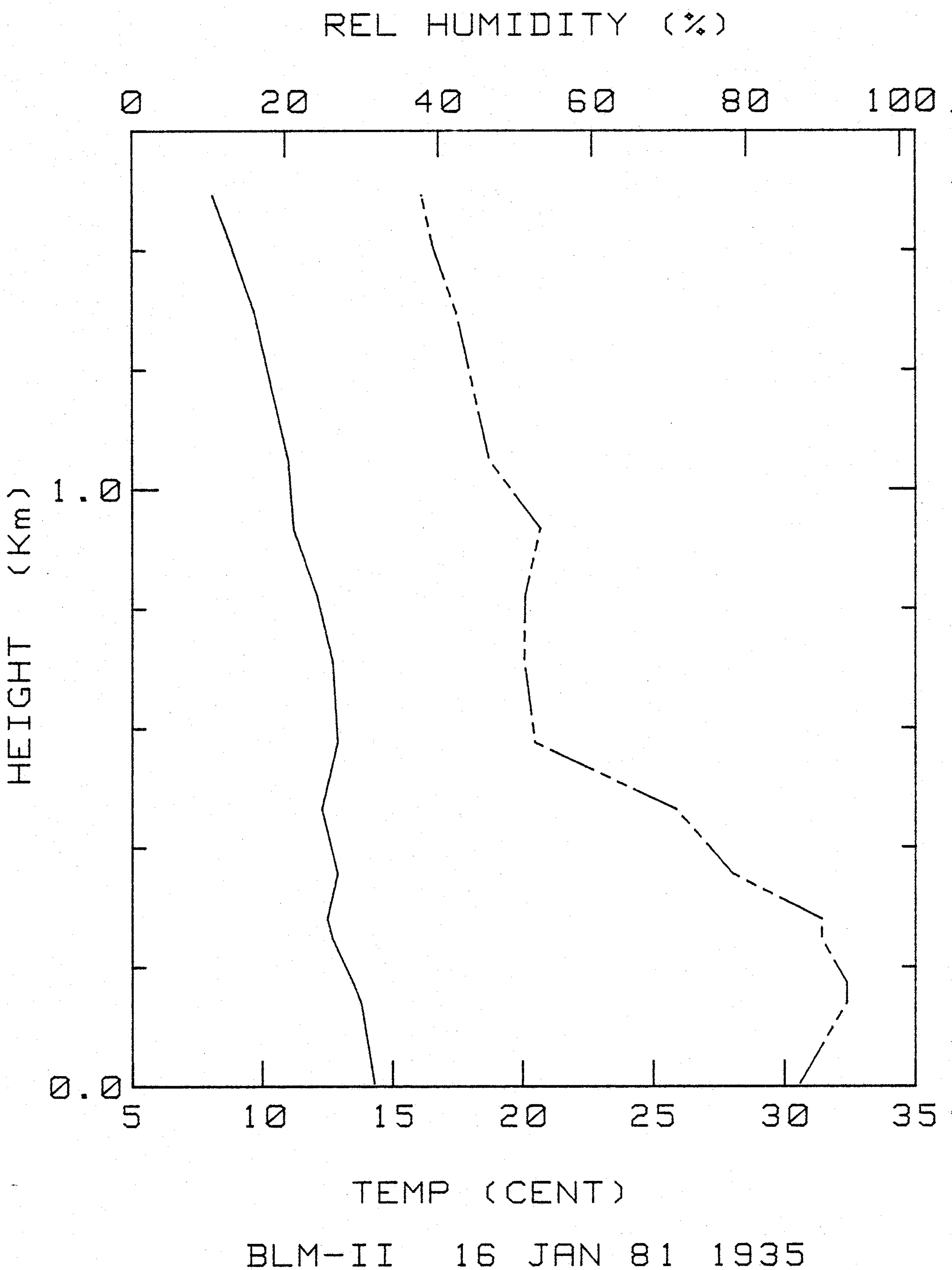

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 15 JAN 81 1950

Figure 2p



BLM-II 16 JAN 81 820

Figure 2q



REL HUMIDITY (%)
0
20
40
60
80
100.
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-II 16 JAN 81 1935

VII. Acoustic Sounder Results

The acoustic sounder was operated continuously throughout the cruise and Figures 3 are photographs of the strip chart output. As can be seen there was very seldom a well defined return that would allow one to easily determine the boundary layer depth. In Table 5 we list the heights of detectable acoustic returns. In many cases the returns were so weak that one is not certain if they indicate the height of the base of the inversion. Also listed in the table are the heights of the base and top of the temperature inversion as determined from the radisondes. These are designated with an R in the table. The radiosonde determined heights are listed as an aid since it is very difficult to determine the boundary layer depth from sounder data alone for these cases.

Figure 3a

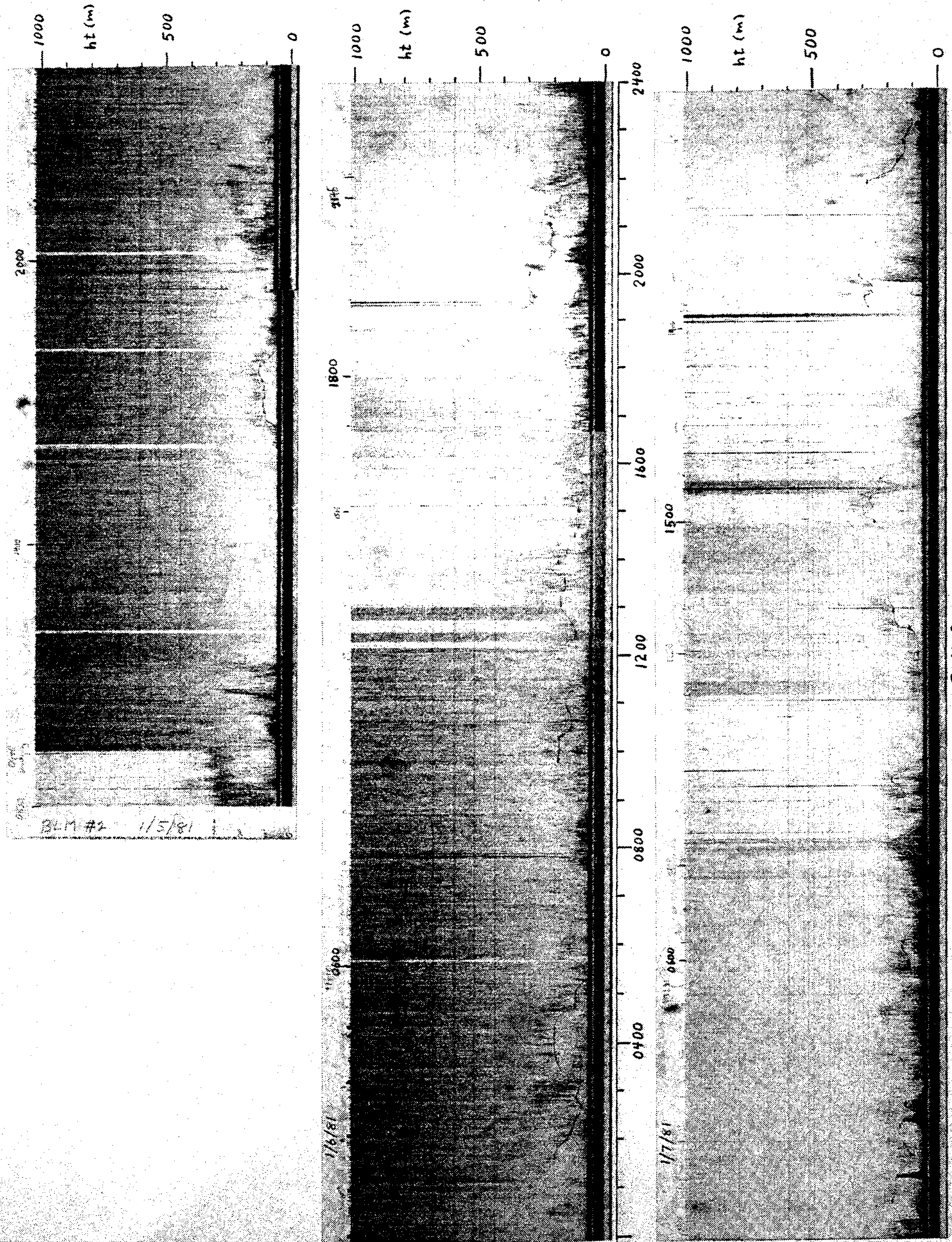

ht (m)
1000
500
0
2000
1800
1600
1400
1200
0800
0600
0400
2400
1500
BLM #2 1/5/81
1/6/81
1/7/81
BLM-2

Figure 3b

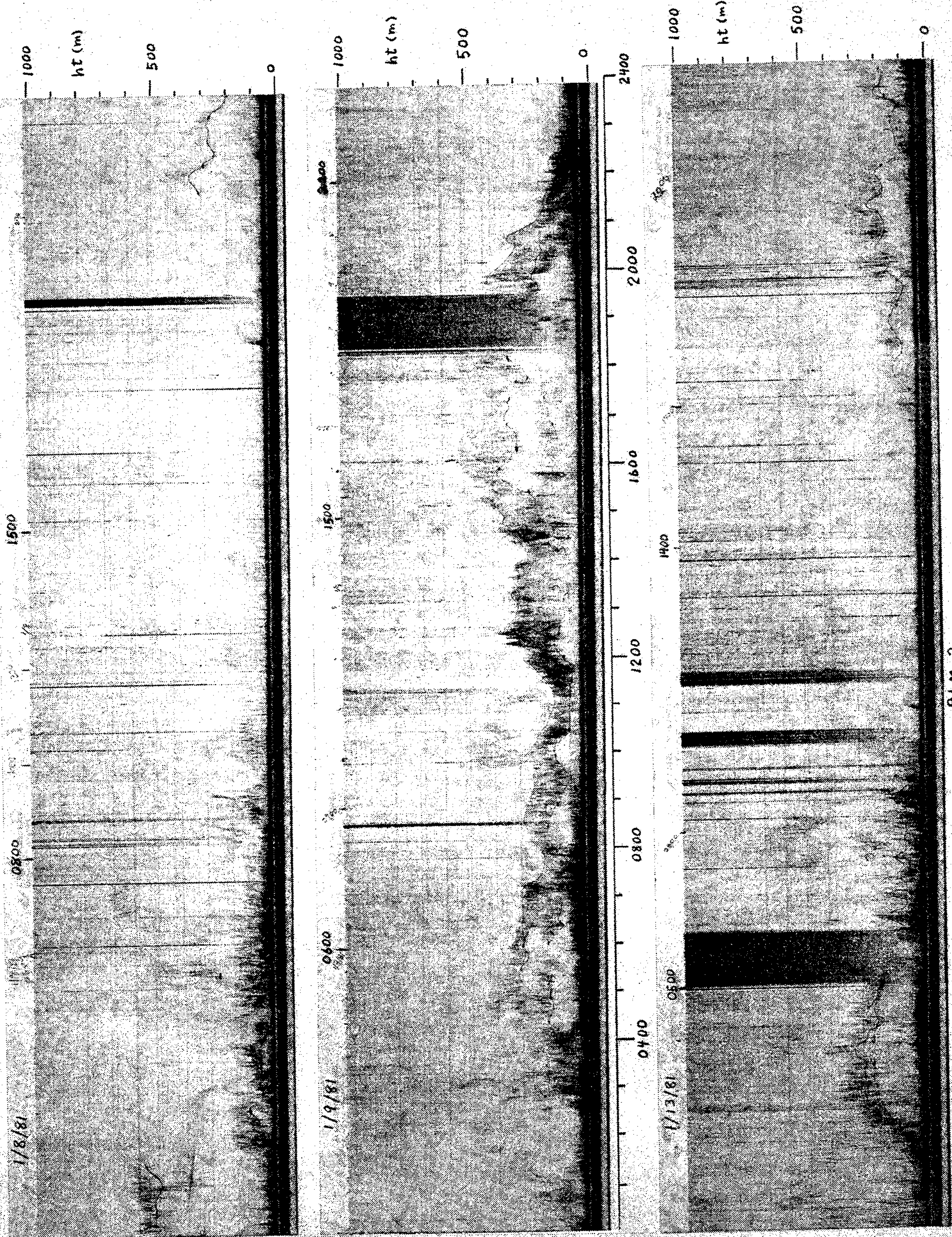
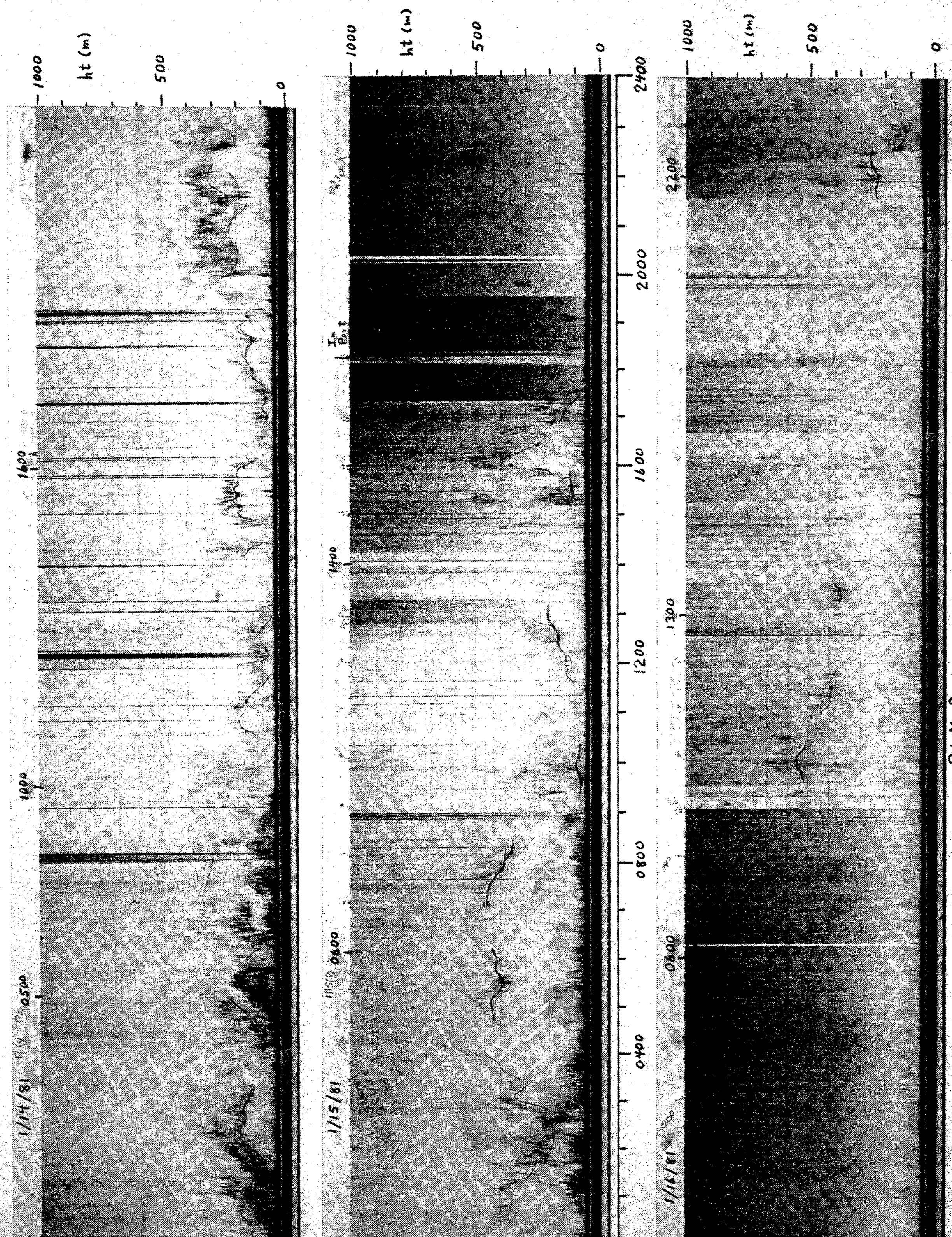

ht (m)
1000
500
0
1/8/81
1/9/81
1/13/81
0400
0800
1200
1600
2000
2400
BLM-2

Figure 3c



ht (m)
1000
500
0
1/14/81
1/15/81
1/16/81
0400
0500
0600
0800
1000
1200
1300
1400
1600
2000
2200
2400
BLM-2

Table 5. Heights of acoustic echo return from the acoustic sounder. Also listed, and designated with an R, are the heights of the base and top of the temperature inversion as determined from the radiosondes.

DATE	TIME	Z(m)	
1/6	1230	120	
	1300	140	
	1330	140	
	1400	160	
	1700	180	
	1730	180	
	1800	240	
	1830	160	
	1900	300	
	1930	280	
		R 0-200	
	2000	300	
	2030	200	
	2100	200	
1/7	0200	140	
	0600	120	
		R 0-150	
	0900	120	
	1100	80	
	1130	80	
	1200	80	
	1230	100	180
	1300	200	
	1500	250	
	1530	260	
	1600	200	
	1730	160	
		R 120-650	
	1930	300	
	2000	300	
	2130	400	
	2200	280	
	2230	160	450
	2300	120	
	2330	340	
	2400	440	
1/8	0030	520	
	0100	500	
	0130	540	
	0200	100	
	0230	140	
	0300	80	
	0330	100	
	0400	100	
	0530	260	
	0830	180	
	0845	R70-160,560-900	
1/8	1936	R 320-600	
	2000	330	
	2100	320	
	2200	320	
	2230	240	
	2300	270	
	2330	360	
1/9	0430	200	
	0500	190	
	0530	200	300
	0600	200	300
	0630	160	240
	0730	250	
	0800	160	
	0830	200	
		R 0-200,200-700	
	0900	160	
	1000	160	
	1030	100	
	1100	100	
	1130	100	
	1200	120	
	1230	140	
	1430	100	
	1530	260	
	1600	360	
	1630	140	300
	1700	180	340
	1730	300	
	1800	260	
		R 90-160,220-300	
	1900	80	160
	1930	200	
	2000	160	
	2030	120	280
	2100	120	
1/13	0200	160	
	0230	220	
	0300	260	
	0330	250	
	0400	260	
	0430	240	
	0500	220	
	0800	180	500
	0924	R 0-170 weak	
	1800	100	
	1830	130	
	1900	120	
	1930	100	
	2000	140	
		R 150-350	

DATE	TIME	Z(m)	
1/13	2030	160	
	2100	200	
	2130	180	
	2330	180	
1/14	0130	100	
	0200	180	
	0230	180	
	0300	160	
	0400	80	
	0500	100	
	0630	160	
	0823	R 30-420	
	1000	200	
	1100	170	
	1130	160	
	1200	100	
	1230	80	
	1300	100	
	1400	180	
	1500	200	
	1600	160	
	1700	80	
	1730	80	
	1800	160	
	1830	120	
	1900	160	
		R 0-150,230-480	
	2000	200	
	2030	230	
	2100	220	
	2130	160	240
	2200	200	300
	2230	210	300
	2300	300	
	2330	190	
1/15	0100	350	
	0130	260	
	0200	180	
	0230	160	
	0300	100	300
	0330	300	
	0400	420	
	0500	420	
	0530	360	
	0600	400	
	0700	460	
	0730	450	
	0800	380	
	0830	340	
		R 150-350	
	0930	140	
1/15	1200	120	
	1230	160	
	1300	200	
	1530	100	
	1600	350	
	1630	260	
	1700	150	
	2018	R None	
1/16	0845	R 400-620	
	1000	550	
	1130	400	
	1330	360	
	2005	R 480-700	
	2200	220	
	2230	160	260
	2300	100	
	2330	180	

VIII. Meteorological Data

Table 6 presents the basic meteorological data and calculated parameters. Only data taken during the tracer gas release periods are included. Wind speed, relative humidity, and air temperature values are those measured at the upper level (20.5 m). All calculated parameters were determined using the bulk aerodynamic method.

The boundary layer mixing rate and mixing height depend on the boundary layer depth, Z_i. We have already mentioned the difficulty in determining the depth for these data. We have used a combination of the radisonde data and the acoustic sounder data to find Z_i, and, unless a radiosonde was launched close to the time of interest, the value used was only an estimate. Thus, most of the mixing rate values, w_*, and the mixing times, t, are suspect.

Table 6. Meteorological Data

BLM II-81
Release #1

Date/Time	U (m/sec)	RH (%)	T (C)	Ts (C)	Zi (m)	U* (m/sec)	T* (C)	10↑3*Qo (m/secK)	z/L	w* (m/sec)	t (min)
01/06 1355	5.6	66	16.7	15.6	160	0.175	-0.039	-18.6	7.40E-02	0.3	8.0
01/06 1425	5.3	66	16.8	15.6	160	0.163	-0.041	-21.5	9.79E-02	0.3	8.0
01/06 1455	4.3	60	17.3	15.7	160	0.118	-0.051	-30.6	2.65E-01	0.3	8.3
01/06 1542	2.6	64	17.1	15.8	160	0.057	-0.036	-19.6	7.39E-01	0.2	11.9
01/06 1612	5.4	53	17.7	15.7	170	0.157	-0.068	-42.2	2.05E-01	0.4	7.2
01/06 1642	4.7	58	17.3	15.6	170	0.132	-0.056	-34.1	2.35E-01	0.4	8.1
01/06 1712	5.3	61	17.1	15.6	180	0.159	-0.051	-29.4	1.40E-01	0.4	8.2
01/06 1742	4.5	61	17.2	15.6	180	0.128	-0.050	-30.5	2.24E-01	0.3	8.8
01/06 1812	4.8	52	18.0	15.5	160	0.137	-0.064	-42.2	2.72E-01	0.4	7.4
01/06 1842	3.7	66	16.7	15.5	160	0.101	-0.041	-22.5	2.65E-01	0.3	9.5
01/06 1912	2.7	69	16.5	15.5	140	0.066	-0.032	-16.9	4.74E-01	0.2	10.8
01/06 1942	1.6	55	16.0	15.4	140	0.053	-0.015	18.7	-7.62E-01	0.2	14.9

BLM II-81
Release #2

Date/Time	U (m/sec)	RH (%)	T (C)	Ts (C)	Zi (m)	U* (m/sec)	T* (C)	10↑3*Qo (m/secK)	z/L	w* (m/sec)	t (min)
01/09 1149	3.7	79	14.0	15.4	80	0.122	0.046	68.9	-5.49E-01	0.2	5.4
01/09 1221	4.1	84	14.0	15.3	180	0.134	0.042	59.9	-3.94E-01	0.3	9.2
01/09 1309	4.1	85	14.1	15.3	200	0.137	0.037	54.2	-3.42E-01	0.3	10.2
01/09 1339	4.6	87	14.2	15.3	240	0.154	0.036	51.0	-2.53E-01	0.4	11.2
01/09 1409	4.7	88	14.2	15.3	240	0.156	0.033	47.1	-2.30E-01	0.3	11.5
01/09 1439	4.6	87	14.4	15.3	250	0.153	0.028	42.0	-2.13E-01	0.3	12.6
01/09 1509	5.0	84	14.6	15.3	260	0.166	0.019	34.0	-1.45E-01	0.3	14.2
01/09 1539	4.2	85	14.8	15.4	260	0.136	0.014	28.2	-1.79E-01	0.3	16.7
01/09 1609	3.2	85	15.0	15.3	200	0.101	0.008	21.0	-2.43E-01	0.2	18.9
01/09 1639	2.9	83	15.2	15.3	180	0.091	0.001	15.0	-2.10E-01	0.1	32.2
01/09 1709	4.1	87	15.1	15.3	160	0.131	0.004	15.7	-1.07E-01	0.1	18.3
01/09 1739	4.7	88	15.0	15.3	120	0.154	0.008	18.6	-9.16E-02	0.2	11.9
01/09 1809	5.2	85	15.0	15.3	100	0.170	0.005	17.8	-7.25E-02	0.1	11.5

BLM II-81
Release #3

Date/Time	U (m/sec)	RH (%)	T (C)	Ts (C)	Zi (m)	U* (m/sec)	T* (C)	10↑3*Qo (m/secK)	z/L	w* (m/sec)	t (min)
01/13 0852	3.9	70	14.4	15.0	180	0.129	0.021	44.1	-3.14E-01	0.3	11.7
01/13 0948	3.0	79	15.1	15.0	100	0.090	-0.007	7.5	-1.06E-01	0.1	13.0
01/13 1049	3.3	67	16.0	15.2	100	0.096	-0.024	-6.2	8.59E-02	0.2	8.4
01/13 1119	4.5	78	15.5	15.2	100	0.141	-0.014	-0.2	2.68E-03	0.2	8.9
01/13 1239	4.9	73	16.0	15.3	100	0.152	-0.024	-9.0	4.79E-02	0.2	7.2
01/13 1309	5.4	77	15.9	15.4	100	0.172	-0.022	-8.2	3.42E-02	0.2	7.1
01/13 1339	5.3	71	16.3	15.4	100	0.167	-0.030	-14.8	6.49E-02	0.3	6.5
01/13 1409	6.1	61	17.0	15.4	100	0.194	-0.046	-27.5	8.83E-02	0.3	5.3
01/13 1439	5.5	64	16.9	15.5	100	0.171	-0.045	-26.6	1.10E-01	0.3	5.6
01/13 1509	5.6	71	16.5	15.5	100	0.176	-0.036	-20.5	8.02E-02	0.3	6.0
01/13 1521	5.1	81	16.1	15.4	100	0.157	-0.027	-16.4	8.07E-02	0.2	6.9
01/13 1559	5.4	83	15.9	15.3	130	0.169	-0.023	-13.2	5.58E-02	0.3	8.4
01/13 1629	4.0	87	15.7	15.4	130	0.120	-0.015	-6.8	5.71E-02	0.2	10.9
01/13 1659	4.3	83	15.8	15.4	130	0.132	-0.014	-4.7	3.32E-02	0.2	10.7
01/13 1729	4.4	83	15.7	15.4	130	0.137	-0.013	-2.2	1.52E-02	0.2	11.0

BLM II-81
Release #4

Date/Time	U (m/sec)	RH (%)	T (C)	Ts (C)	Zi (m)	U* (m/sec)	T* (C)	10↑3*Qo (m/secK)	z/L	w* (m/sec)	t (min)
01/15 1441	3.3	86	14.8	15.7	150	0.106	0.026	40.2	-4.23E-01	0.2	10.4
01/15 1500	4.8	84	14.8	15.7	200	0.160	0.026	41.1	-1.90E-01	0.3	10.9
01/15 1552	4.0	84	15.1	15.6	100	0.128	0.013	26.2	-1.87E-01	0.2	9.4
01/15 1622	5.3	85	14.9	15.6	360	0.176	0.021	34.6	-1.32E-01	0.4	16.8
01/15 1652	6.2	85	14.8	15.6	260	0.210	0.022	35.6	-9.56E-02	0.3	12.6
01/15 1722	5.9	85	14.8	15.5	120	0.200	0.021	34.9	-1.02E-01	0.3	7.8

IX. Mixed Layer Parameters

It is very important in understanding transport and dispersion to determine whether the boundary layer is well mixed. We do this by examining the virtual potential temperature and water vapor mixing ratio. These parameters will be well mixed in the well mixed boundary layer and will, then, be constant with height. The two parameters have been determined from the radiosonde results and are shown in Figures 4a-q. Again note that the lowest point for each sounding is not reliable. These results can be easily used to determine if the boundary layer is well mixed.

Figure 4a

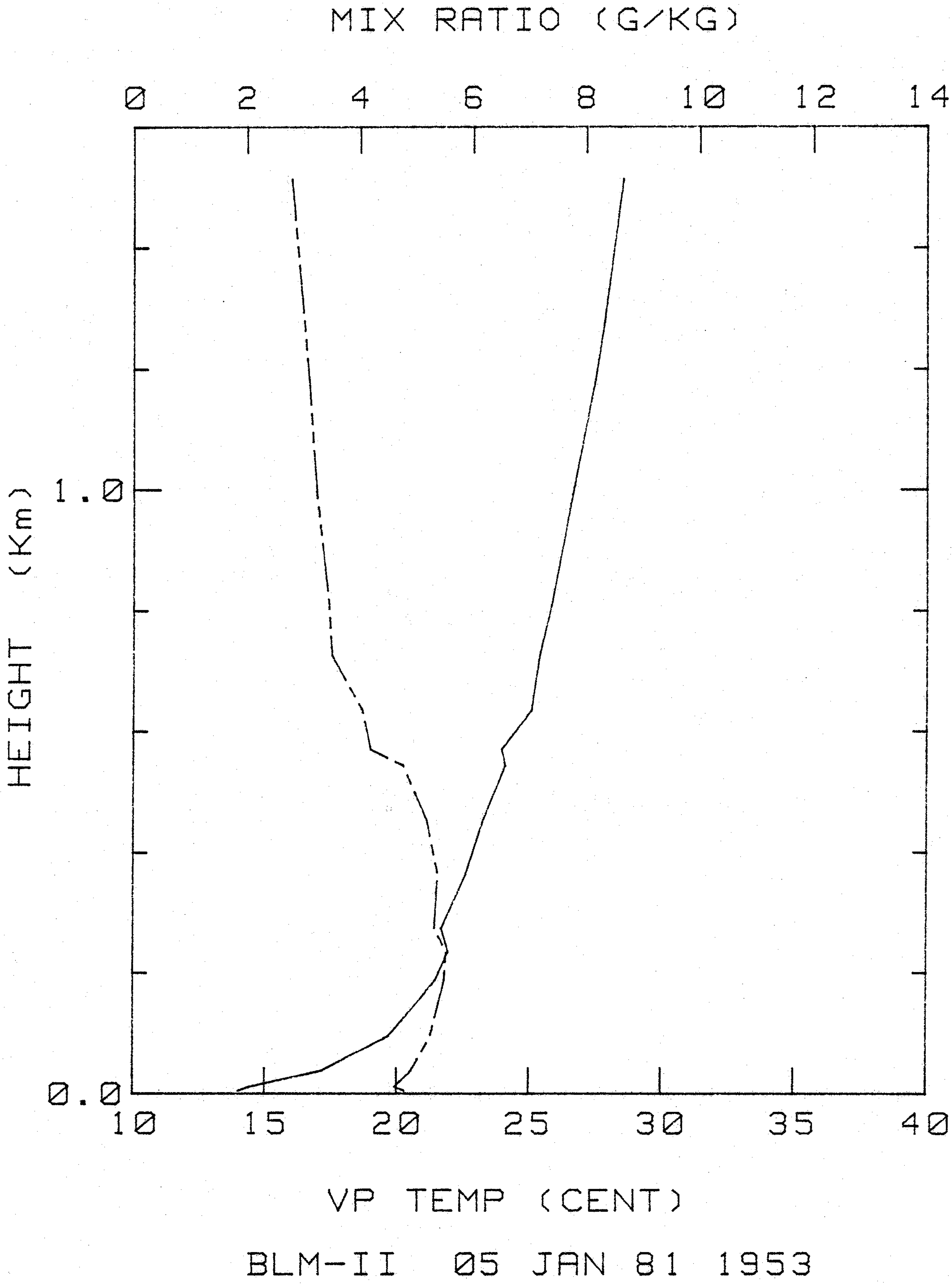

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-II 05 JAN 81 1953

Figure 4b

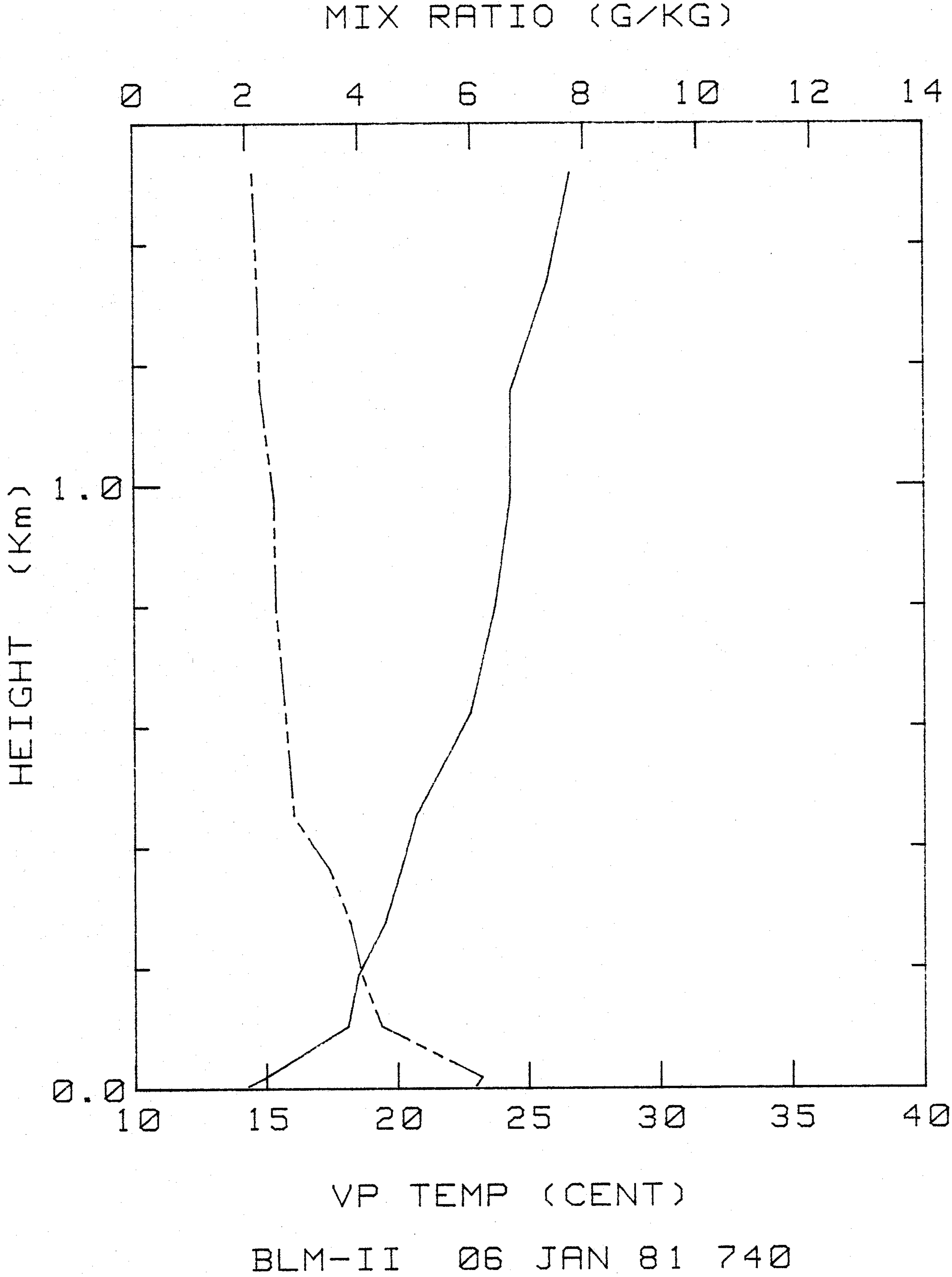

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 06 JAN 81 740

Figure 4c

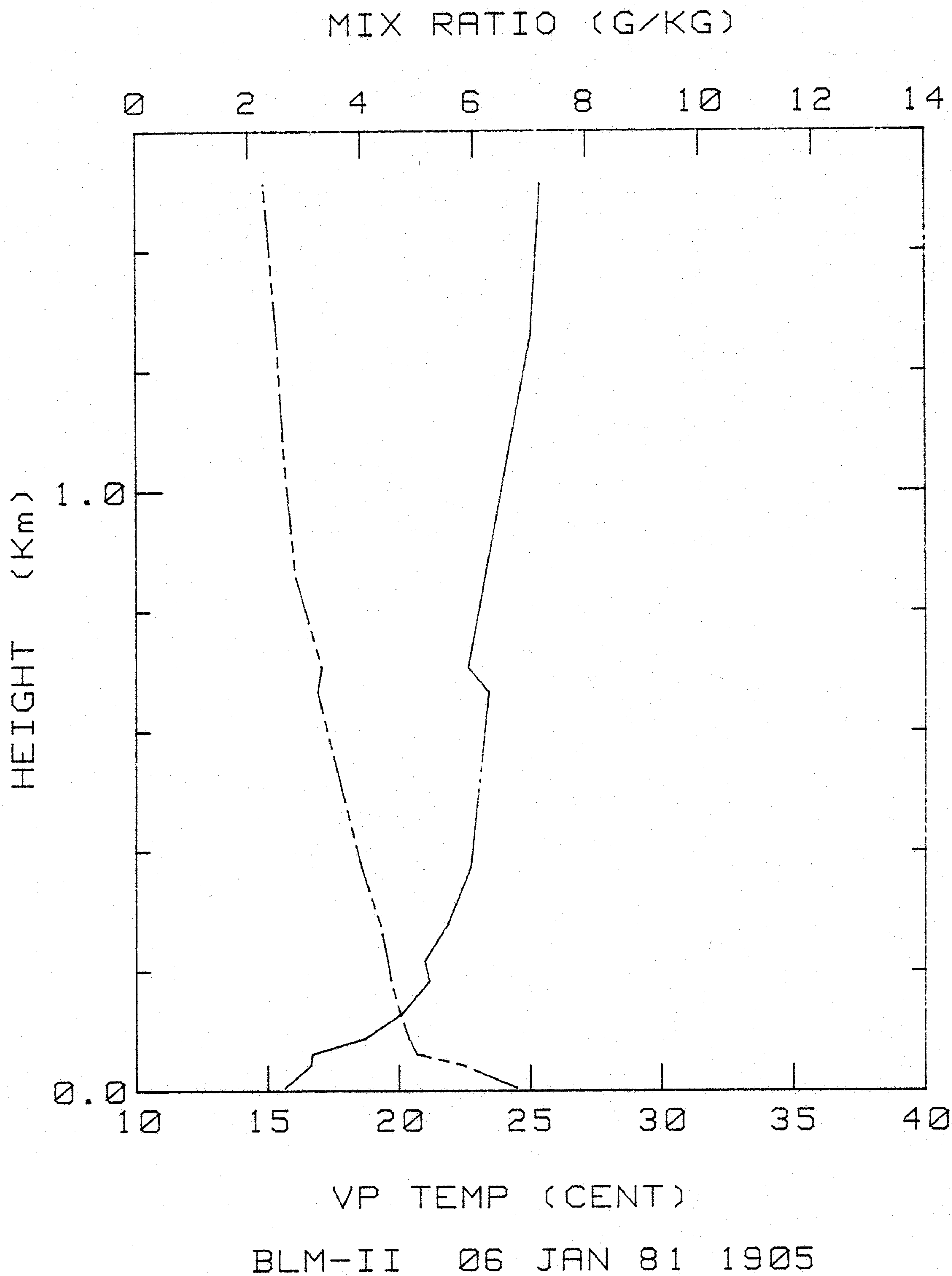

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 06 JAN 81 1905

Figure 4d

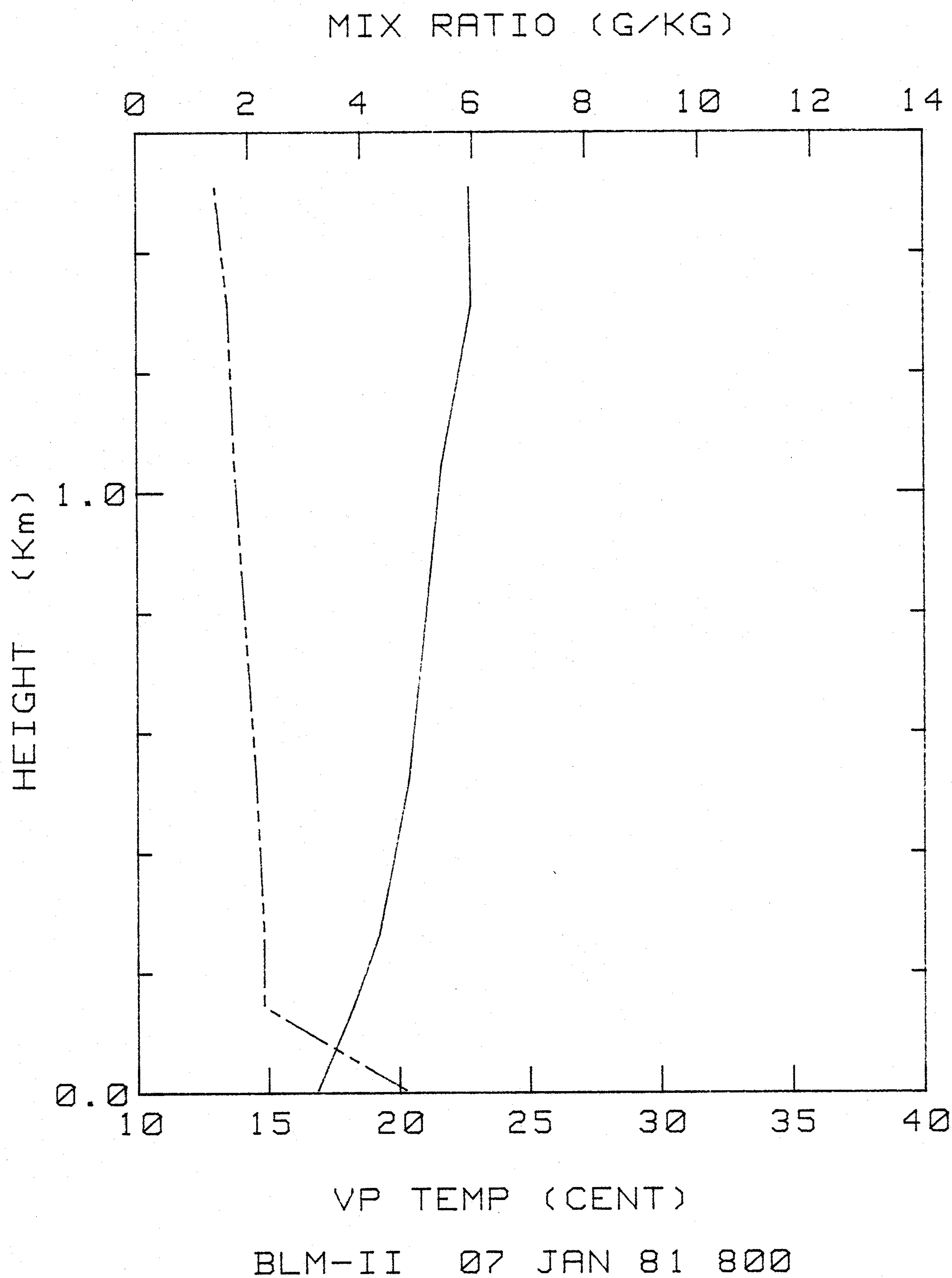

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 07 JAN 81 800

Figure 4e

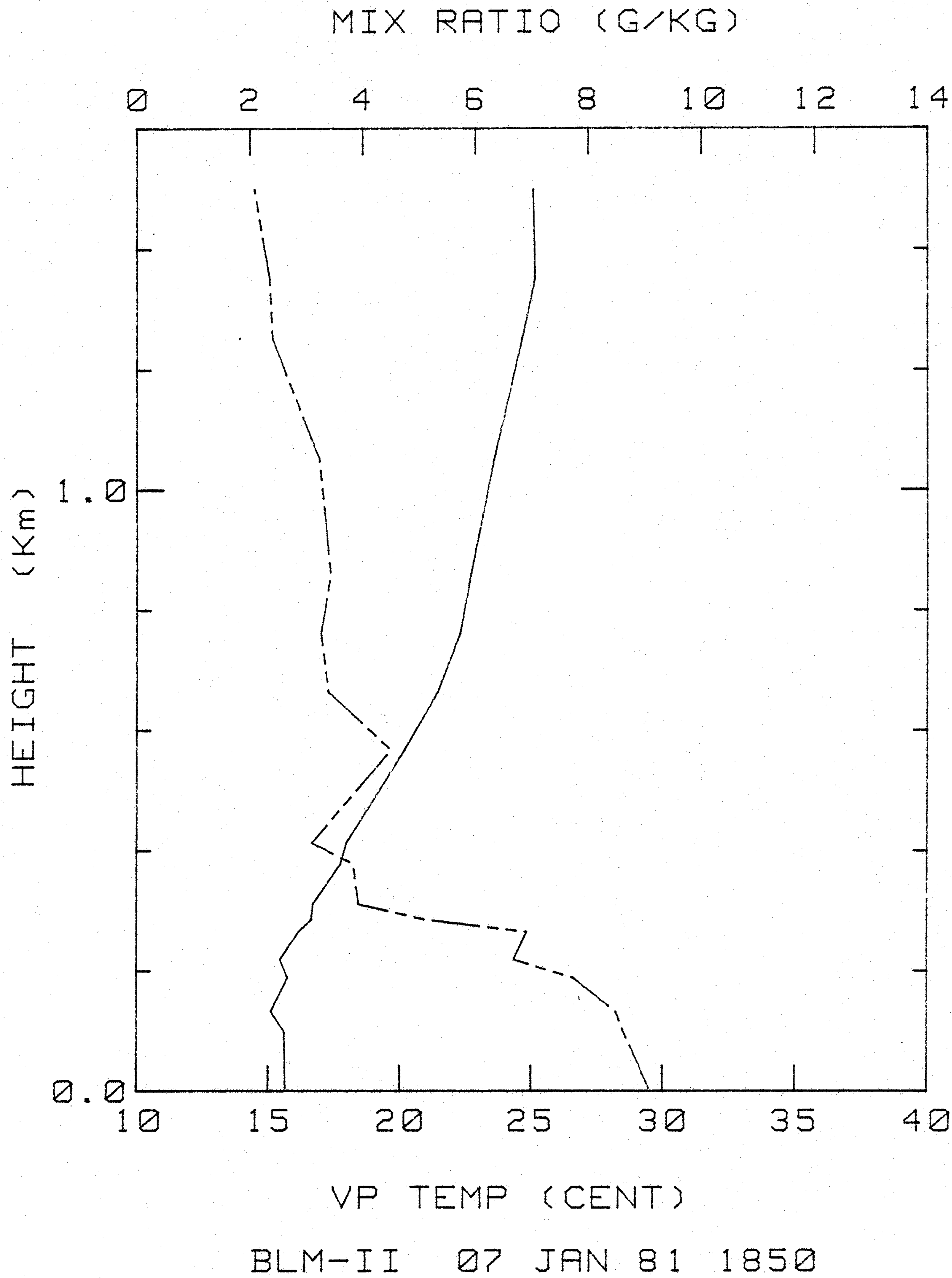

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-II 07 JAN 81 1850

Figure 4f

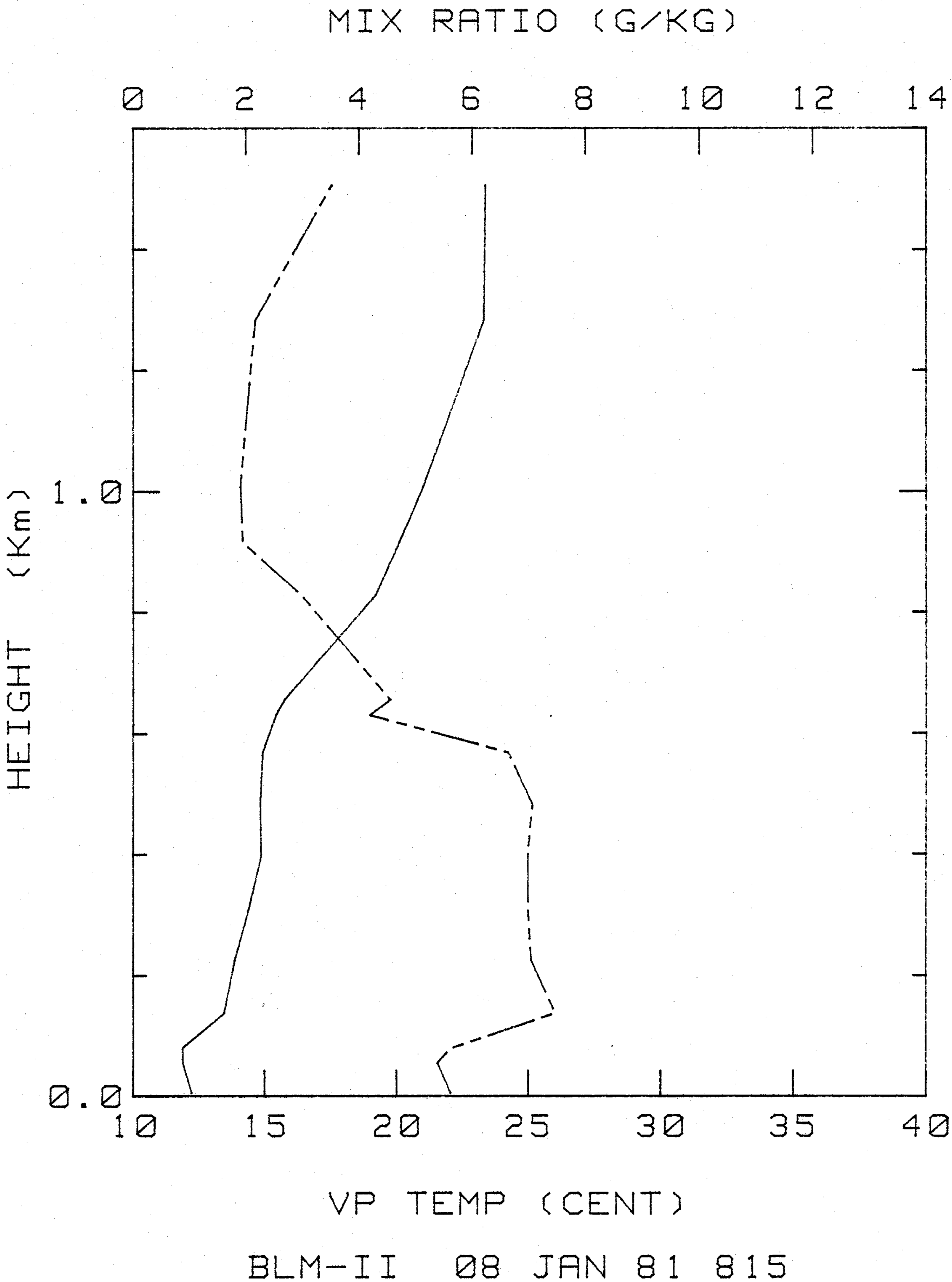

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 08 JAN 81 815

Figure 4g

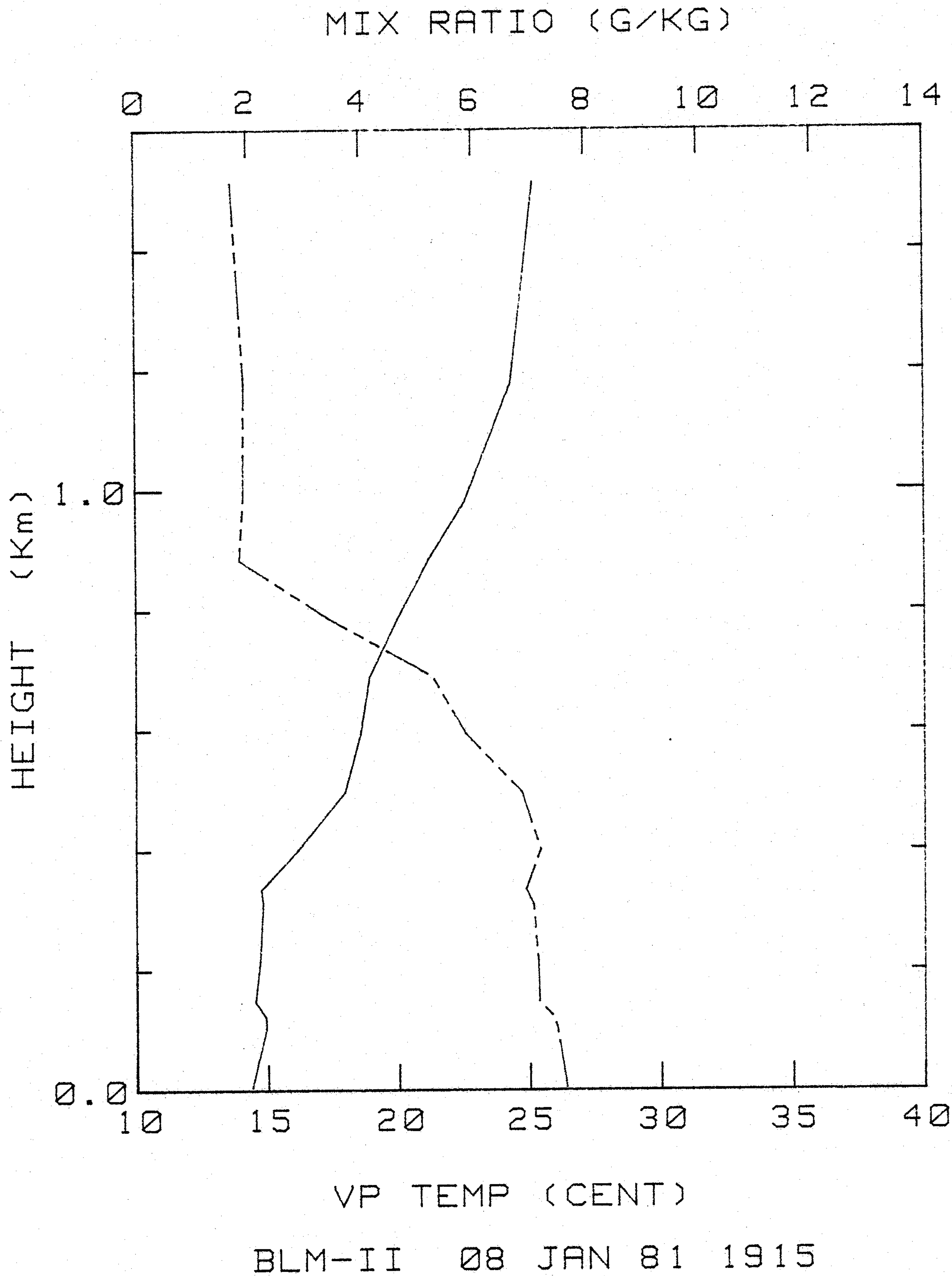
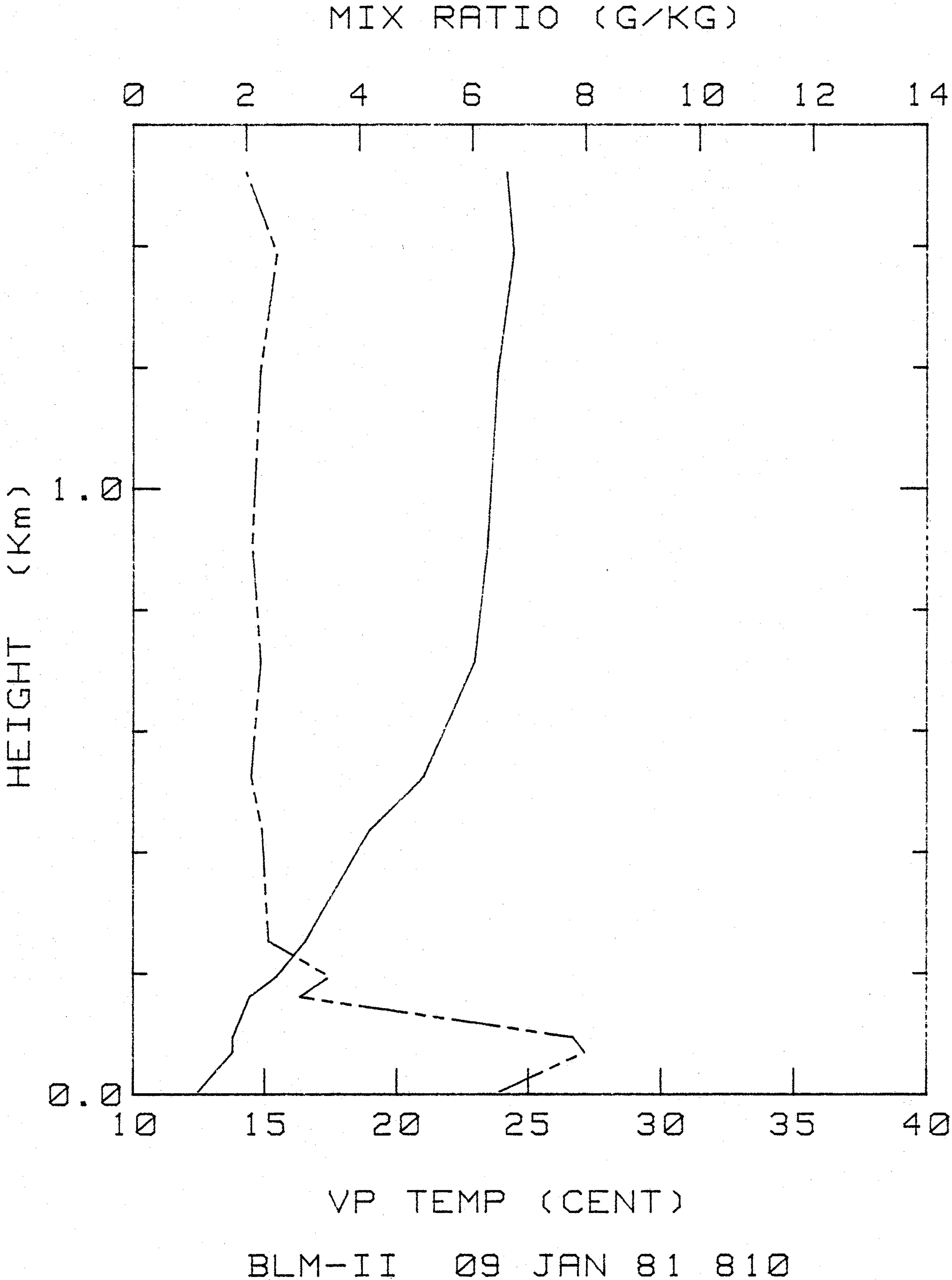

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 08 JAN 81 1915

Figure 4h



MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 09 JAN 81 810

Figure 4i

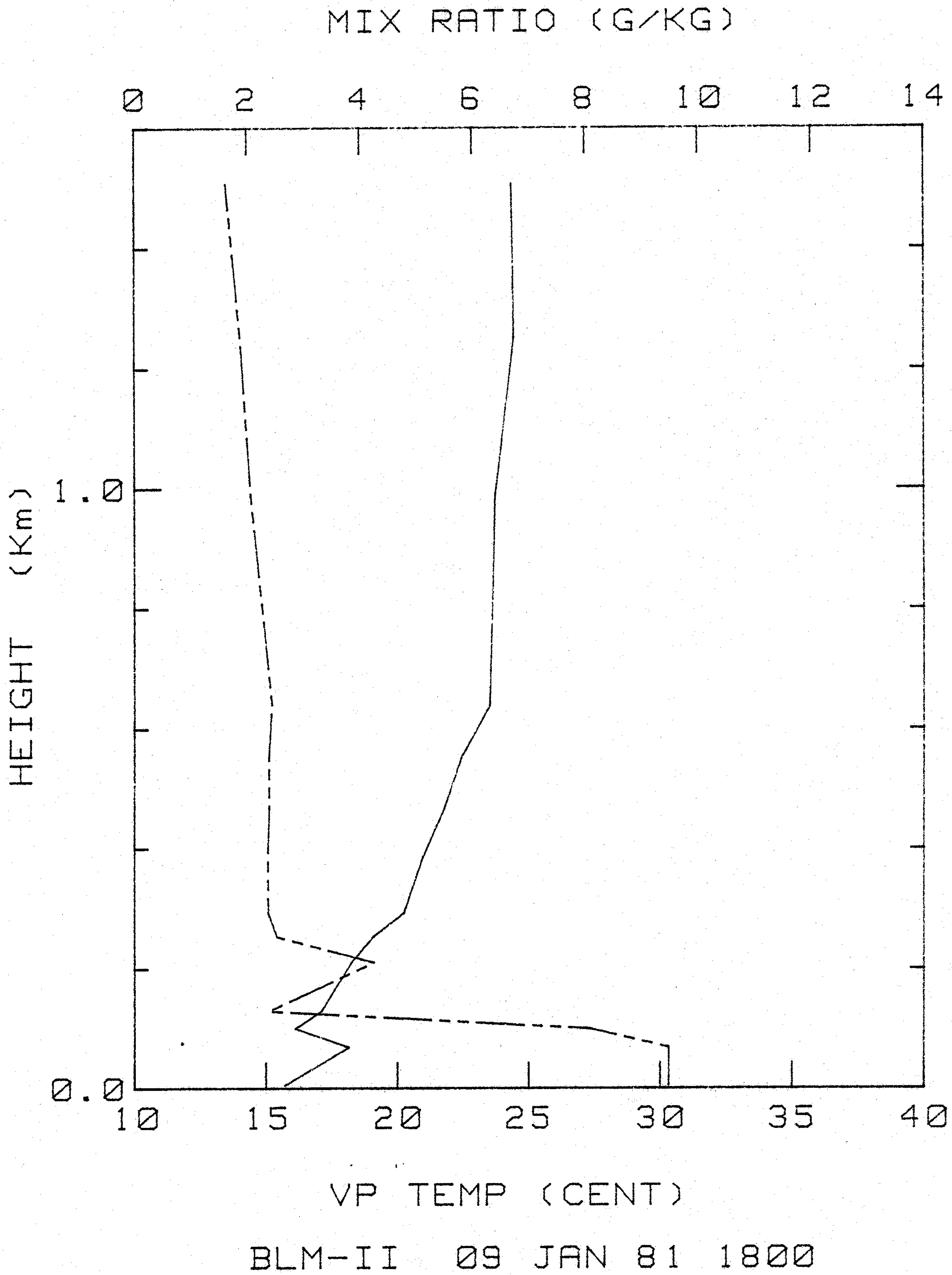

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 09 JAN 81 1800

Figure 4j

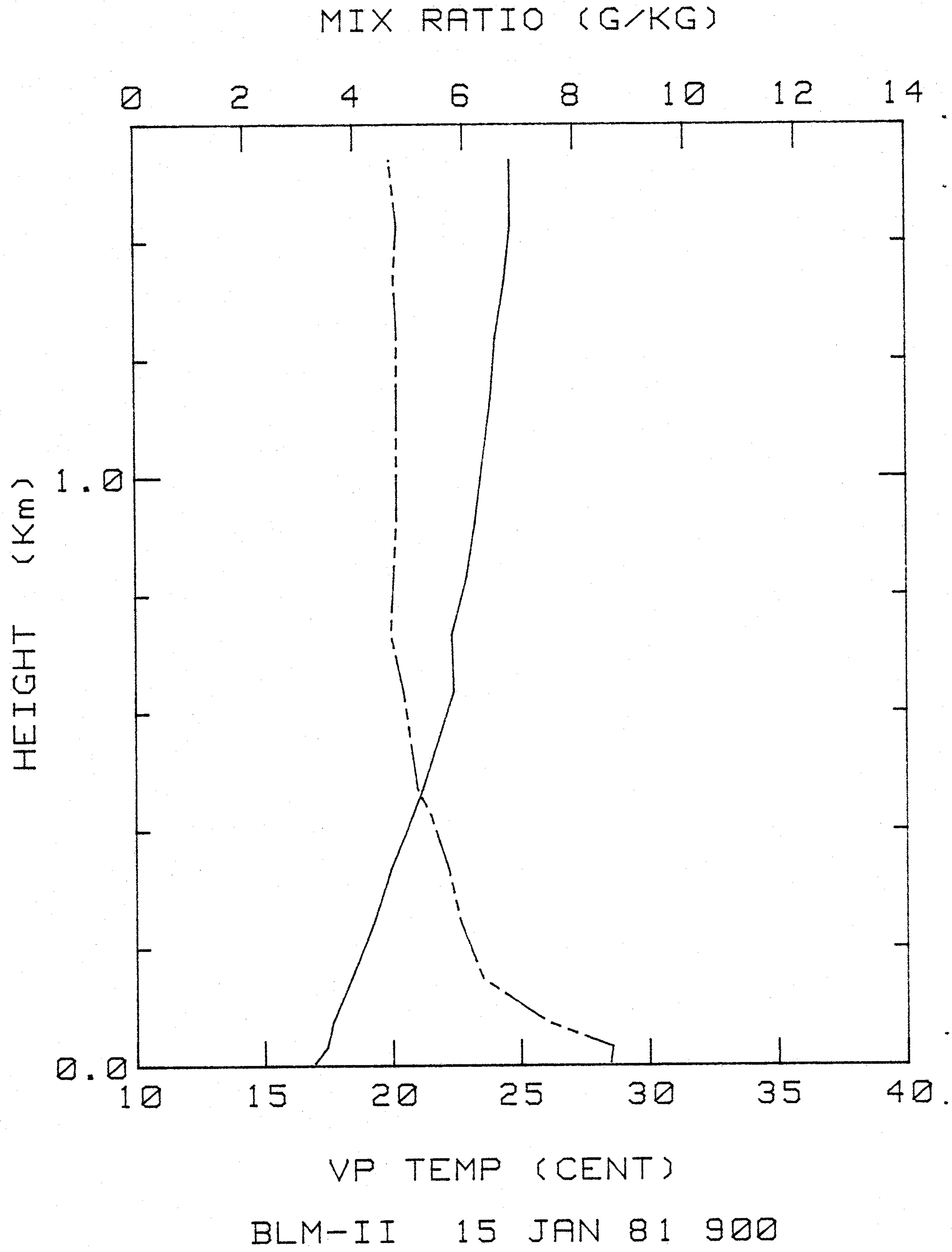

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40.
VP TEMP (CENT)
BLM-II 15 JAN 81 900

Figure 4k

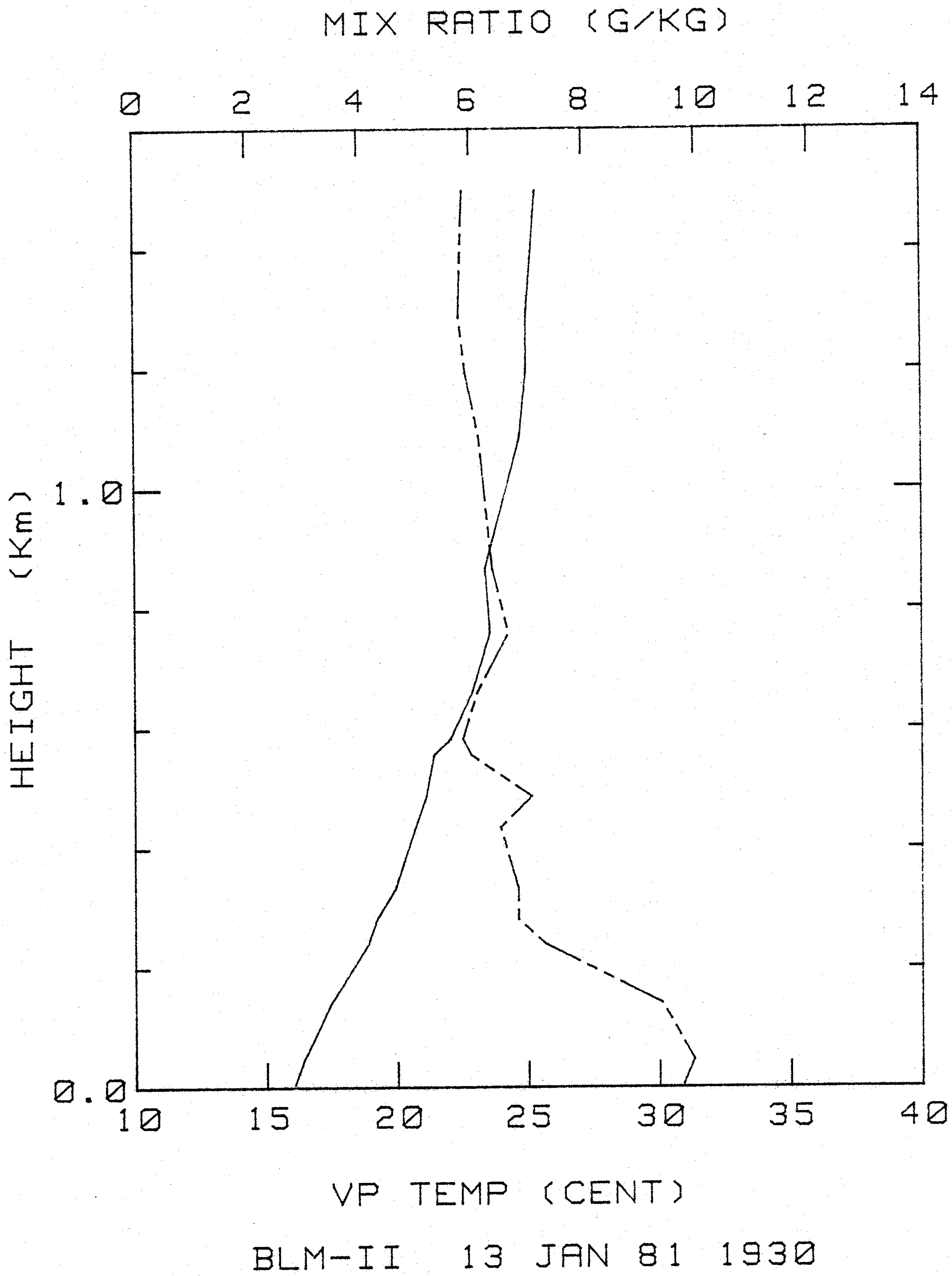

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-II 13 JAN 81 1930

Figure 41

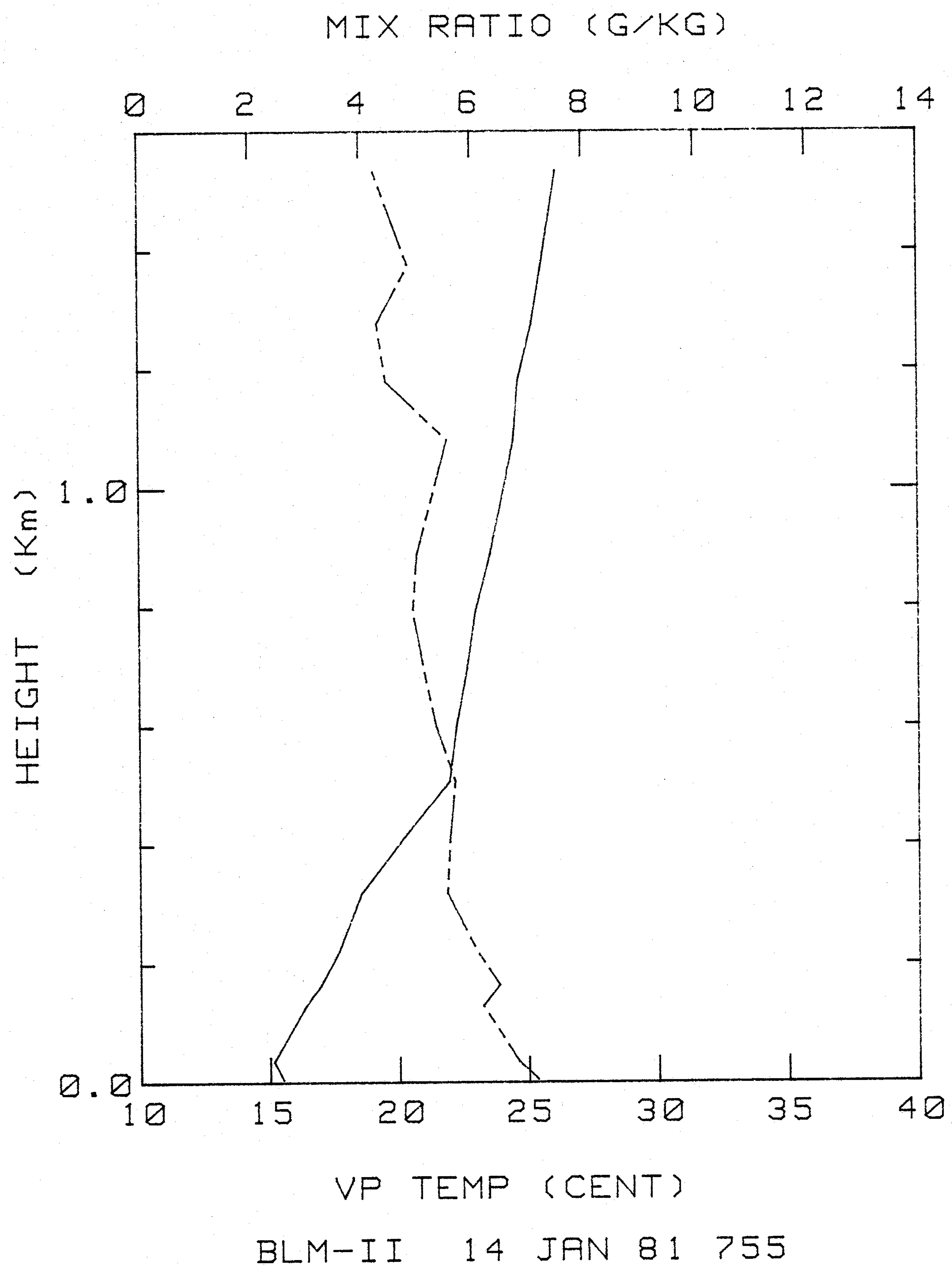

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 14 JAN 81 755

Figure 4m

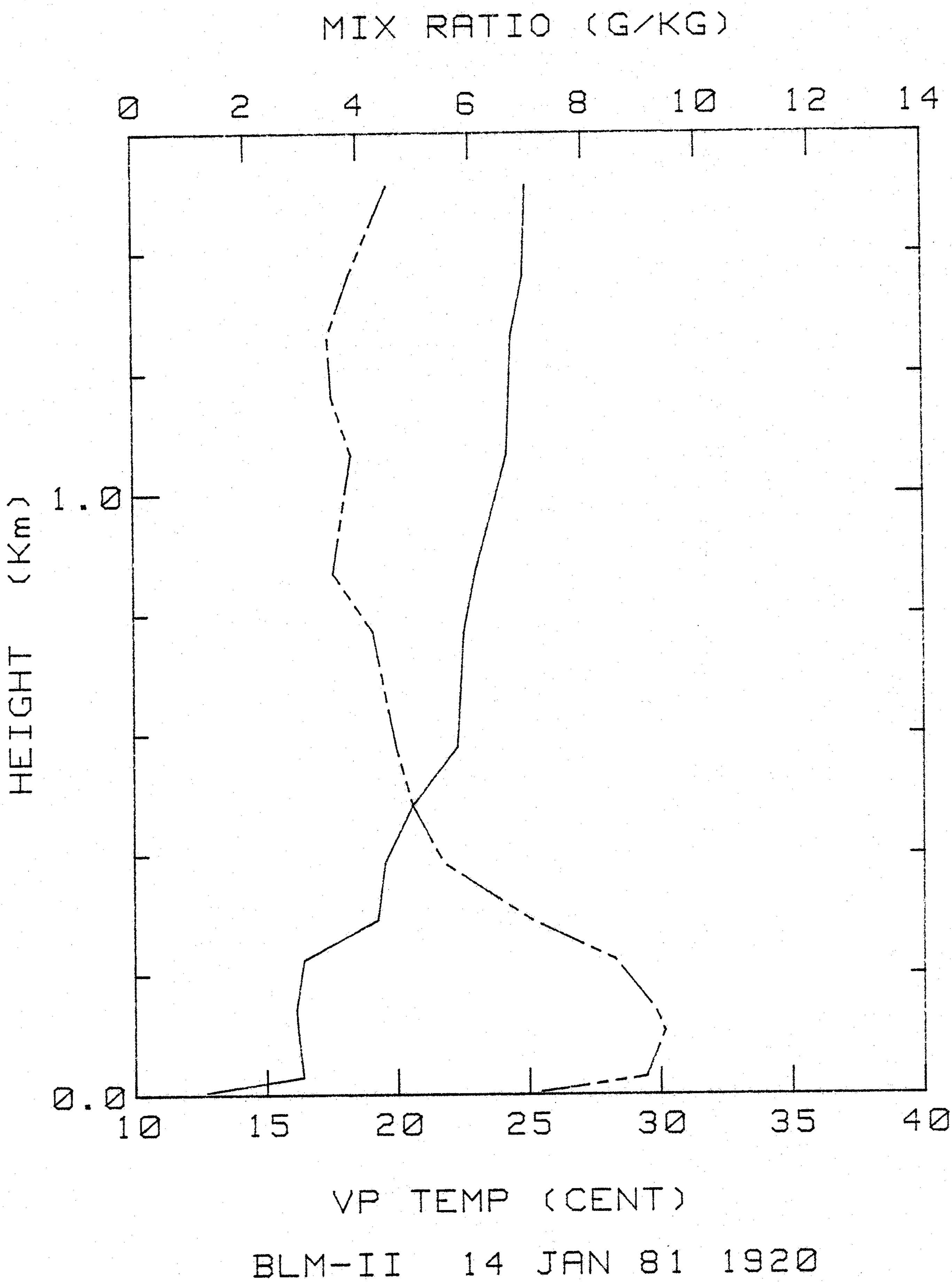

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 14 JAN 81 1920

Figure 4n

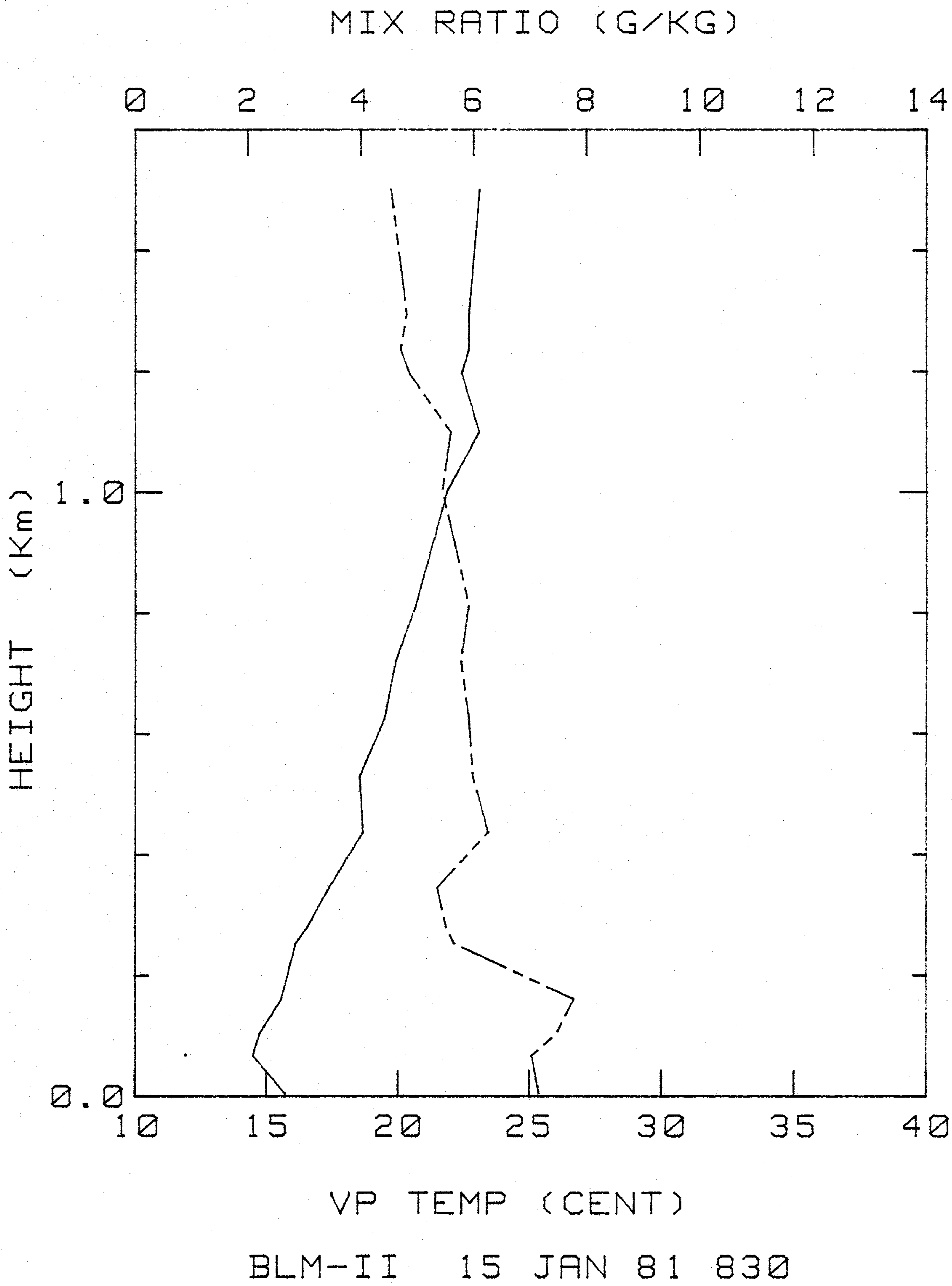

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-II 15 JAN 81 830

Figure 4o

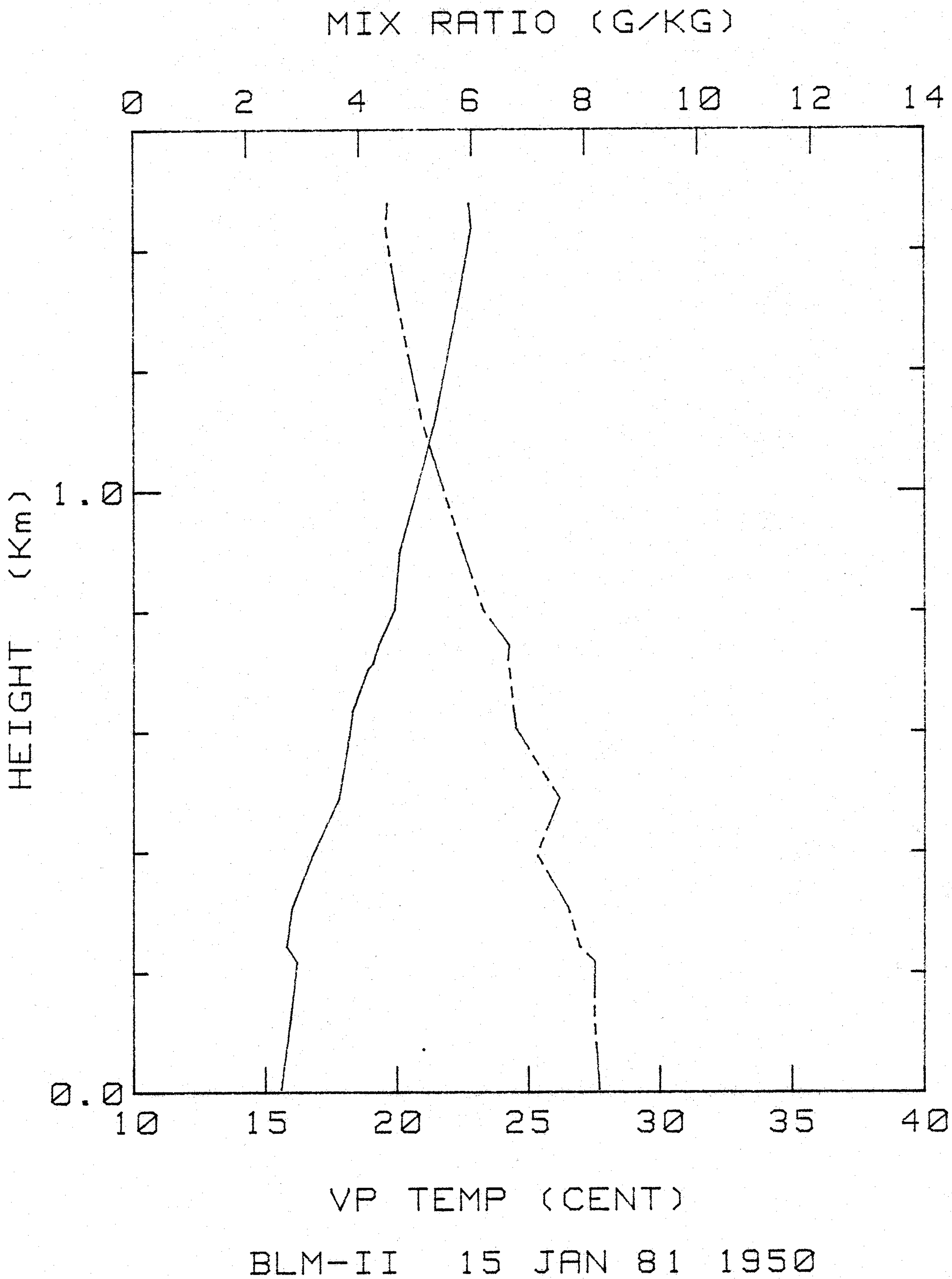

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 15 JAN 81 1950

Figure 4p

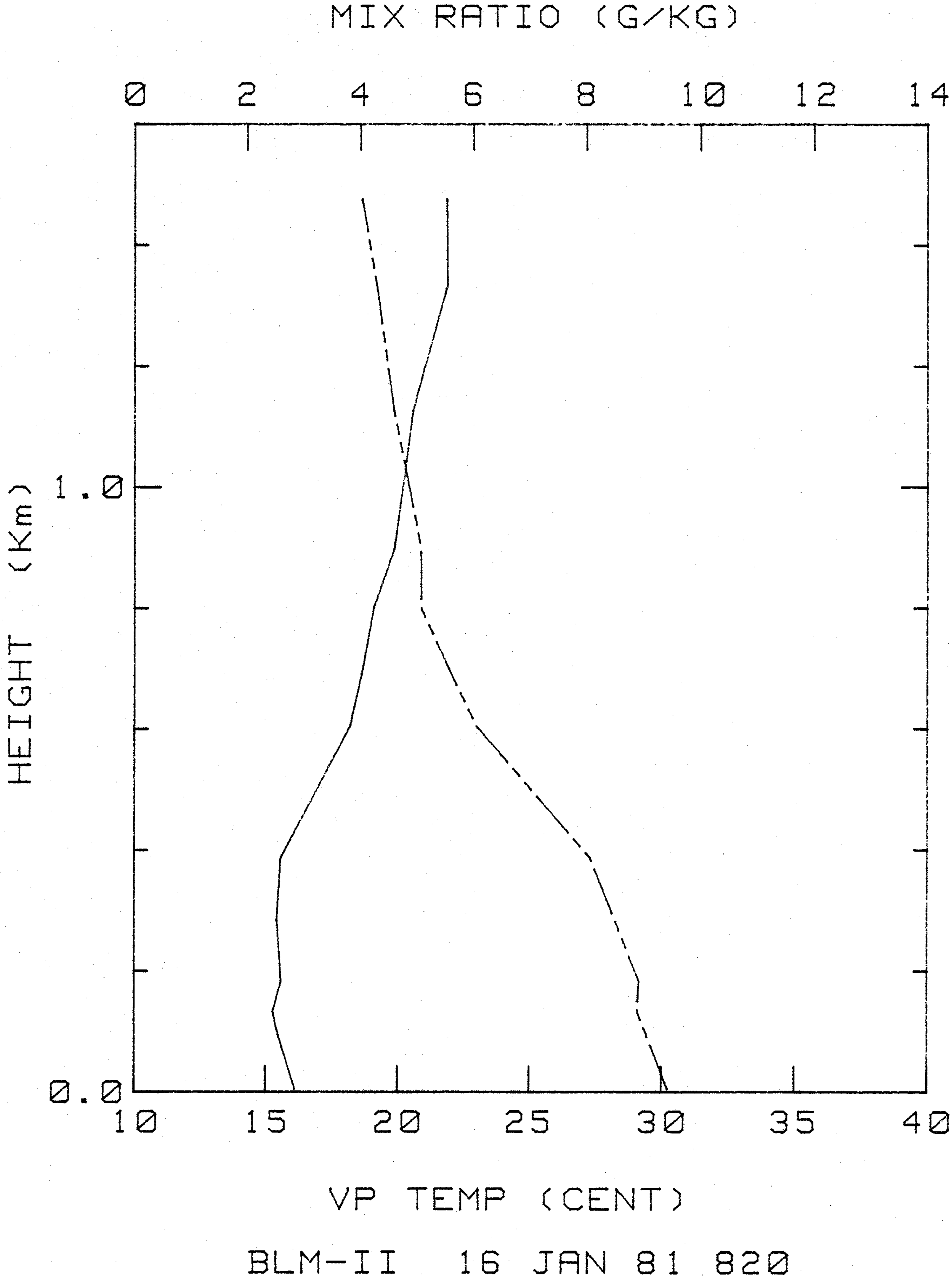
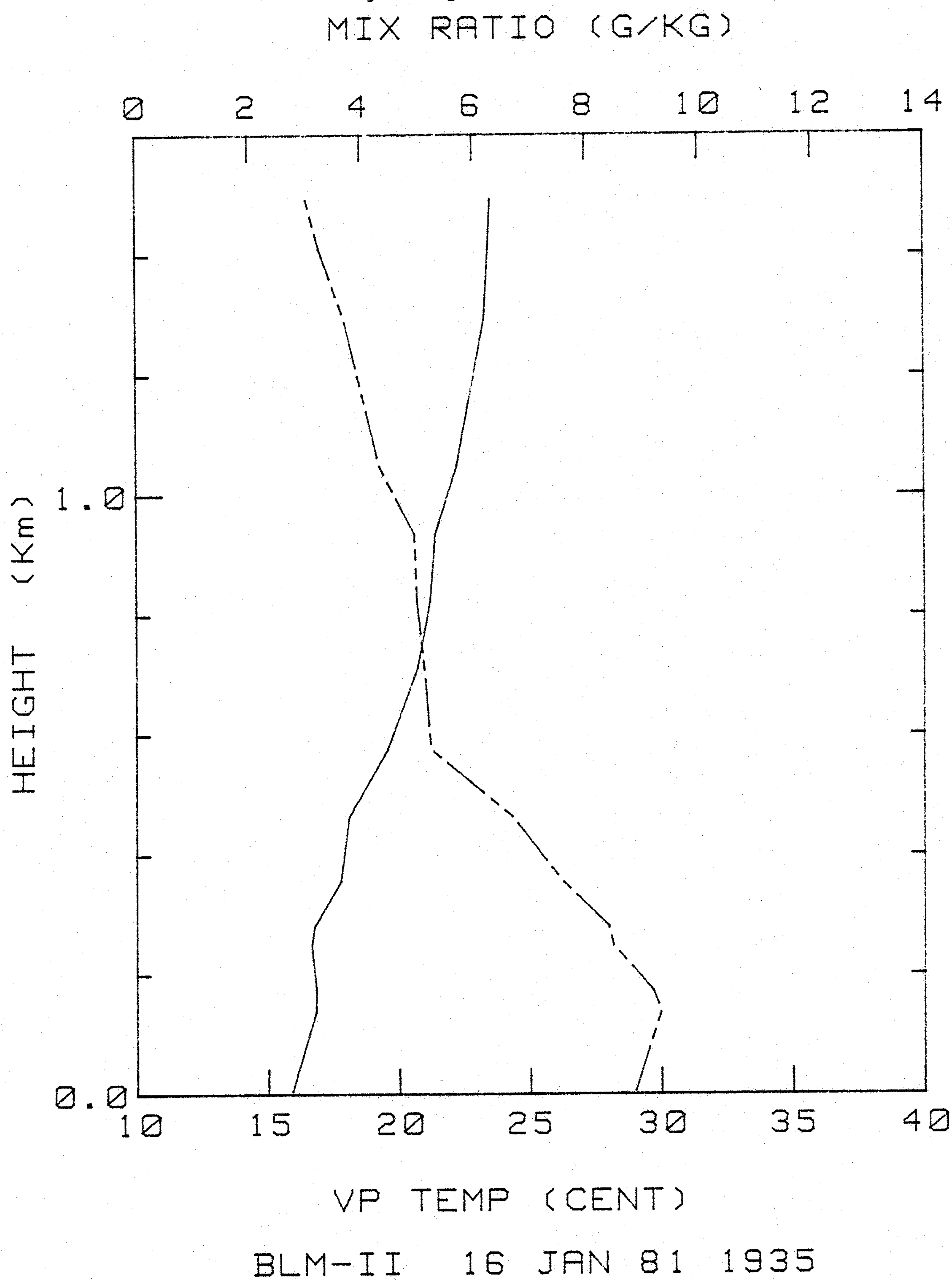

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-II 16 JAN 81 820

Figure 4q


MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-II 16 JAN 81 1935

Appendix A. BLM-1 Radiosonde and Mixed Layer Parameter Results

The radiosonde results for BLM-1 have been reprocessed by computer in order to put them in the same format as used here for BLM-II results. Also the mixed layer parameters have been calculated. These results are shown in Figures 5.

Figure 5al

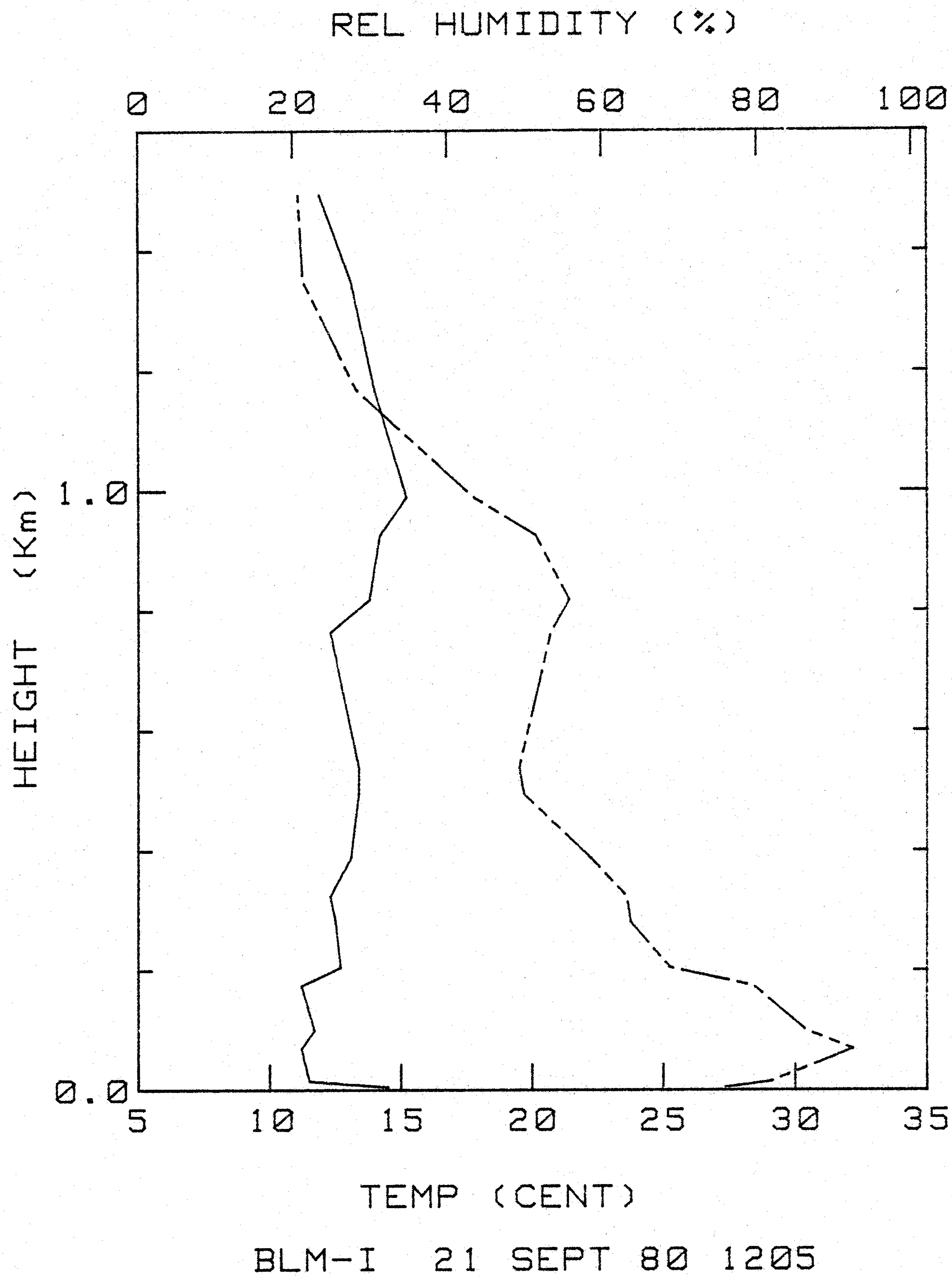

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 21 SEPT 80 1205

Figure 5a2

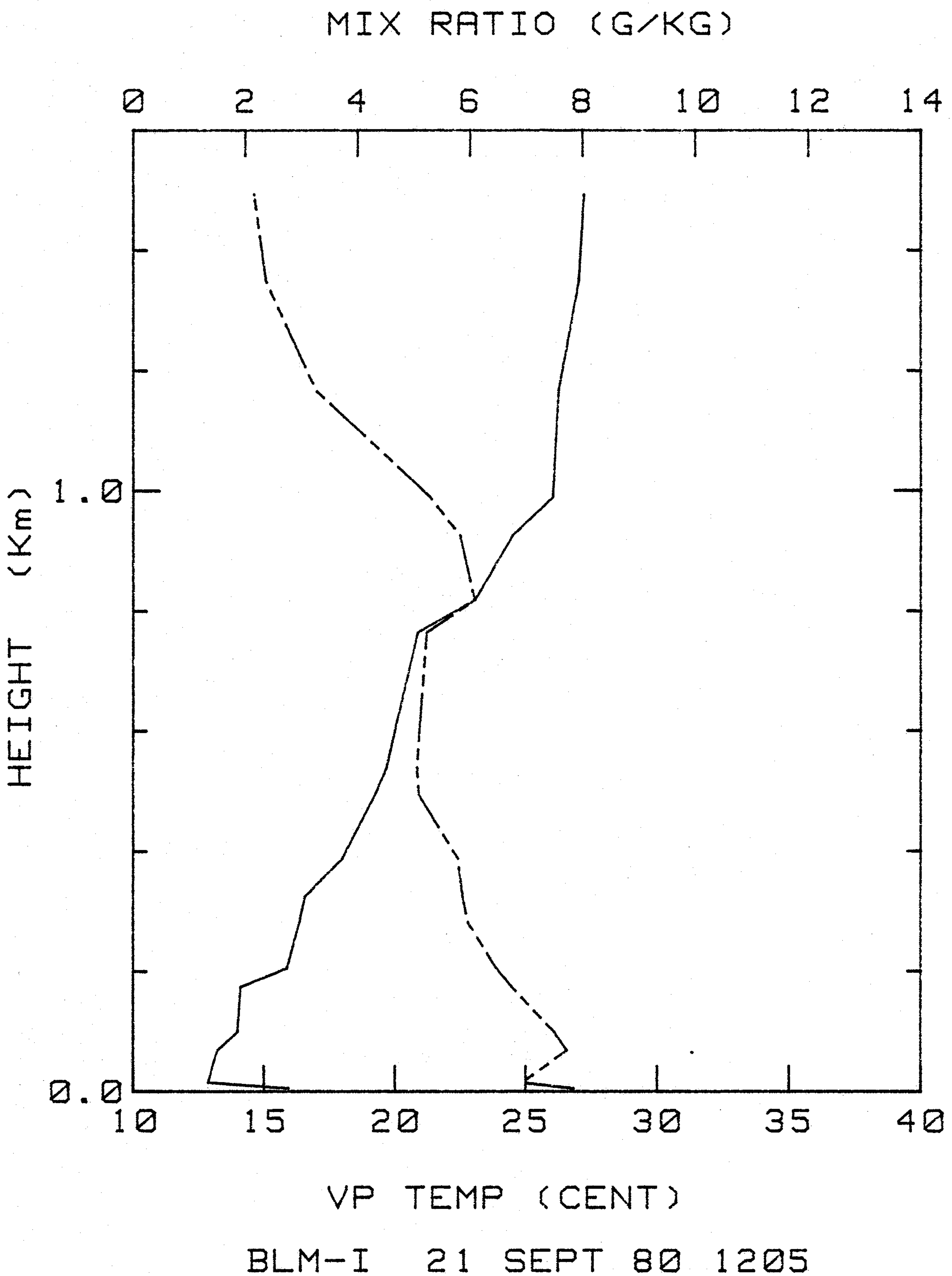
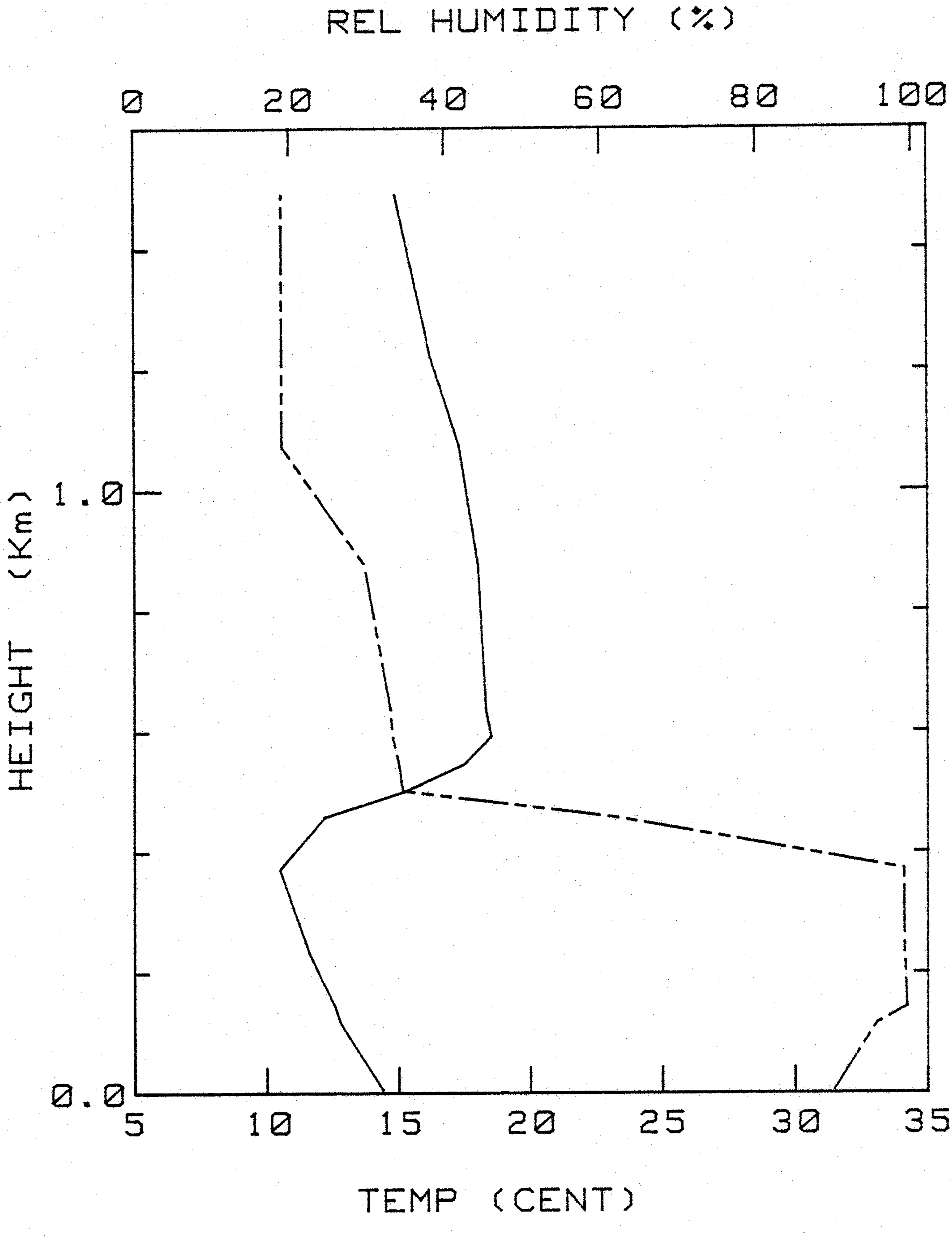

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 21 SEPT 80 1205

Figure 5b1



BLM-I 22 SEPT 80 15

Figure 5b2

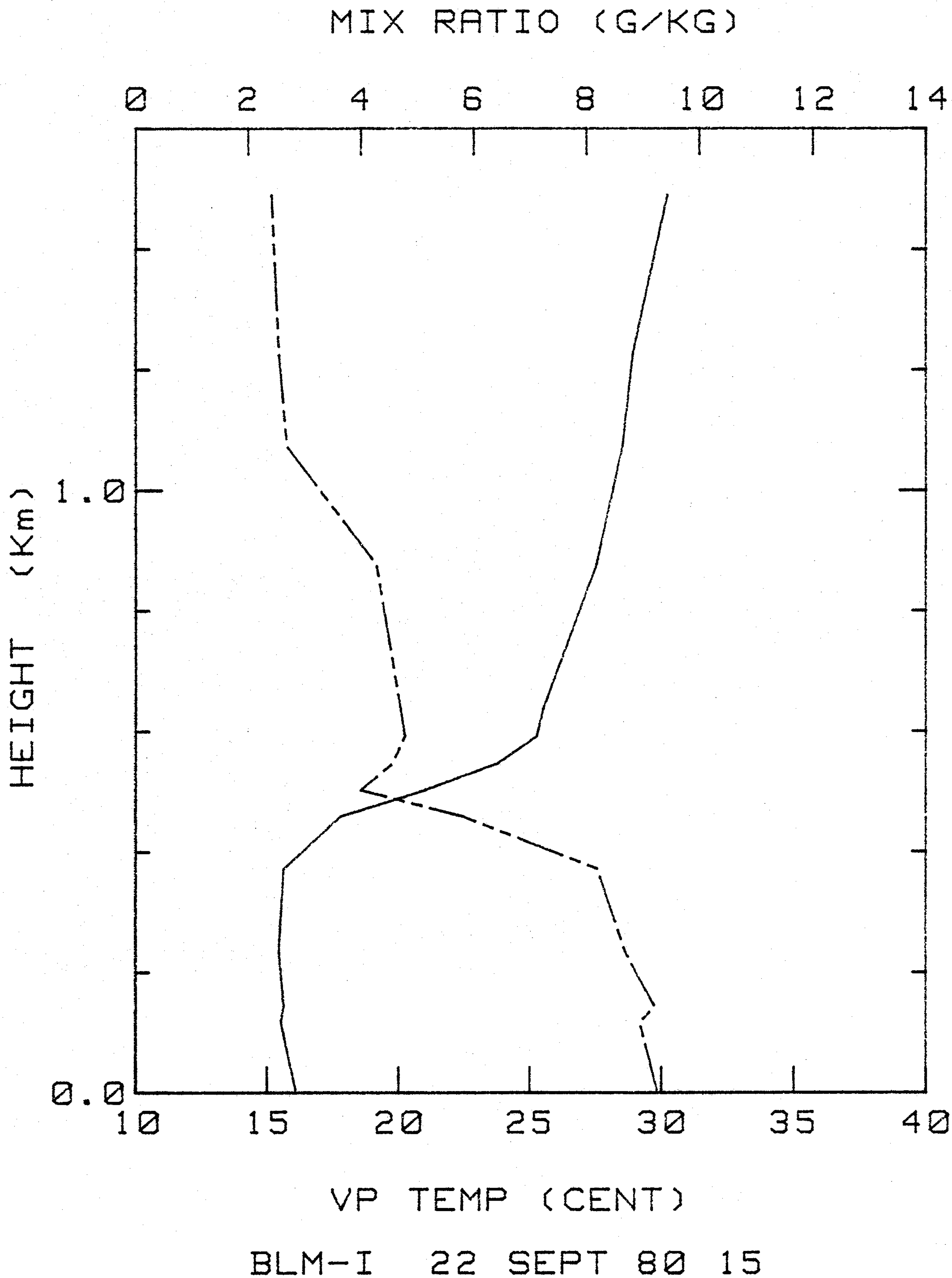

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-I 22 SEPT 80 15

Figure 5cl

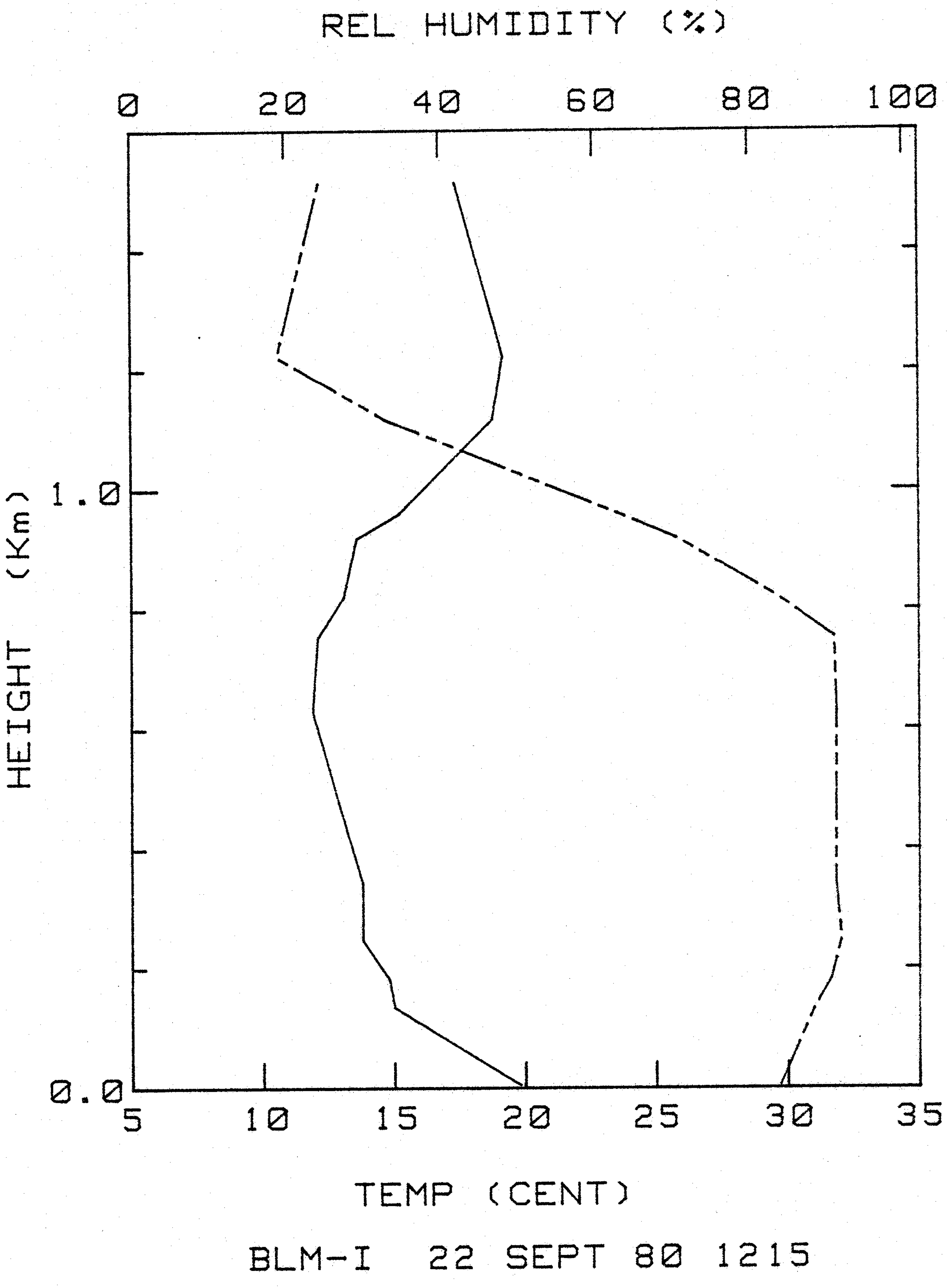

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 22 SEPT 80 1215

Figure 5c2

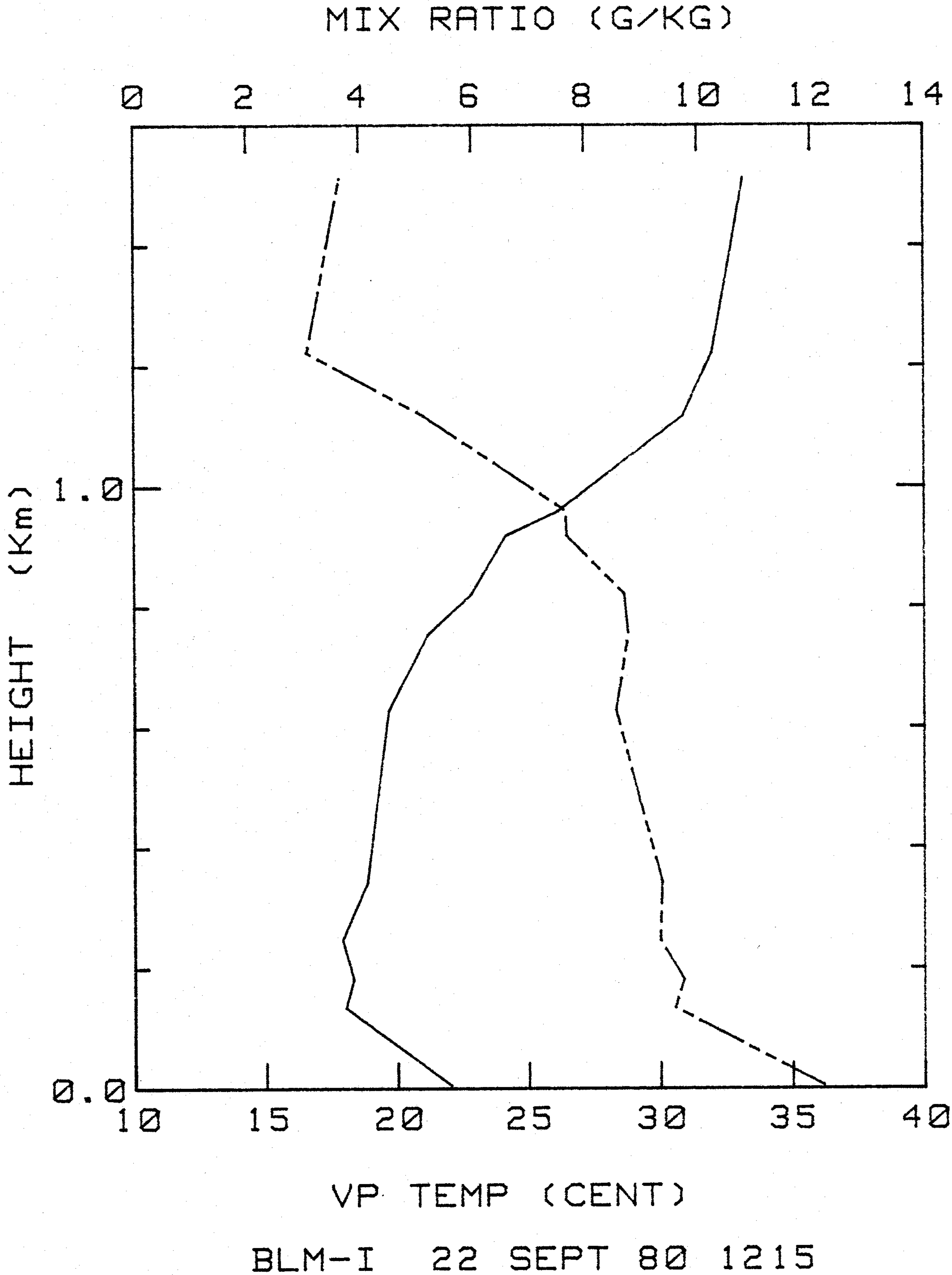

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-I 22 SEPT 80 1215

Figure 5d1

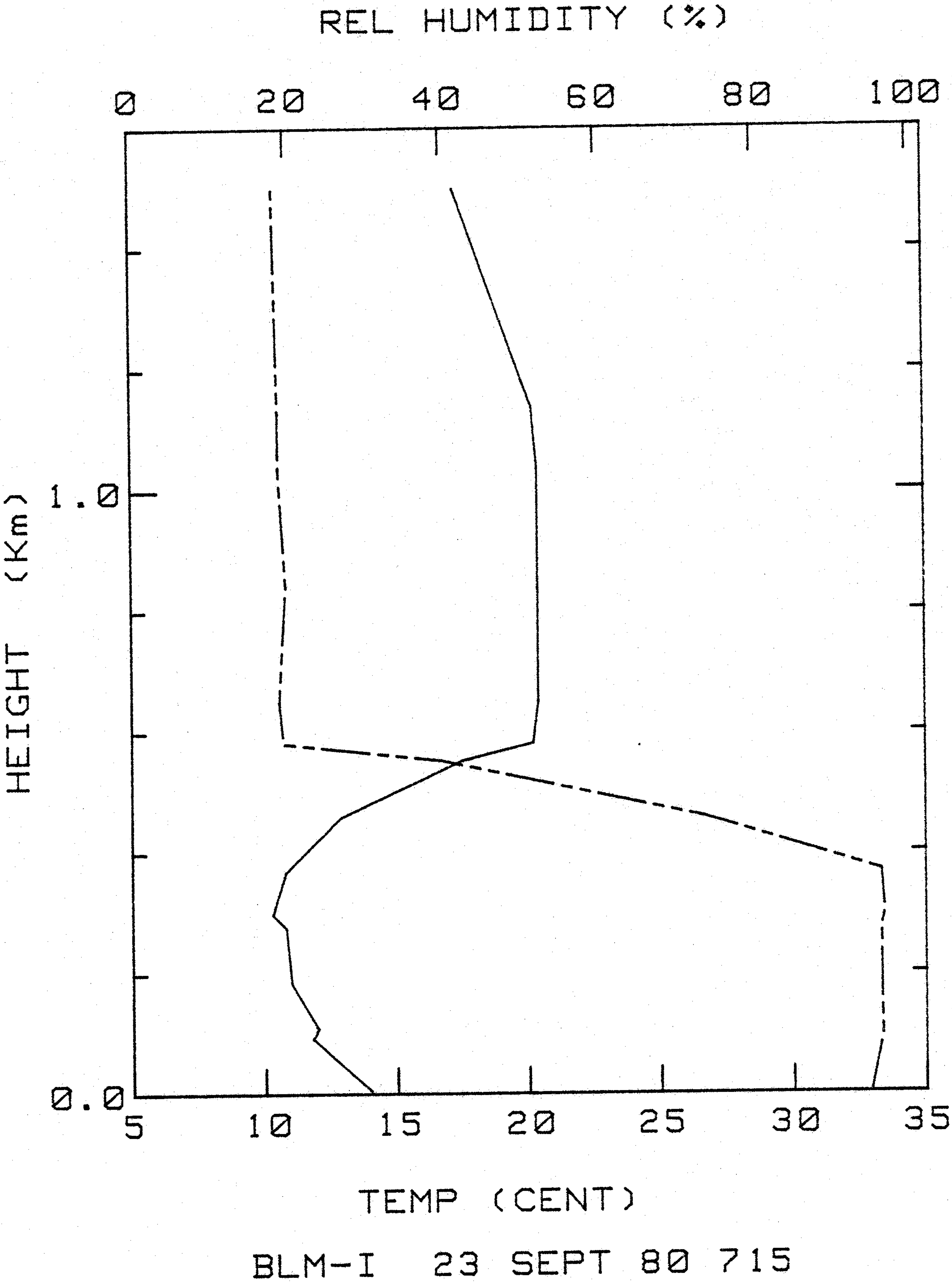

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 23 SEPT 80 715

Figure 5d2

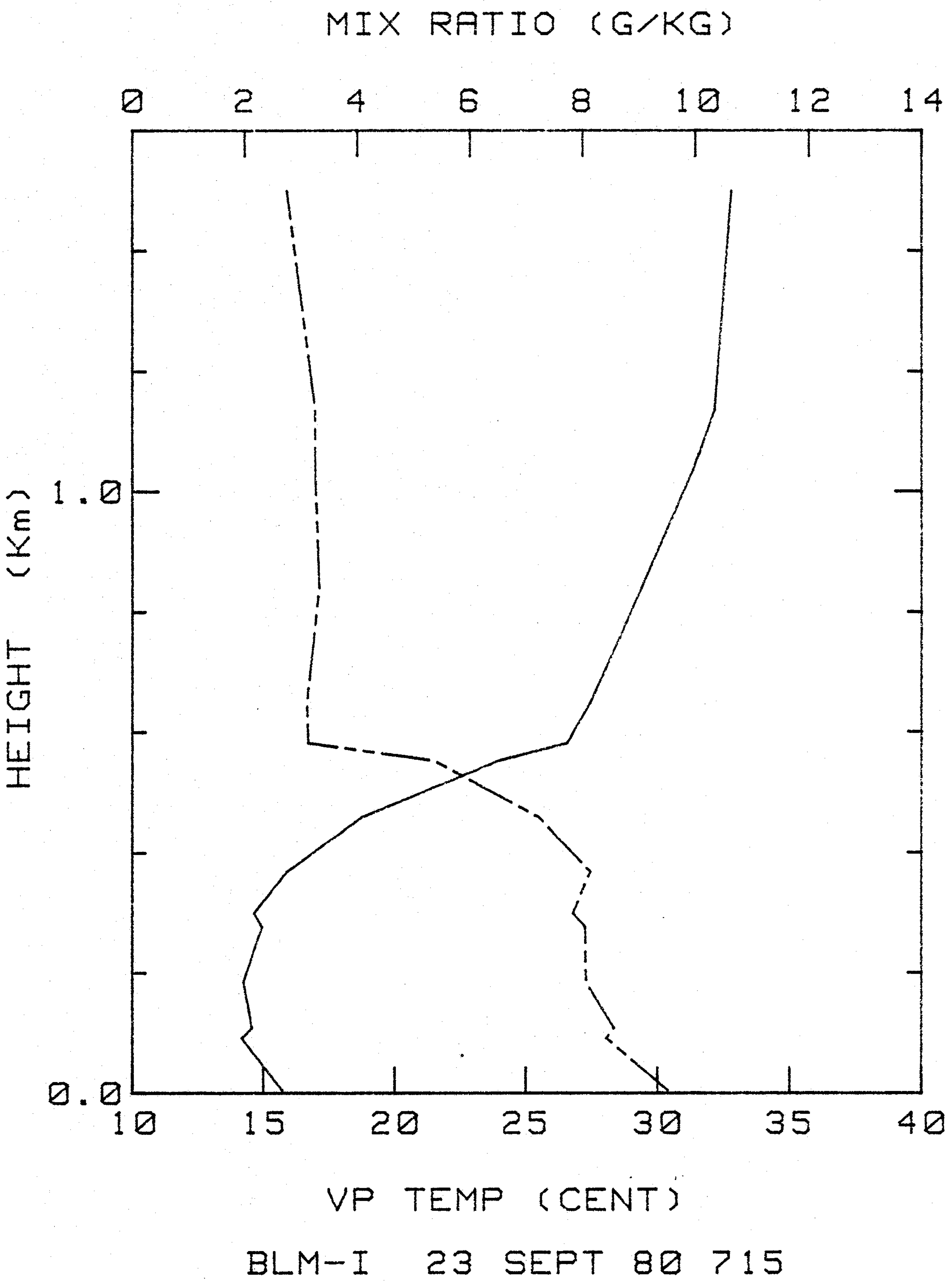
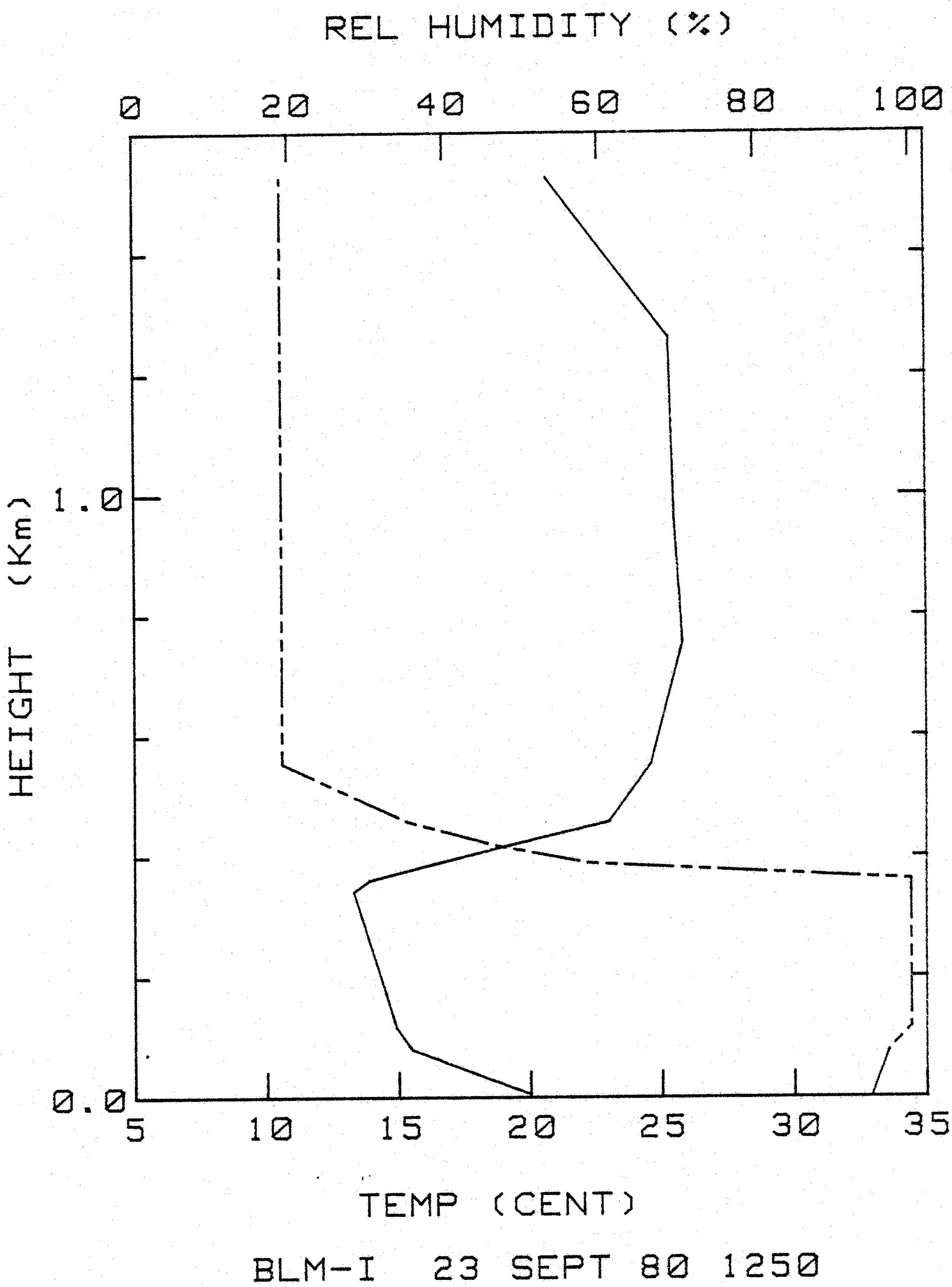
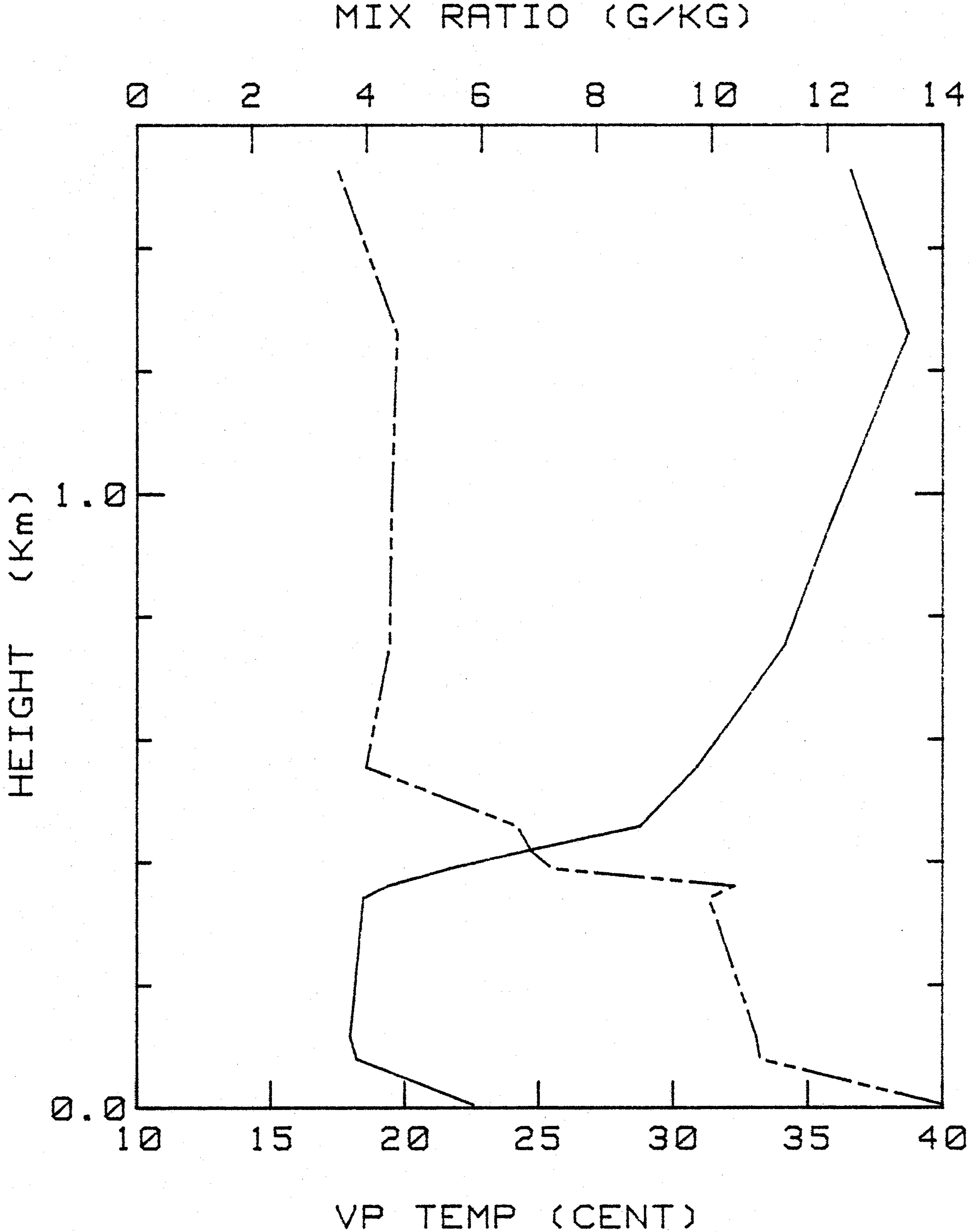

MIX RATIO (G/KG)
0 2 4 6 8 10 12 14
HEIGHT (Km)
1.0
0.0
10 15 20 25 30 35 40
VP TEMP (CENT)
BLM-I 23 SEPT 80 715

Figure 5el



REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 23 SEPT 80 1250

Figure 5e2



BLM-I 23 SEPT 80 1250

Figure 5f1

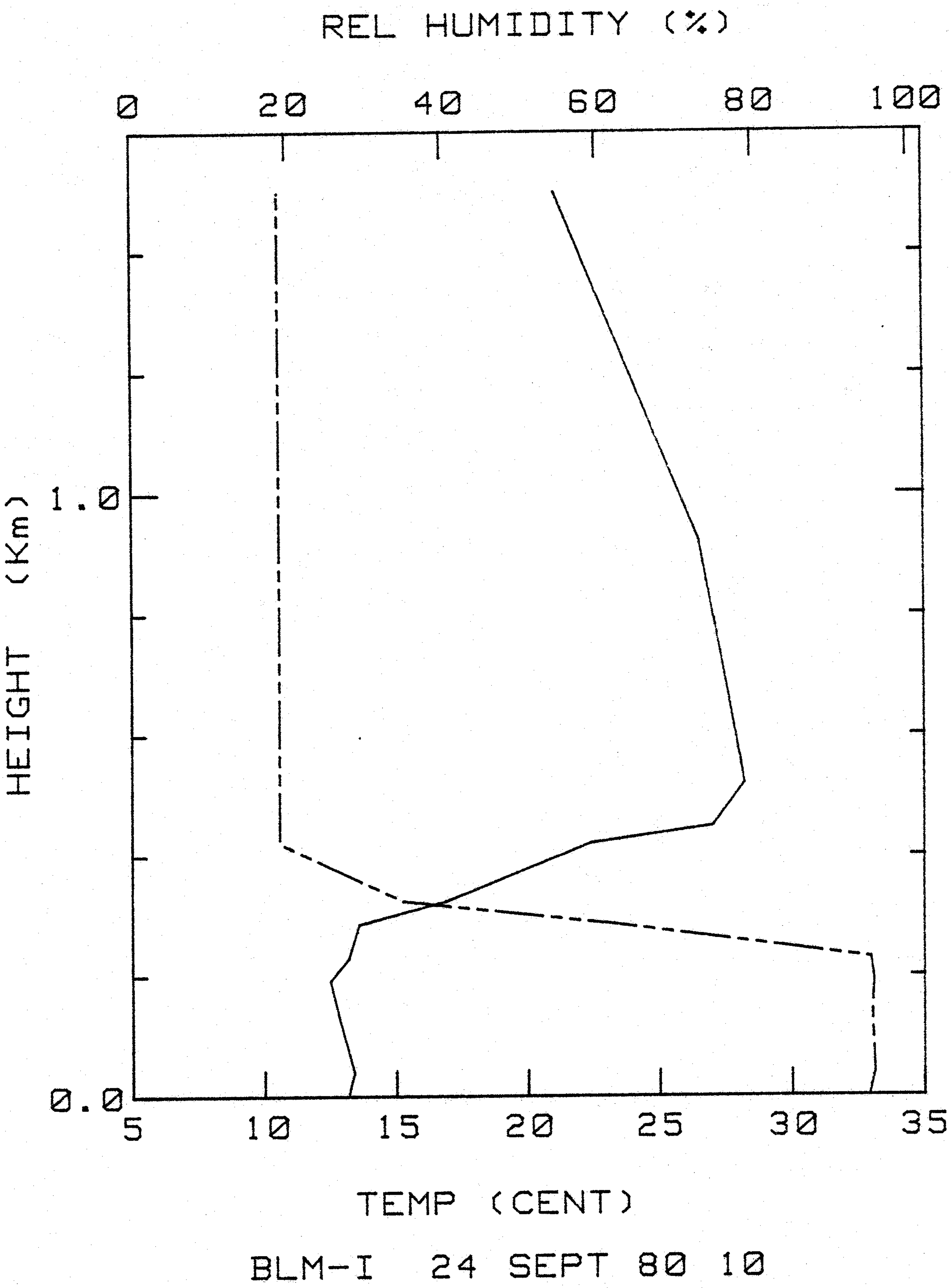

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 24 SEPT 80 10

Figure 5f2

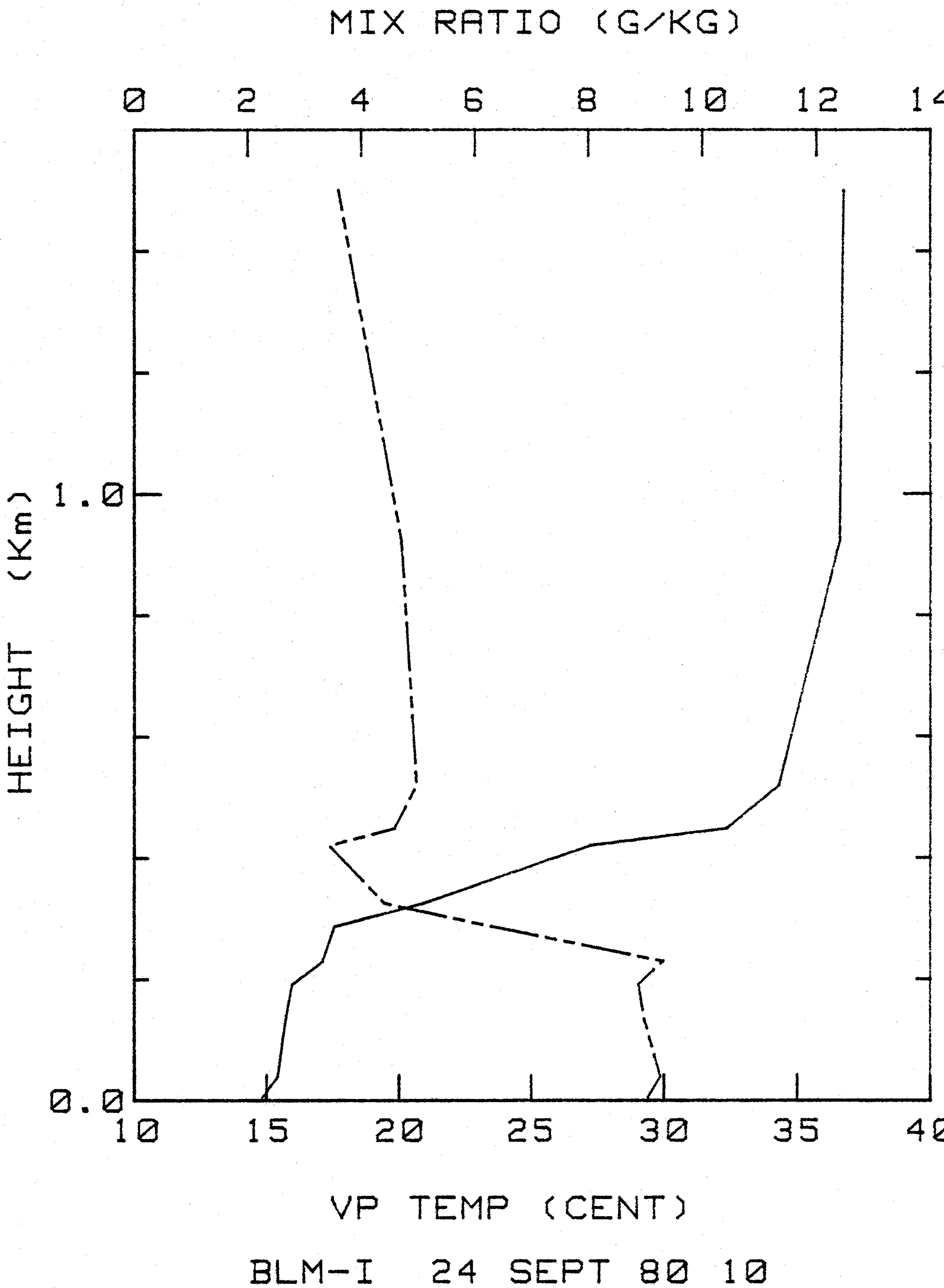

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 24 SEPT 80 10

Figure 5g1

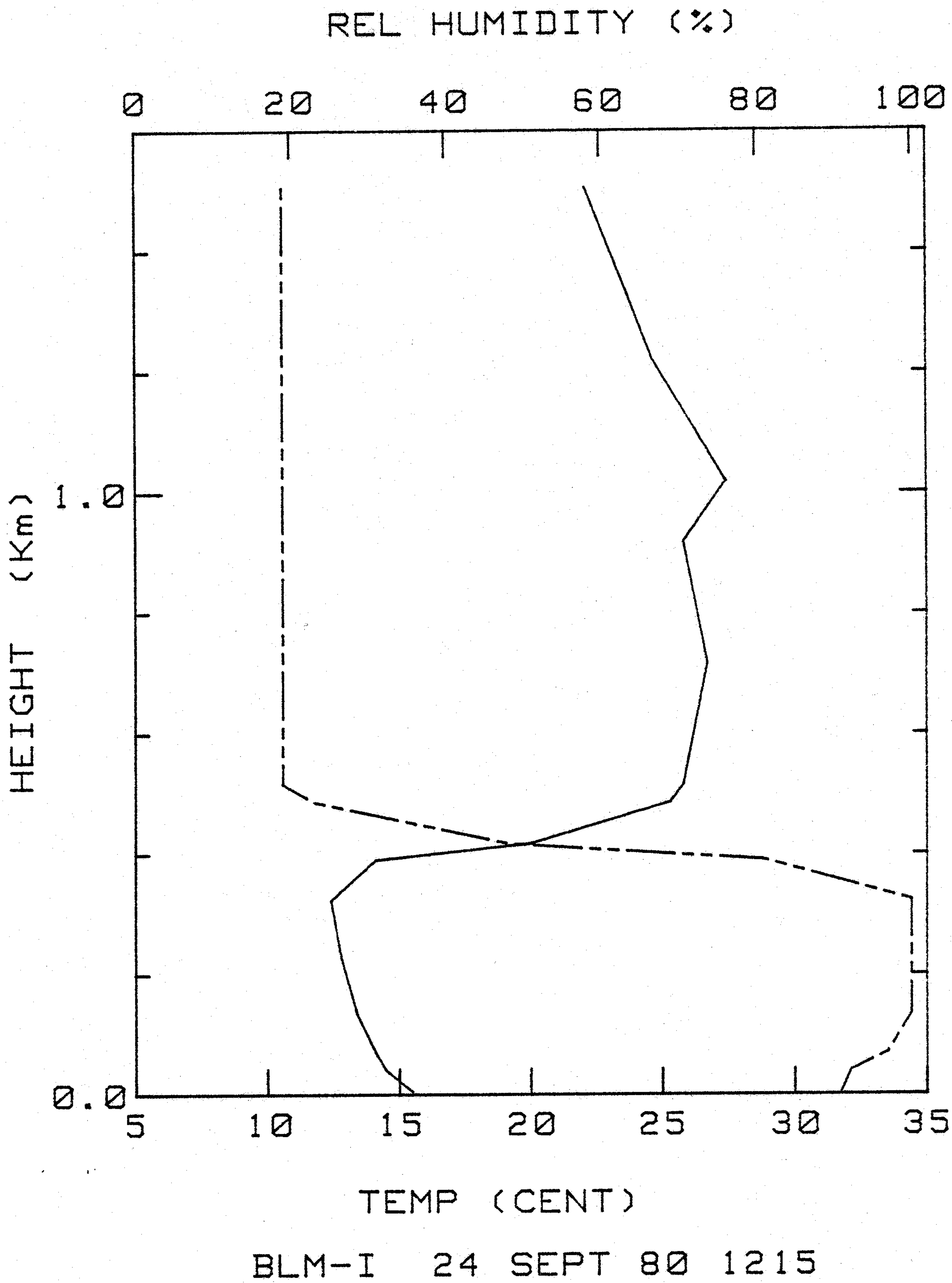

REL HUMIDITY (%)
0 20 40 60 80 100
HEIGHT (Km)
1.0
0.0
5 10 15 20 25 30 35
TEMP (CENT)
BLM-I 24 SEPT 80 1215

Figure 5g2

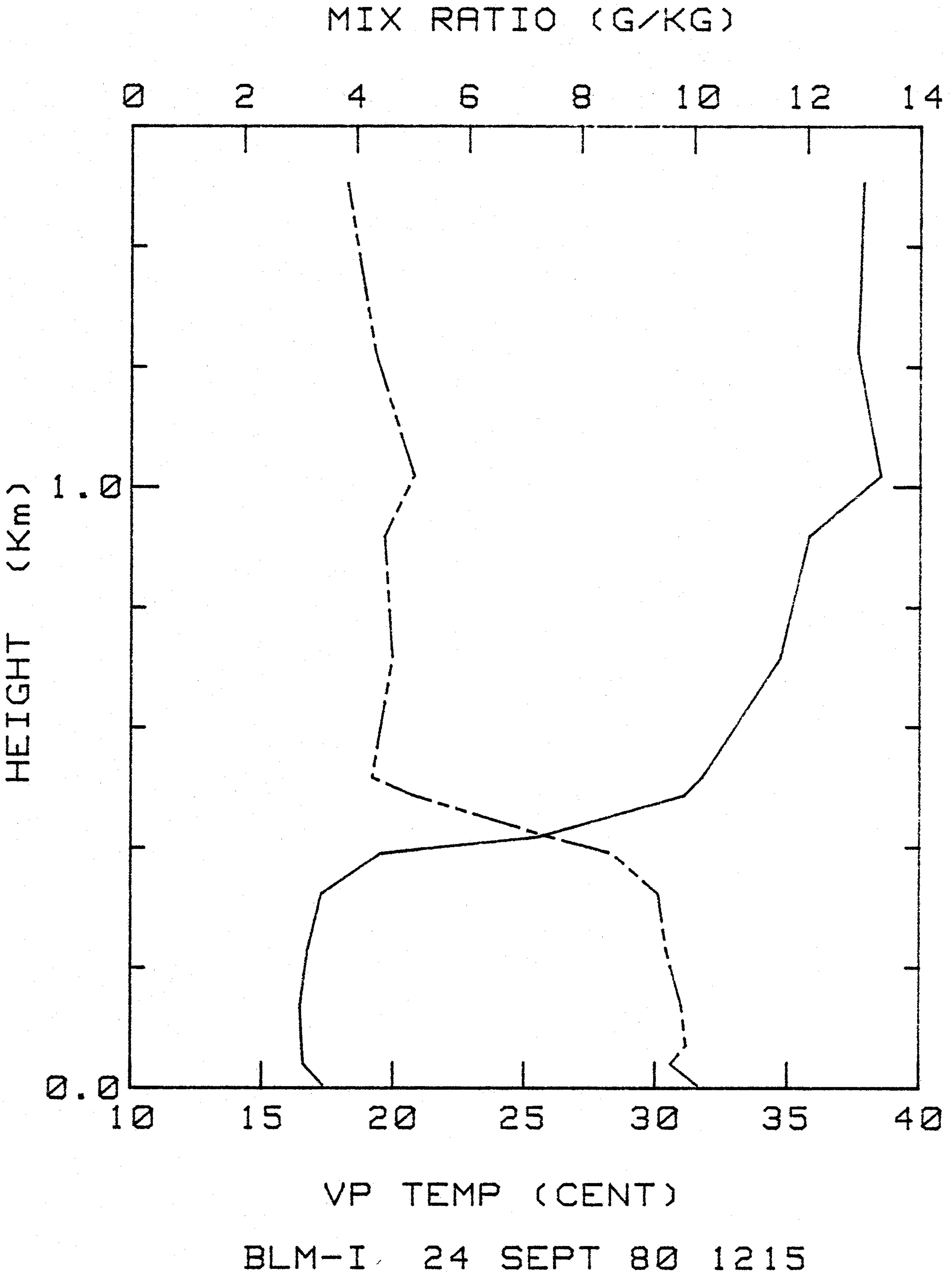

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 24 SEPT 80 1215

Figure 5h1

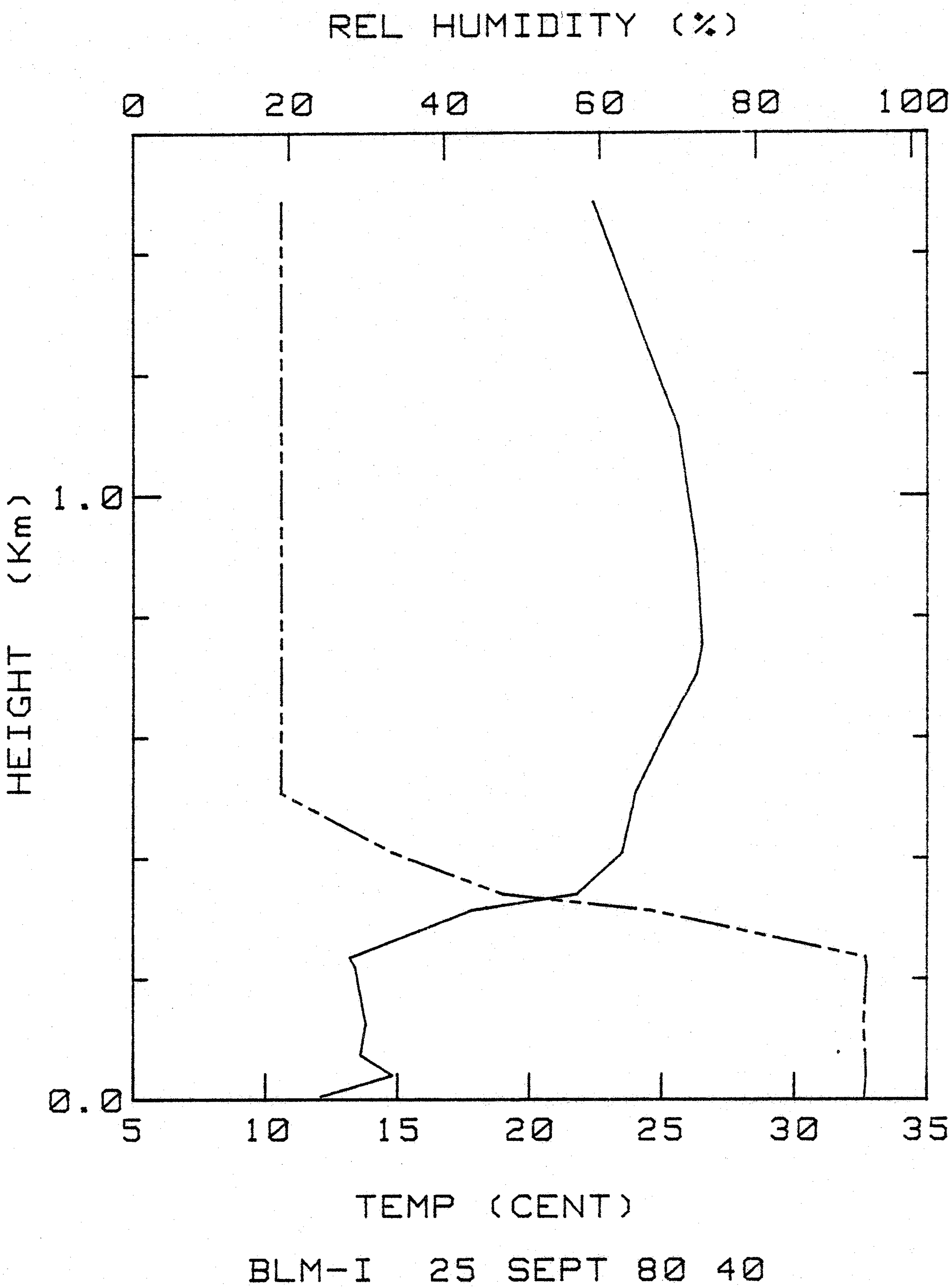
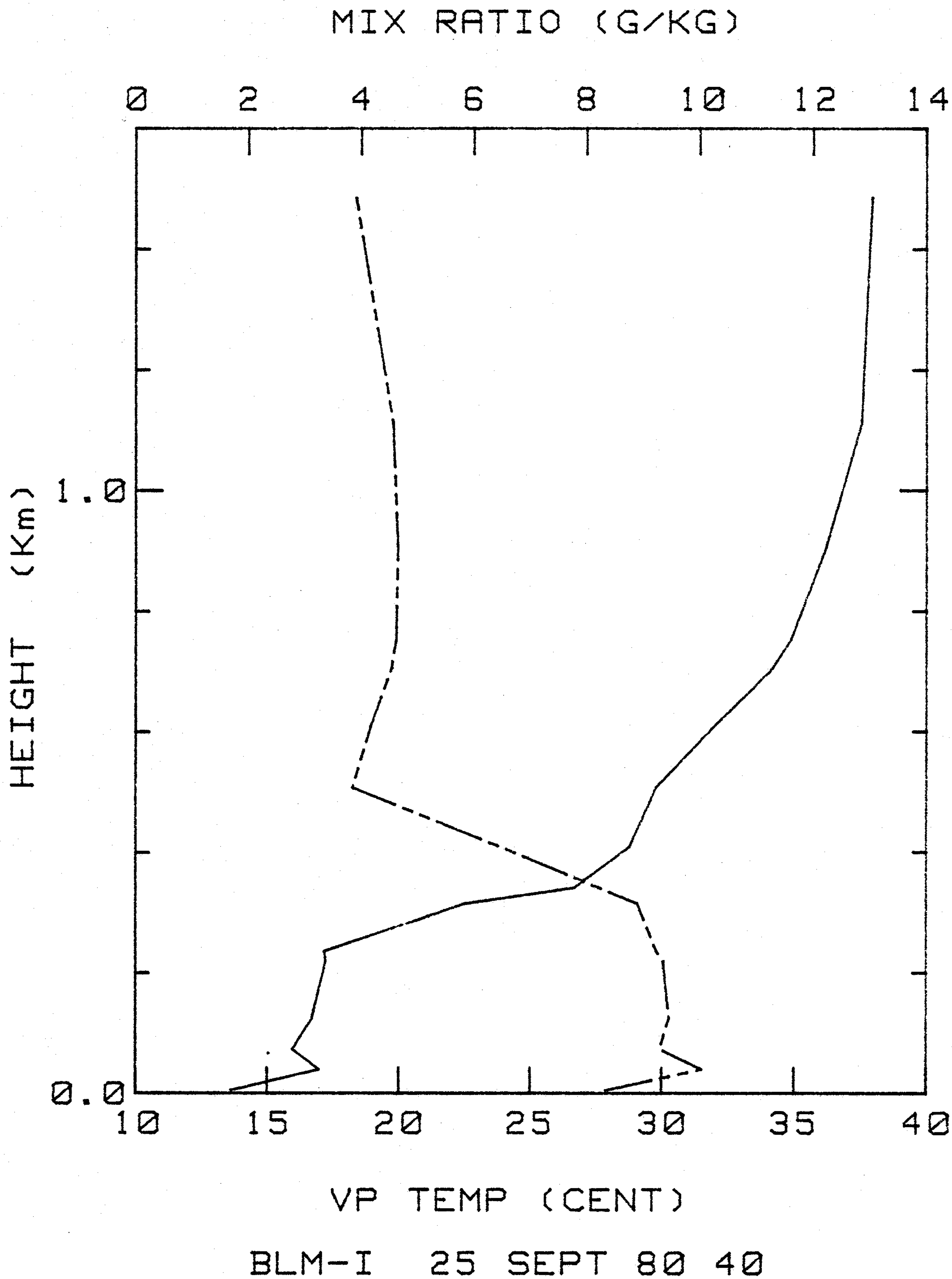

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 25 SEPT 80 40

Figure 5h2



MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 25 SEPT 80 40

Figure 5il

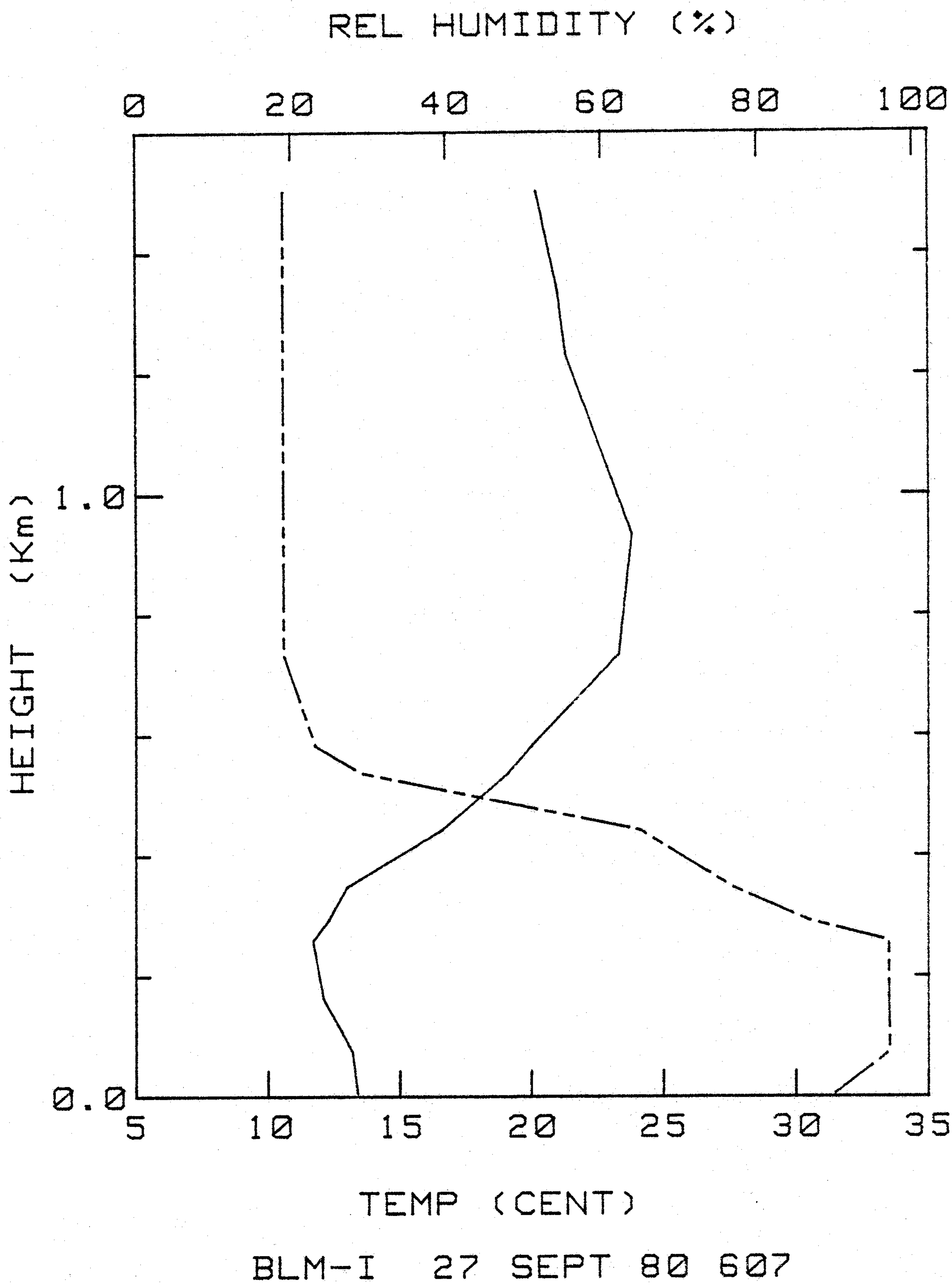
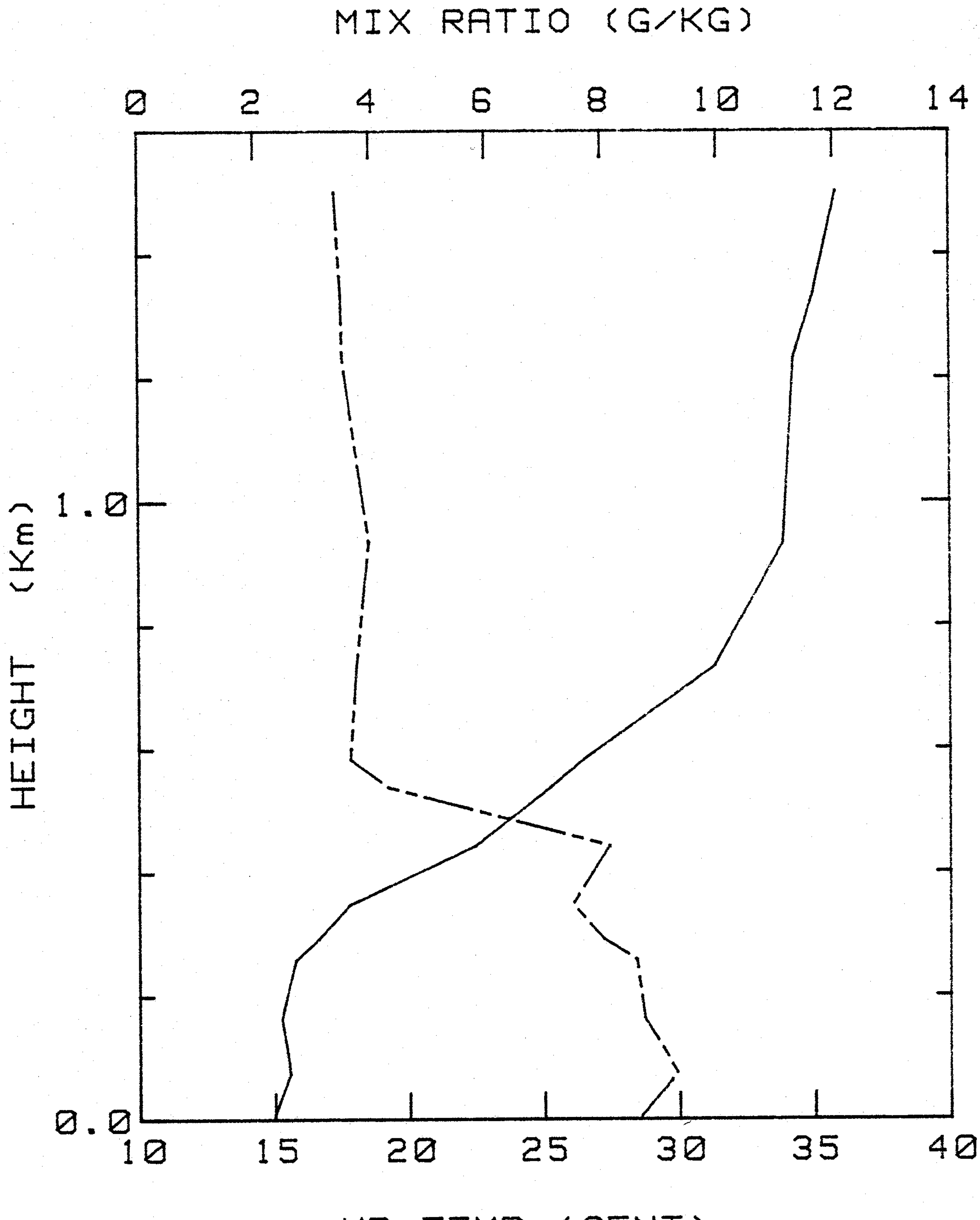
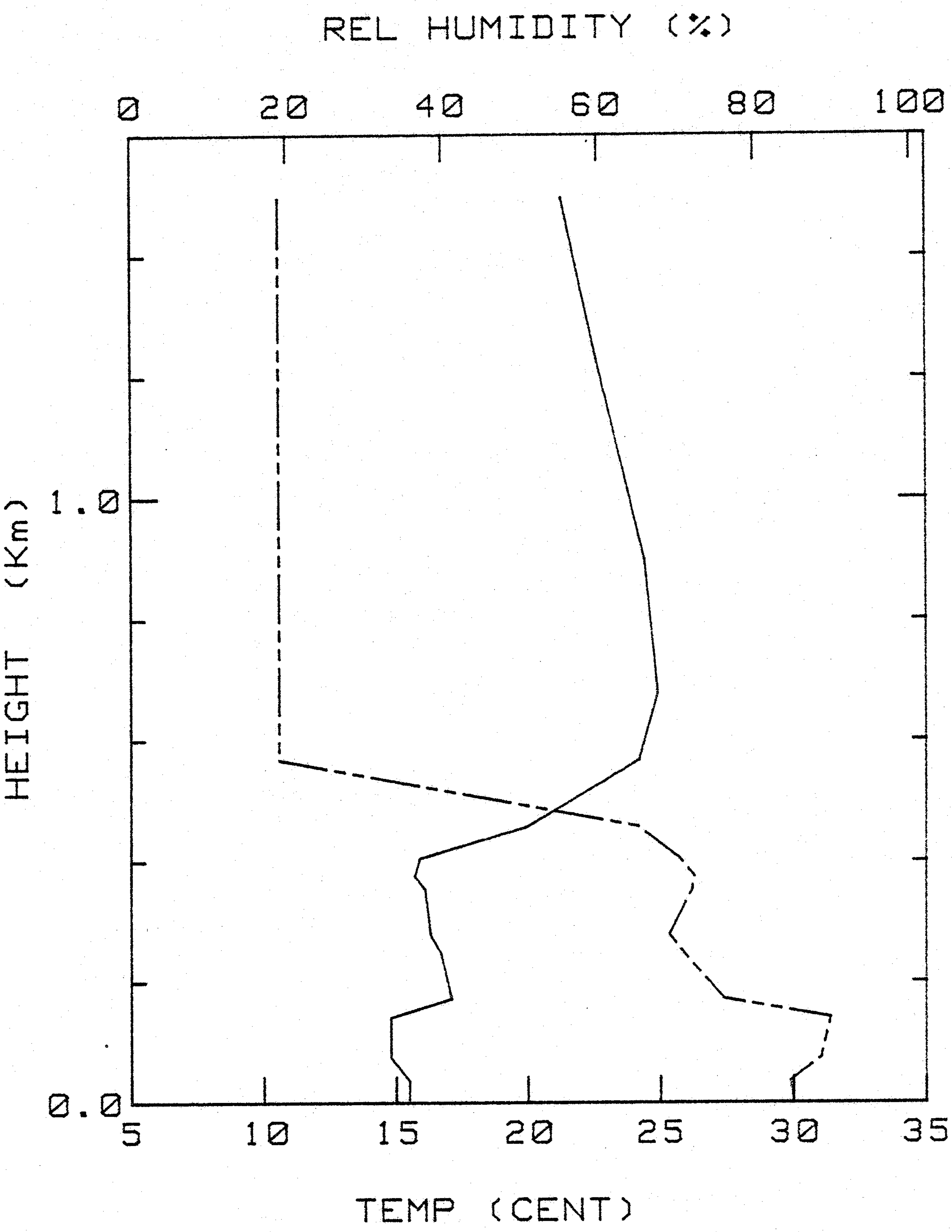

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 27 SEPT 80 607

Figure 5i2



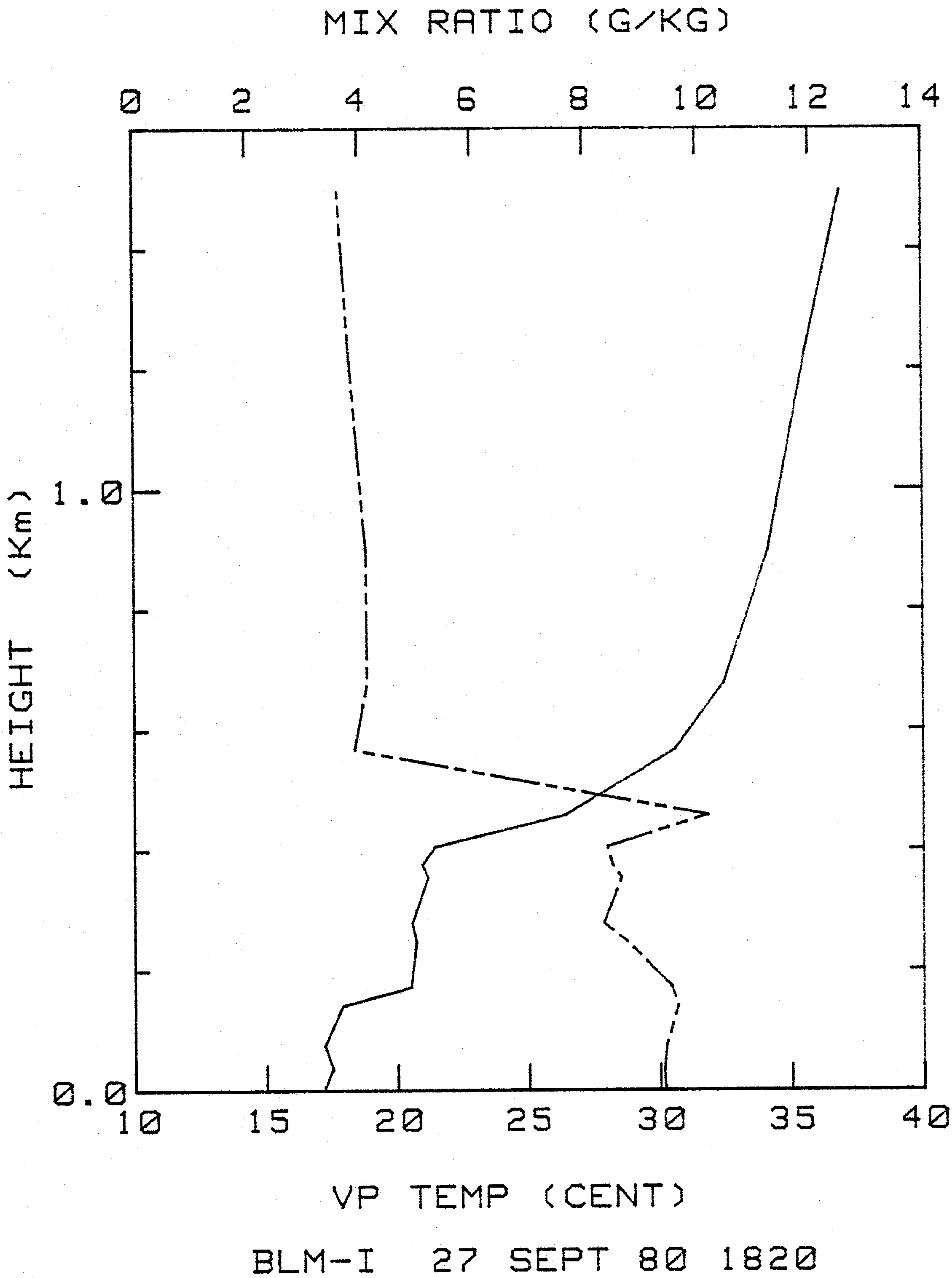
BLM-I 27 SEPT 80 607

Figure 5jl



BLM-I 27 SEPT 80 1820

Figure 5j2



MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 27 SEPT 80 1820

Figure 5k1

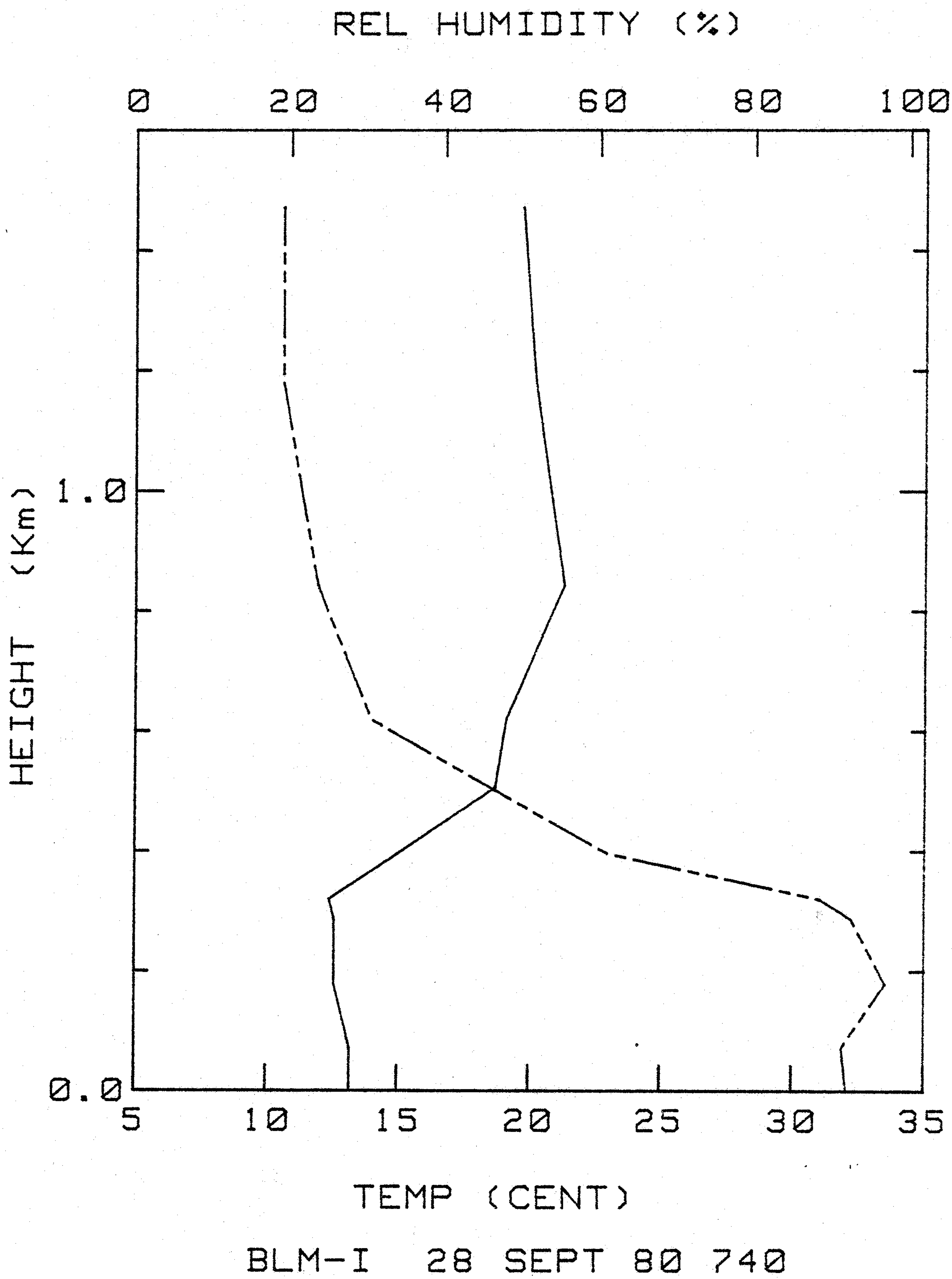
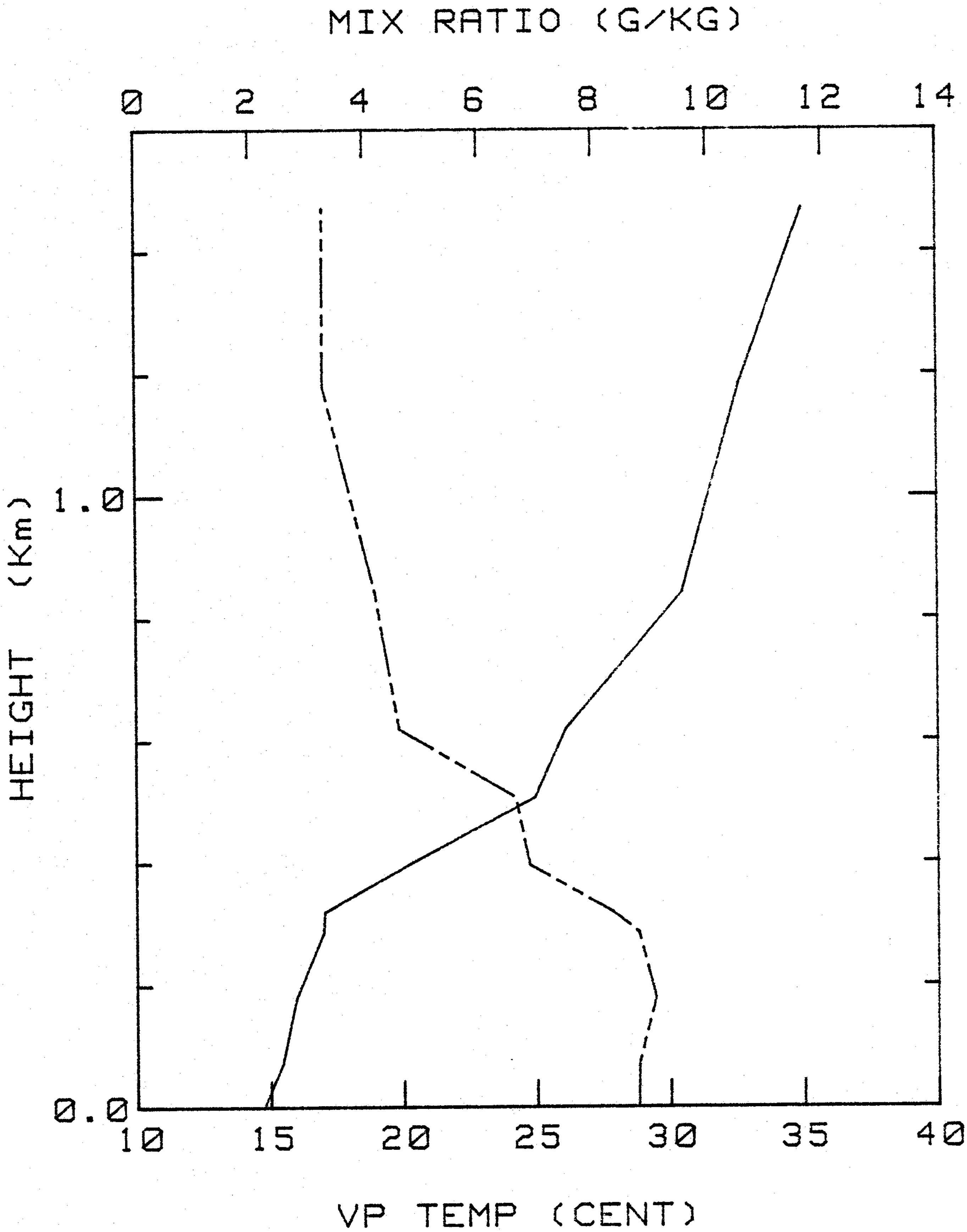

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 28 SEPT 80 740

Figure 5k2



BLM-I 28 SEPT 80 740

Figure 511

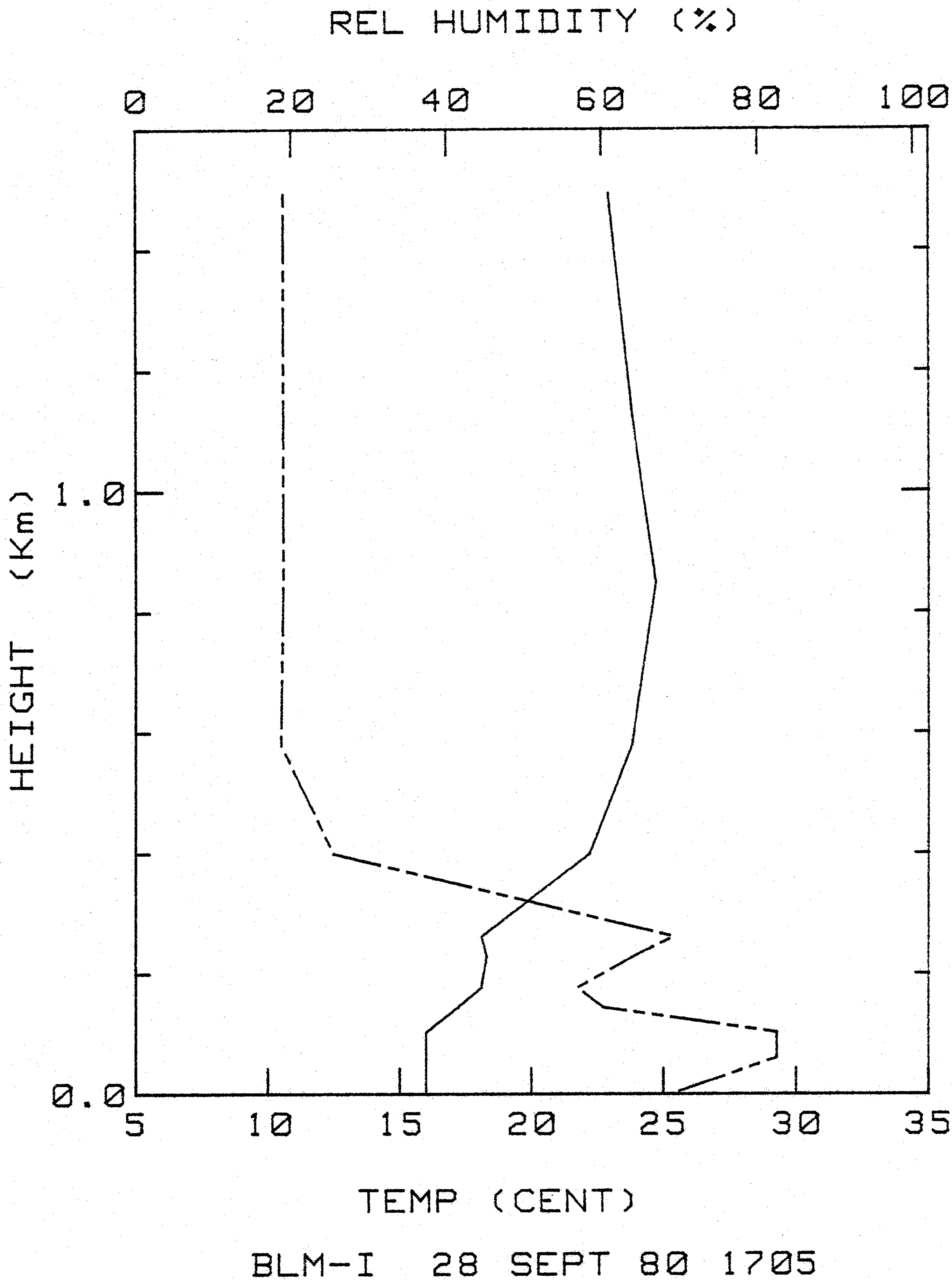
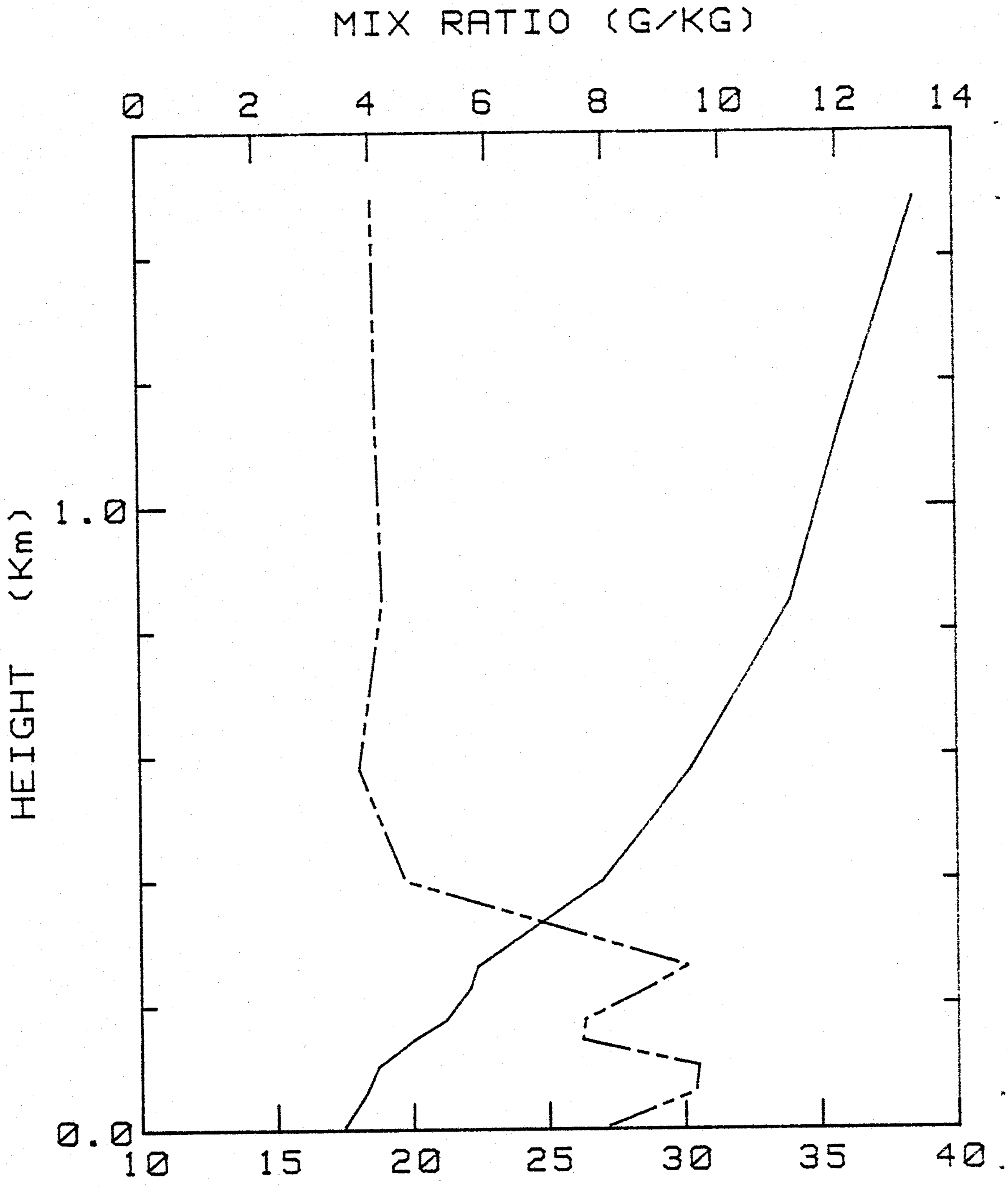

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 28 SEPT 80 1705

Figure 512



BLM-I 28 SEPT 80 1705

Figure 5ml

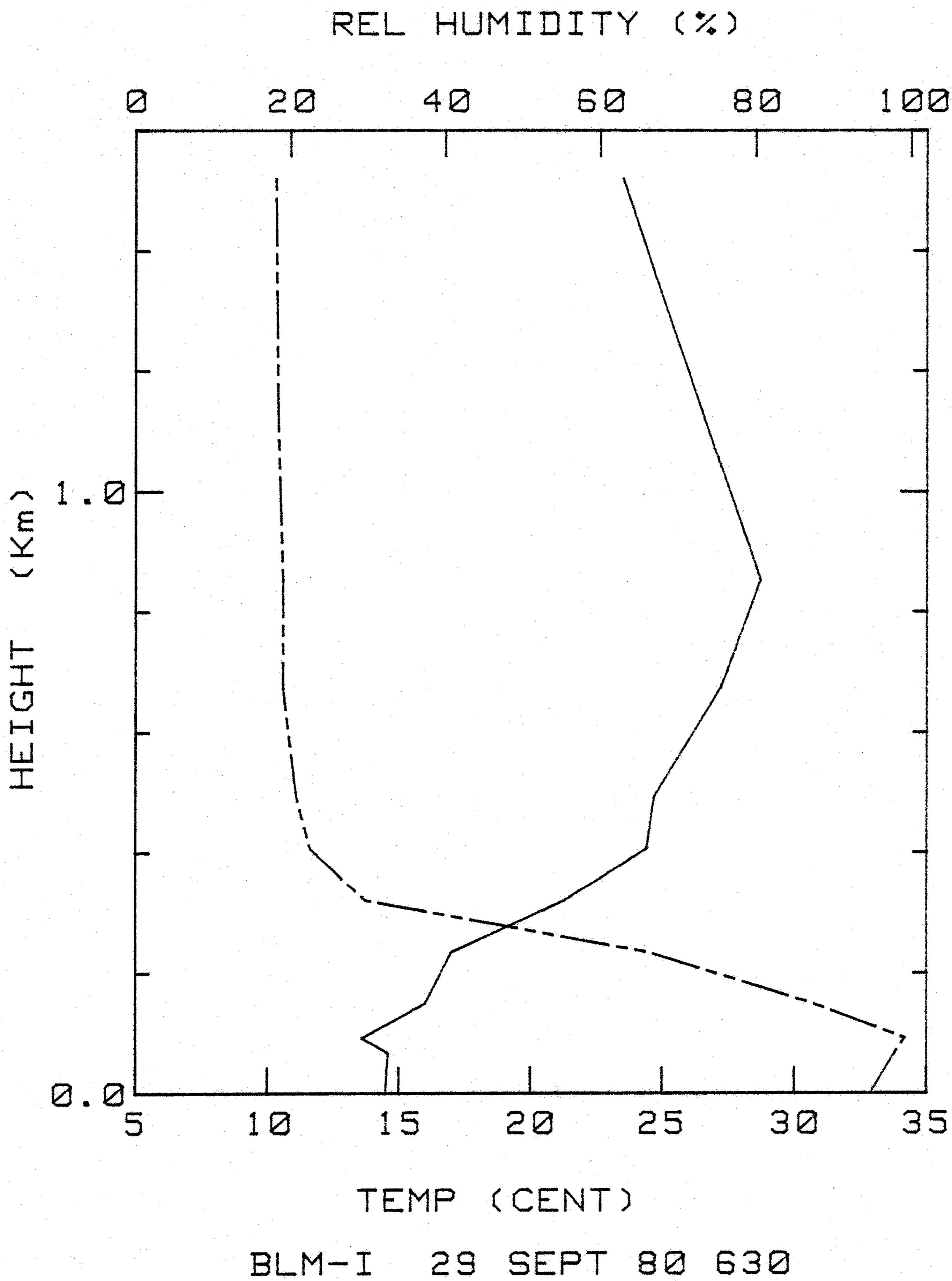

REL HUMIDITY (%)
0 20 40 60 80 100
HEIGHT (Km)
1.0
0.0
5 10 15 20 25 30 35
TEMP (CENT)
BLM-I 29 SEPT 80 630

Figure 5m2

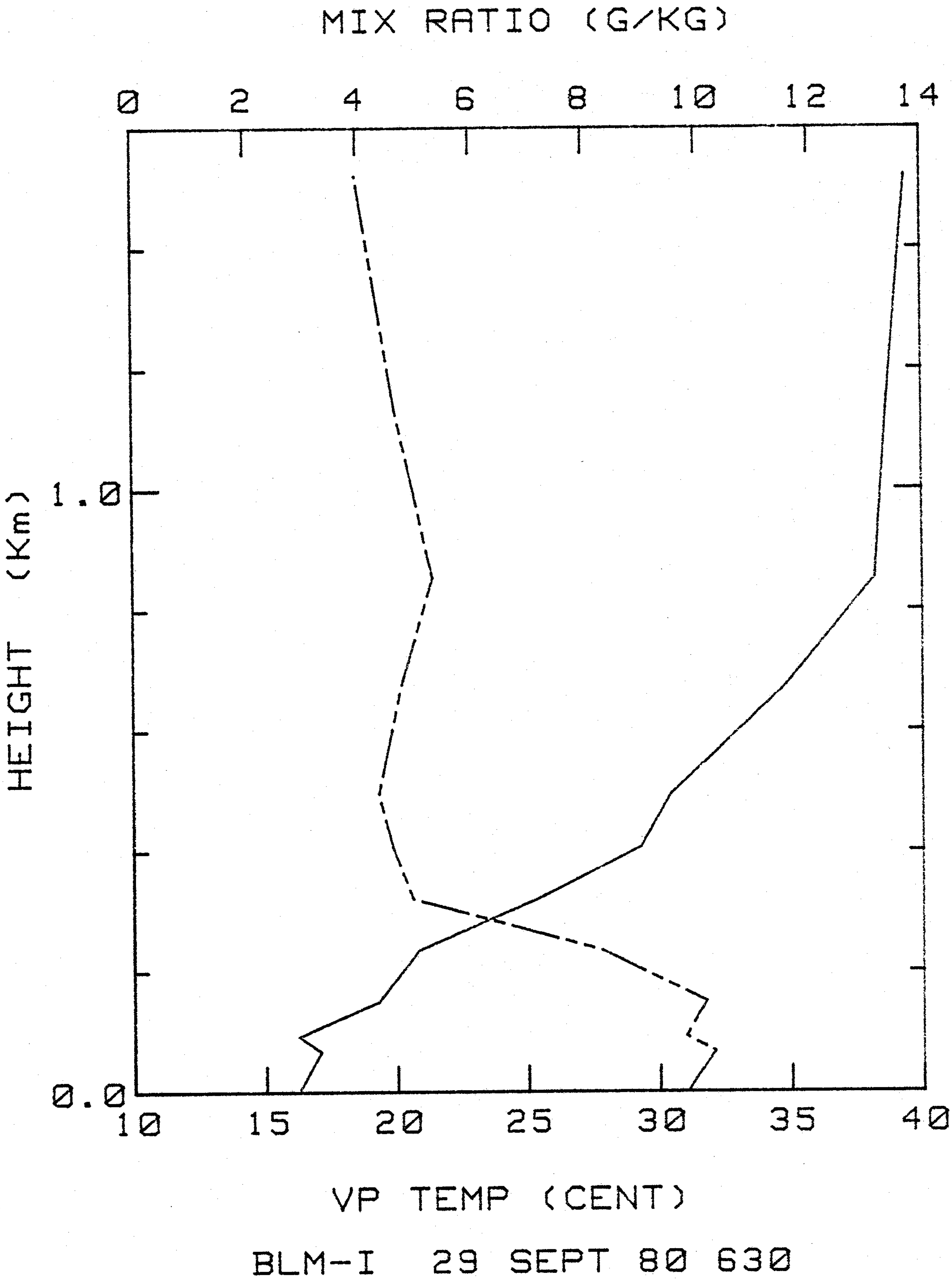

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 29 SEPT 80 630

Figure 5nl

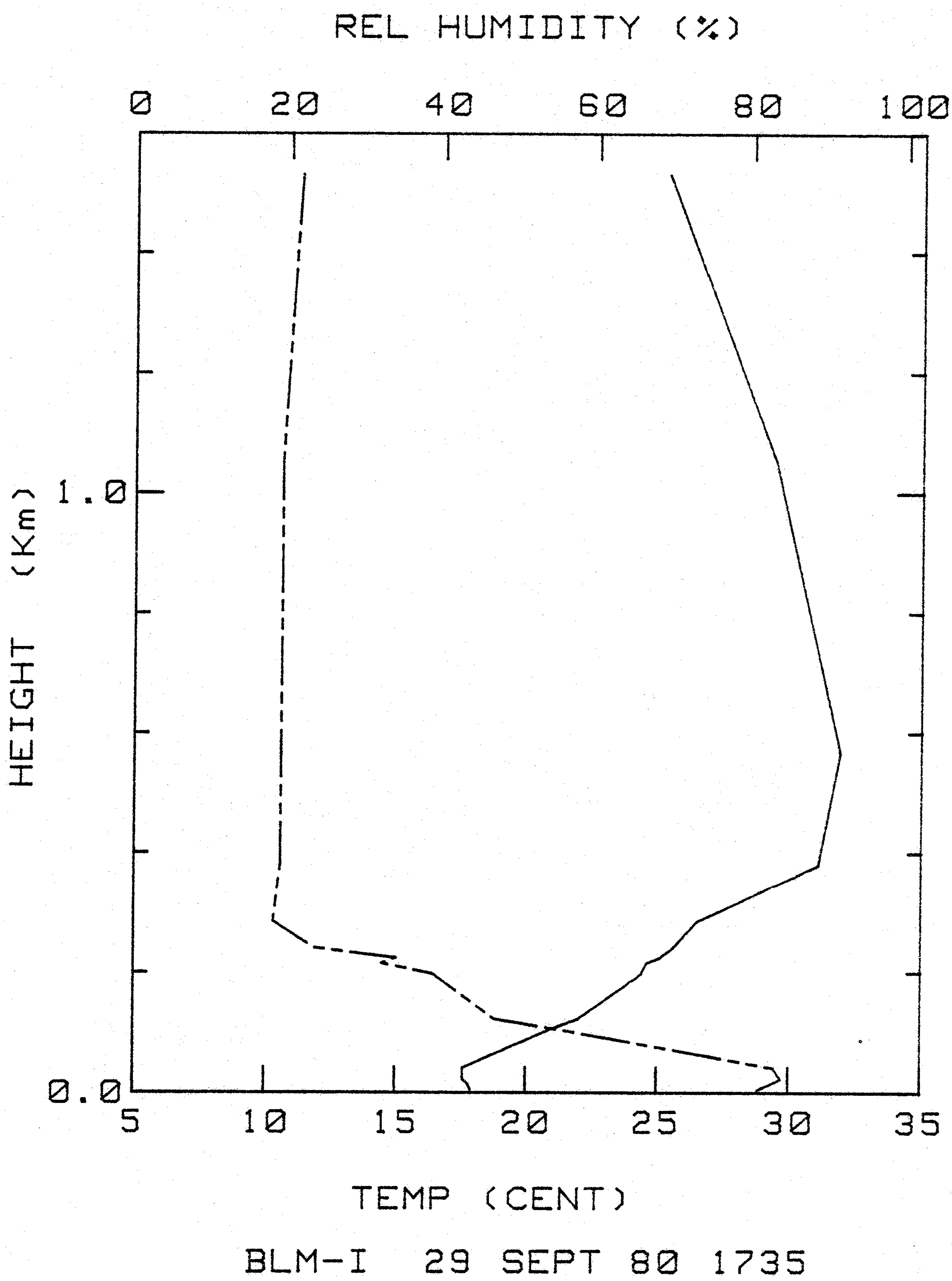
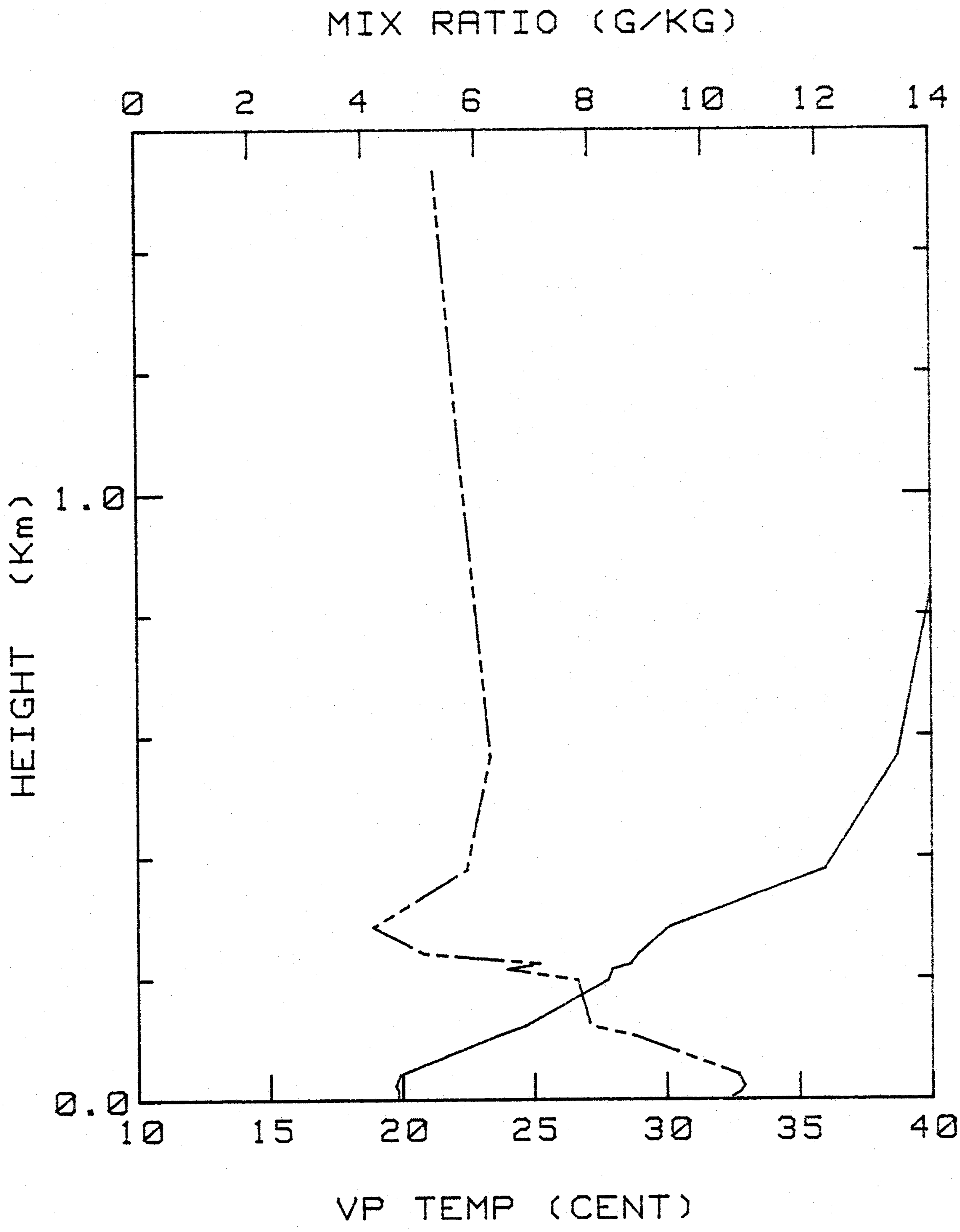

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 29 SEPT 80 1735

Figure 5n2



BLM-I 29 SEPT 80 1735

Figure 5ol

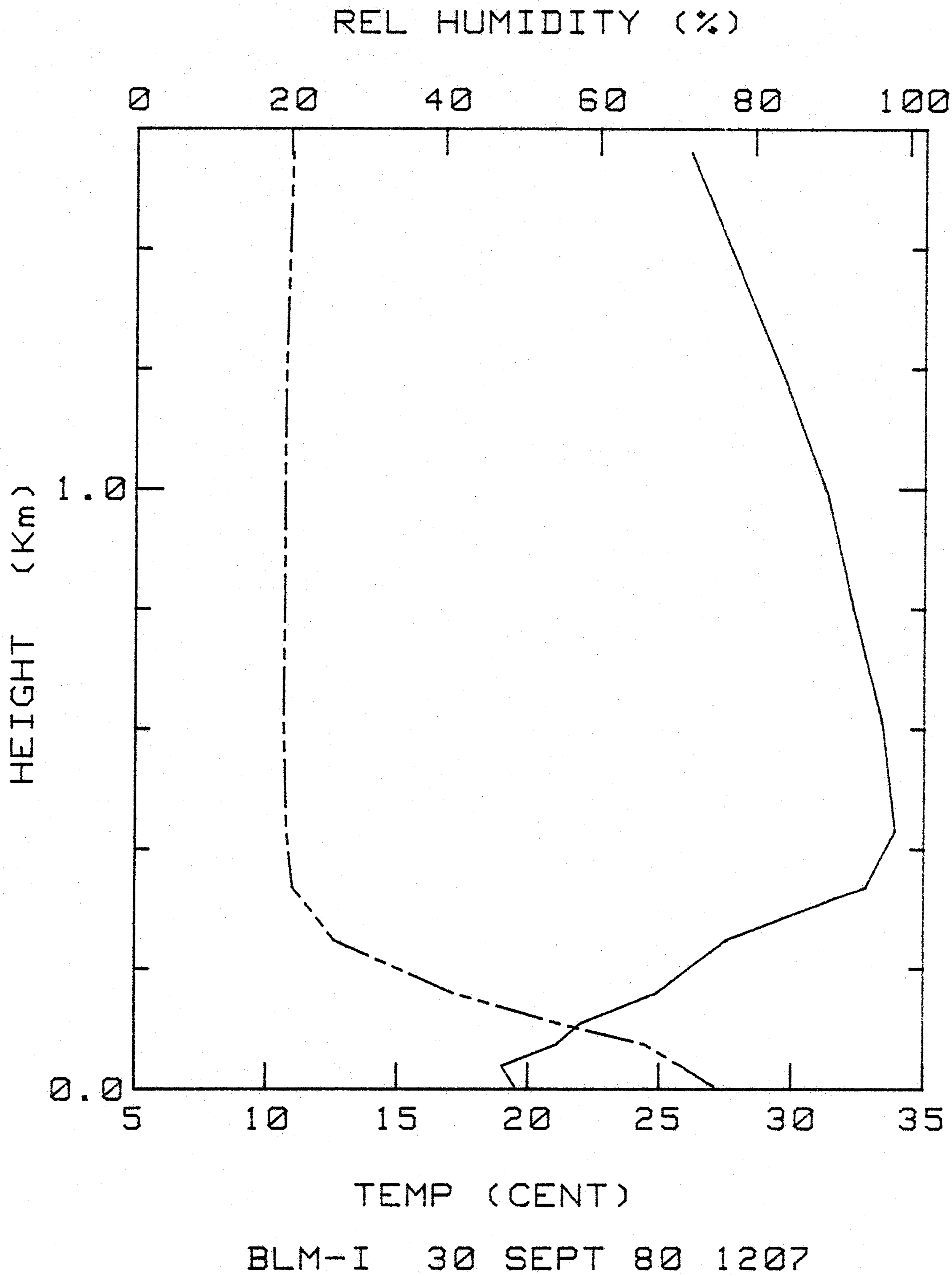
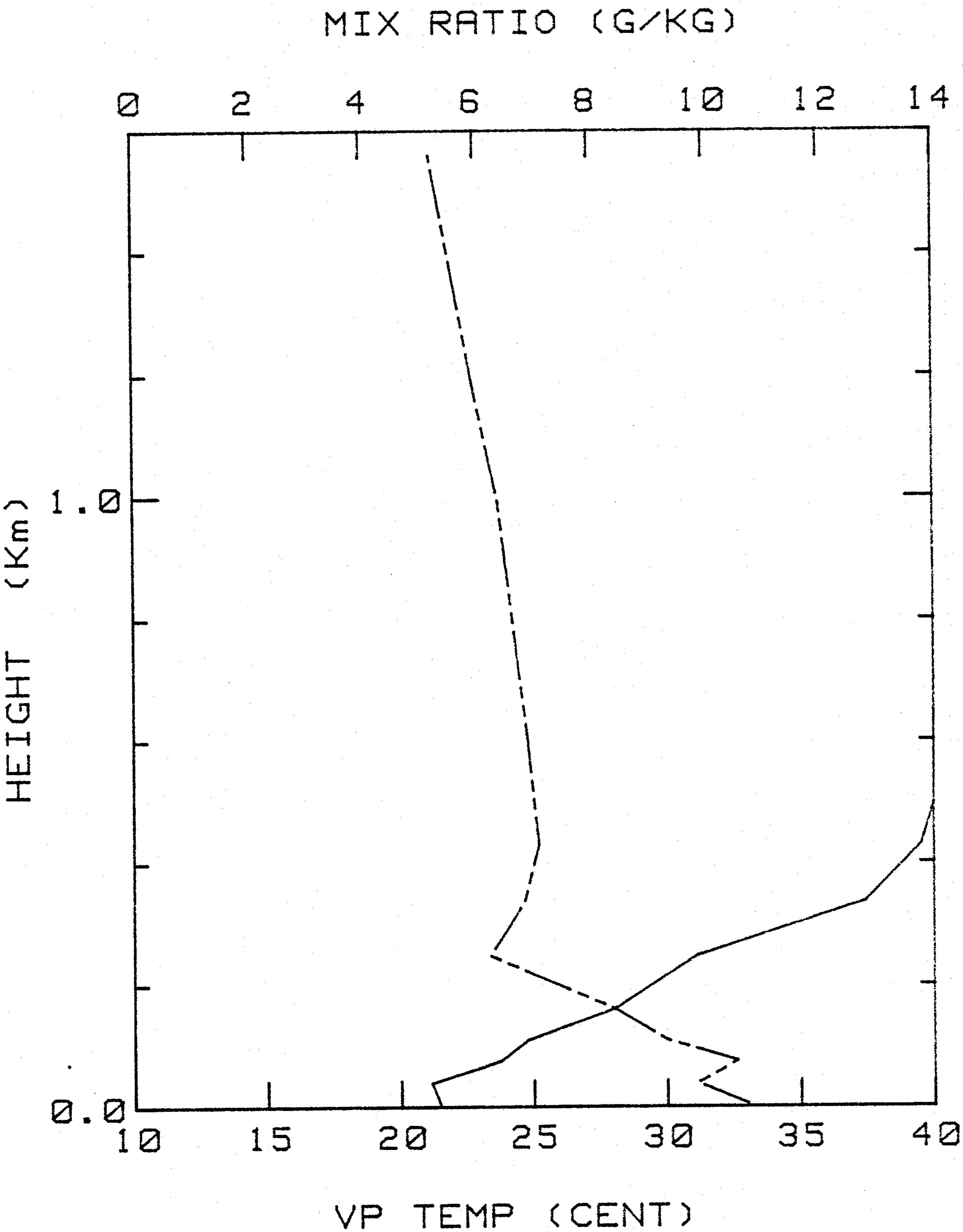

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 30 SEPT 80 1207

Figure 5o2



BLM-I 30 SEPT 80 1207

Figure 5pl

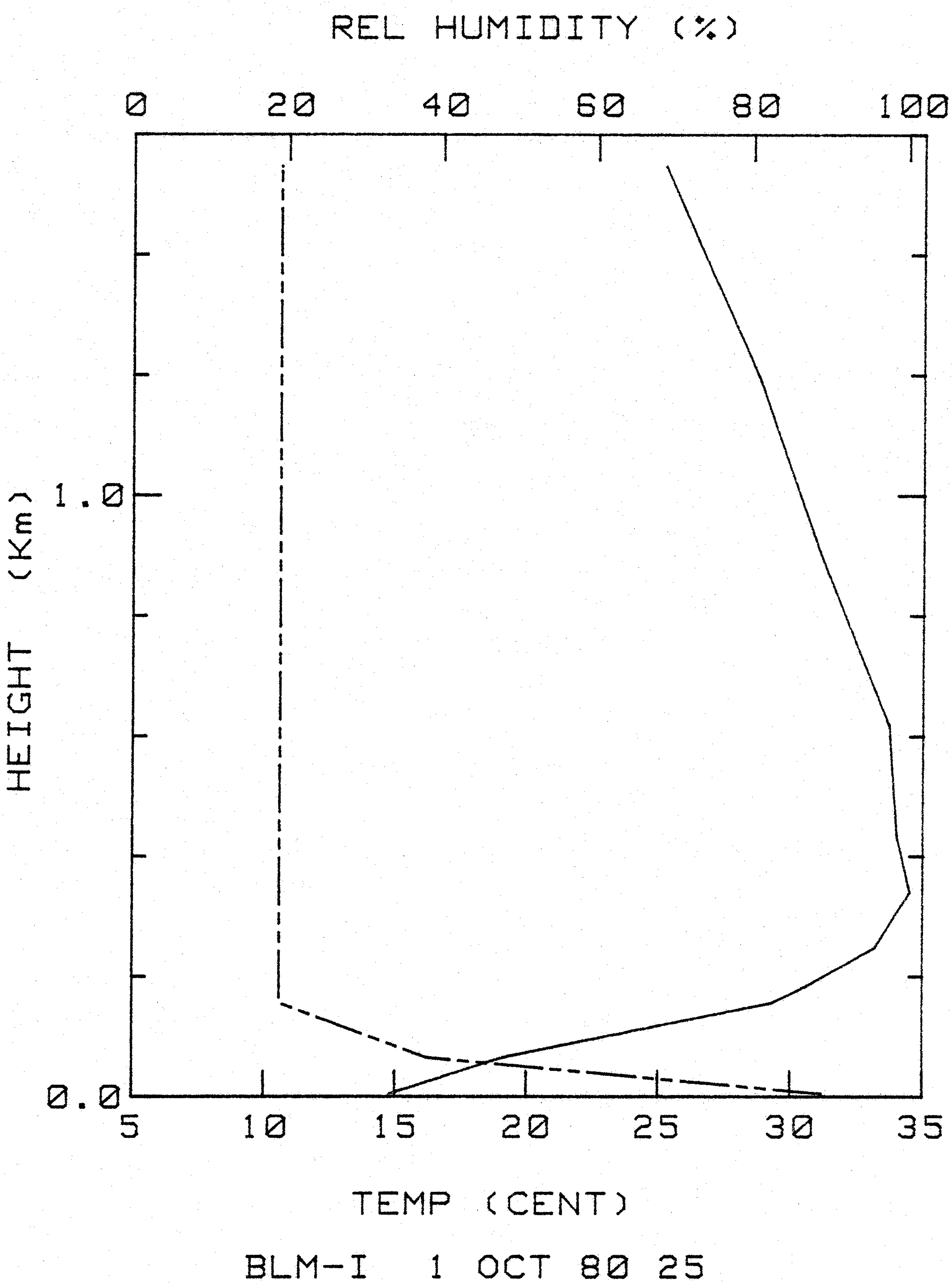
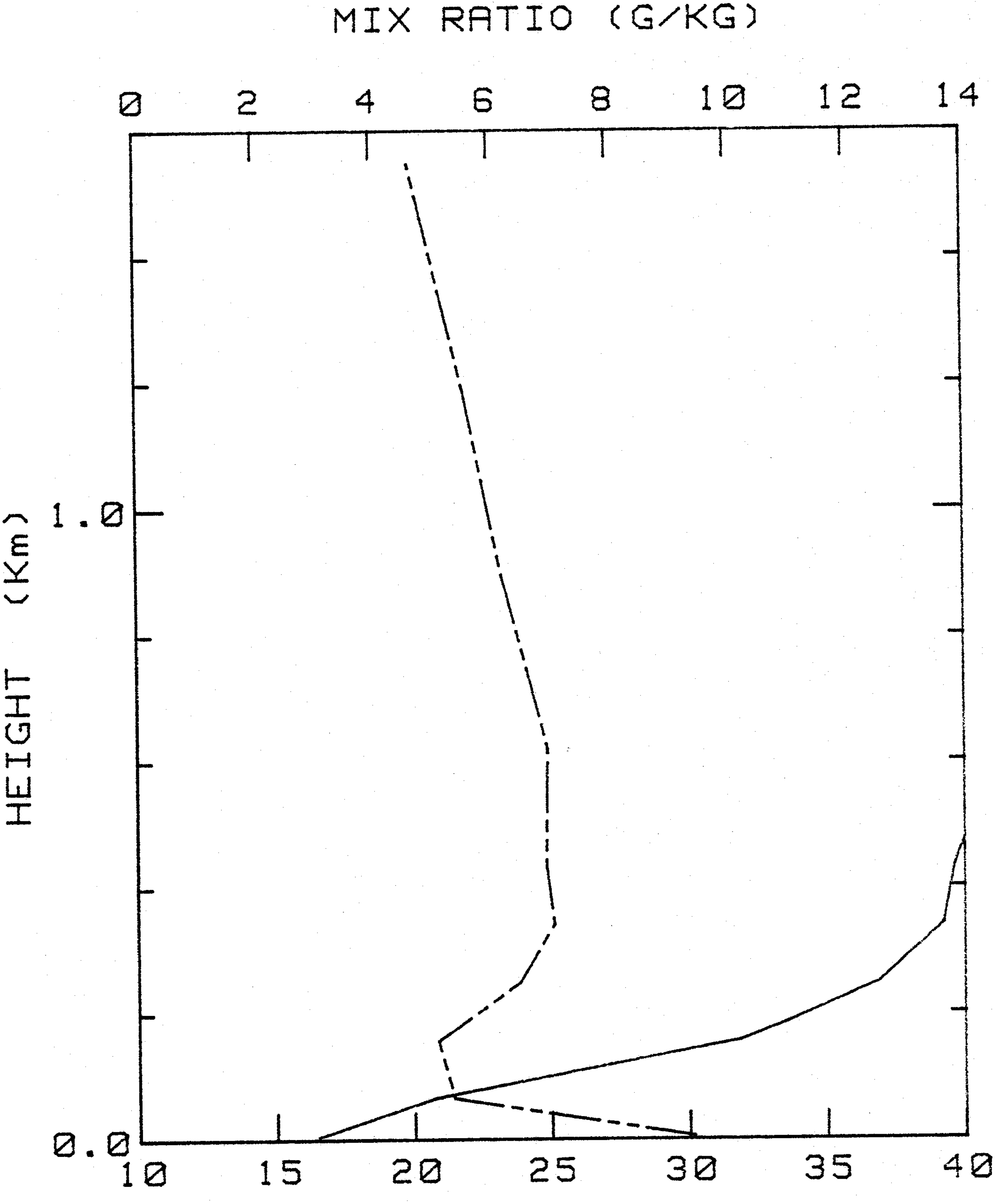

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 1 OCT 80 25

Figure 5p2



BLM-I 1 OCT 80 25

Figure 5ql

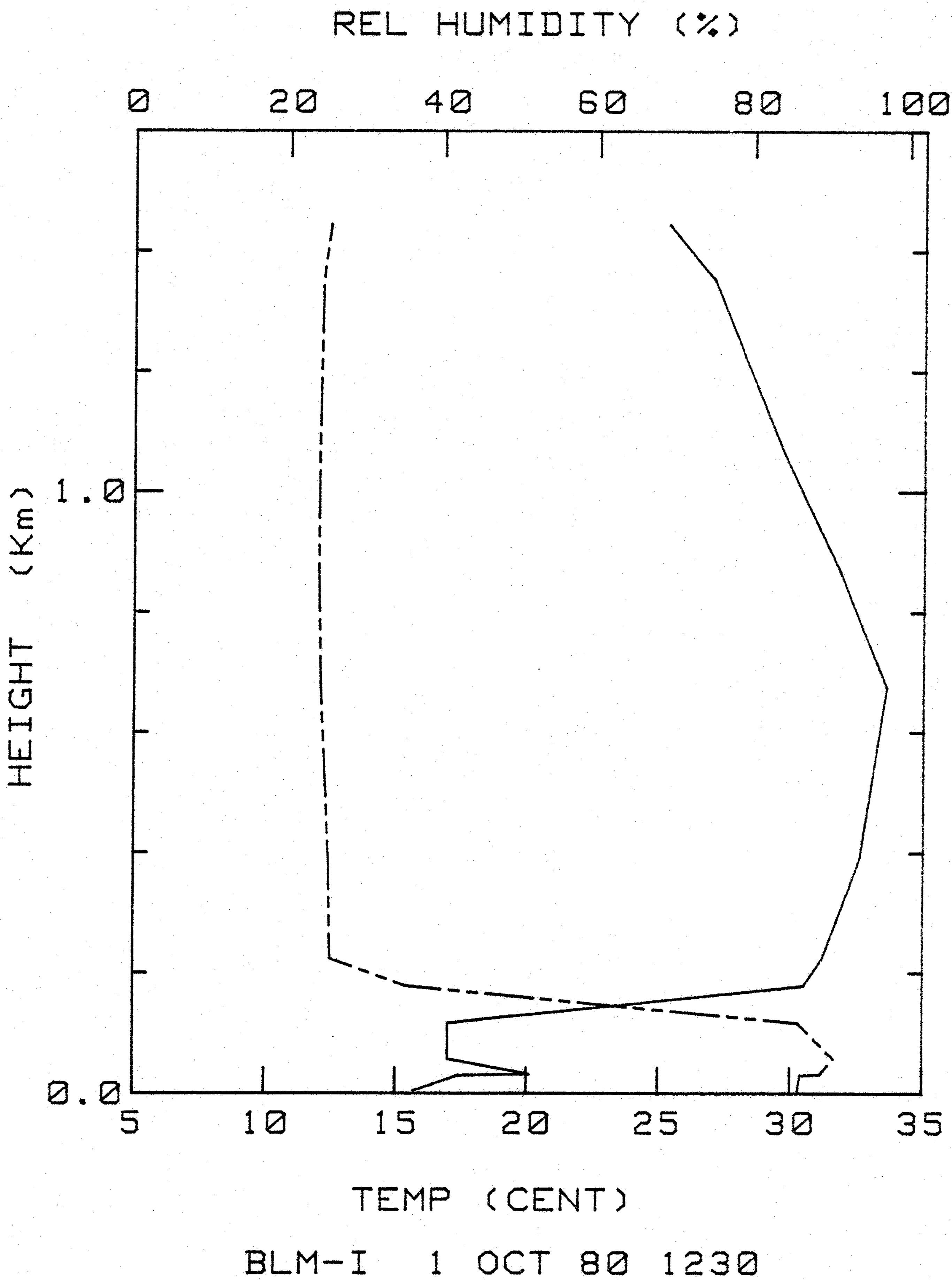

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 1 OCT 80 1230

Figure 5q2

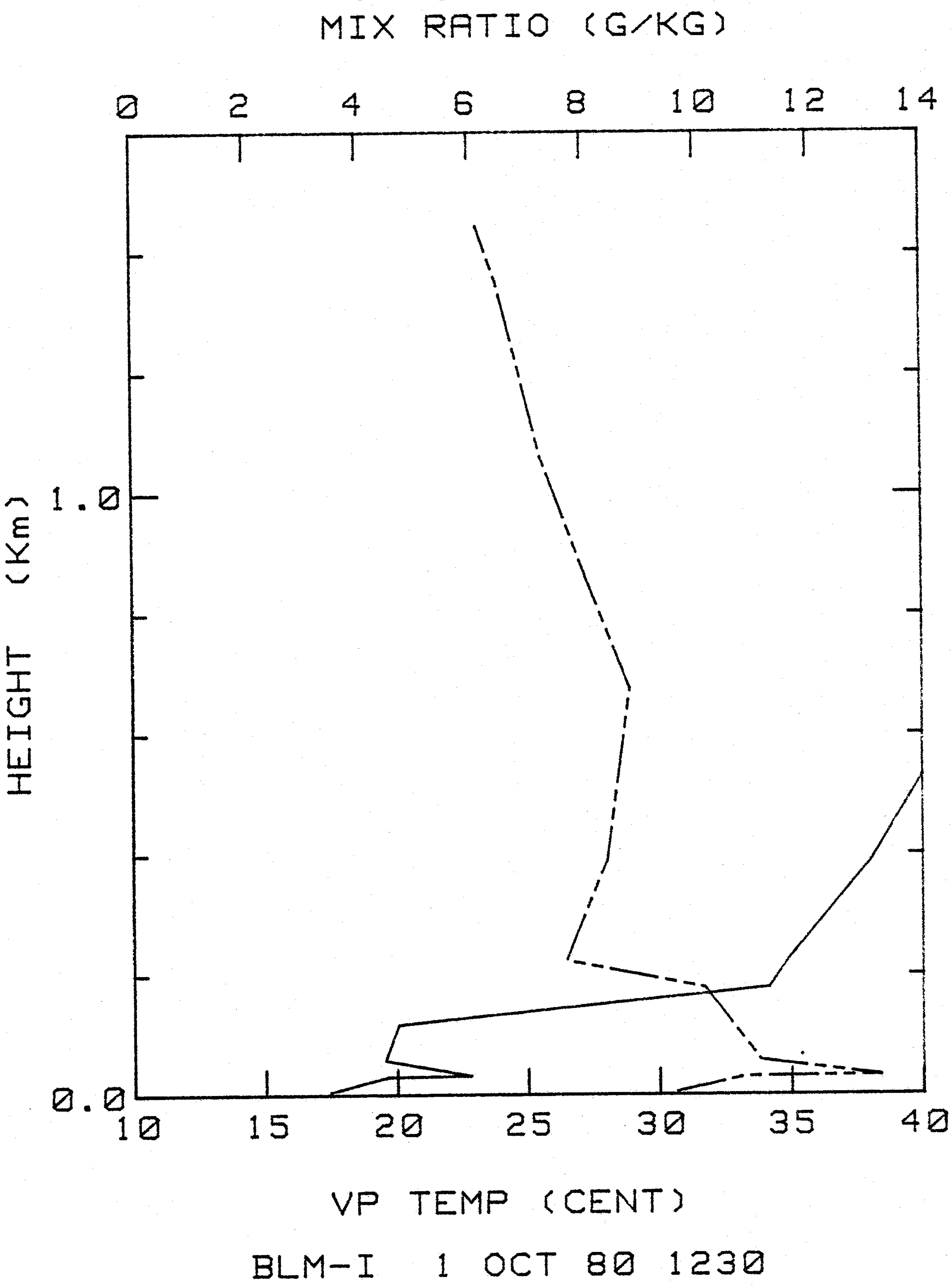

MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 1 OCT 80 1230

Figure 5ql

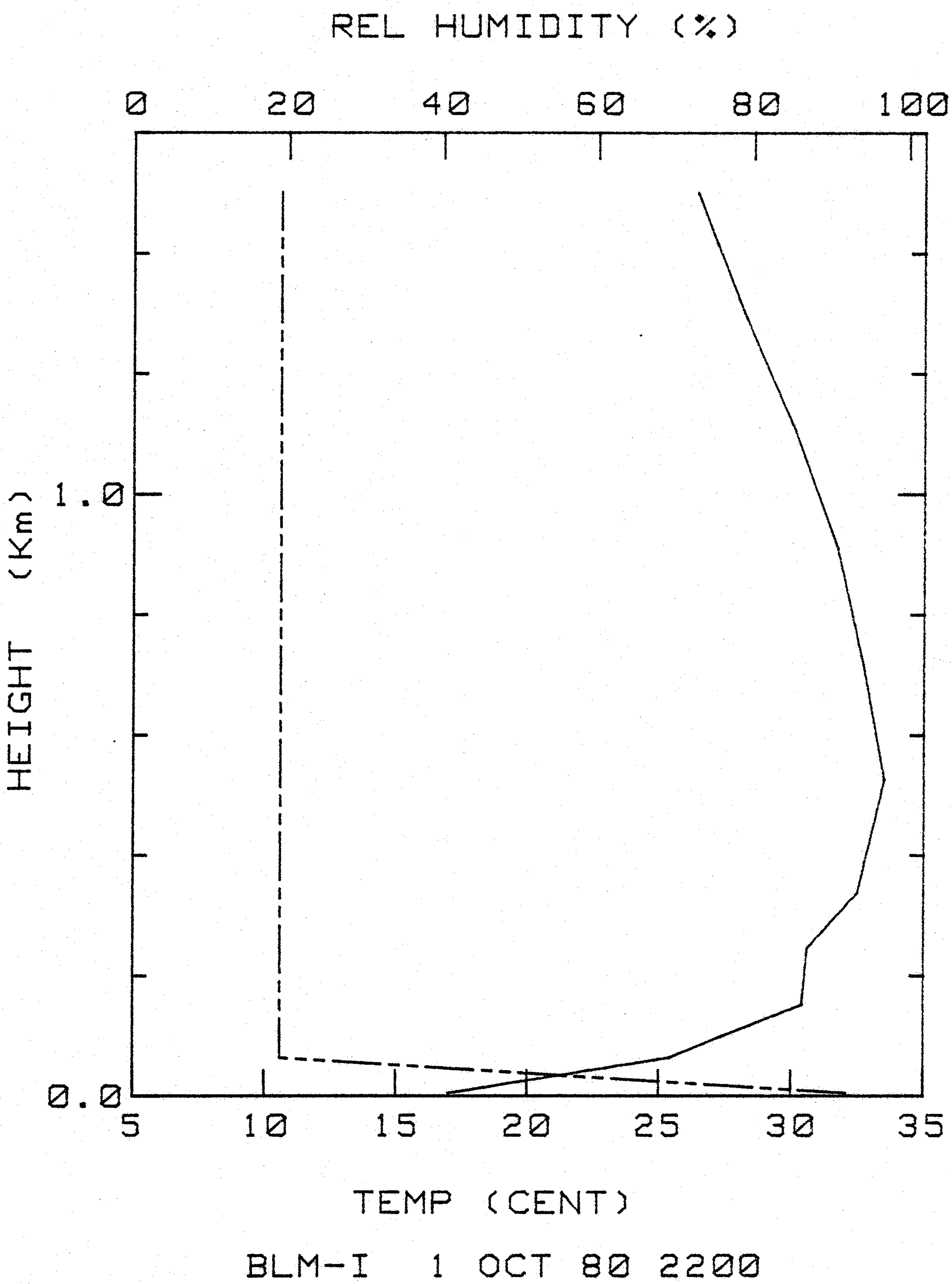
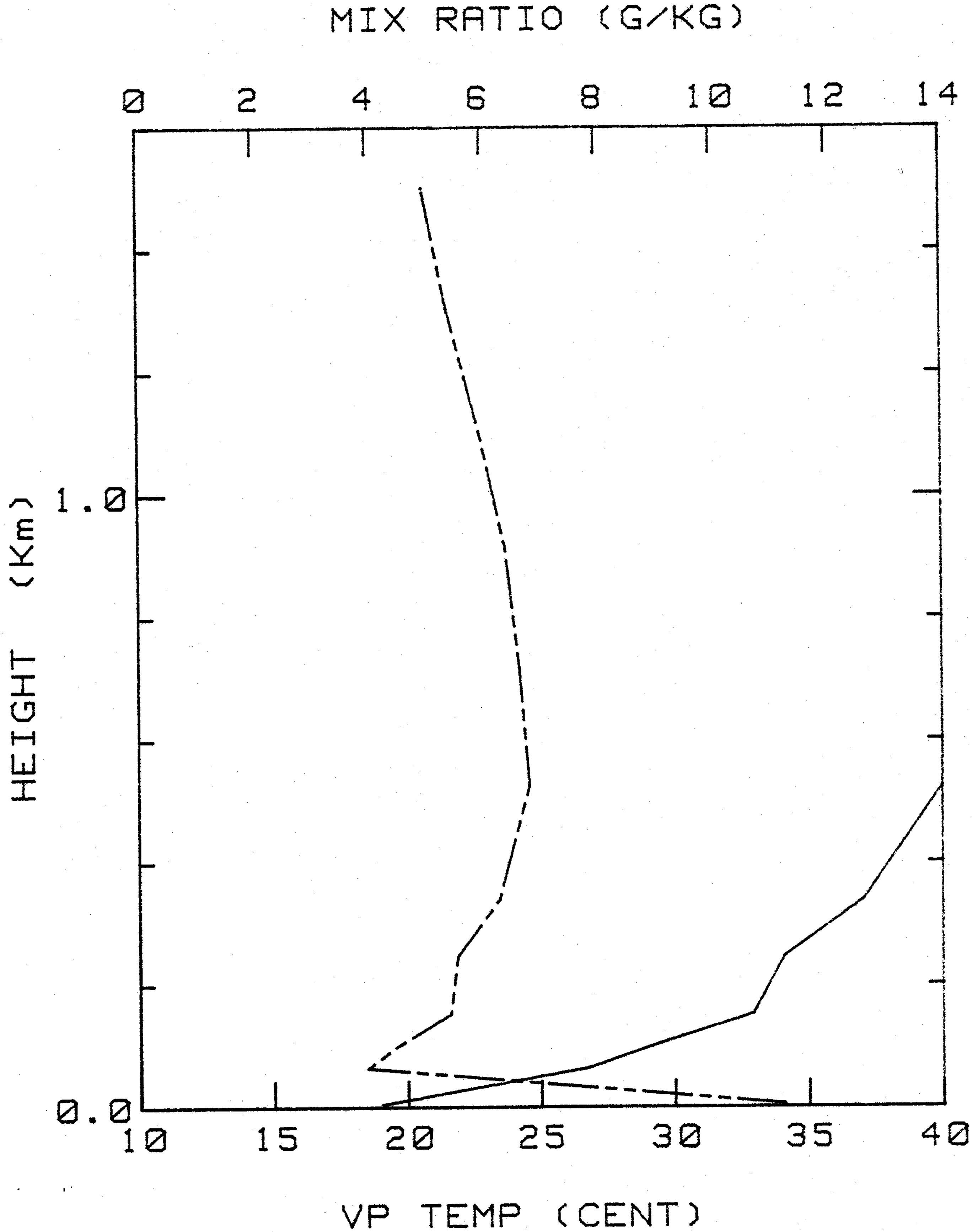
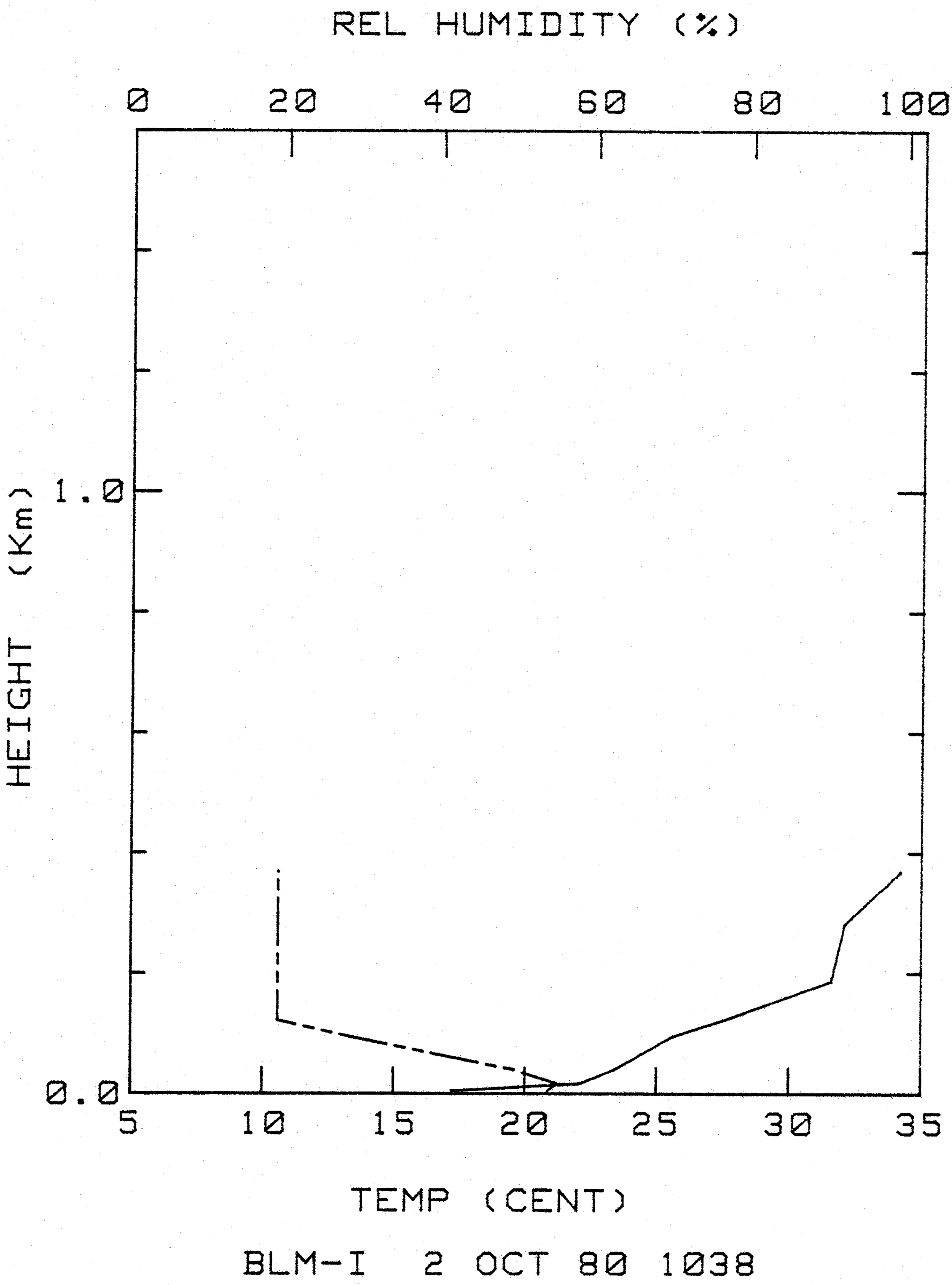

REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 1 OCT 80 2200

Figure 5r2



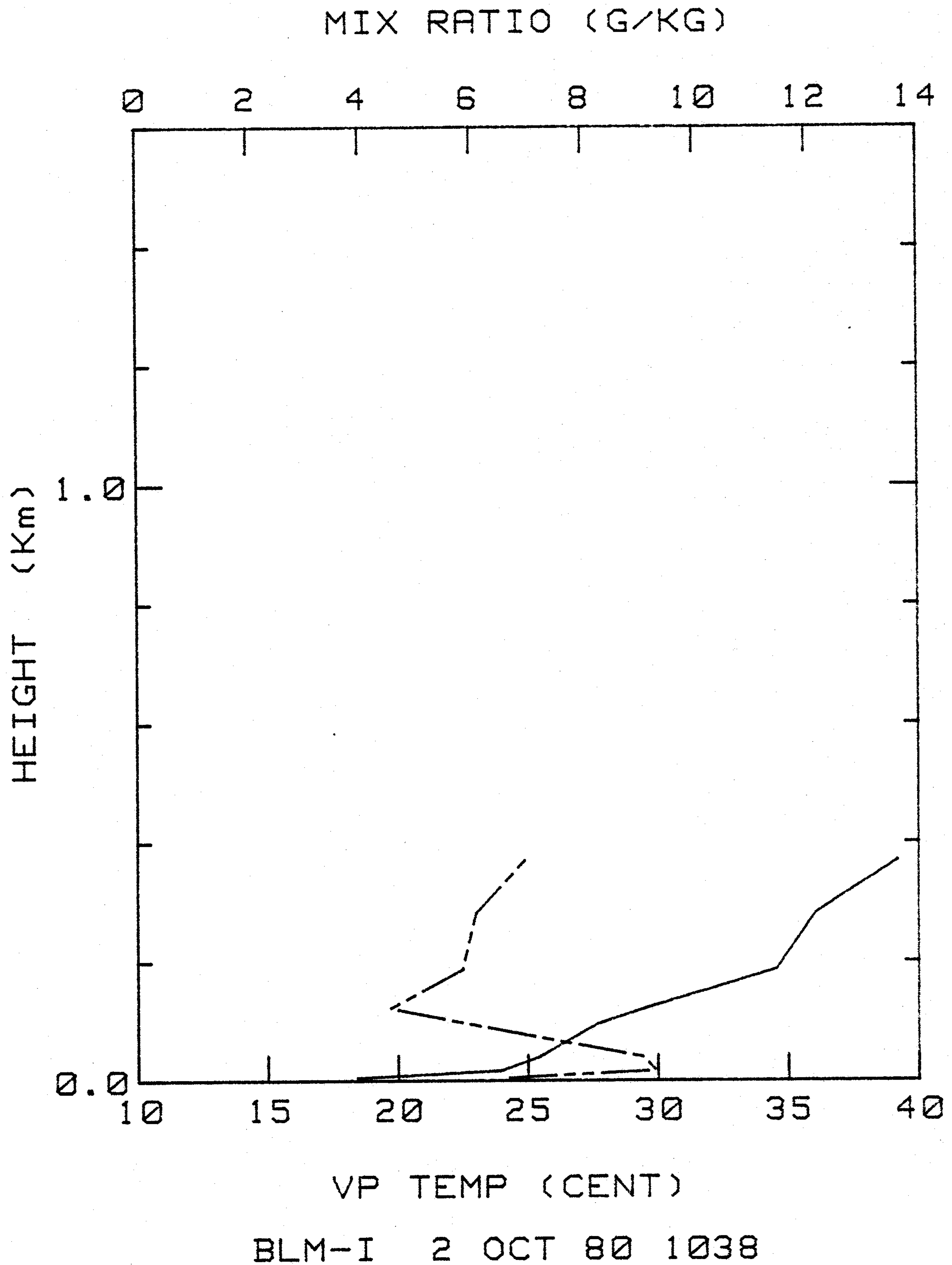
BLM-I 1 OCT 80 2200

Figure 5sl



REL HUMIDITY (%)
0
20
40
60
80
100
HEIGHT (Km)
1.0
0.0
5
10
15
20
25
30
35
TEMP (CENT)
BLM-I 2 OCT 80 1038

Figure 5s2


MIX RATIO (G/KG)
0
2
4
6
8
10
12
14
HEIGHT (Km)
1.0
0.0
10
15
20
25
30
35
40
VP TEMP (CENT)
BLM-I 2 OCT 80 1038

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