NOAA Data Report ERL PMEL-16

UPPER-AIR OBSERVATIONS IN THE VICINITY OF SHELIKOF STRAIT DURING THE FISHERY OCEANOGRAPHY EXPERIMENT (FOX), MARCH 1985

S. Allen Macklin
Nora I. Jenkins
Andrew T. Roach

Pacific Marine Environmental Laboratory
Seattle, Washington
November 1986

UNITED STATES DEPARTMENT OF COMMERCE

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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CONTENTS

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1.0 INTRODUCTION

The Fishery Oceanography Experiment (FOX), a coordinated investigation by two National Oceanic and Atmospheric Administration agencies (Pacific Marine Environmental Laboratory and the Northwest and Alaska Fisheries Center) was a one-year study of the biotic and abiotic environment of the early life stages of pollock (*Theragra chalcogramma*) spawned in Shelikof Strait, Alaska (Wilson *et al.*, 1986). FOX provided initial research for a long-term research program, the Fisheries-Oceanography Coordinated Investigations (FOCI).

This report contains atmospheric data from forty upper-air observations conducted twice daily (more frequently during research aircraft overflights) from the NOAA Ship DISCOVERER during cruise FOX 85 I from 11 March to 2 April 1985. The upper-air surveys were designed to define the atmospheric boundary layer processes that force the upper ocean in the vicinity of Shelikof Strait. This data report discusses the observation system, the observation schedule, and presents plots of the upper-air soundings.

2.0 MEASUREMENT SYSTEM

The vertical structures of atmospheric temperature and humidity were sampled routinely (generally daily at 00 and 12 GMT). Each sounding was made by an expendable, lightweight Airsonde™ bearing an aneroid pressure capsule and dry- and wet-bulb aspirated thermistors (A.I.R., Inc., 1977). A 100-g helium-filled balloon carried the sonde aloft at a nominal rate of 200 m min^{-1} to an altitude of 3 to 9 km. As it ascended, the sonde radioed barometric pressure, temperature, and wet-bulb temperature (wet-bulb temperature is a humidity variable defining the temperature an air parcel would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it, all latent heat being supplied by the parcel [Huschke, 1959]) observations every 5 seconds to an A.I.R., Inc. model TS-2AR receiver/computer/data logger. The system is reported by the manufacturer to be accurate to 0.5°C for temperature and 3 mb for pressure. Data were stored in analog form on cassette tapes and also on paper through a modified HP-97 calculator connected to the TS-2AR.

Prior to launch, each airsonde's pressure sensor was biased to agree with the ship's barometer (which is routinely serviced and calibrated with a transfer standard traceable to the National Bureau of Standards). Then each sonde was allowed to equilibrate to ambient weather conditions on deck, and comparison temperatures were measured with independent sensors. In general, these comparisons corroborated the airsonde sensor accuracies cited by the manufacturer

3.0 DATA PROCESSING

3.1 Editing

After the cruise, the cassette tapes were played back through the TS-2AR. Digital output was channeled by RS-232C protocol to a Digital Equipment Corporation VAX computer. VAX data files were edited according to the following criteria:

- records before sonde launch were deleted, as they were recorded as the instrument came to equilibrium on the weather deck
- records were deleted if the pressure value was below 500 mb (i.e. the sonde was higher than approximately 5 km)

- records were deleted if temperature was missing or erroneous
- if wet bulb temperature was missing or erroneous it was replaced by the "missing value" sentinel of -99.0
- if pressure was not available, a value was interpolated from the pressures above and below the missing value
- if a group of records were missing, the data were compared to the printed record from the HP-97 calculator (which were recorded as the sonde ascended) and data were manually entered to fill gaps in the data files
- a header was added as the first record for each airsonde launch. The header contained: SOUNDING NUMBER, DATE, TIME (GMT), LATITUDE, LONGITUDE, SEA-SURFACE TEMPERATURE and SEA-LEVEL PRESSURE.

3.2 Derived Variables

Recorded values of barometric pressure, air temperature, and wet-bulb temperature enabled computation of altitude and potential and equivalent potential temperature. Potential temperature is the temperature a parcel of dry air would have if brought adiabatically to a pressure of 1000 mb; equivalent potential temperature is the potential temperature that an air parcel would have after undergoing the following (physically unrealizable) process: dry-adiabatic expansion until saturated, pseudo-adiabatic expansion until all moisture is precipitated out, dry-adiabatic compression to initial pressure (Huschke, 1959). Potential temperature and equivalent potential temperature are useful indicators of atmospheric stratification.

Altitude z_1 was computed from the hypsometric equation

$$z_1 = z_0 + 29.26 * \overline{T_v} * \ln (p_0/p_1) , \tag{1}$$

where z_0 is a reference altitude with barometric pressure p_0, p_1 the barometric pressure at height z_1, and $\overline{T_v}$ is the average virtual temperature (°K) between two levels.

In order to determine virtual temperature, we first computed dew-point temperature T_d in °C from the Method of Tetons (Saucier, 1955)

$$T_d = \frac{B * \ln (e/6.1078)}{A - \ln (e/6.1078)} \tag{2}$$

where $A = 17.27$

$B = 237.3$ if $T_w \geq 0$

or $A = 21.87$

$B = 265.5$ if $T_w < 0$

T_w is the wet-bulb temperature in °C, and

e is the vapor pressure in mb.

Vapor pressure was determined by the Method of Ferrel (List, 1951)

$$e = e_s - 0.00066 * p * (1 + .00115\ T_w) * (T - T_w), \tag{3}$$

where the barometric pressure p is in mb, temperatures T and T_w are in °C and the saturation vapor pressure e_s is in mb.

Saturation vapor pressure was determined by the Goff-Gratch formulation (List, 1951)

$$\log e_s = -7.90298 * ((373.16/T)-1) + 5.02808 * \log (373.16/10) - (1.3816*10^{-7}) * (10^{11.344(1-T/373.16)}-1) + (8.1328*10^{-3}) * (10^{-3.49149((373.16/T)-1)}-1) + \log 1013.246 \quad (4a)$$

for $T \geq 273.16°K$

or

$$\log e_s = -9.09718 * ((273.16/T)-1) - 3.5665 * \log (273.16/T) + 0.876793 * (1 - T/273.16) + \log 6.1071 \quad (4b)$$

for $T < 273.16°K$.

Potential temperature was computed from

$$\theta = T\ (1000/p)^{R/C_p} \quad (5)$$

where T is the Kelvin temperature, p the pressure in mb, R is the gas constant for dry air, and C_p is the specific heat of dry air at constant pressure.

Equivalent potential temperature, θ_e, is the potential temperature (Eq. 5) for the adiabatic equivalent temperature

$$T_{ae} = T \exp [(L/C_pT) * ((0.662e)/(p-e))] \quad (6)$$

where L is the latent heat of condensation and the other quantities are as defined above. The temperature θ_e is conservative with respect to dry- and pseudo-adiabatic processes.

4.0 RESULTS

The positions occupied by the NOAA Ship DISCOVERER at the time of each launch are summarized in Fig. 1. Surface meteorological data at launch times are contained in Table 1. The Appendix contains a graphic page for each sounding. Each page contains four plots: a) temperature vs. height, b) wet-bulb temperature vs. height, c) potential temperature vs. height, and d) equivalent potential temperature vs. height. The bottommost datum (indicated by an asterisk) in each plot was determined from sea-surface temperature measured by the ship's sea-water intake. For humidity computation, the atmosphere was assumed saturated at the sea surface.

Empty spaces in the profiles are representative of missing values. The wet-bulb temperature is missing when it measured higher than the dry-bulb temperature and was therefore deleted. Due to the equipment used and the weather conditions, the following often occurred: water on the wick of the wet-bulb thermistor was initially super-cooled after passing through the freezing level; when the wick finally froze, the wet-bulb temperature rose abruptly to 0.0°C and slowly equilibrated thereafter. At the moment it froze and during the equilibration, wet-bulb temperature was higher than dry-bulb temperature.

At their lowest levels, some profiles may be biased to warmer temperatures by the ship's "heat island" effect. Similarly, wet-bulb and equivalent potential temperatures may be too warm just above the gaps representing the equilibration of the wet-bulb thermistor to a frozen wick. We have attempted to edit these errors from the profiles, but the inability to decide objectively dictated a conservative approach to data deletion.

The following airsonde soundings had circumstances which affected the plots:

- airsonde sounding 6 - variables were recorded to 621 mb (3.6 km)
- airsonde sounding 13 - variables were recorded to 557 mb (4.7 km)
- airsonde sounding 14 - there are no data from this sounding due to launching problems
- airsonde sounding 26 - variables were recorded to 659 mb (3.2 km)
- airsonde sounding 29 - variables begin at 973 mb (0.1 km) because of a "restart", i.e., the system was reinitialized after the sonde was launched
- airsonde sounding 30 - the thermistors broke resulting in constant temperature signals
- airsonde sounding 35 - variables begin at 833 mb (1.3 km) because of a restart
- airsonde sounding 36 - variables begin at 940 mb (0.4 km) because of a restart.

5.0 ACKNOWLEDGMENTS

These atmospheric observations were a contribution to the Fisheries-Oceanography Coordinated Investigations. We wish to thank the Captain and crew of the NOAA Ship DISCOVERER for their skill and support. J.E. Overland offered helpful advice on editing the profiles.

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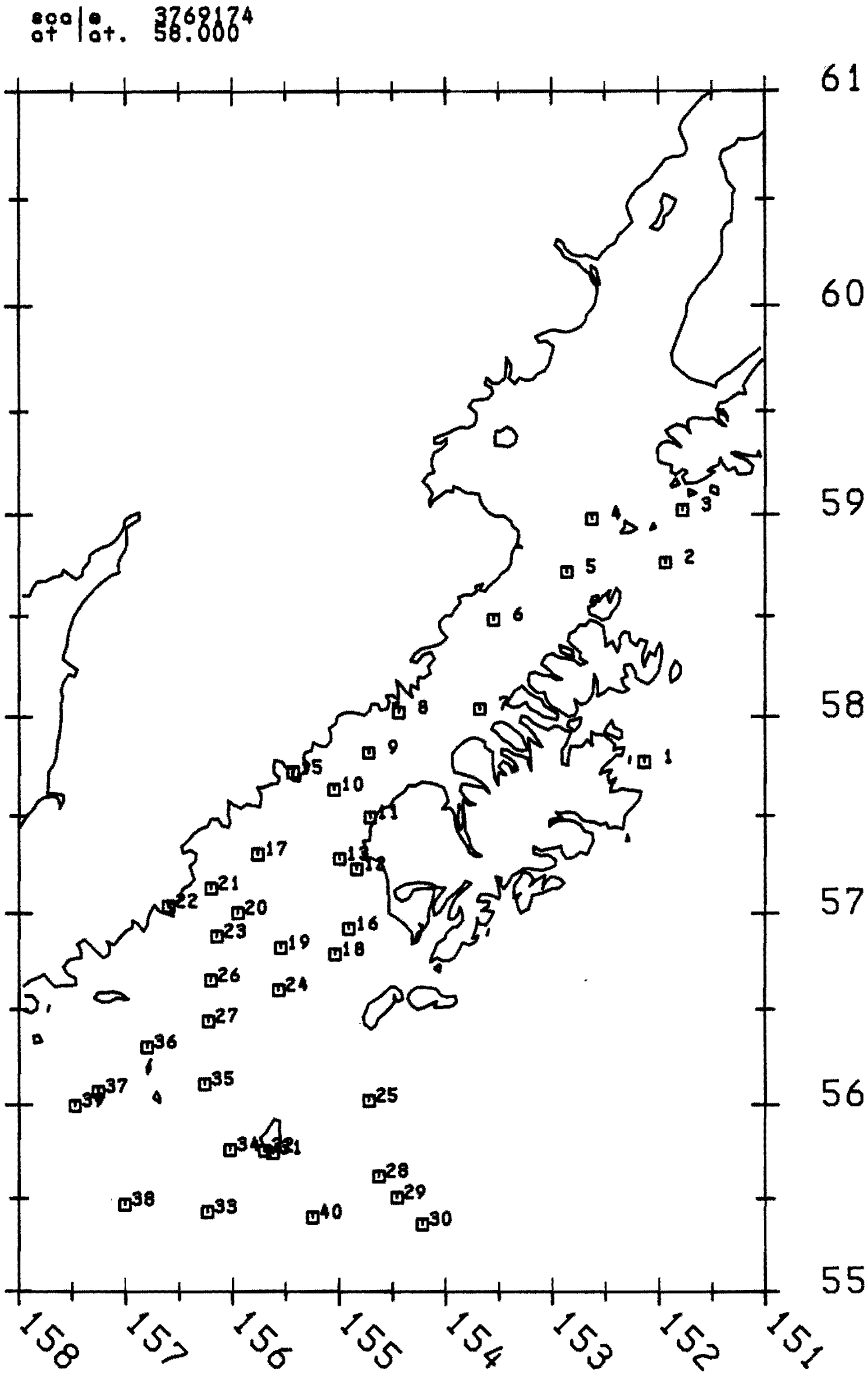


Figure 1.--Map of airsonde launches in the vicinity of Shelikof Strait, Alaska.

Table 1.--NOAA ship DISCOVERER surface meteorological data at time of airsonde launches (March, 1985)

Launch No.	Date YYMMDD	Time (GMT)	Location Lat (°N)	Long (°W)	Pressure (mb)	Air Temp (°C)	Wet Bulb Temp (°C)	Surface Wind Speed (kt)	Dir (deg)	Max Height (mb)
1	850312	0026	57°46.2'	152°08.1'	991.3	7.5	6.0	4	320	416
2	850312	1136	58°45.9'	151°56.1'	995.0	2.0	1.5	18	215	392
3	850312	2328	59°01.3'	151°46.6'	999.1	6.0	3.0	14	172	477
4	850313	1136	58°58.8'	152°37.4'	1001.5	2.2	0.5	12	270	650
5	850313	2326	58°43.1'	152°51.6'	1000.5	4.5	2.8	12	235	494
6	850314	1125	58°28.9'	153°32.8'	994.0	2.1	0.8	10	025	666
7	850315	0001	58.02.2'	153°40.9'	990.0	2.8	2.5	16	035	752
8	850315	1201	58°01.1'	154°26.5'	992.2	3.0	1.0	4	340	445
9	850316	0016	57°49.0'	154°43.5'	996.2	0.5	0.2	50	310	390
10	850316	1200	57°37.8'	155°03.0'	1001.0	-3.2	-4.5	30	285	394
11	850316	1904	57°29.4'	154°42.7'	999.6	-0.4	-0.4	18	140	455
12	850316	2104	57°13.6'	154°50.3'	996.5	0.5	-1.0	16	120	441
13	850317	0001	57°16.8'	154°59.9'	996.0	0.0	2.7	18	120	578
15	850318	0017	57°43.0'	155°26.0'	977.5	1.8	1.7	20	100	490
16	850319	0002	56°55.1'	154°54.6'	987.7	3.3	2.5	32	150	435
17	850319	1128	57°18.2'	155°45.9'	988.2	1.0	0.8	42	130	366
18	850320	0002	56°47.2'	155°02.4'	992.5	2.8	2.0	10	095	369
19	850320	1142	56°49.2'	155°33.0'	996.6	2.5	2.0	10	090	447
20	850320	1613	57°00.0'	155°57.0'	997.4	2.2	1.8	calm	calm	414
21	850320	1821	57°07.6'	156°12.0'	997.6	1.2	0.8	19	355	317
22	850321	0003	57°02.0'	156°36.0'	994.8	4.5	3.1	14	035	
23	850321	0309	56°52.7'	156°08.7'	993.8	3.1	1.1	14	135	391
24	850321	1145	56°36.0'	155°34.0'	990.0	2.8	1.2	28	335	399

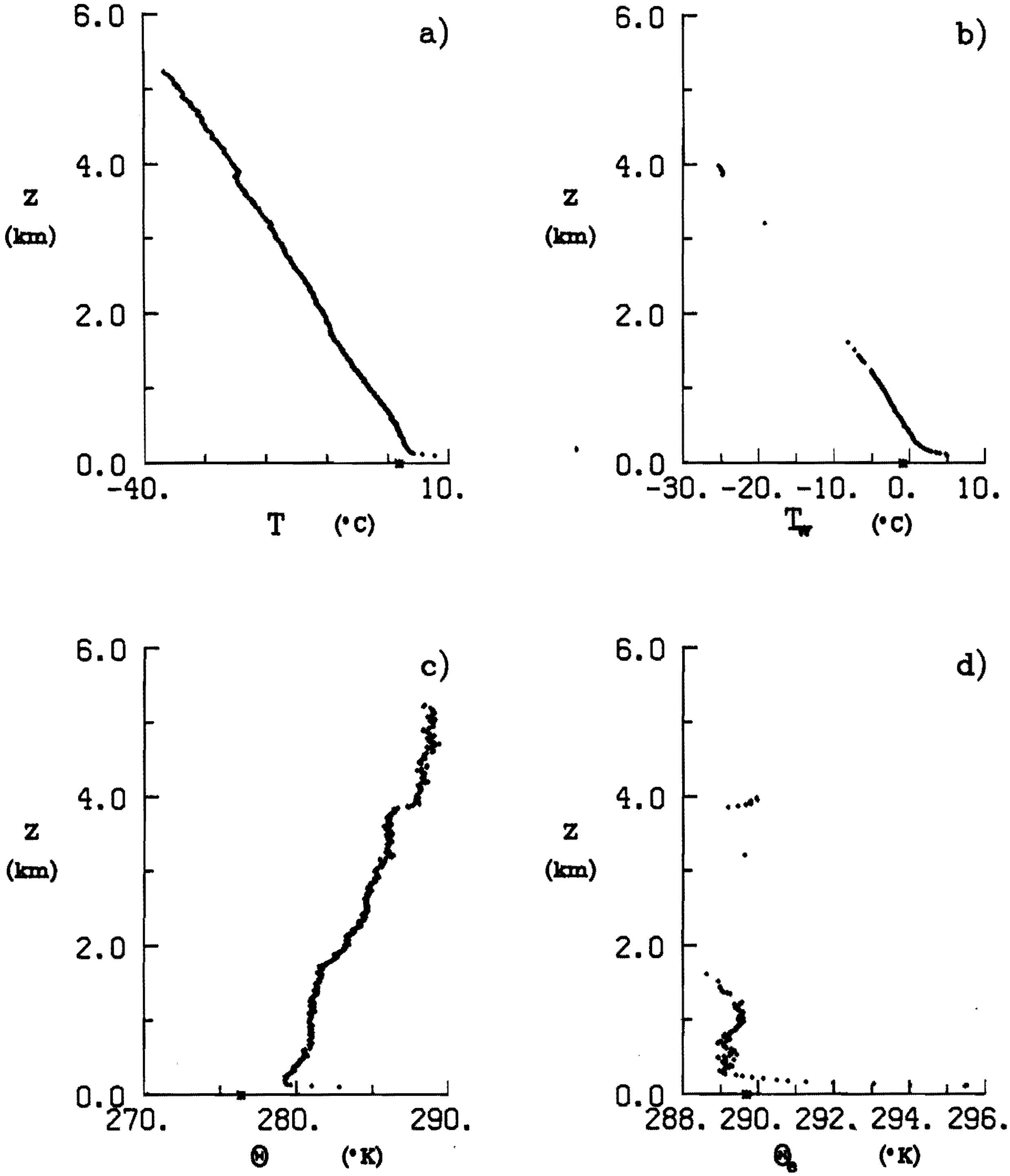
Table 1.--(continued)

Launch No.	Date YYMMDD	Time (GMT)	Location Lat (°N)	Location Long (°W)	Pressure (mb)	Air Temp (°C)	Wet Bulb Temp (°C)	Surface Wind Speed (kt)	Surface Wind Dir (deg)	Max Height (mb)
25	850322	0042	56°01.1'	154°43.6'	984.5	3.7	3.2	40	335	453
26	850322	1153	56°38.9'	156°12.2'	984.9	4.0	3.1	18	035	660
27	850323	0001	56°26.2'	156°13.6'	988.2	3.3	2.7	20	345	
28	850323	1201	55°37.1'	154°37.8'	993.1	0.8	0.4	25	330	455
29	850323	1530	55°30.2'	154°27.8'	995.4	2.1	1.9	35	330	
30	850323	1726	55°21.7'	154°13.2'	995.9	1.8	1.0	28	350	
31	850324	0329	55°44.6'	155°37.4'	1006.1	-2.5	-3.1	32	310	425
32	850324	0616	55°45.3'	155°42.1'	1007.2	-2.4	-2.8	22	315	315
33	850324	2359	55°25.5'	156°14.2'	1005.7	1.5	0.0	calm	calm	388
34	850325	1203	55°45.6'	156°01.3'	1001.0	-2.0	-2.2	8	065	550
35	850326	0004	56°06.4'	156°15.8'	1002.9	-0.8	-1.0	14	340	423
36	850326	1220	56°18.0'	156°48.0'	1007.2	-2.3	-2.4	14	310	
37	850327	0001	56°04.1'	157°15.4'	1011.7	-2.0	-2.3	36	310	504
38	850327	1158	55°27.9'	157°00.6'	1016.8	-2.7	-2.9	30	320	540
39	850327	2355	55°59.6'	157°28.6'	1018.8	-1.5	-1.7	14	355	600
40	850328	1154	55°23.9'	155°15.0'	1012.5	1.4	0.2	10	065	345

APPENDIX

Plots of upper-air soundings during FOX

a) Temperature vs. height
b) Wet-bulb temperature vs. height
c) Potential temperature vs. height
d) Equivalent potential temperature vs. height



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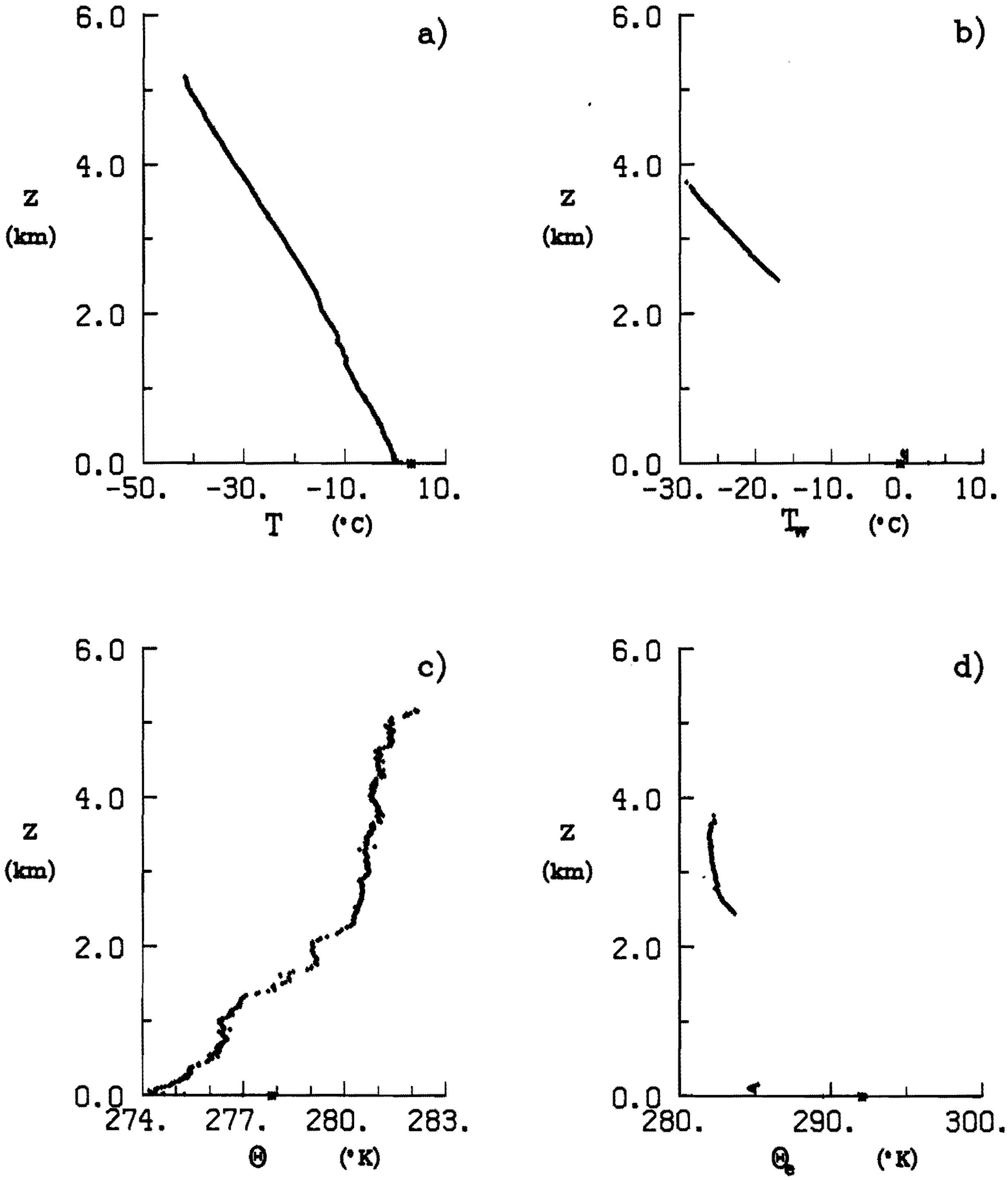

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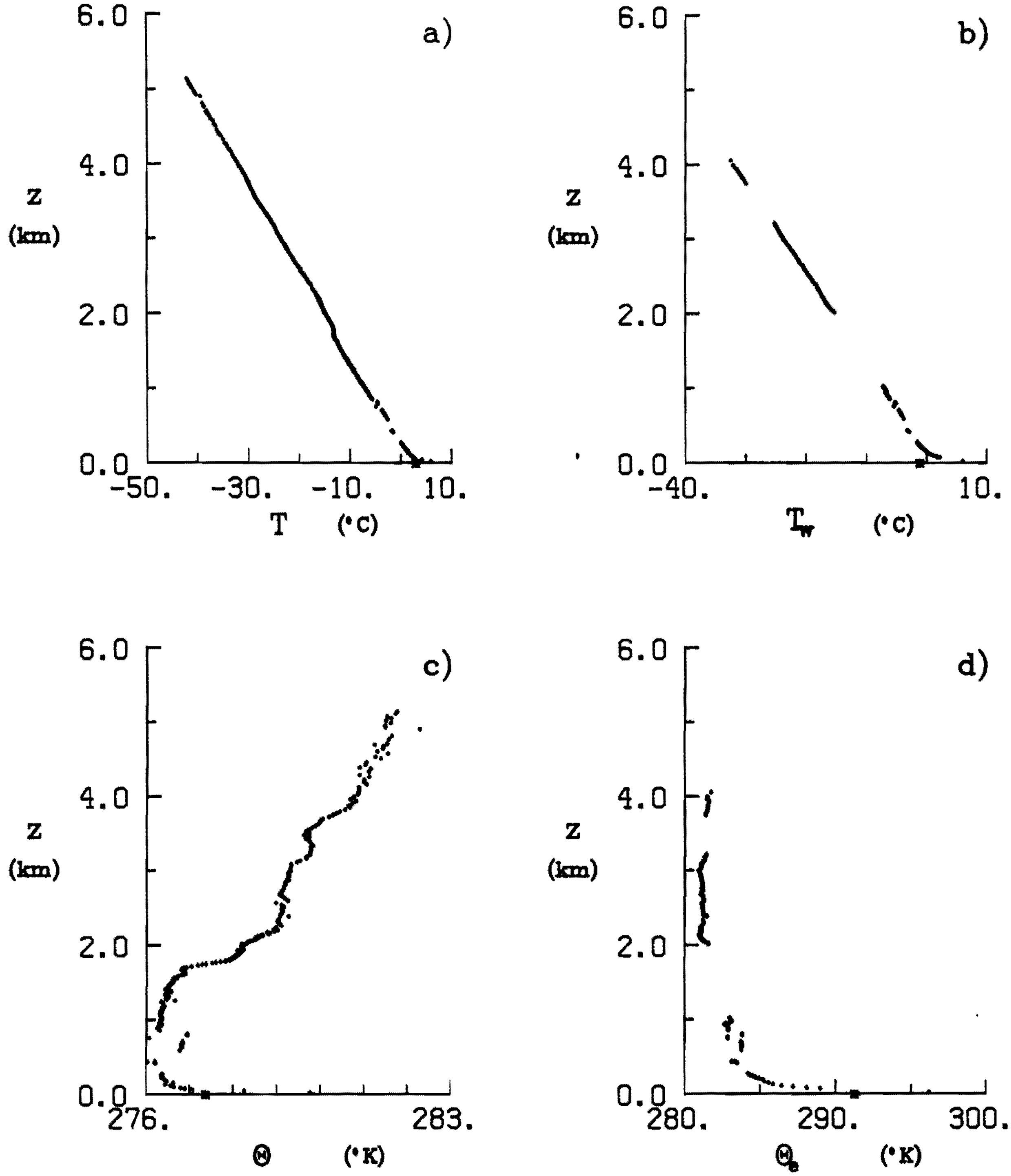

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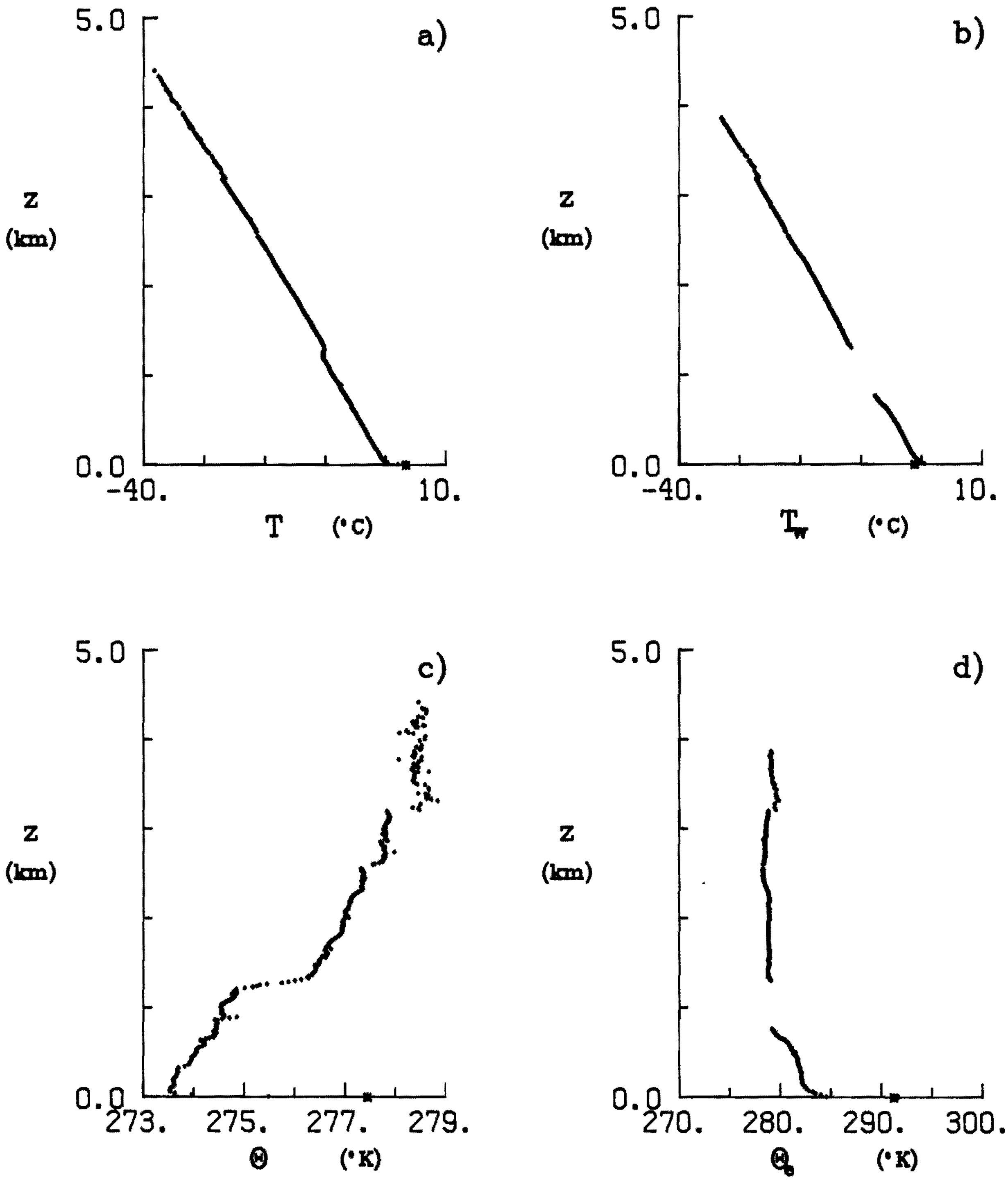

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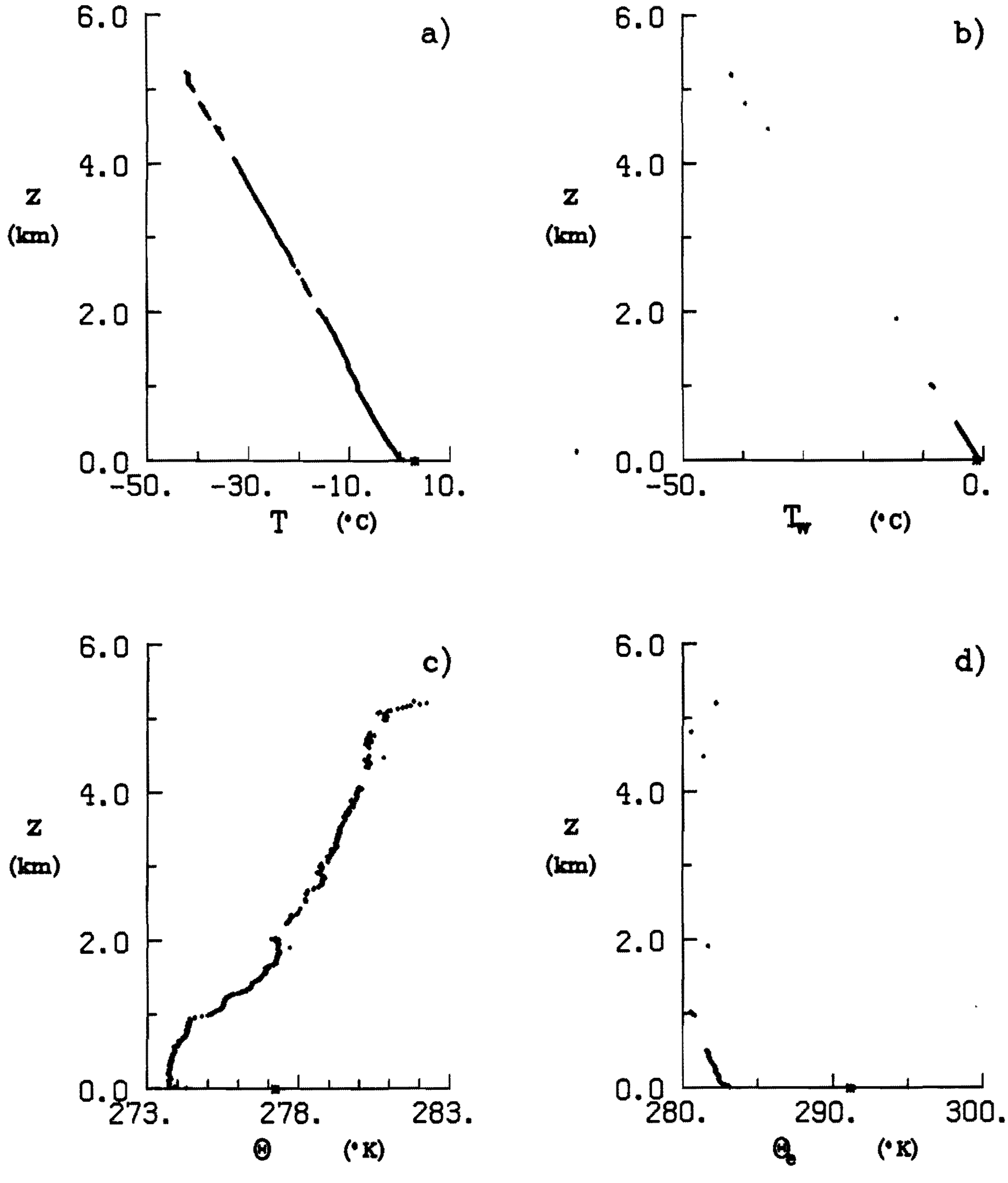

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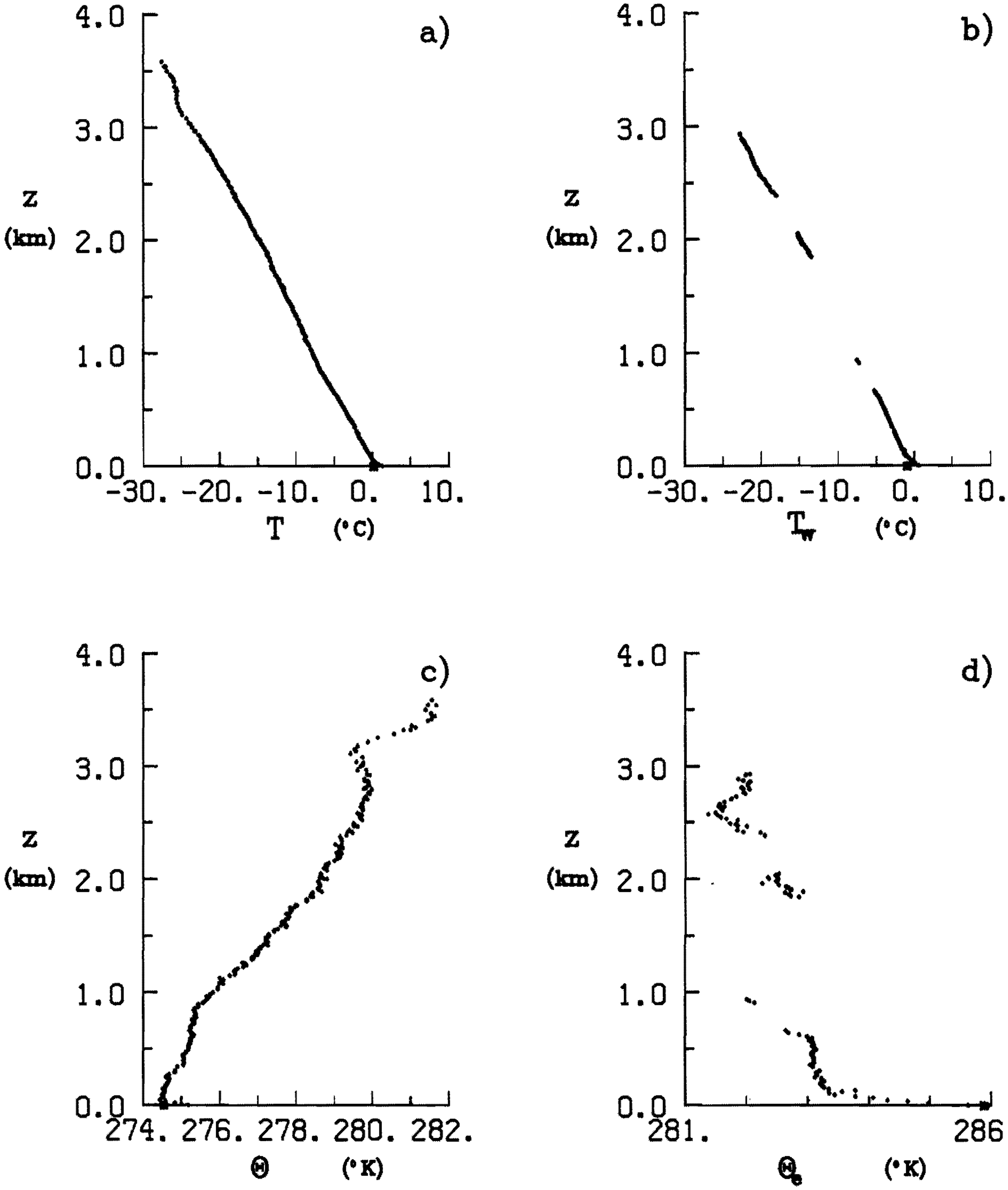

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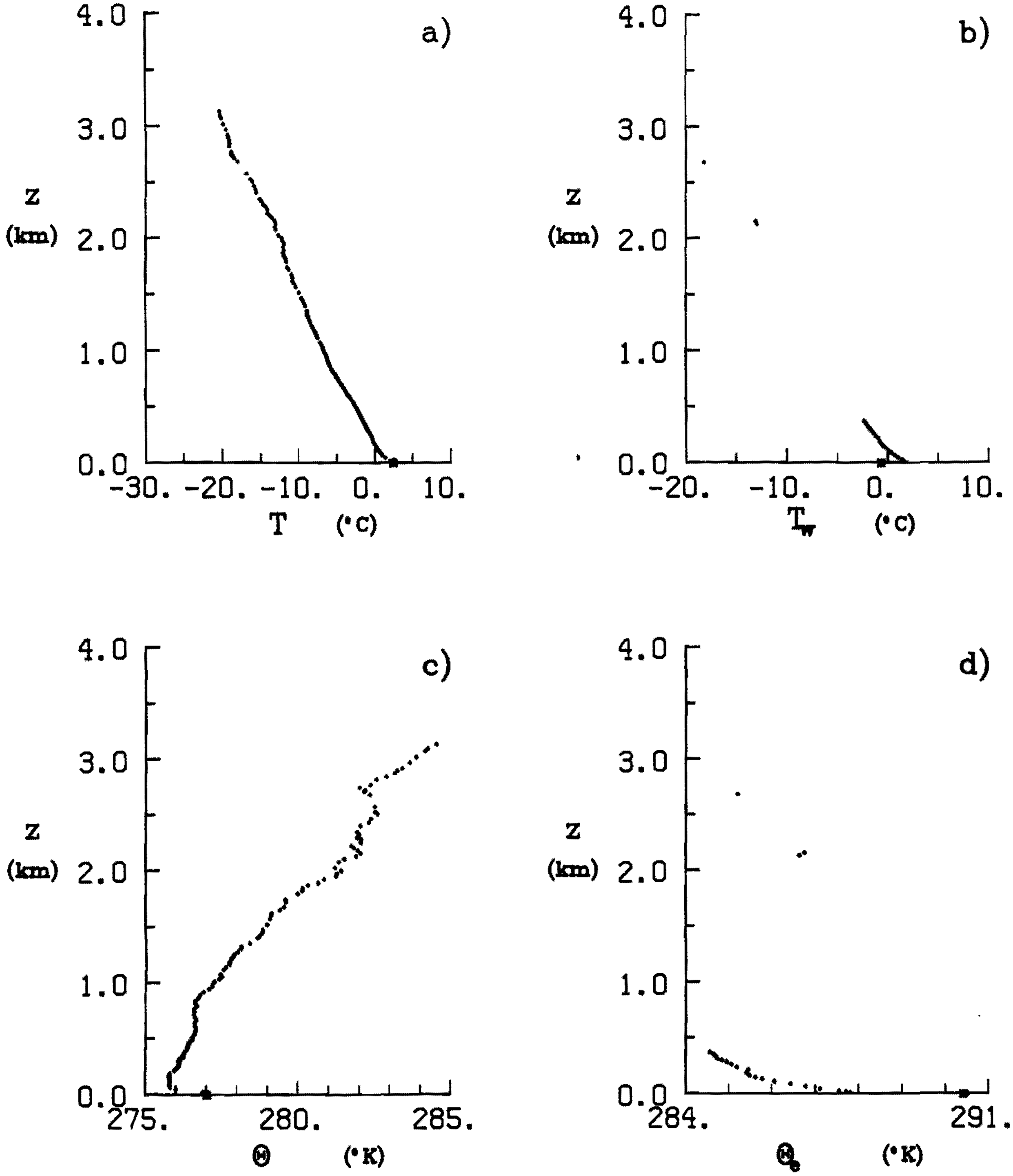

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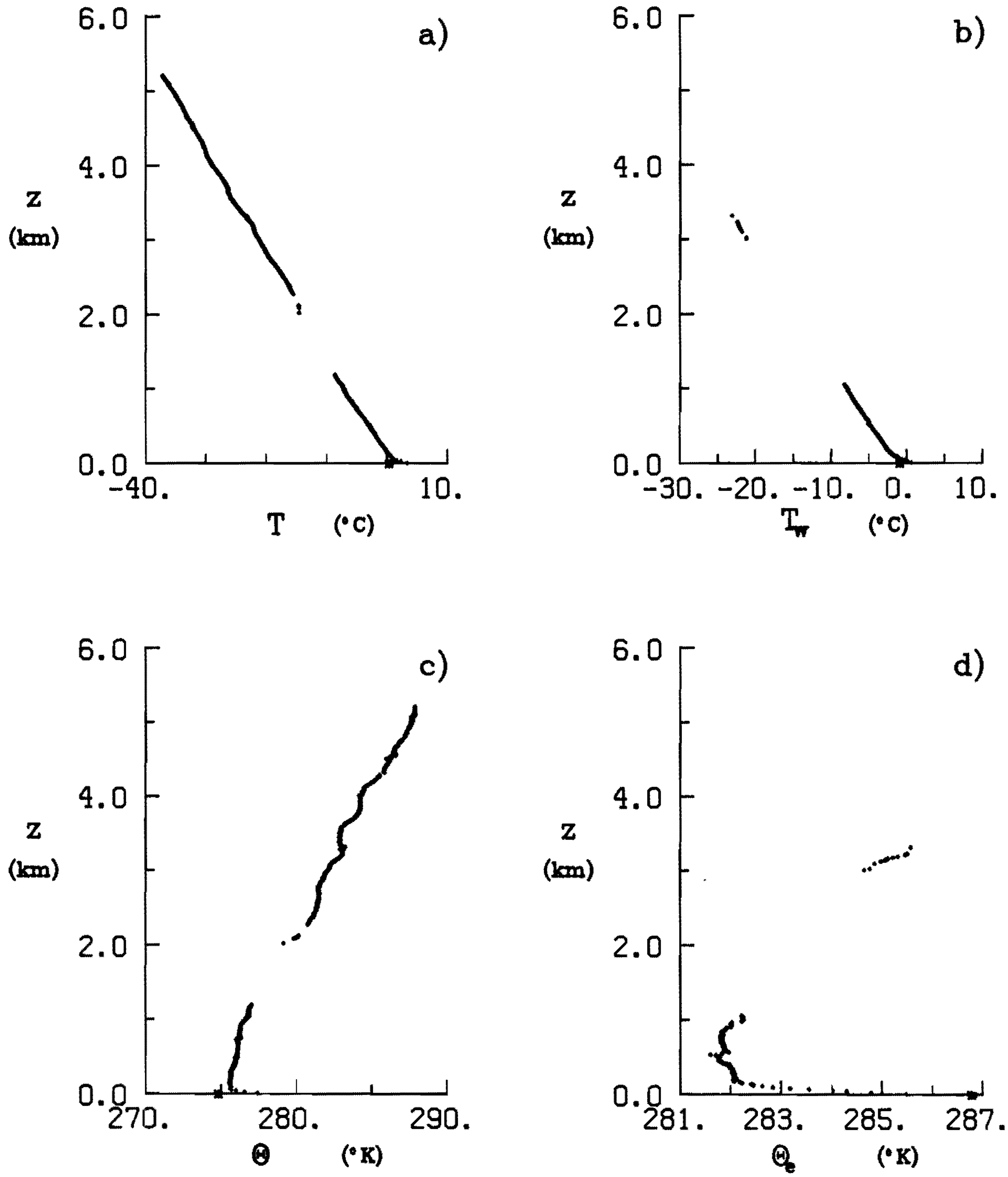

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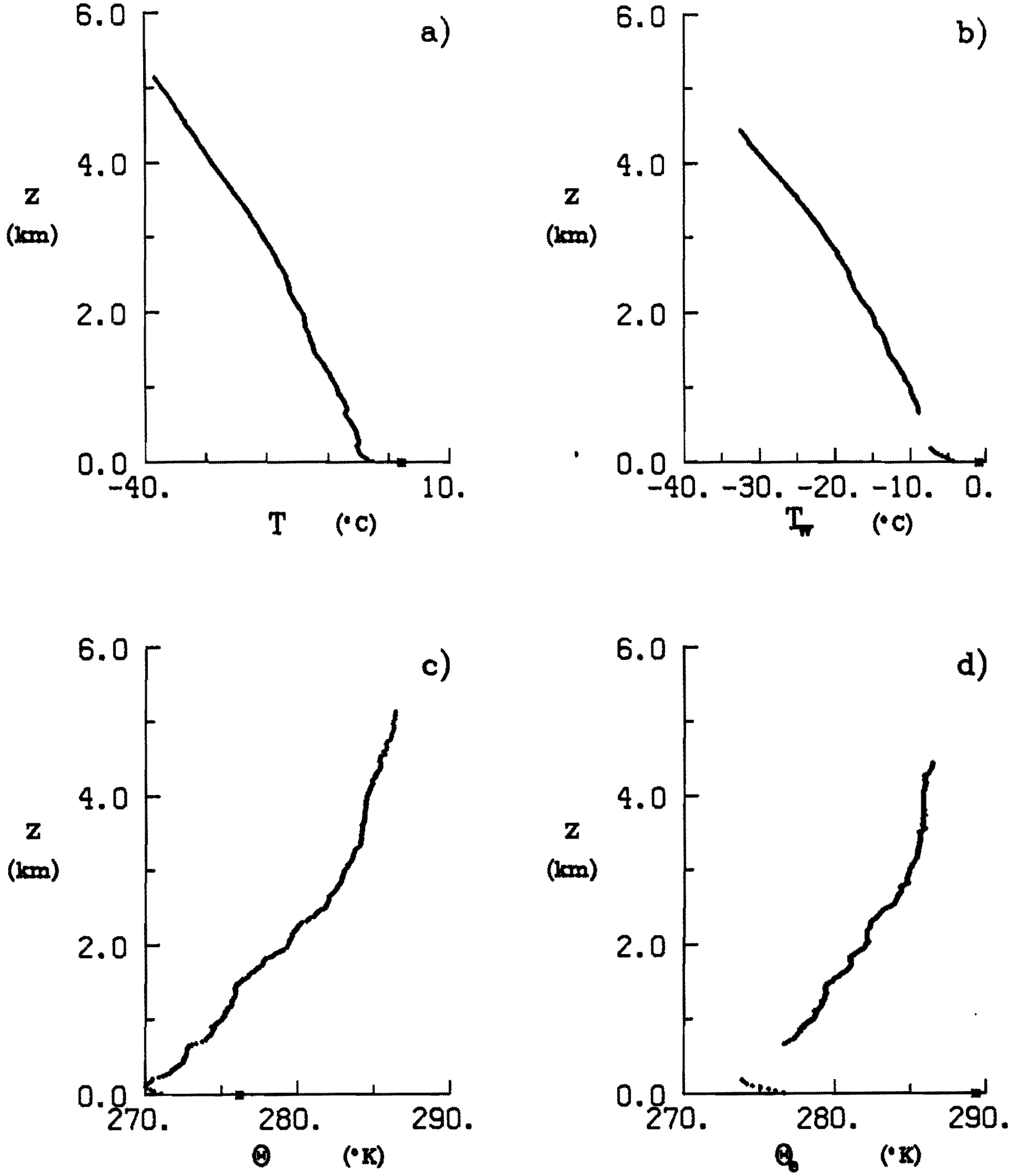

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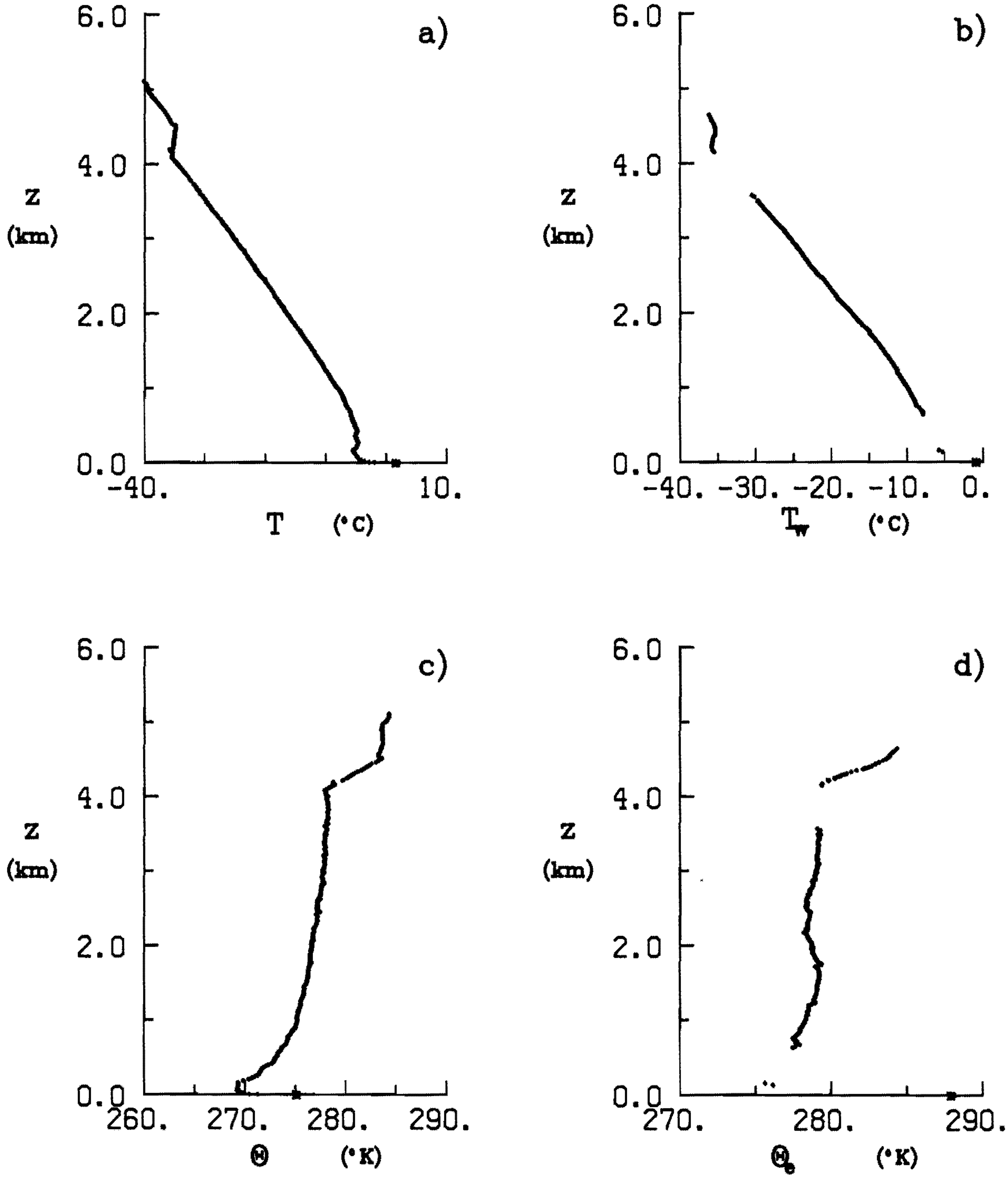

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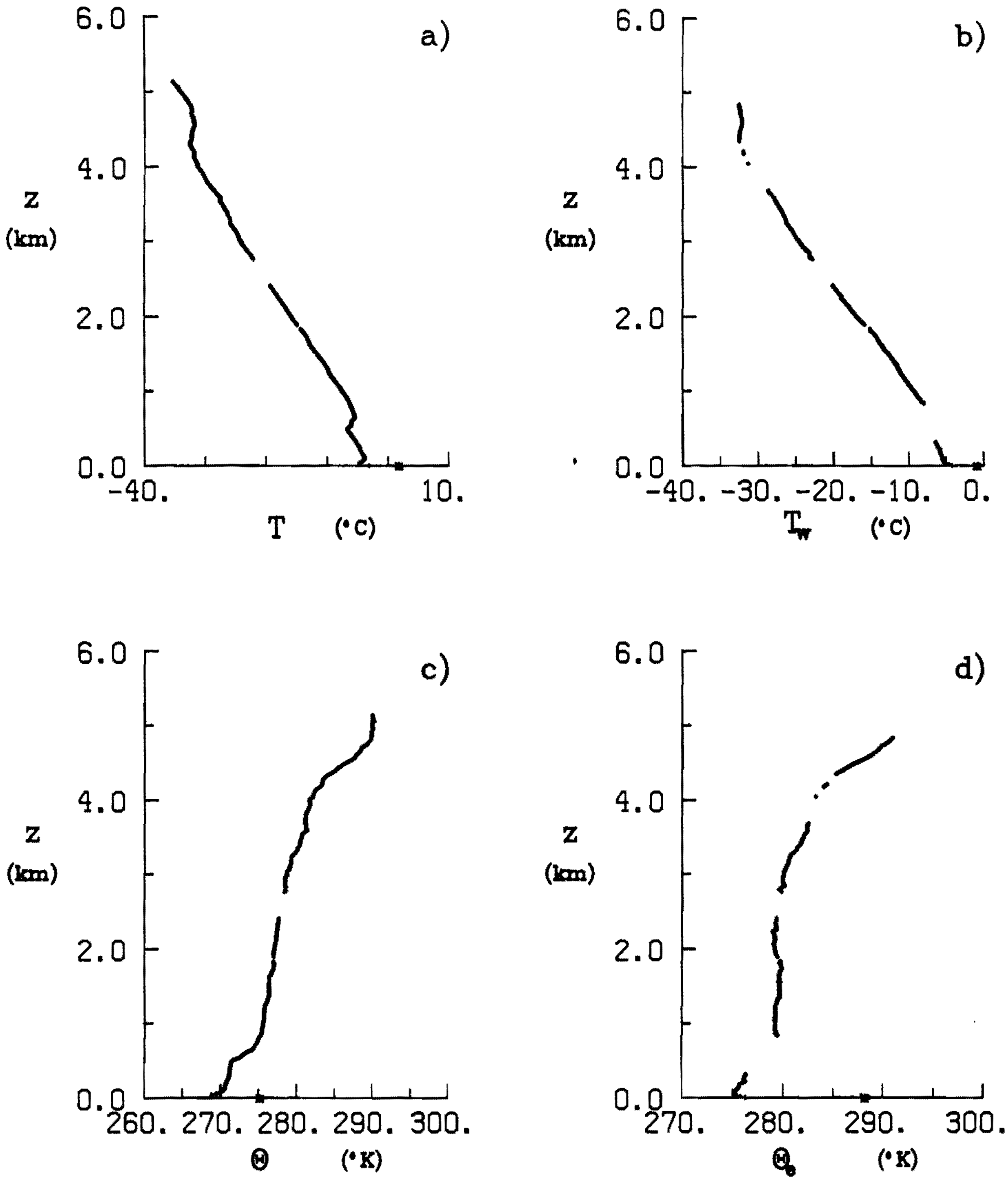

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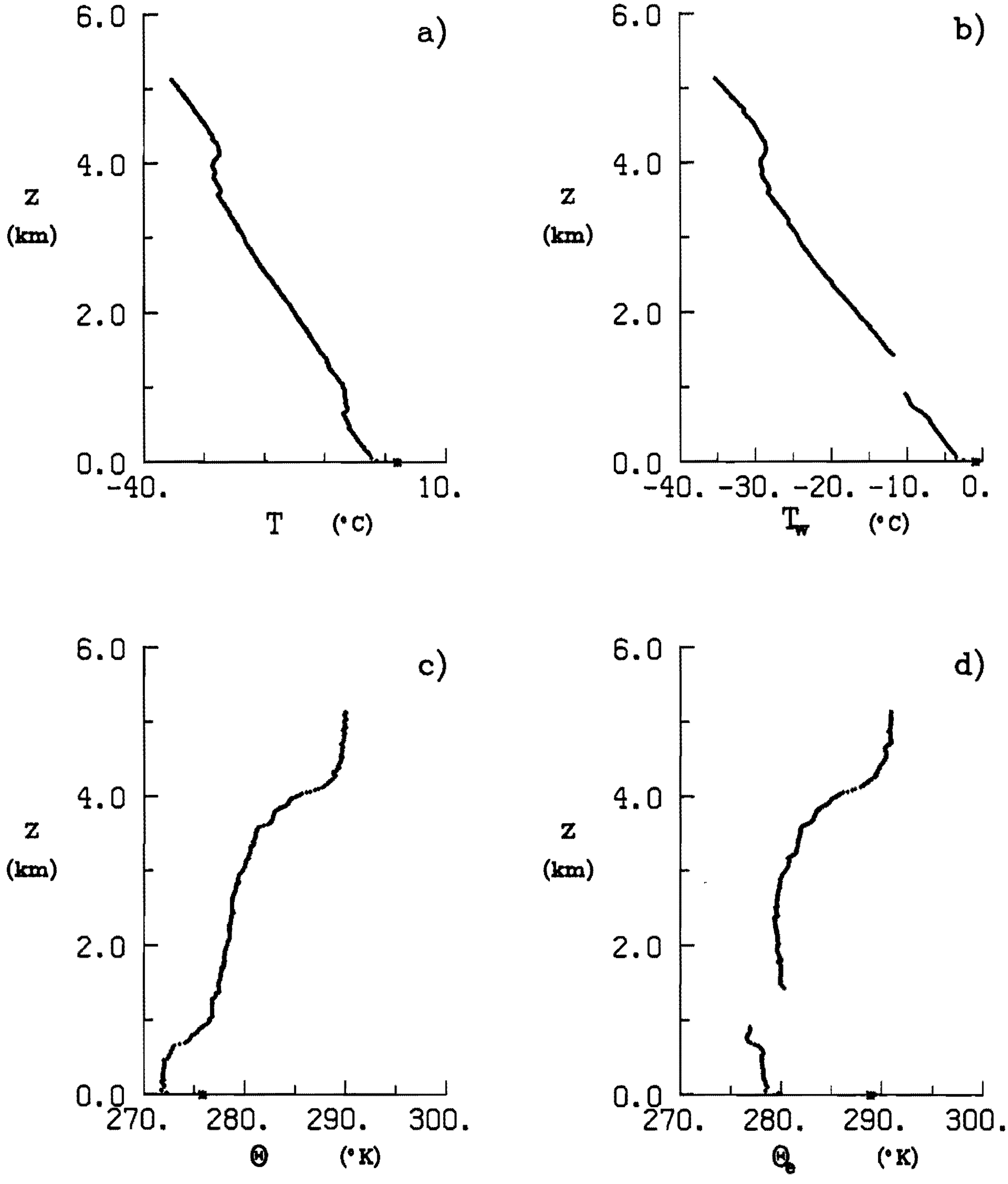

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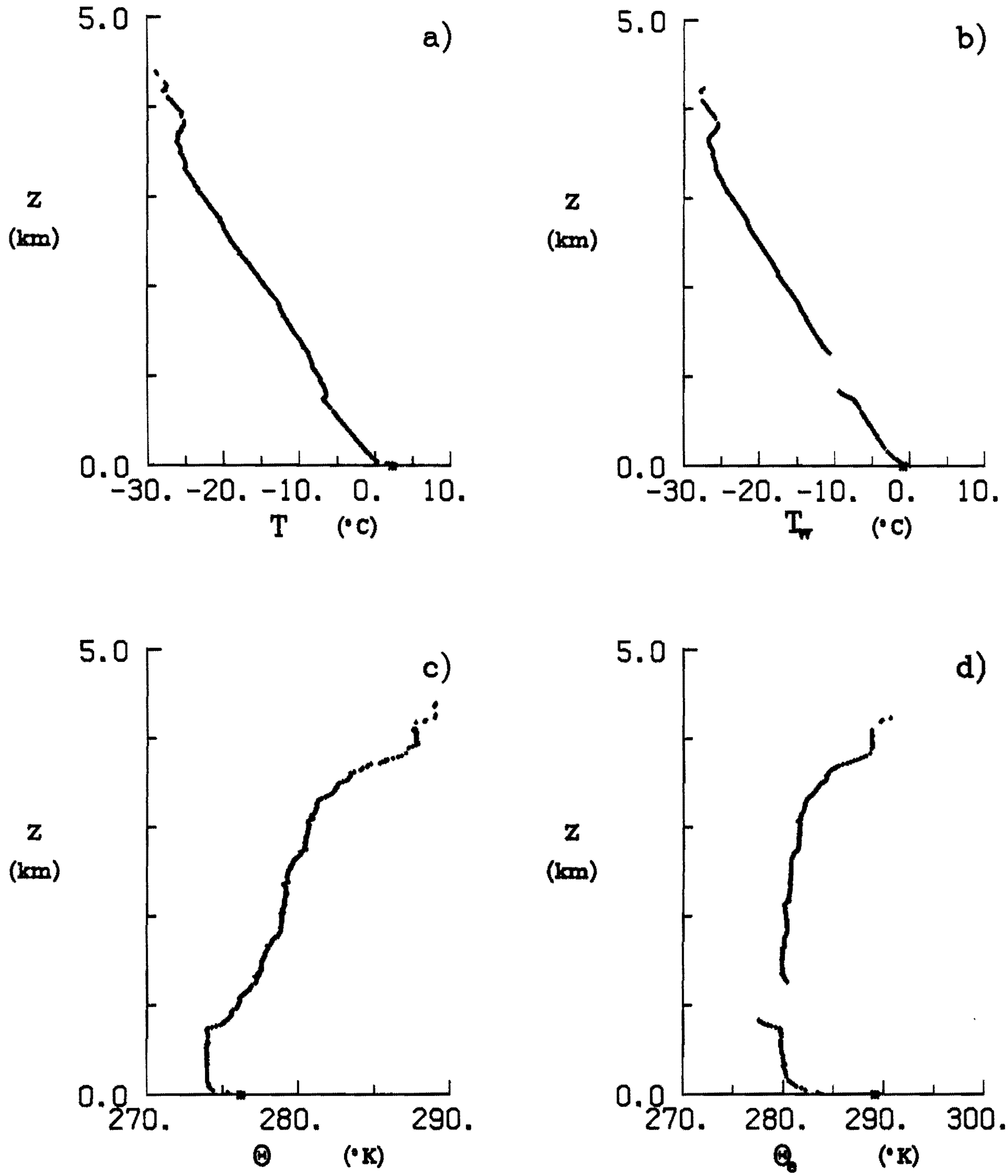

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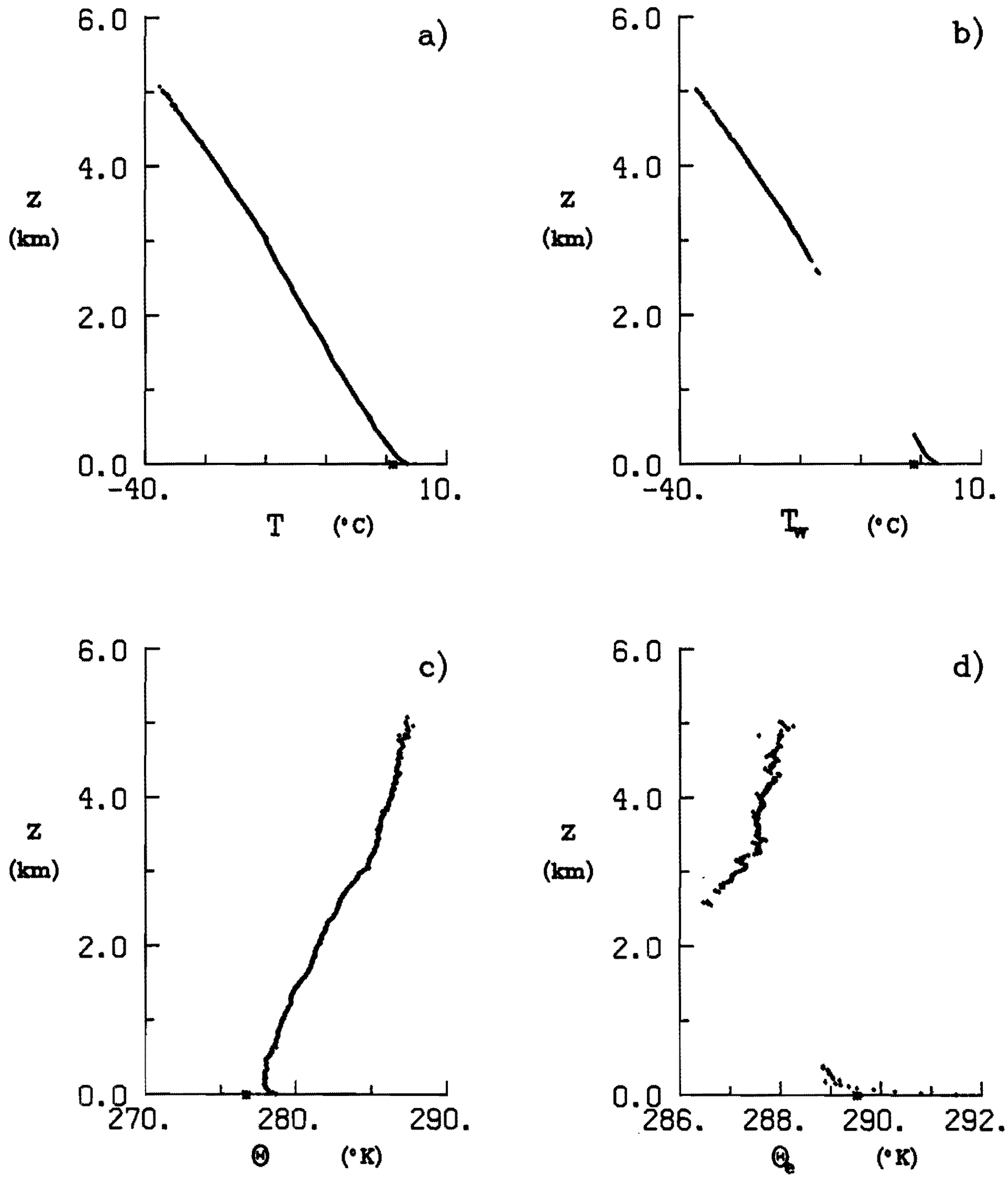

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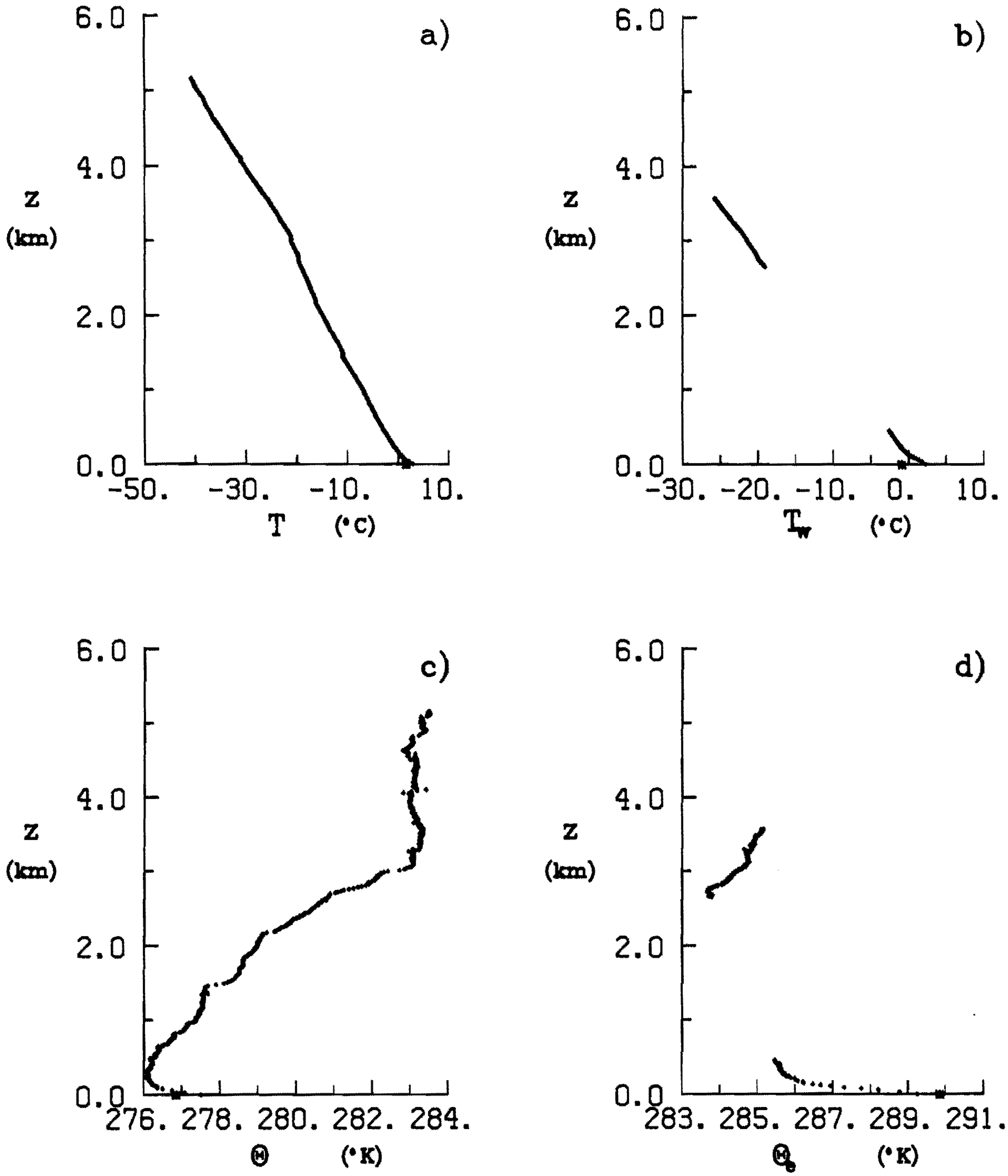

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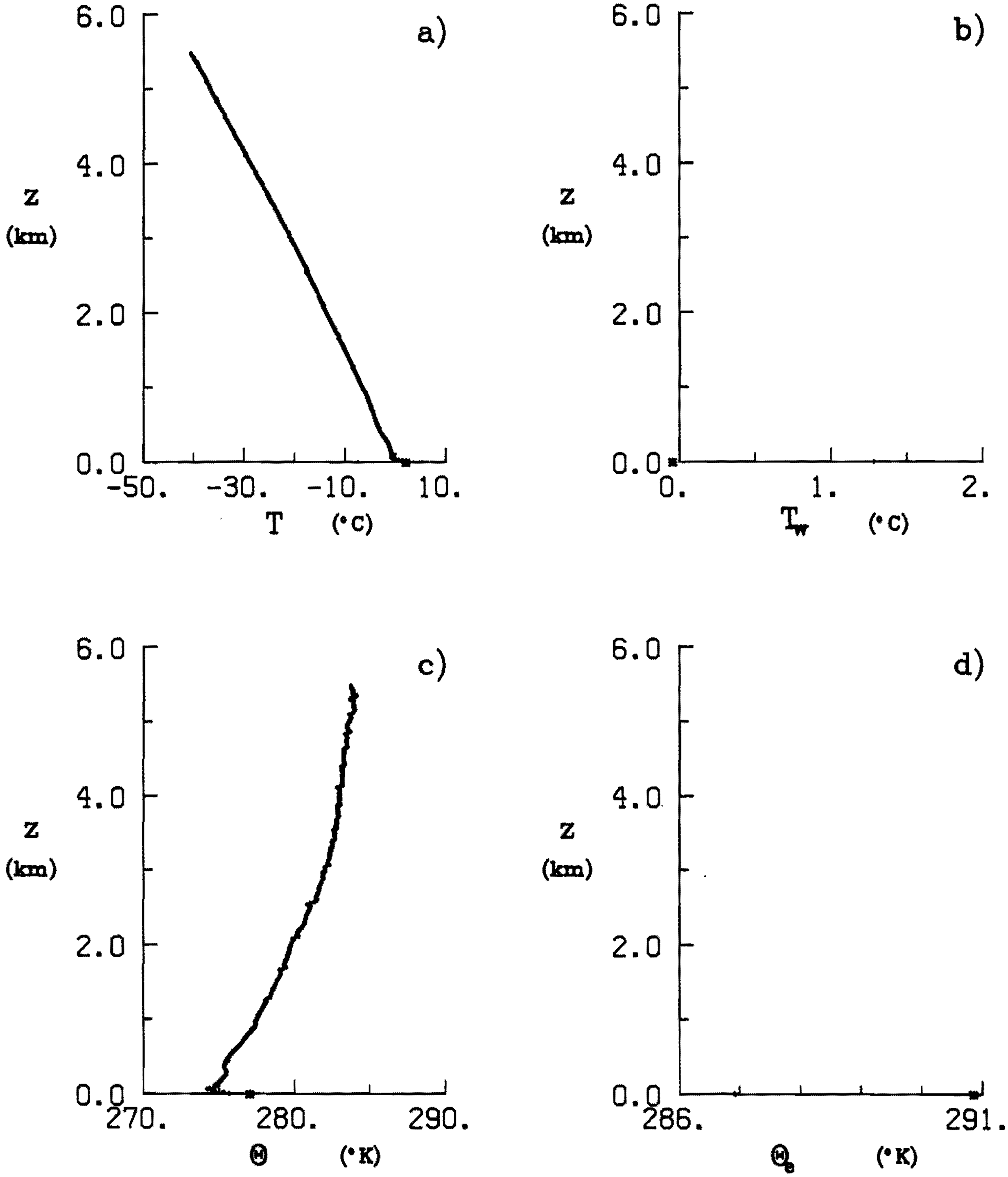

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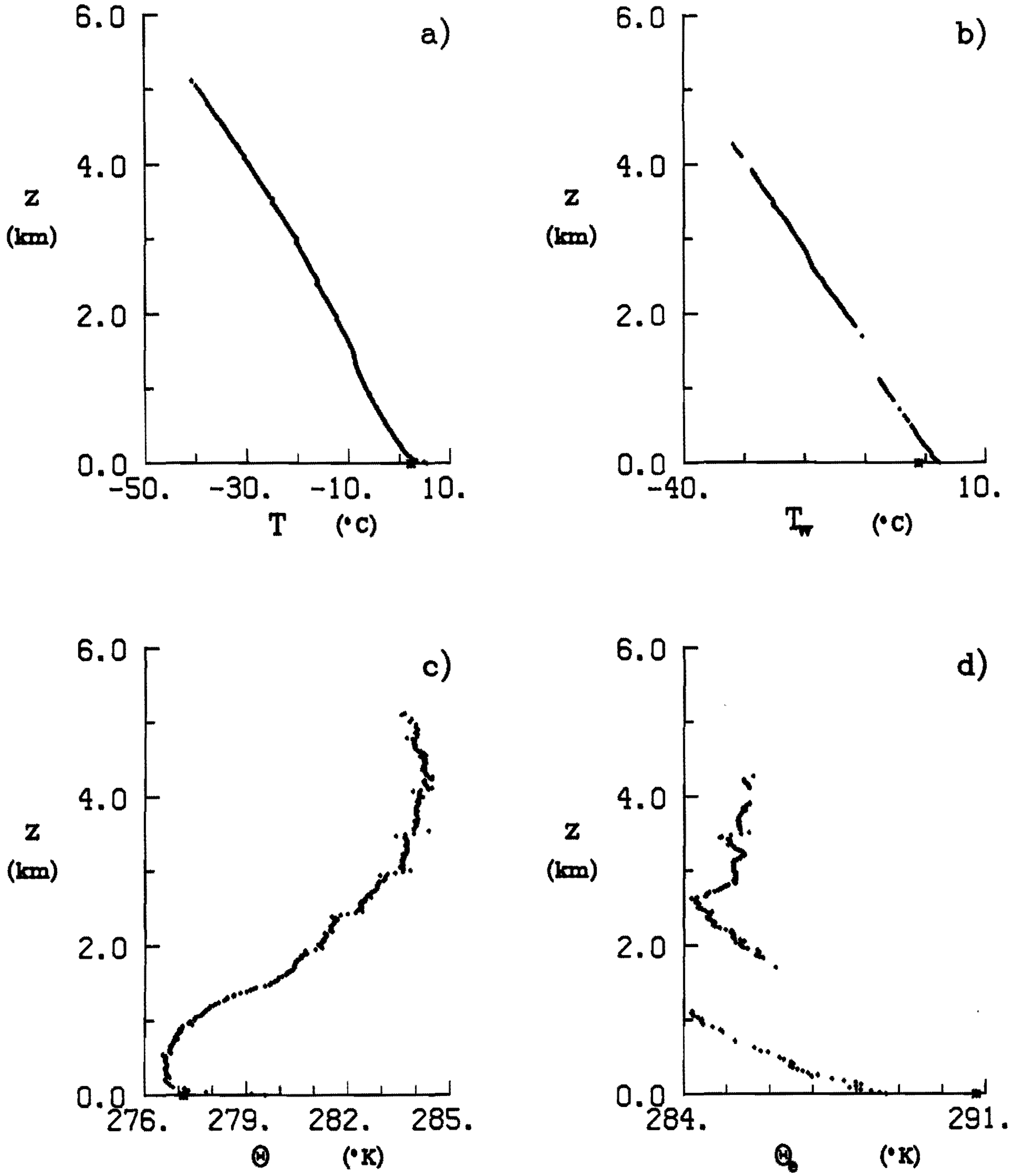

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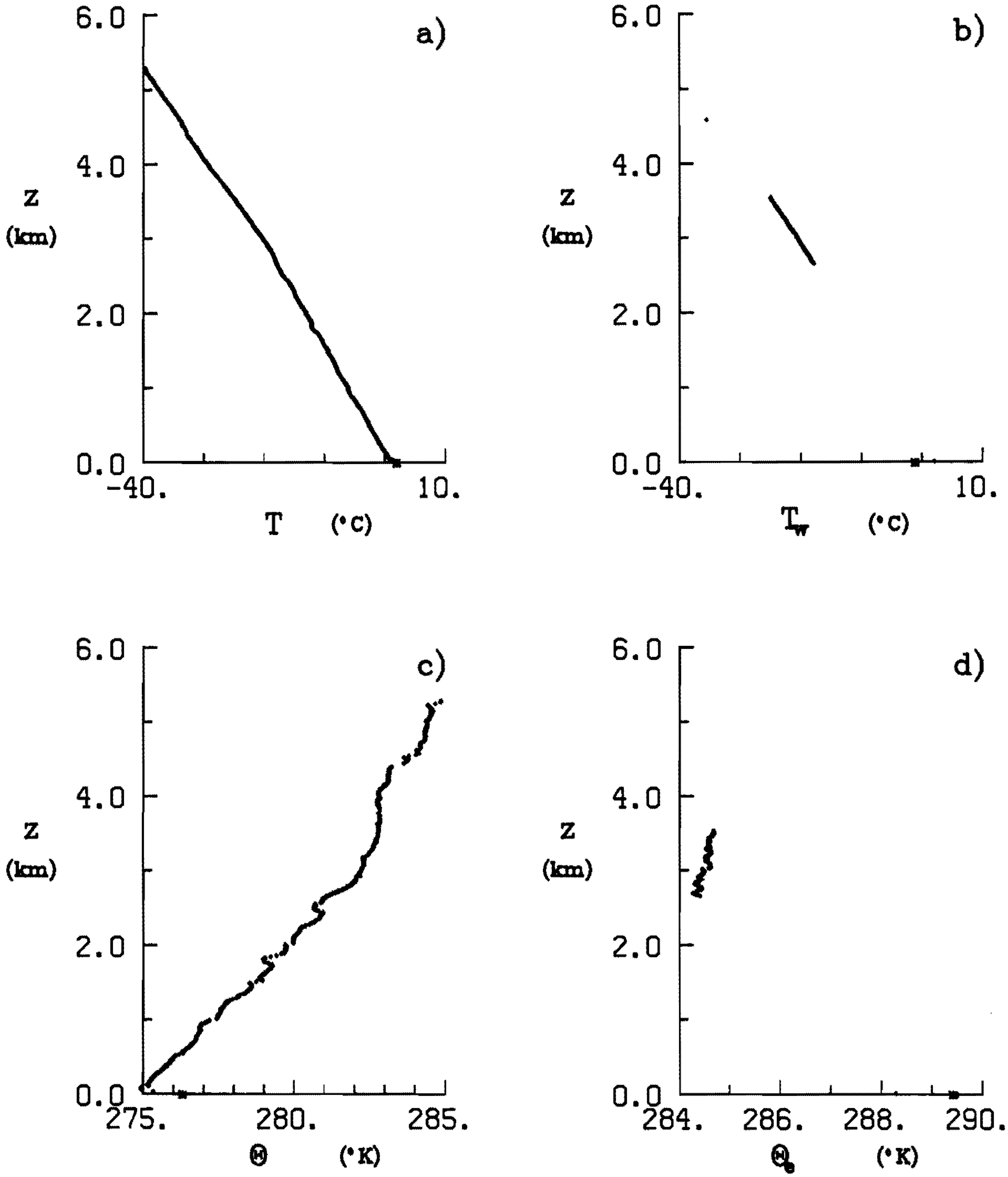

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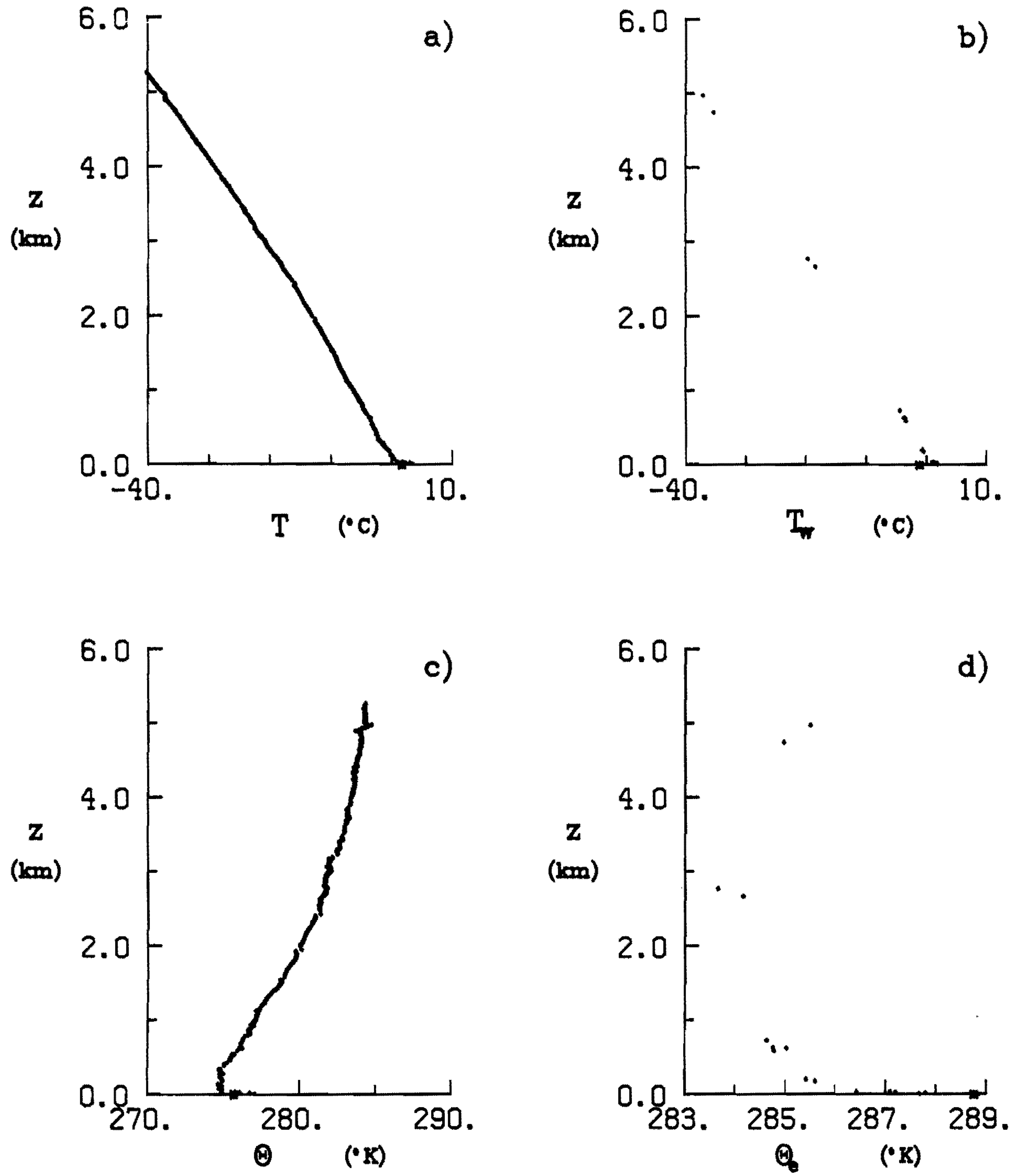

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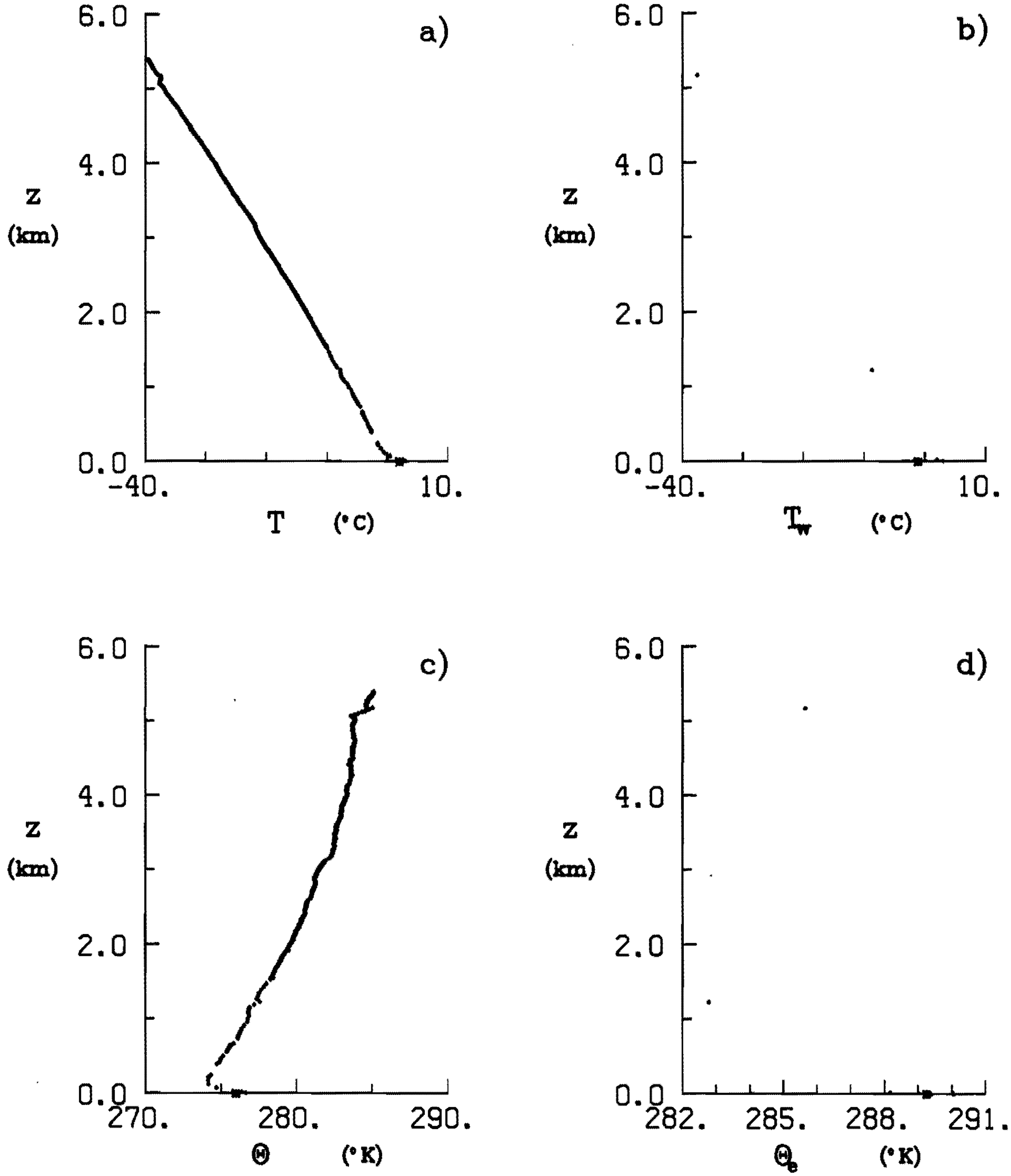

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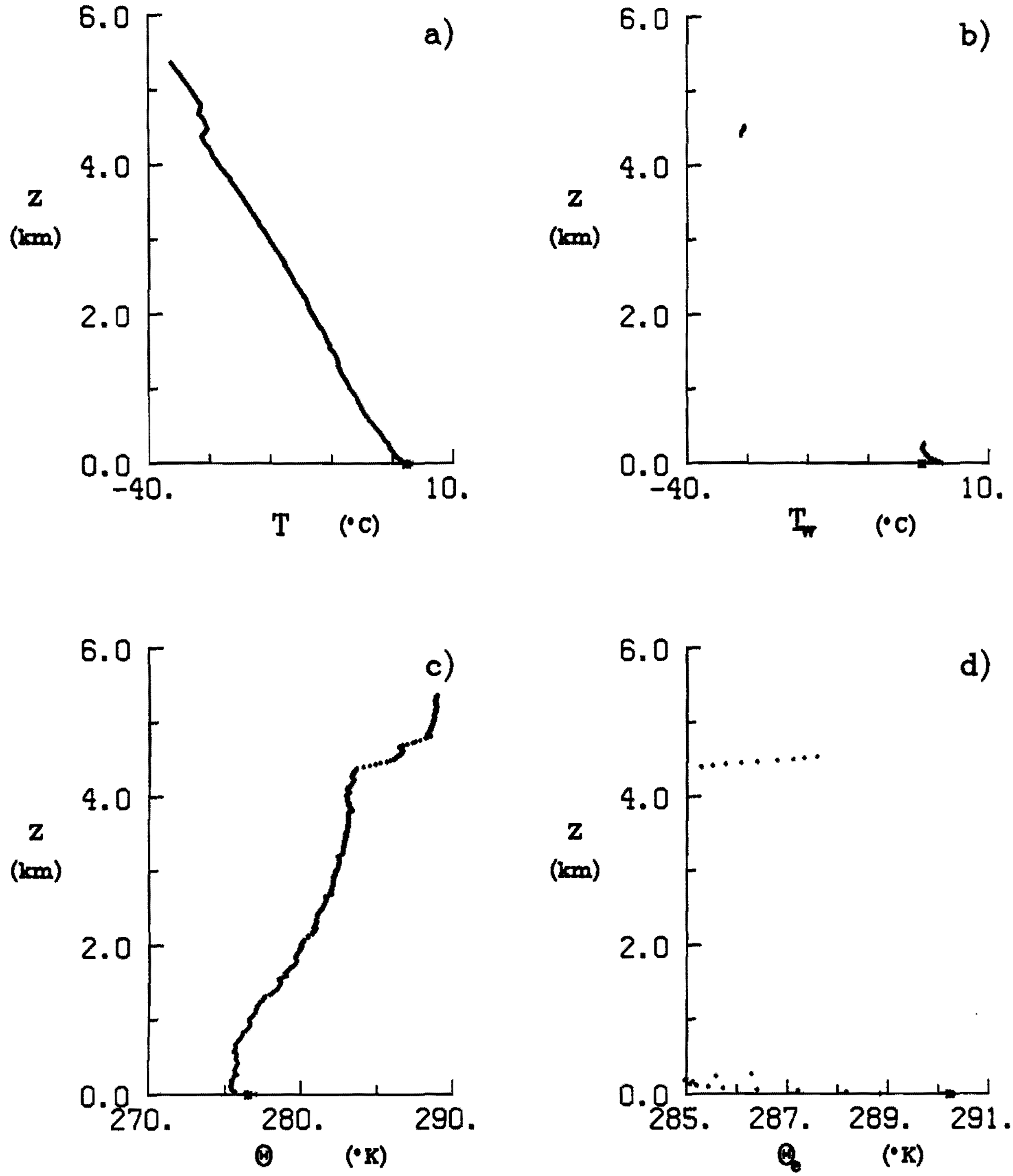

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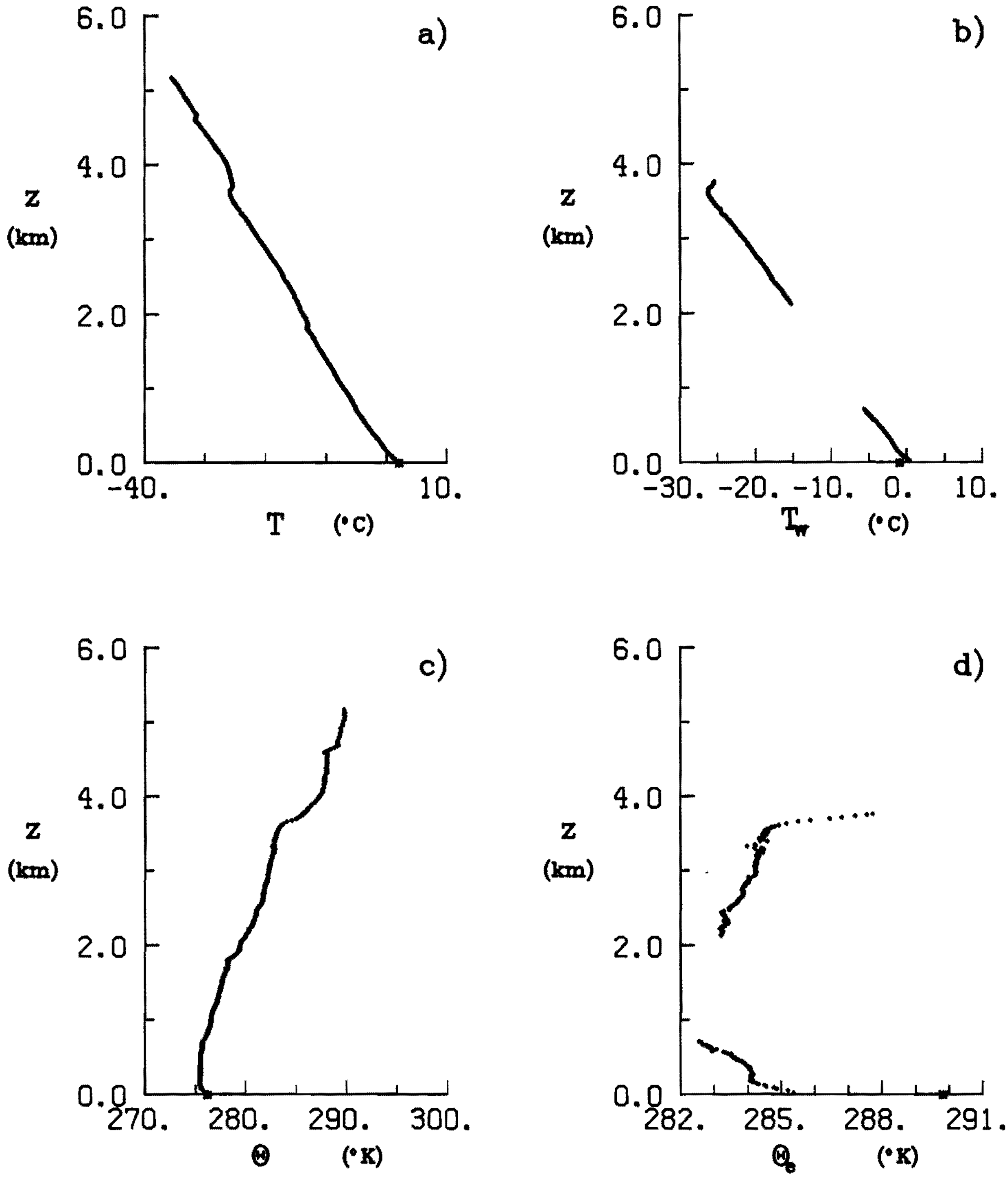

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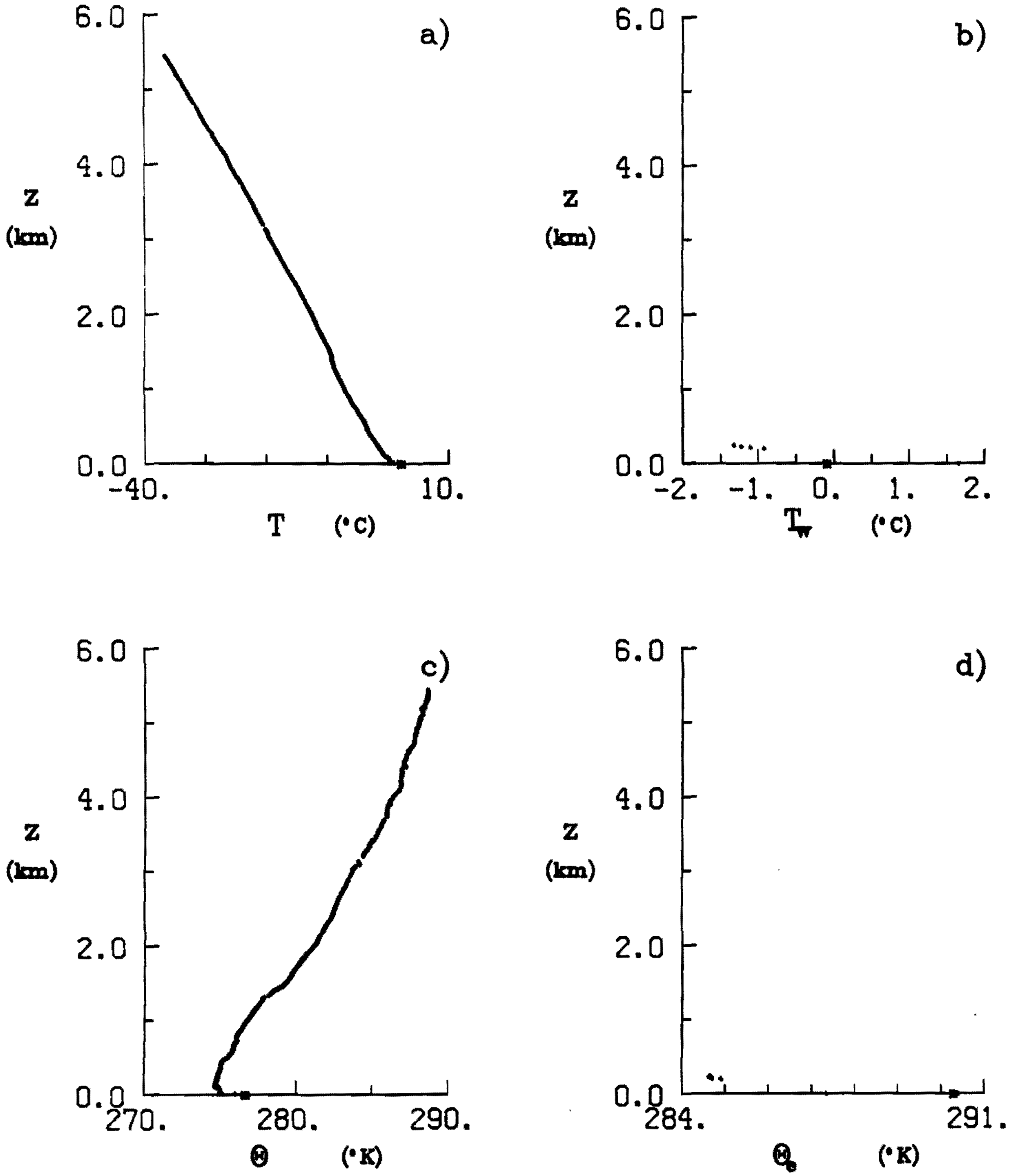

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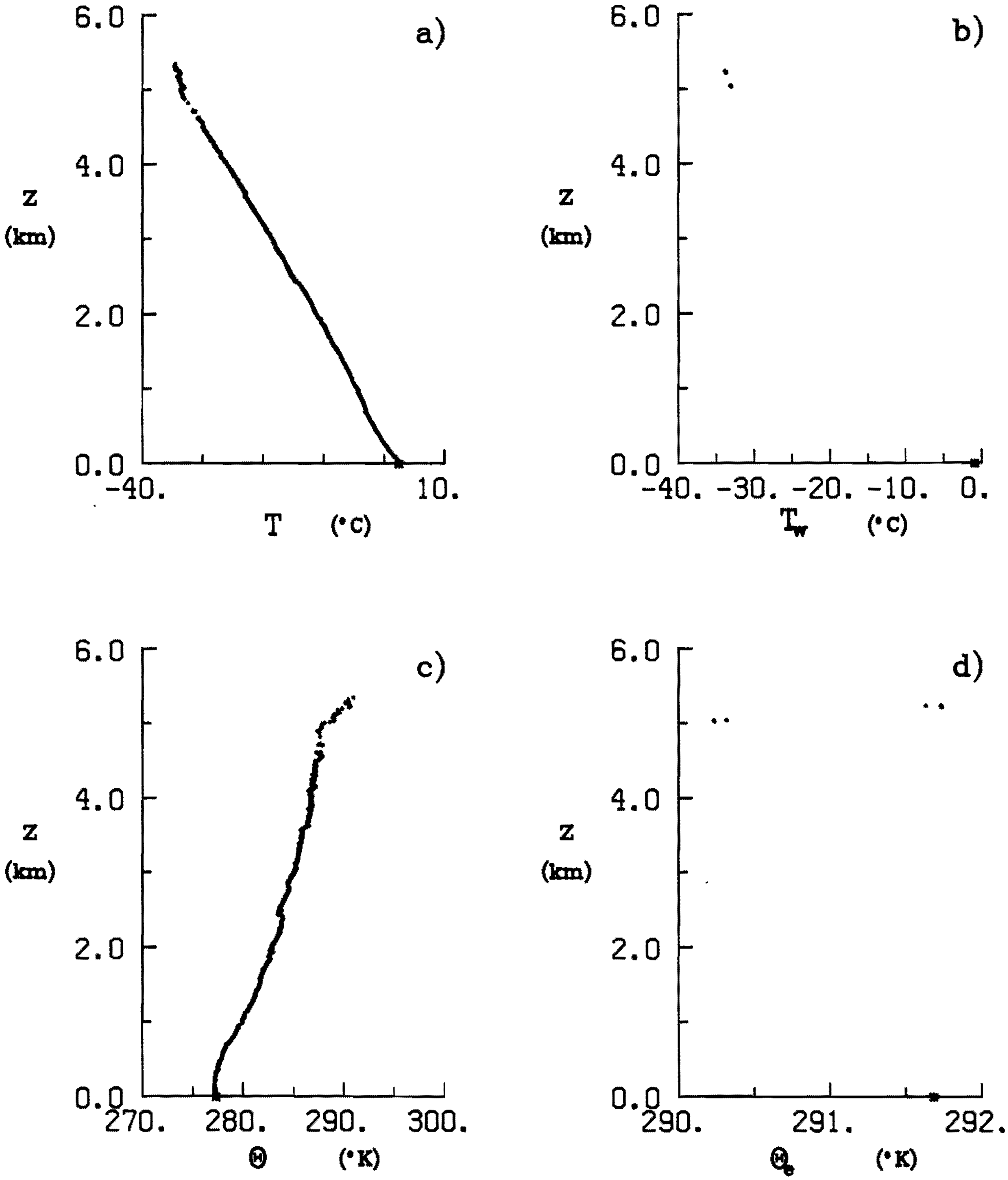

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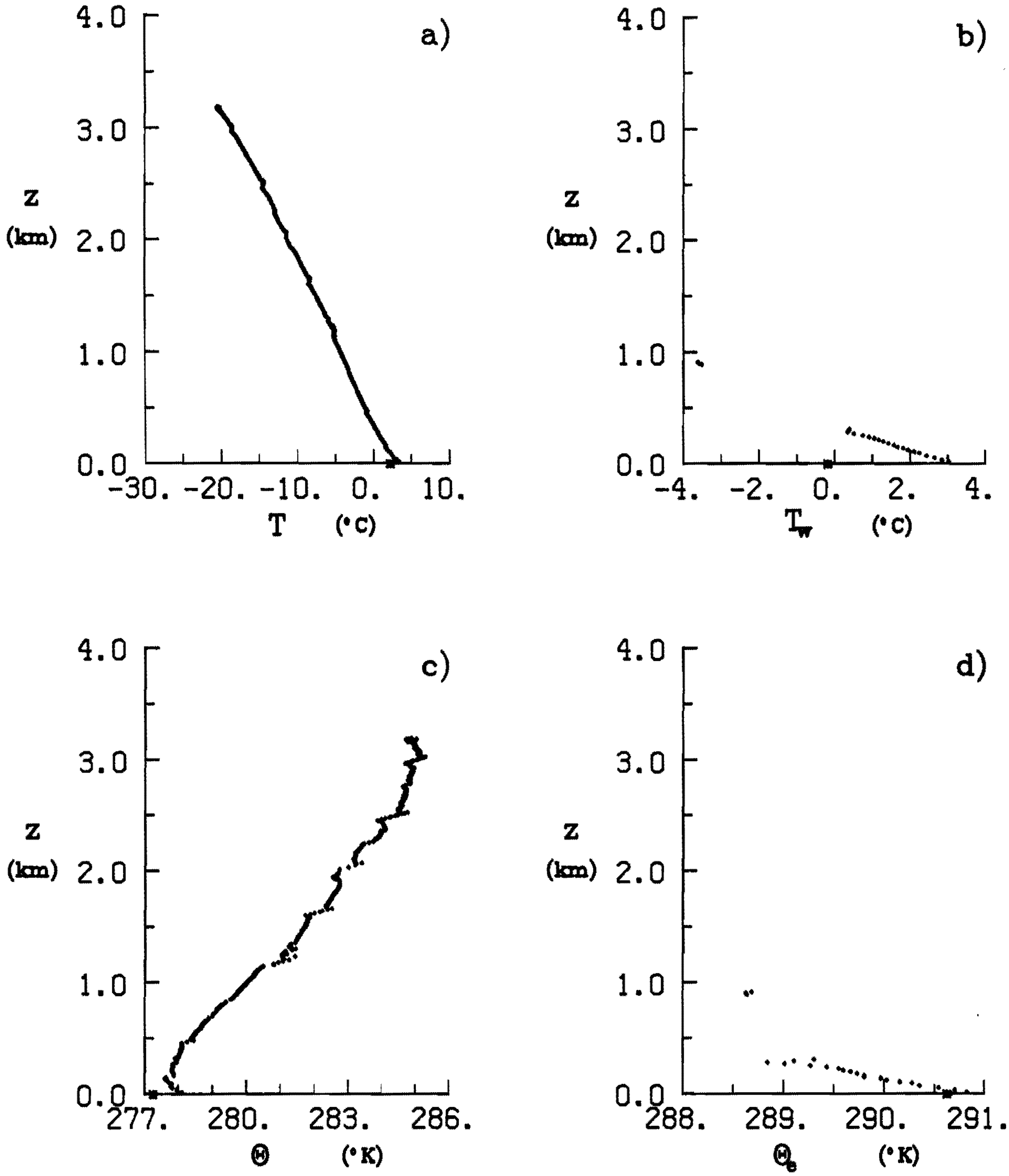

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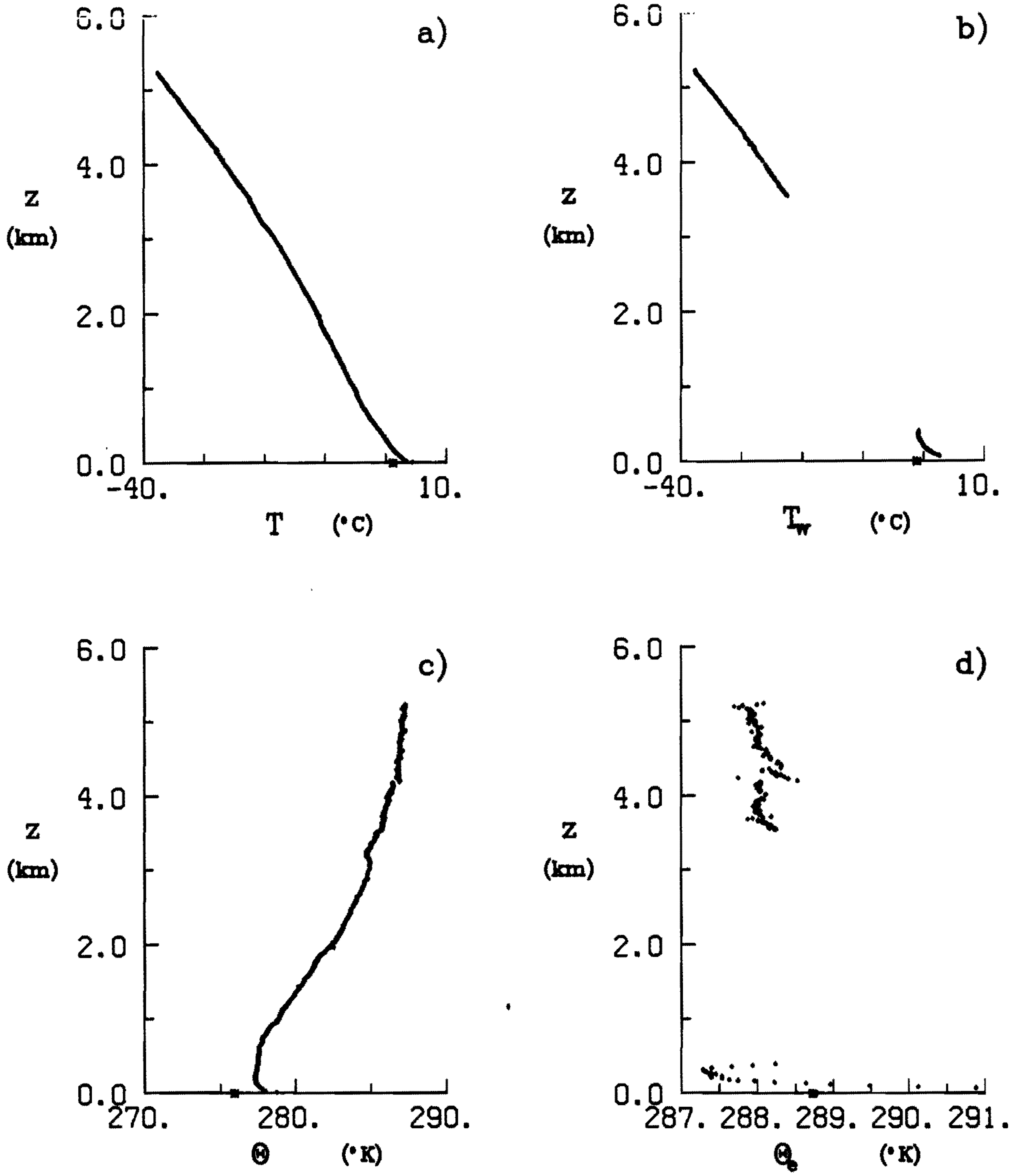
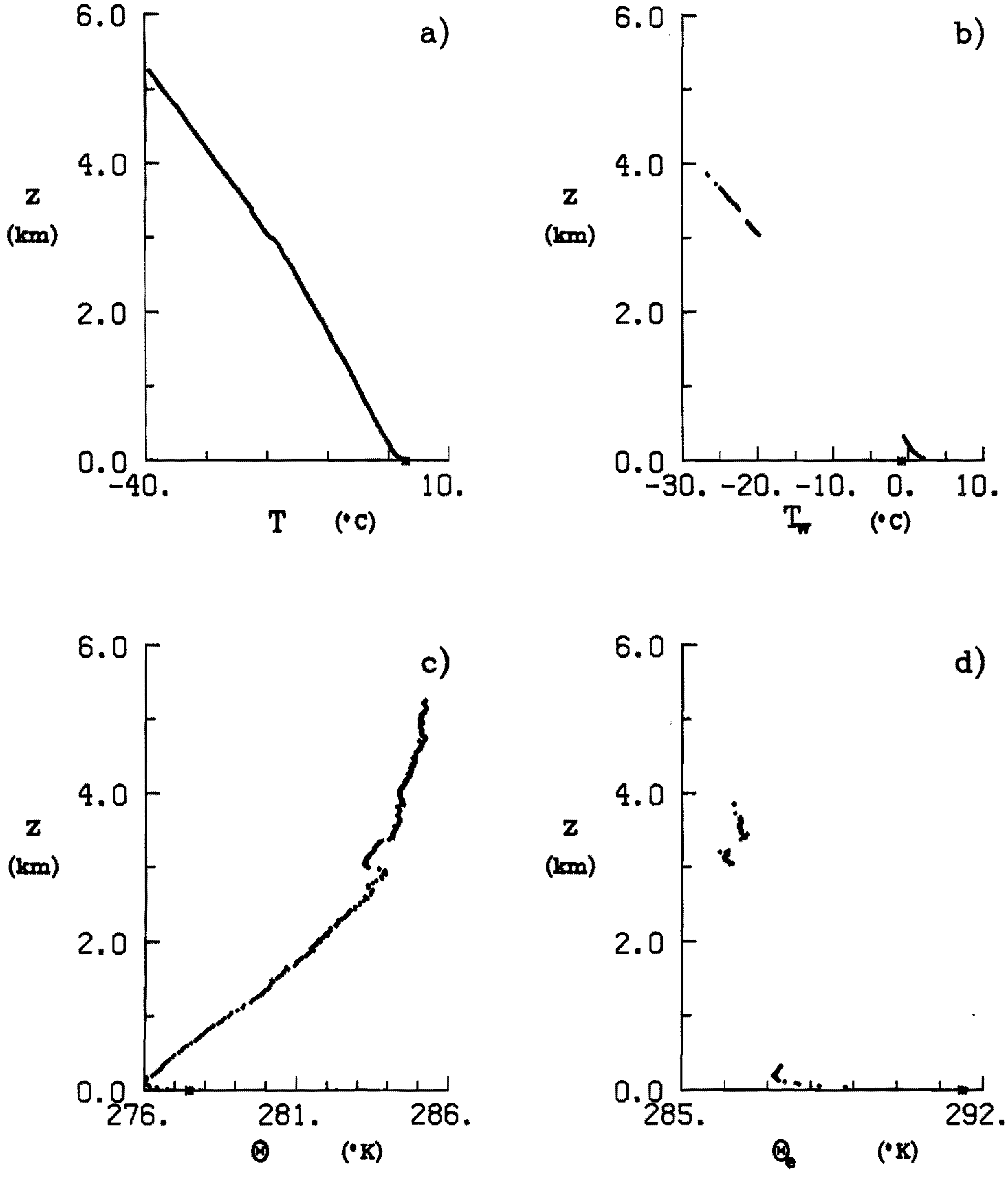
FOX SOUNDING 26



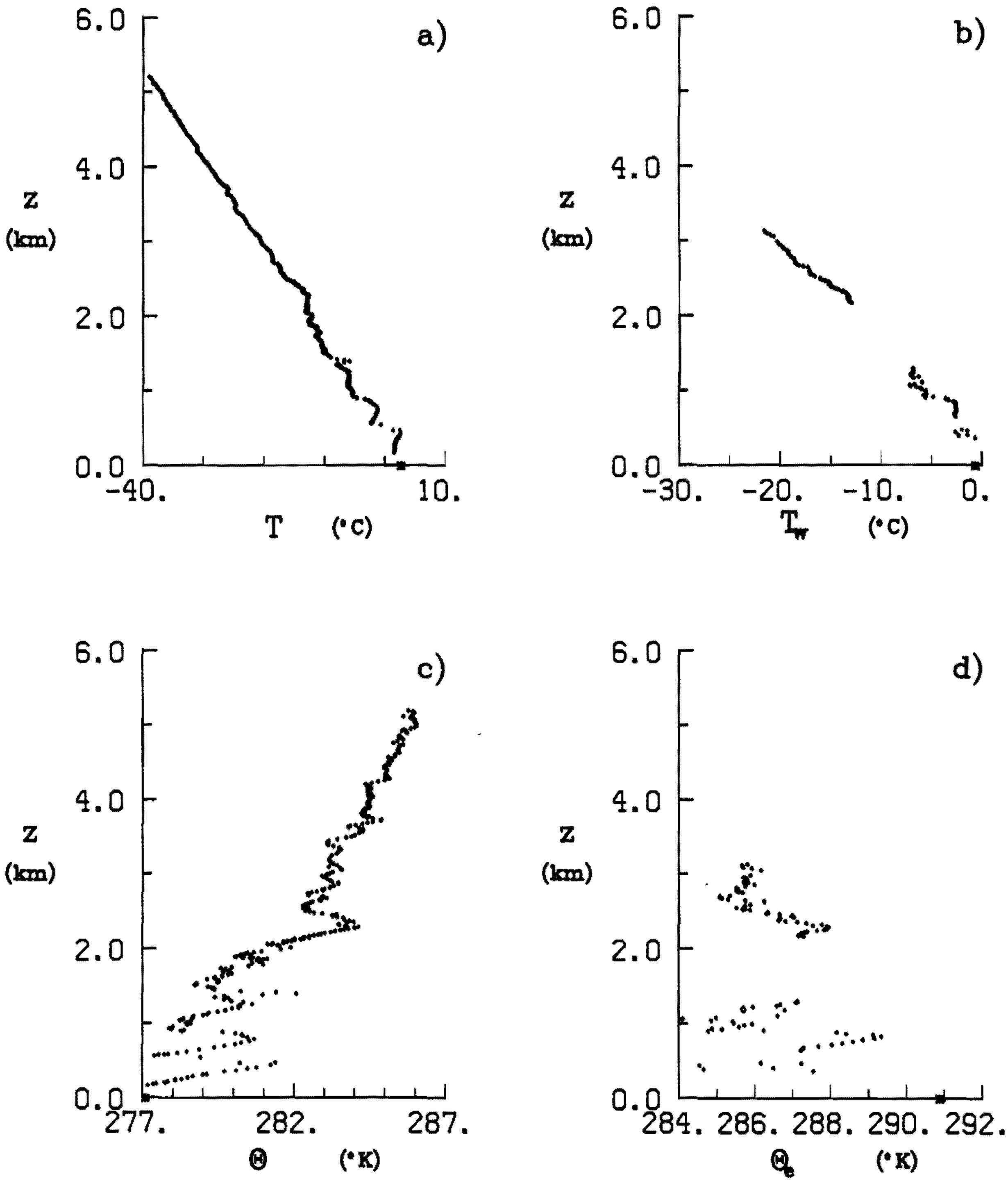
850323 0001 GMT, LAT 56.44 LONG −156.23

FOX SOUNDING 27



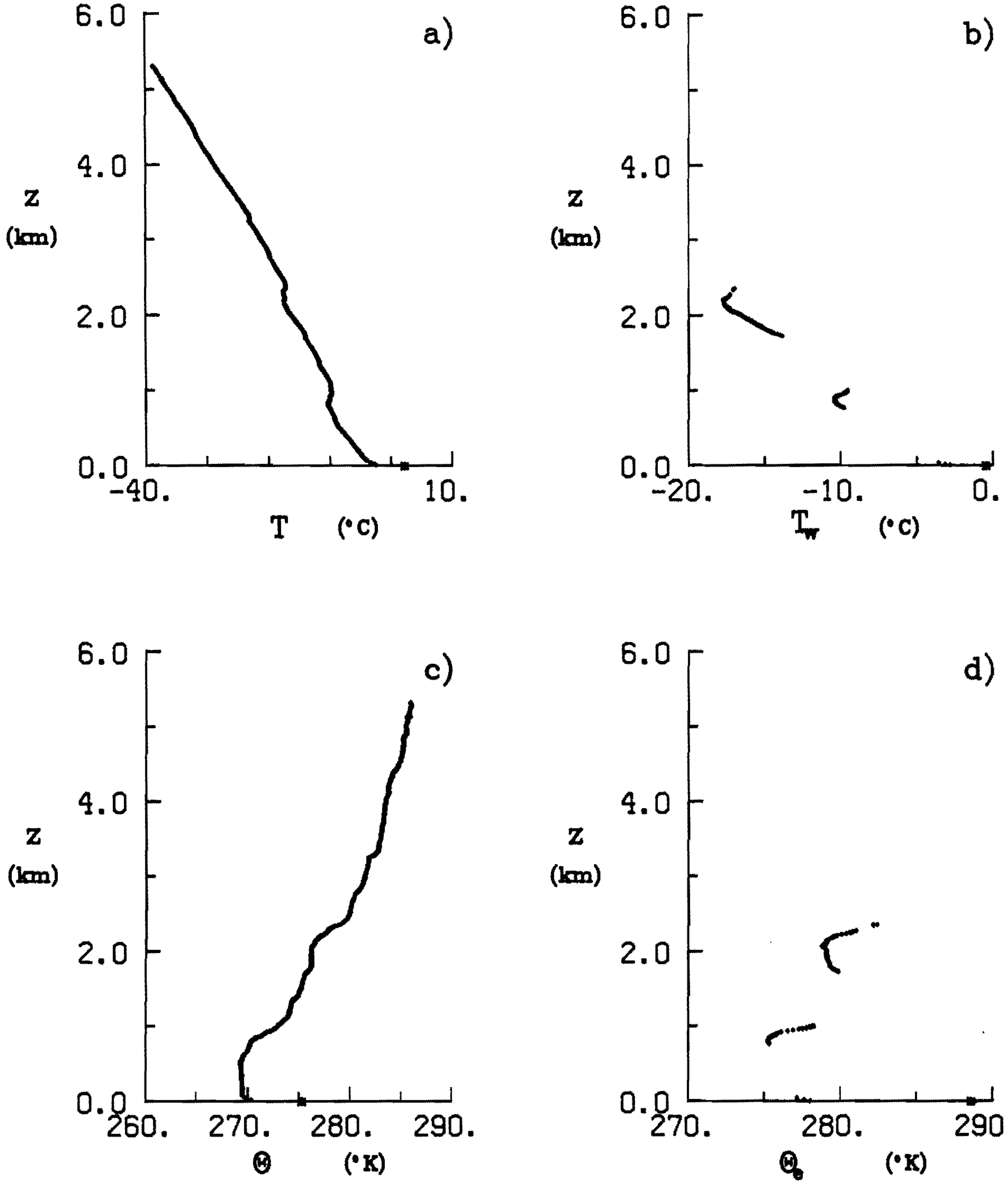
850323 1201 GMT, LAT 55.62 LONG −154.63

FOX SOUNDING 28



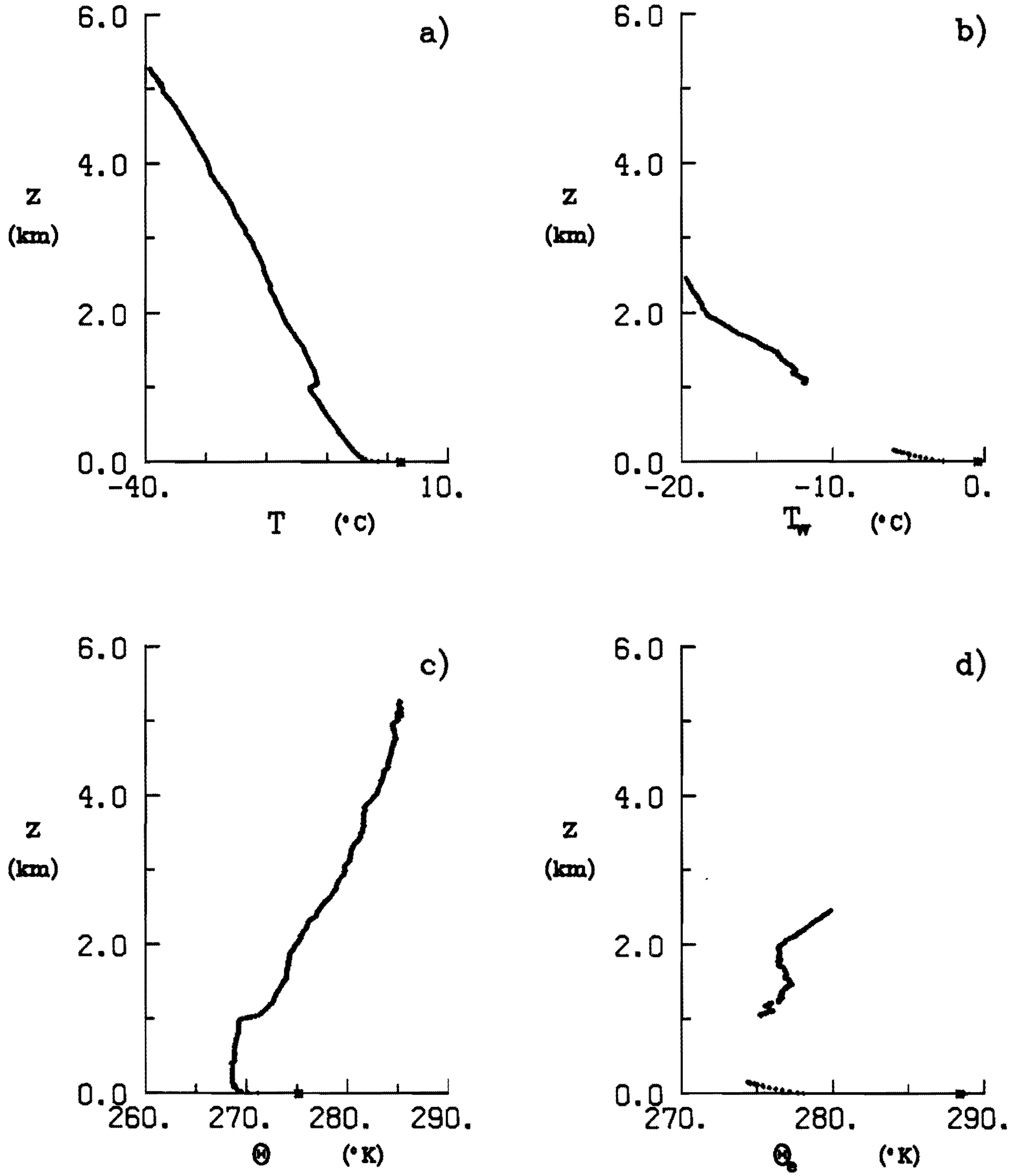
850323 1530 GMT, LAT 55.50 LONG -154.46

FOX SOUNDING 29



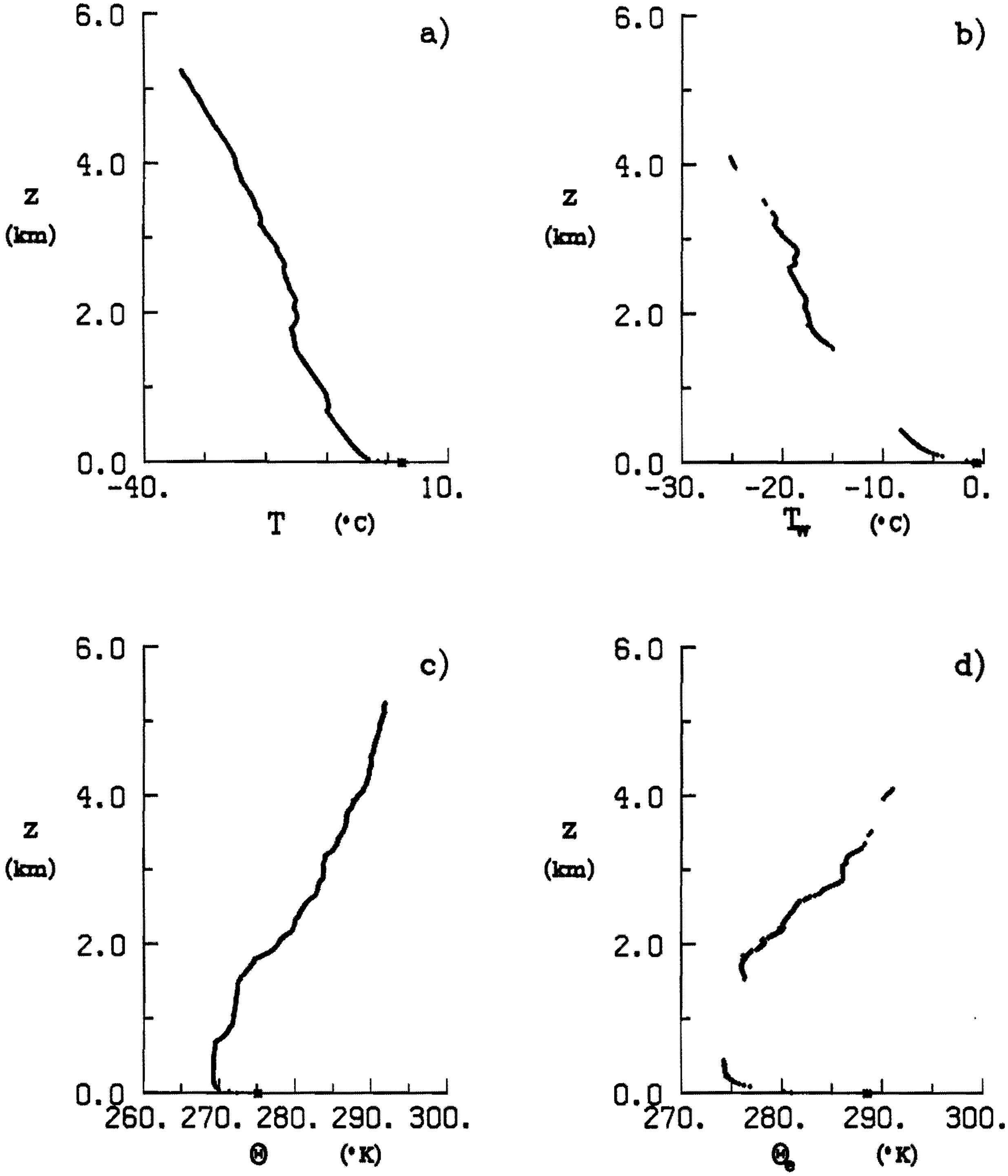
850324 0329 GMT, LAT 55.74 LONG -155.62

FOX SOUNDING 31



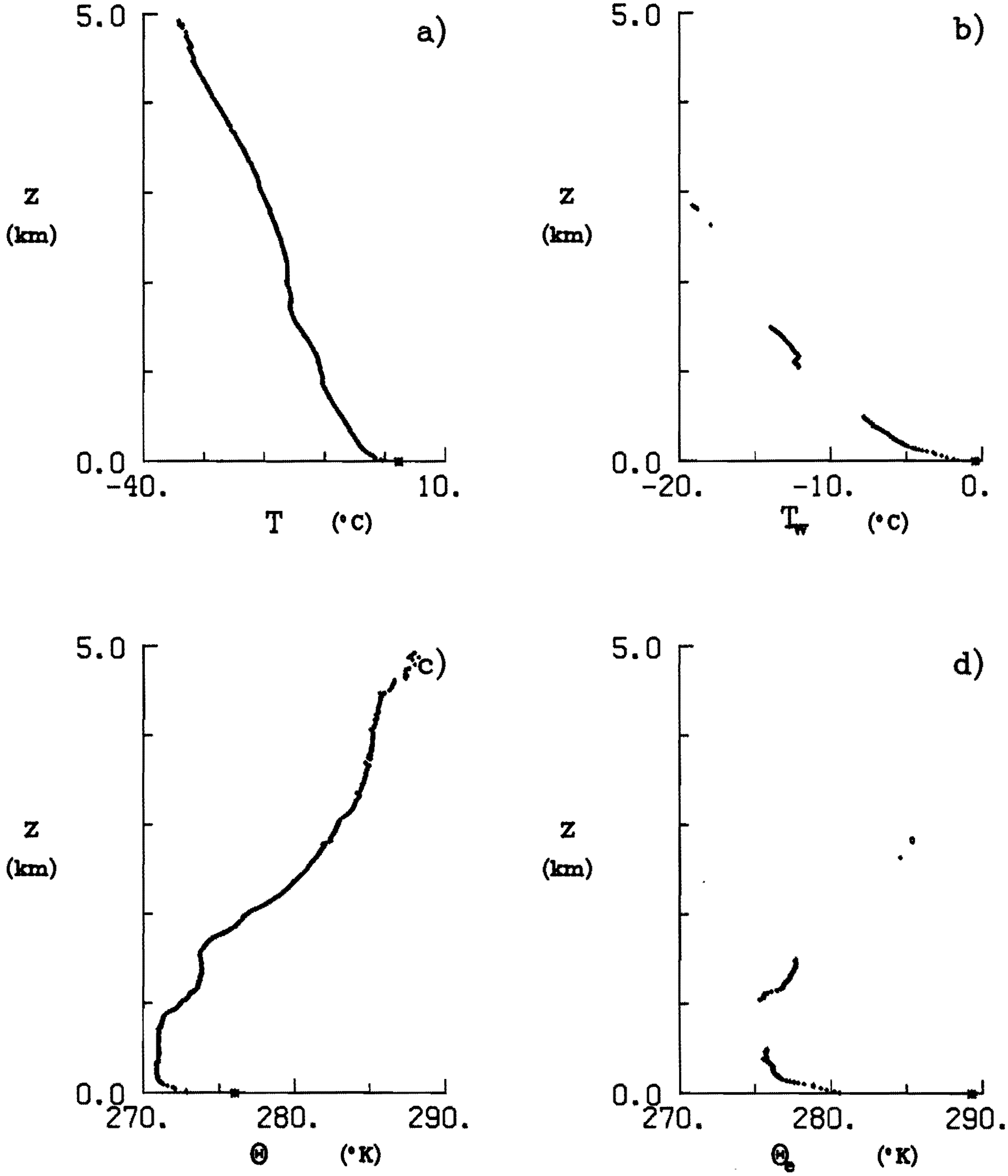
850324 0616 GMT, LAT 55.76 LONG −155.70

FOX SOUNDING 32



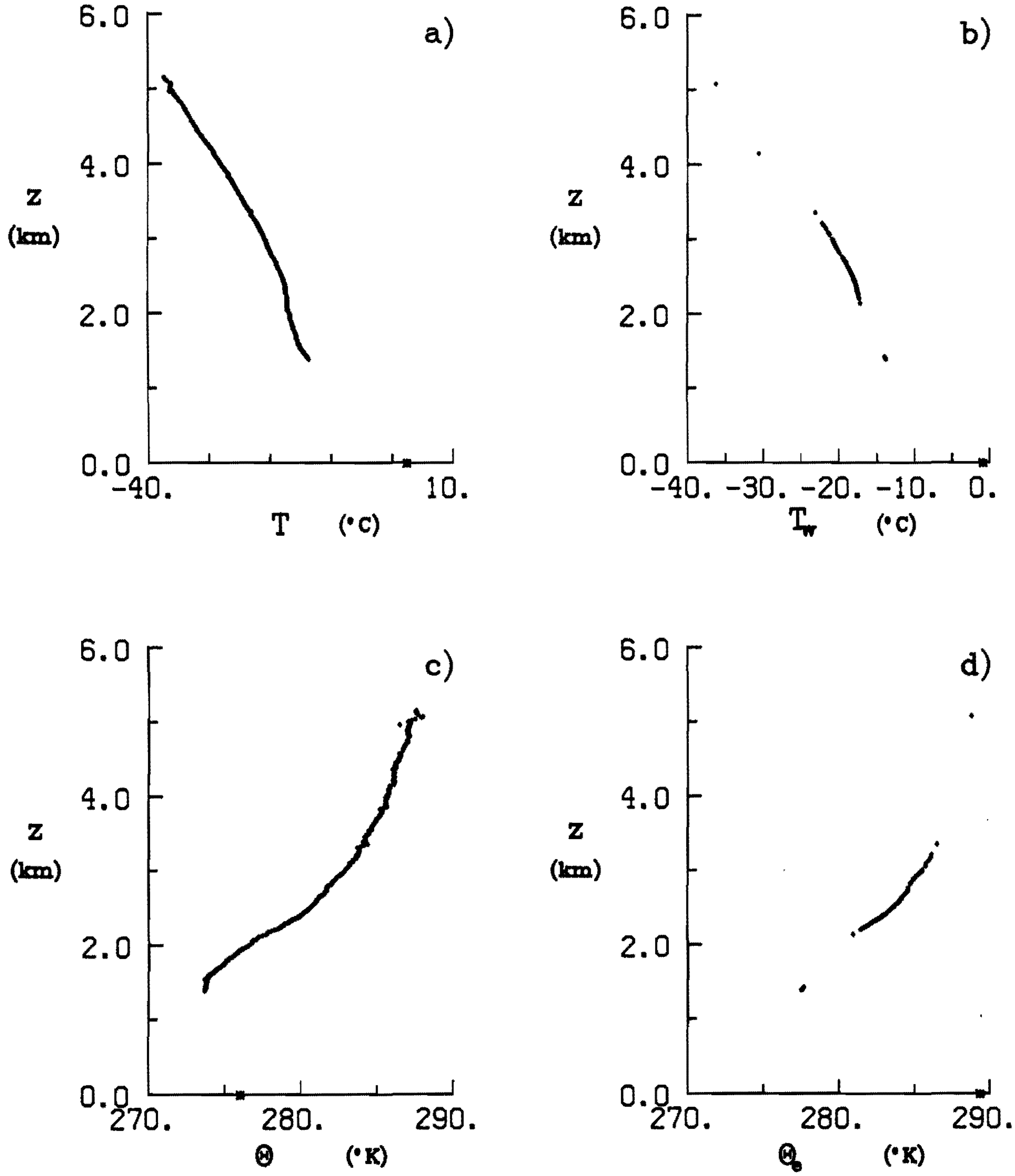
850324 2359 GMT, LAT 55.42 LONG -156.24

FOX SOUNDING 33



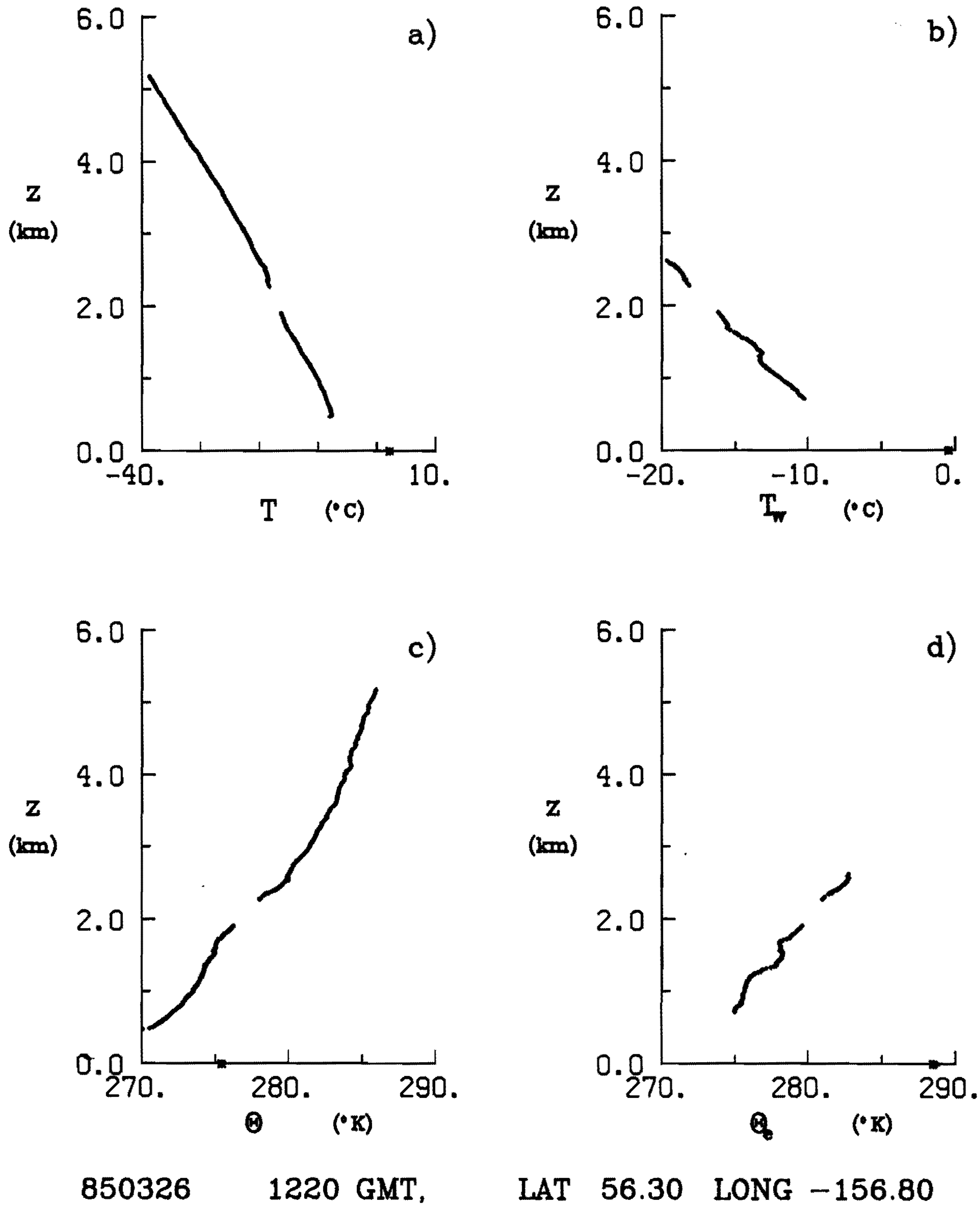
850325 1203 GMT, LAT 55.76 LONG −156.02

FOX SOUNDING 34



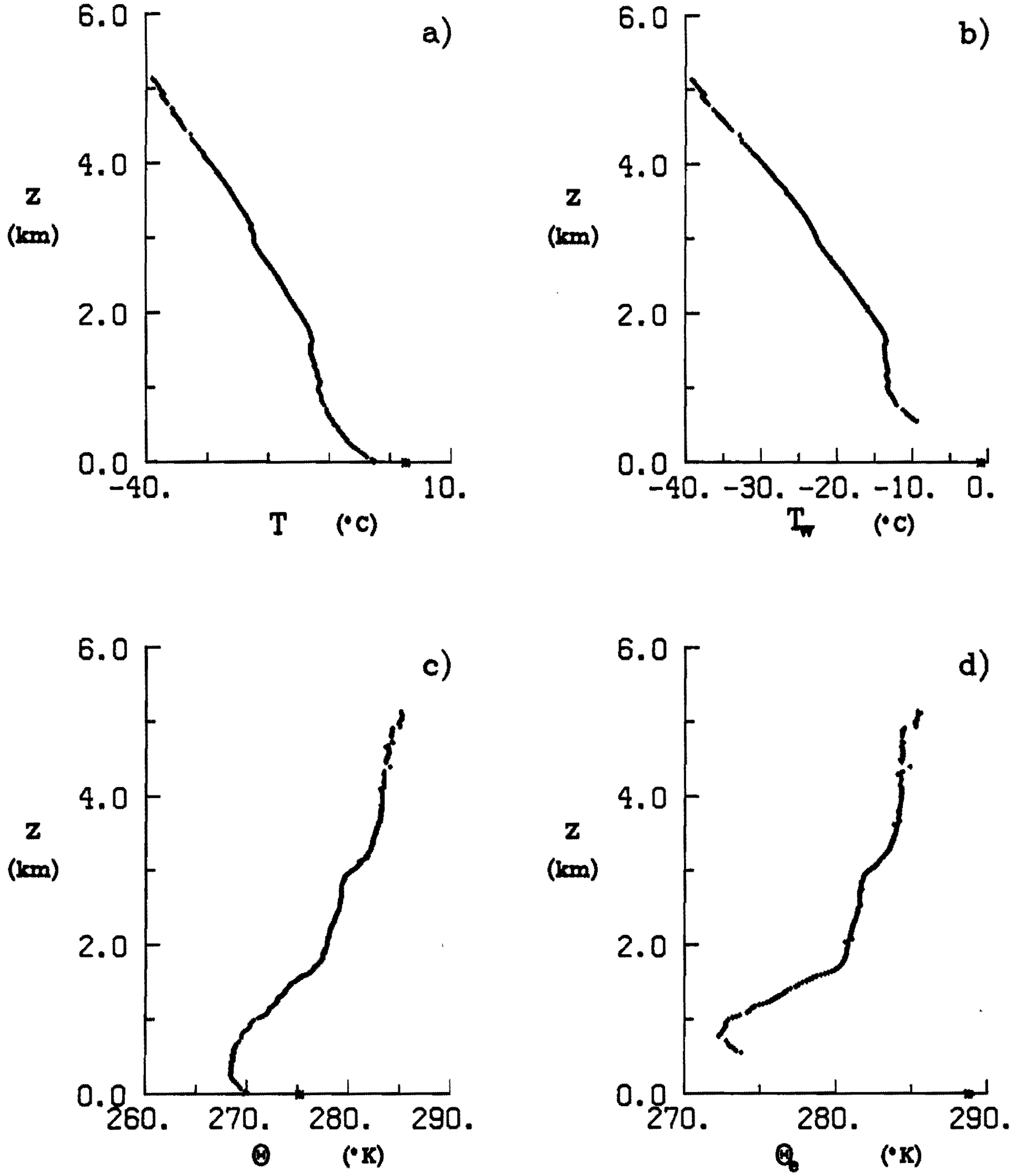
850326 0004 GMT, LAT 56.11 LONG −156.26

FOX SOUNDING 35



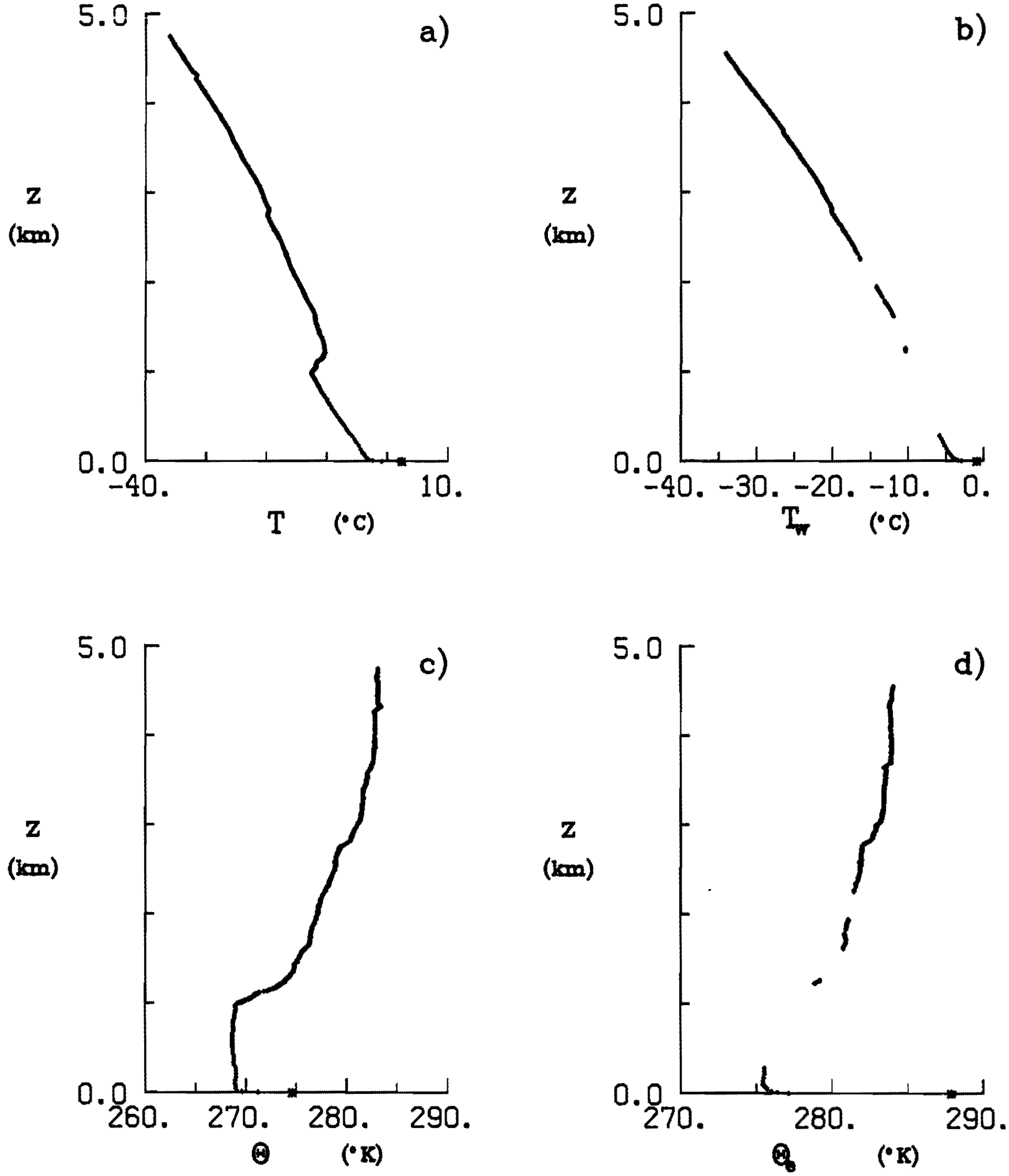
850326 1220 GMT, LAT 56.30 LONG −156.80

FOX SOUNDING 36



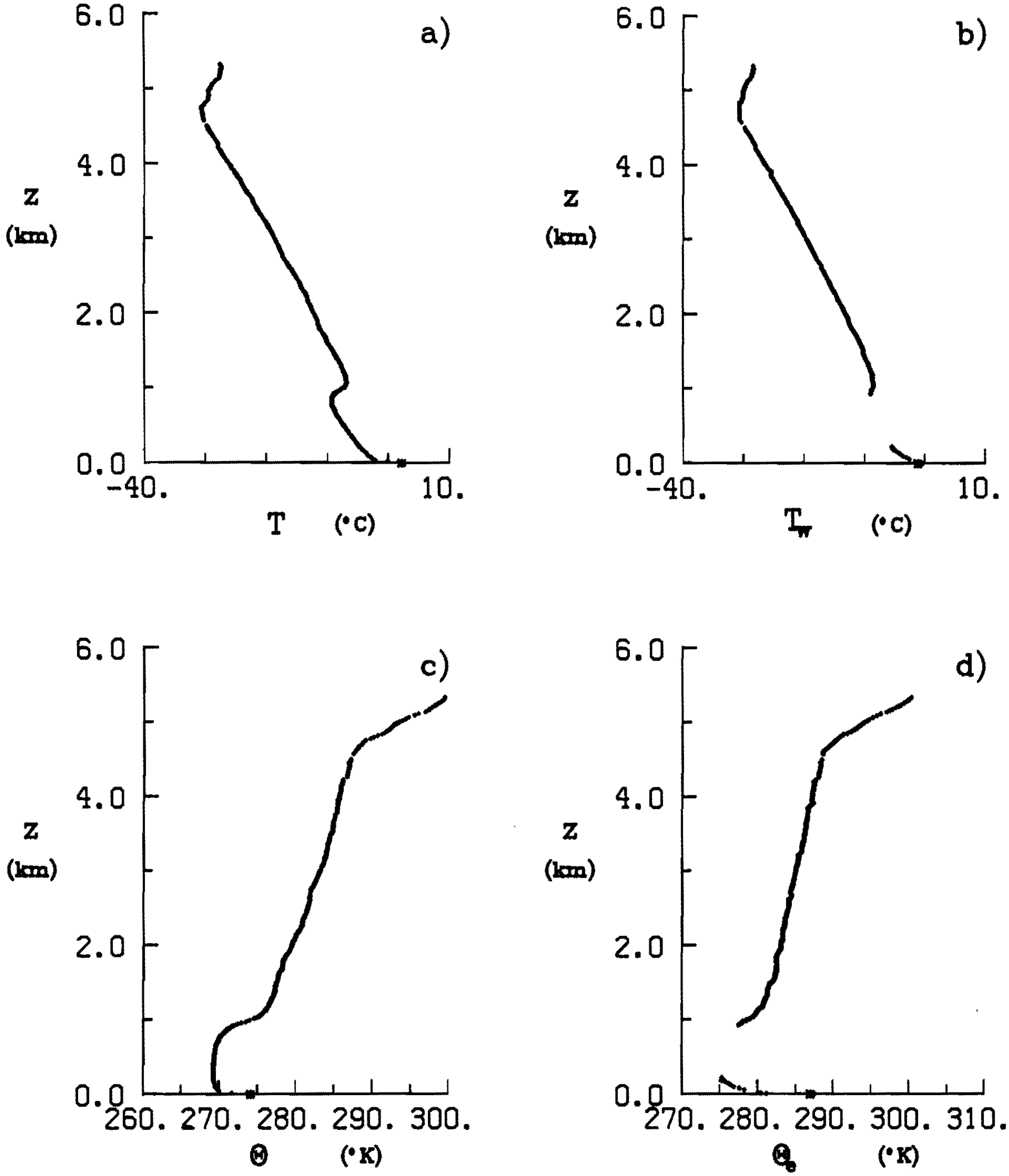
850327 0001 GMT, LAT 56.07 LONG −157.26

FOX SOUNDING 37



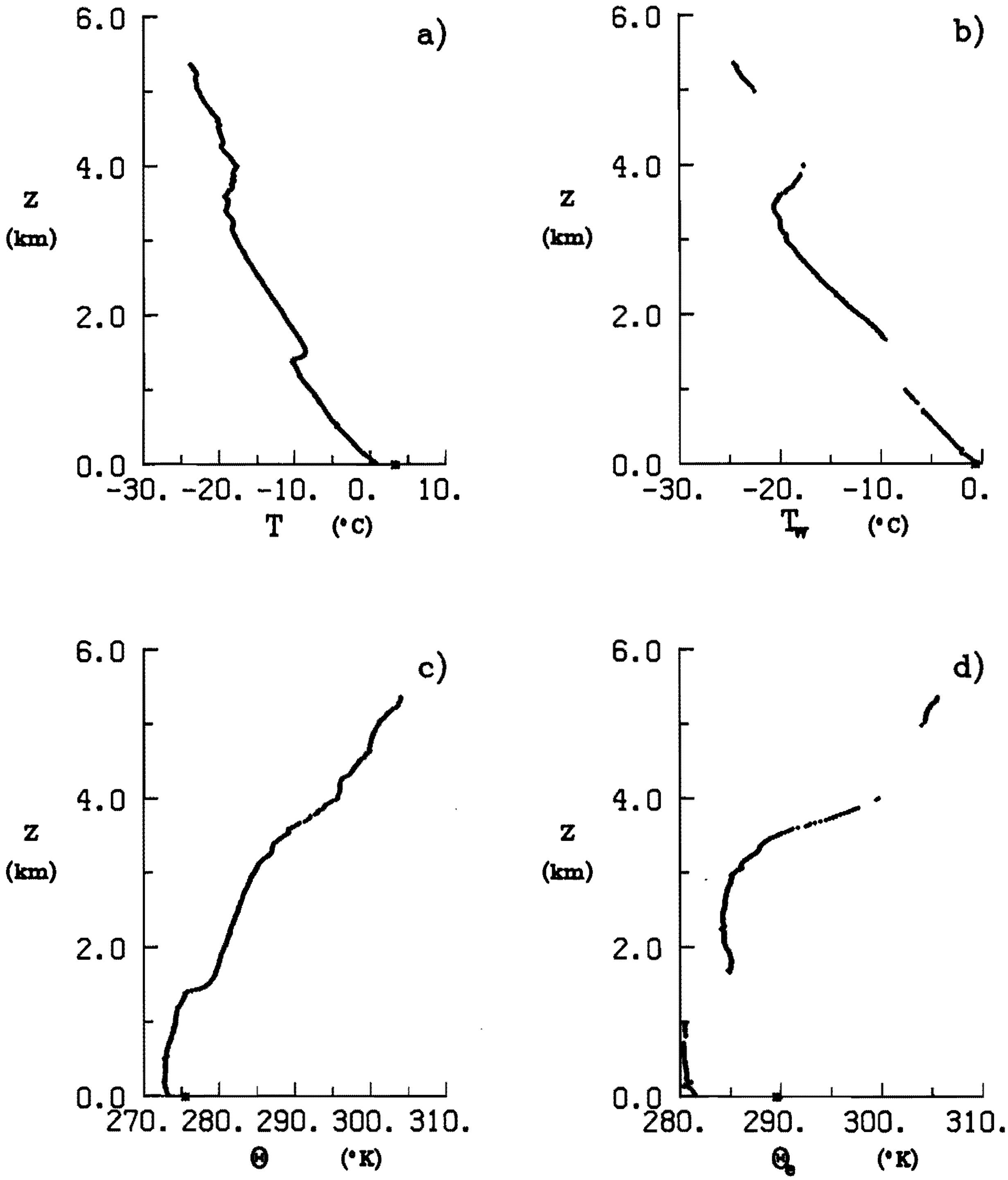
850327 1158 GMT, LAT 55.47 LONG −157.01

FOX SOUNDING 38



850327 2355 GMT, LAT 55.99 LONG -157.48

FOX SOUNDING 39



850328 1154 GMT, LAT 55.40 LONG −155.75

FOX SOUNDING 40