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ASCOT 91 FIELD EXPERIMENT PNL AIRSONDE DATA SUMMARY

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1. Introduction

Pacific Northwest Laboratory (PNL) participated in the Winter 1991 Atmospheric Studies in Complex Terrain (ASCOT) field experiment conducted in the vicinity of the Rocky Flats Plant between Boulder and Denver, Colorado. This report contains a summary of operations and data associated with free-release-balloon-borne atmospheric soundings made by PNL between January 29 and February 8, 1991. Given here are descriptions of the site and instrumentation, a brief summary of the soundings, and a description of the data post processing. The appendices contain a detailed summary of all soundings and ASCOT plots of completed soundings.

2. Site Description

The PNL upper-air soundings were made from a site referred to as the Filtration Plant (FP). This site was located at the City of Broomfield Water Treatment Plant, 4.1 km east of the Rocky Flats eastern boundary (1.7 km south of Highway 128). The plant is located in a small tributary of Walnut Creek, 1 km east of the Great Western Reservoir dam. UTM coordinates of the site are 488,408 E, 4,416,335 N. Elevation at the site is 1684 m. The plant compound consists of one two-story building, two (one-story) filtration vessels, and two one-story out-buildings. One of the out-buildings, on the NW corner of the compound, was used as an operations shelter. The surrounding surface cover was mostly short senescent grass, with some oak trees in the gully bottom to the east.

3. Instrumentation

AIR Inc. airsondes, model AS-1A-PTH-4035, reported pressure, dry bulb temperature, and wet bulb temperature, and were tracked with an optical theodolite. The AIR Inc. data acquisition system (ADAS) was programmed to report the following variables:

TMDAY	time of day, hhmmss, MST
ETIME	elapsed time (approximate) from launch time, hhmmss
DT=DC	dry bulb temperature, °C
WT=DC	wet bulb temperature, °C
PR=MB	pressure, mb
AZ=DG	theodolite azimuth angle, °
EL=DG	theodolite elevation angle, °
BS=MS	balloon speed, m/s
BD-DG	balloon direction, °

PHT=M	pressure height, m
AR=MS	ascent rate, m/s
SD=KM	surface distance (to balloon), km

The thermodynamic variables were reported approximately every 5 s. Theodolite angles were sampled by the ADAS at the same frequency from the launch through 300 m. At some altitude above 300 m, the ADAS wind calculation frequency was switched from once per record to once per 3 records (about once per 15 s, see Data Processing below).

4. Sounding Summary

A total of 38 soundings were successfully completed during the study period. Table 1 indicates soundings successfully completed on each experimental night. Appendix A lists, for each sounding, the date and time of launch, height and strength of the first inversion, altitude of top of wind sounding, altitude of top of thermodynamic sounding, and miscellaneous notes.

Table 1. Soundings completed during each experiment. Launch hours are local time (MST). The 06:00 sounding was actually launched at 05:30 because of the schedule established with the Federal Avaiation Administration.

Experiment	18	20	22	00	02	04	06
1/29 - 1/30	√	√	√	√			
1/31 - 2/01		√	√	√	√	√	
2/01 - 2/02	√	√	√	√	√	√	
2/03 - 2/04		√	√	√	√	√	
2/04 - 2/05		√	√	√	√	√	√
2/06 - 2/07		√	√	√	√	√	√
2/07 - 2/08		√	√	√	√	√	√

5. Data Processing

All soundings were post-processed before being submitted to the ASCOT database in tabular form (in ASCII files) and in plotted form (given in Appendix B). Validated pressure, and dry and wet bulb temperatures were used to recalculate the height of the sonde at the time of each record. These heights are used to report both thermodynamic variables and wind variables. They represent the height above ground at the end of a time interval that corresponds to the top of a height interval. The intervals differ for thermodynamic variables and wind variables. Thermodynamic variables are reported approximately every 5 s. Winds are calculated/reported every 15 s below 300 m, every 30 s between 300 and 3000 m, and every 60 seconds above 3000 m. This scheme provides the important spatial resolution near the surface and reasonably certain estimates at the higher altitudes. The time/height interval for which the wind is valid is between the reported time/height and the time/height of the previous wind value.

At some level during most of the soundings the wick of the wet bulb froze. As the wick froze, the super-cooled water temperature was returned to 0°C instantaneously and then gradually returned to the "ice-bulb" temperature (near the wet

bulb temperature). This creates erroneous mixing ratio values during this time period, in turn introduce typically a 0.25% error in height increment over the affected 300 to 500 m. We have chosen to ignore this error and include the bogus mixing ratio values in the database. This gives the users the option of treating the artifact as they see fit.

Acknowledgments. We thank Mike Bartleson, manager of the Broomfield Water Treatment Plant for his generous support of this work.

APPENDIX A

ASCOT 91 PNL Sounding Summary

Table A.1. ASCOT 91 PNL Airsonde Sounding Summary

mm/dd	hh:mm	top invl	delT invl	top wind	top temp	notes (heights reported AGL)
01/29	18:00	260	15.1	2034	5921	Winds below 130 m noisy because of trouble tracking balloon.
01/29	20:00	219	14.0	2760	5149	Secondary speed maximum near 800 m. Strong winds above 1600 m.
01/29	22:00	128	13.4	2256	5551	Height of speed maximum dropped slightly to 750 m. Strong winds above 1300 m.
01/30	00:00	169	2.9	2370	4285	Speed maximum gone. Strong winds above 1800 m.
01/31	20:00	126	3.3	2812	4936	Two periods of descent, indicating wave motion.
01/31	22:00	121	6.0	2604	2604	Shallow inversion at 1250 m. Balloon burst at 2604 m AGL.
02/01	00:00	98	3.0	3172	4503	Strong jet (13-15 m/s) below 500 m.
02/01	02:00	57	2.8	4269	7180	Jet (12-15 m/s) below 300 m. Apparent wave at 2000 m.
02/01	04:00	30	0.6	3205	4807	Steady winds (approx. 10-15 m/s) from WNW
02/01	18:00	176	6.4	6394	8814	Almost overhead at 18:29:07 MST (3421 m). Moved tripod. Smooth veering from surface to 1500 m; then sharp shear back from E to N and then to W between 1800 & 2000 m.
02/01	20:00	123	9.0	3487	3575	Lost synchronization for a period around 20:33:38. Winds light (2-5 m/s) veering smoothly from NW to E then back to N; then strong shear to SW between 1700 & 1900 m.
02/01	22:00	115	8.3	4479	5644	Winds 1-4 m/s veering from NW all the way to SSW by 2200 m; then increasing speeds.
02/02	00:00	217	11.2	5357	6133	Winds 0-3 m/s below 1500 m; then steadily increasing to 12 m/s at 4000 m.

Table A.1 (contd)

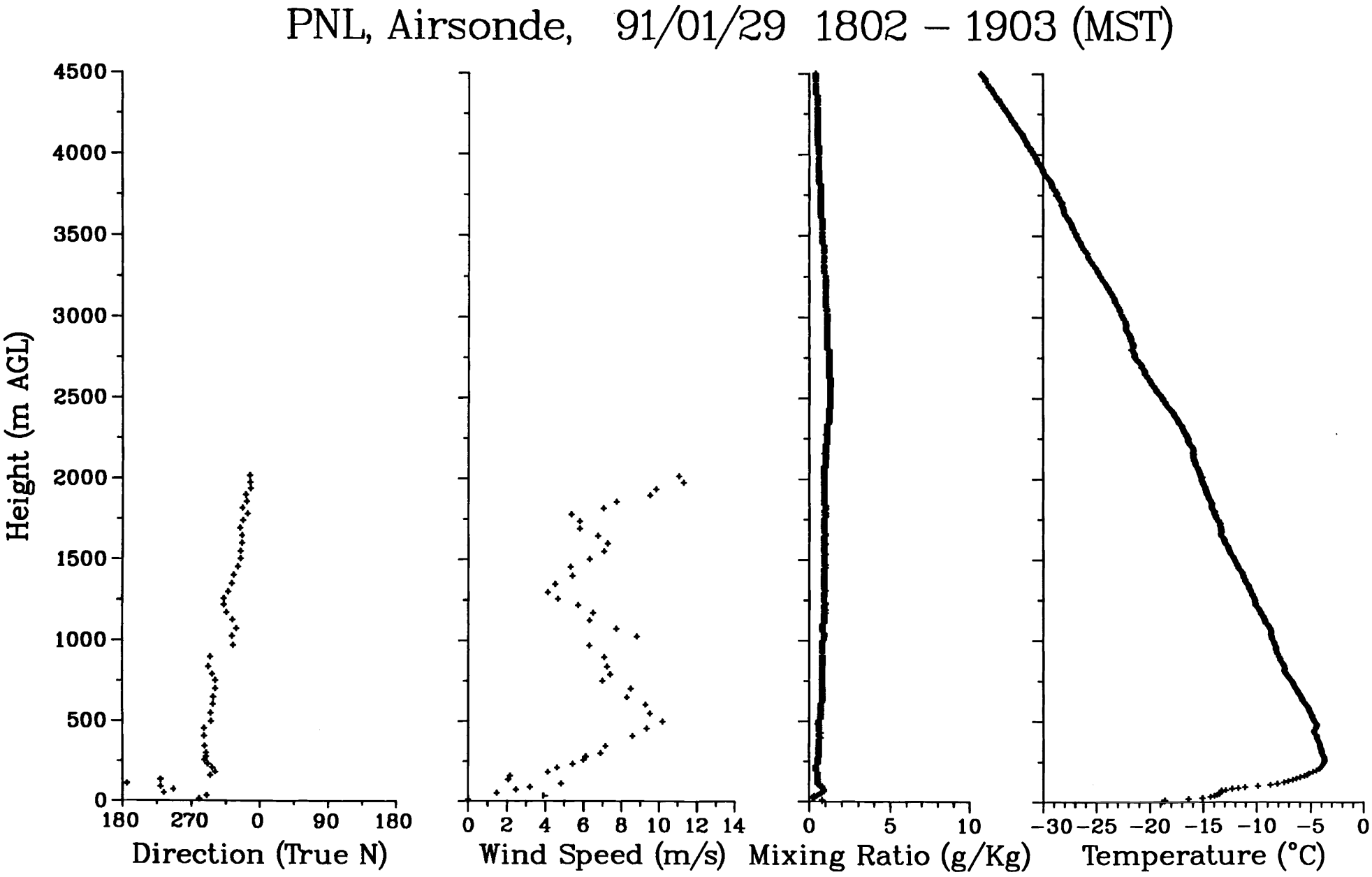
mm/dd	hh:mm	top invl	delT invl	top wind	top temp	notes (heights reported AGL)
02/02	02:00	462	10.3	4156	4476	Slight drainage at surface. Winds 0-3 m/s below 1500 m; weak jet between 1500 & 2000 m, then steadily increasing to 16 m/s at 4000 m.
02/02	04:00	378	11.6	4145	4835	No tracking between 03:56:30 and 03:57:16. Secondary speed maxima at 900-1100 (6 m/s), 1600 (3 m/s), and 2300-2500 m (7 m/s).
02/03	20:00	106	3.0	6154	8097	Secondary speed maximum (5 m/s) at 350 m; 8 m/s maximum between 2800 and 3200 m (inversions at both features).
02/03	22:00	129	4.1	5299	5879	Southerly jet (4-6 m/s) below 500 m; 5 m/s jet between 1000 and 1200 m.
02/04	00:00	209	6.2	3111	5038	Drainage below 250 m (max speed > 5 m/s).
02/04	02:00	<294	>5.7	5859	7714	Bad signal for about 1.5 min at launch (z < 294 m). 5 m/s jet between 1300 & 1400 m.
02/04	04:00	173	6.0	4166	5586	9 m/s VNV jet below 250 m.
02/04	20:00	147	6.0	5022	8433	Winds light below 250 m; secondary max (6 m/s) between 700 & 800 m; secondary max (12 m/s between 2200 & 2300 m.
02/04	22:00	173	5.4	5134	7627	Winds less than 4 m/s below 1500 m, veering form SSE to NE then backing to N.
02/05	00:00	235	9.6	3852	4689	Winds less than 2 m/s below 1250 m; then steadily increasing to about 12 m/s above 3000.
02/05	02:00	183	6.9	2049	2049	Sounding terminated by apparent interference from another sonde. Significant shear from W to N at 1250 m (wind speed minimum).
02/05	04:00	263	10.2	4317	5693	Speed minimum still present near 1250 m. Secondary maxima at about 650 m and 1800 m.

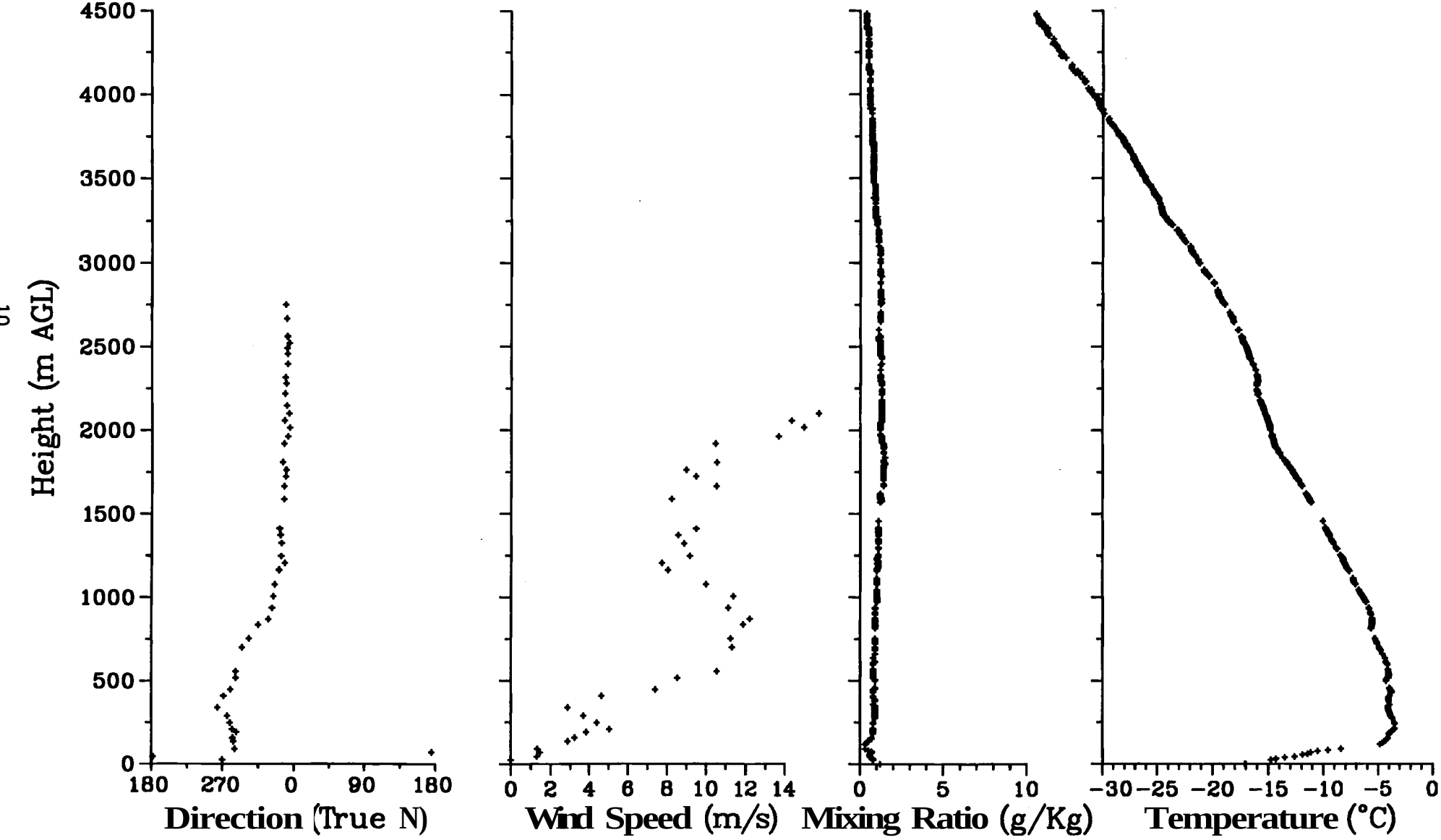
Table A.1 (contd)

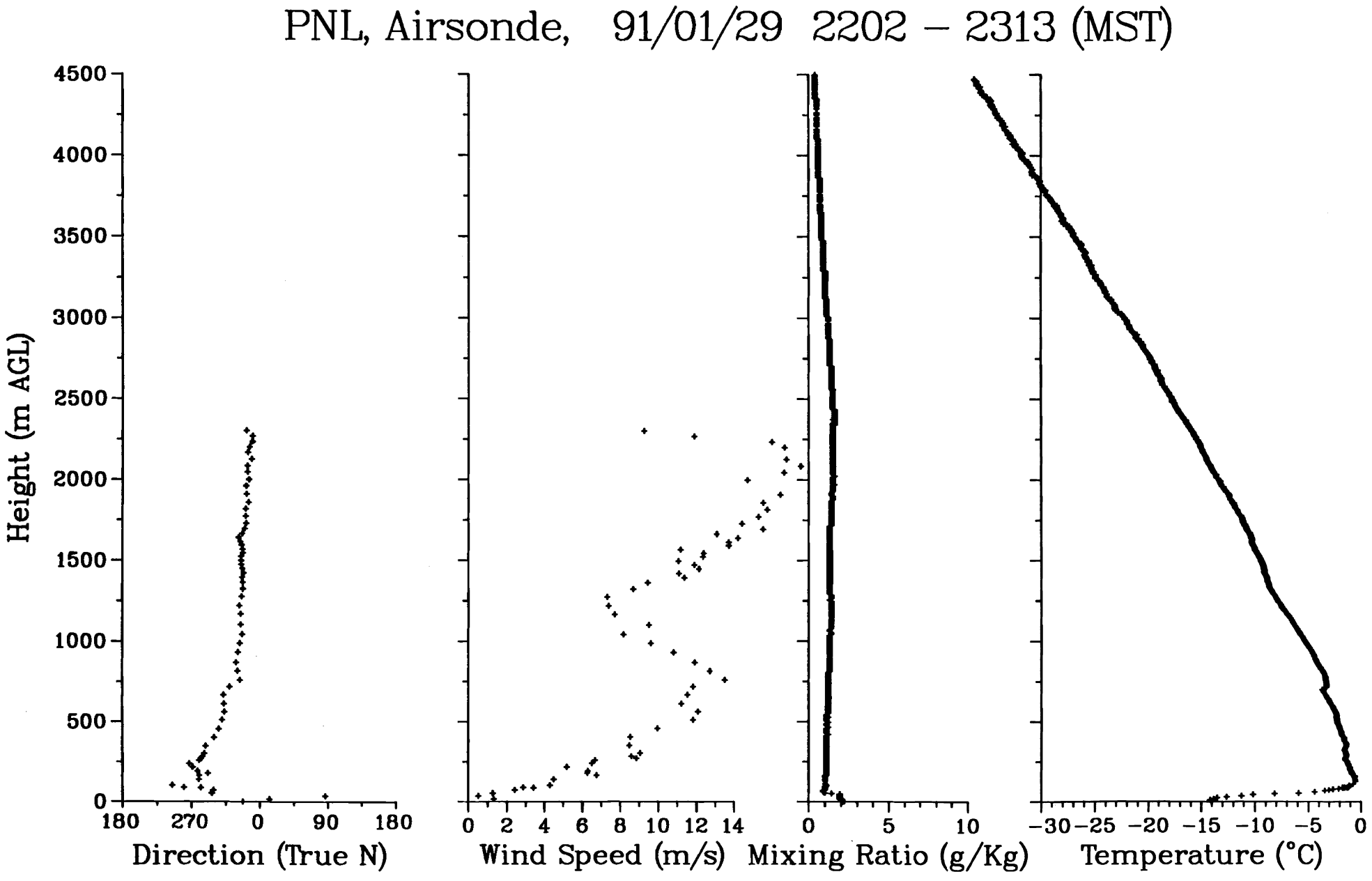
mm/dd	hh:mm	top invl	delT invl	top wind	top temp	notes (heights reported AGL)
02/05	05:30	277	12.0	4830	6842	Speed 6-7 m/s between 250 & 700 m. Speed minimum still present near 1300 m.
02/06	20:00	113	5.1	5103	7456	4 m/s low level jet below 200 m; 5 m/s jet max between 600 & 700 m.
02/06	22:00	131	6.0	5130	7821	Strong inversion between 1700 & 1900 m; with significant speed and direction shear.
02/07	00:00	116	5.5	5292	5321	Near-surface pooling evident. Strong inversion descended to between 1500 & 1750 m; shears still marked.
02/07	02:00	331	7.9	4630	7236	Strong inversion descended to between 1200 & 1400 m; wind speed minimum near its base. Decoupling between 200 & 300 m.
02/07	04:00	212	5.04	5092	7678	Strong inversion descended to between 800 & 1100 m. Near-surface N flow is notable.
02/07	05:30	131	3.26	5307	5847	Fault in pressure sensor/ADAS required inversion of pressure increments.
02/07	20:00	235	8.34	6176	8404	Secondary speed maxima near 600 m (6 m/s) and 2600 m (7 m/s); minimum near 1800 m (<2 m/s). Winds mostly southerly to westerly.
02/07	22:00	300	9.83	6256	7771	Wind speed max/min/max at 1150/1500/2000 m (7/4/7 m/s).
02/08	00:00	350	10.7	4881	7639	Significant near-surface flow below 250 m. Significant wind shear near 2000 m.
02/08	02:00	311	7.79	5574	6164	Strong near-surface flow (8 m/s) from N below 200 m.
02/08	04:00	407	7.63	6637	8430	Similar strong near-surface flow somewhat deeper (below 300 m). Secondary wind maximum at 750 m.
02/08	05:30	380	7.05	5385	5920	Near-surface flow now elevated (between 200 & 500 m). Other winds weak until 2500 m.

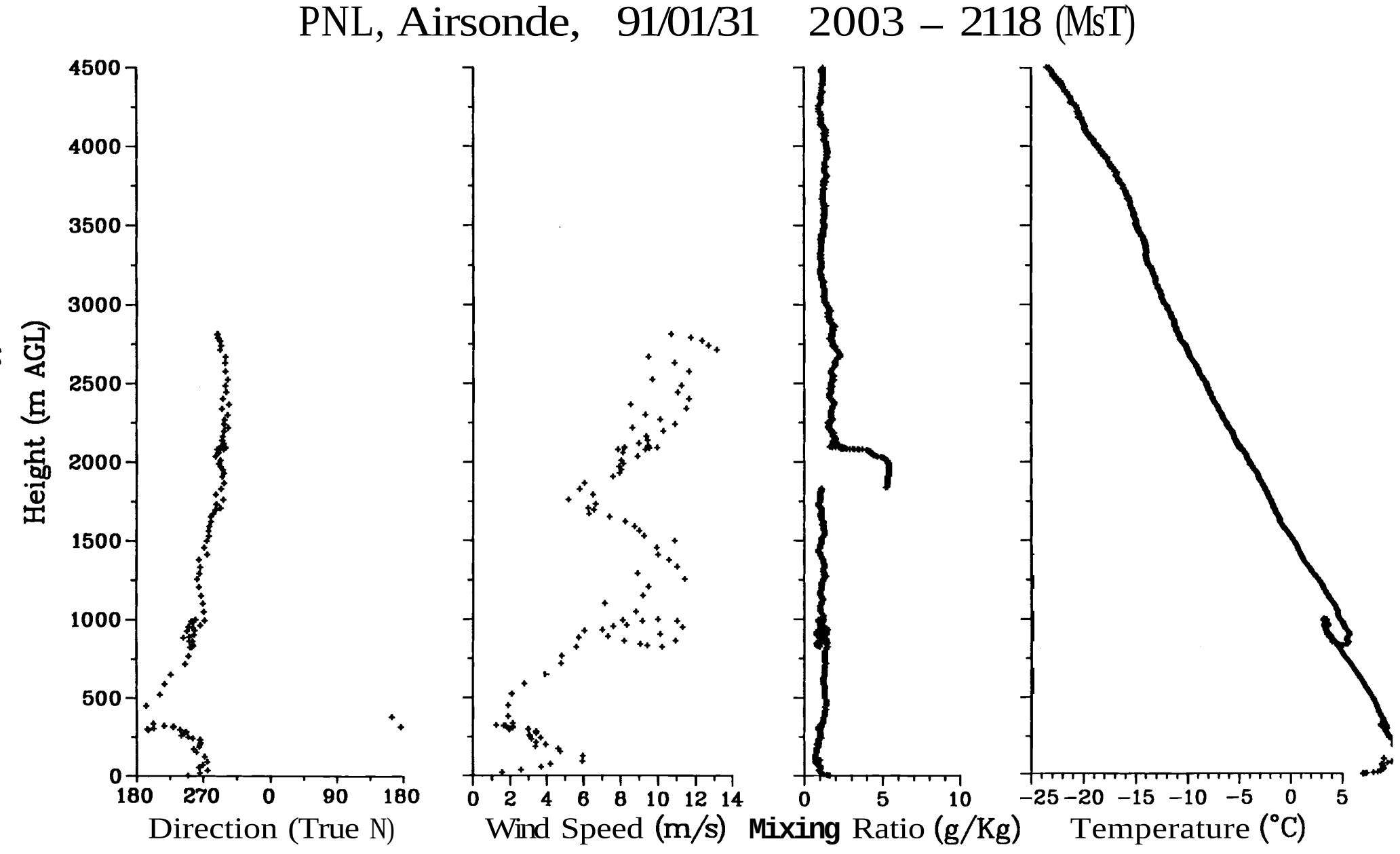
APPENDIX B

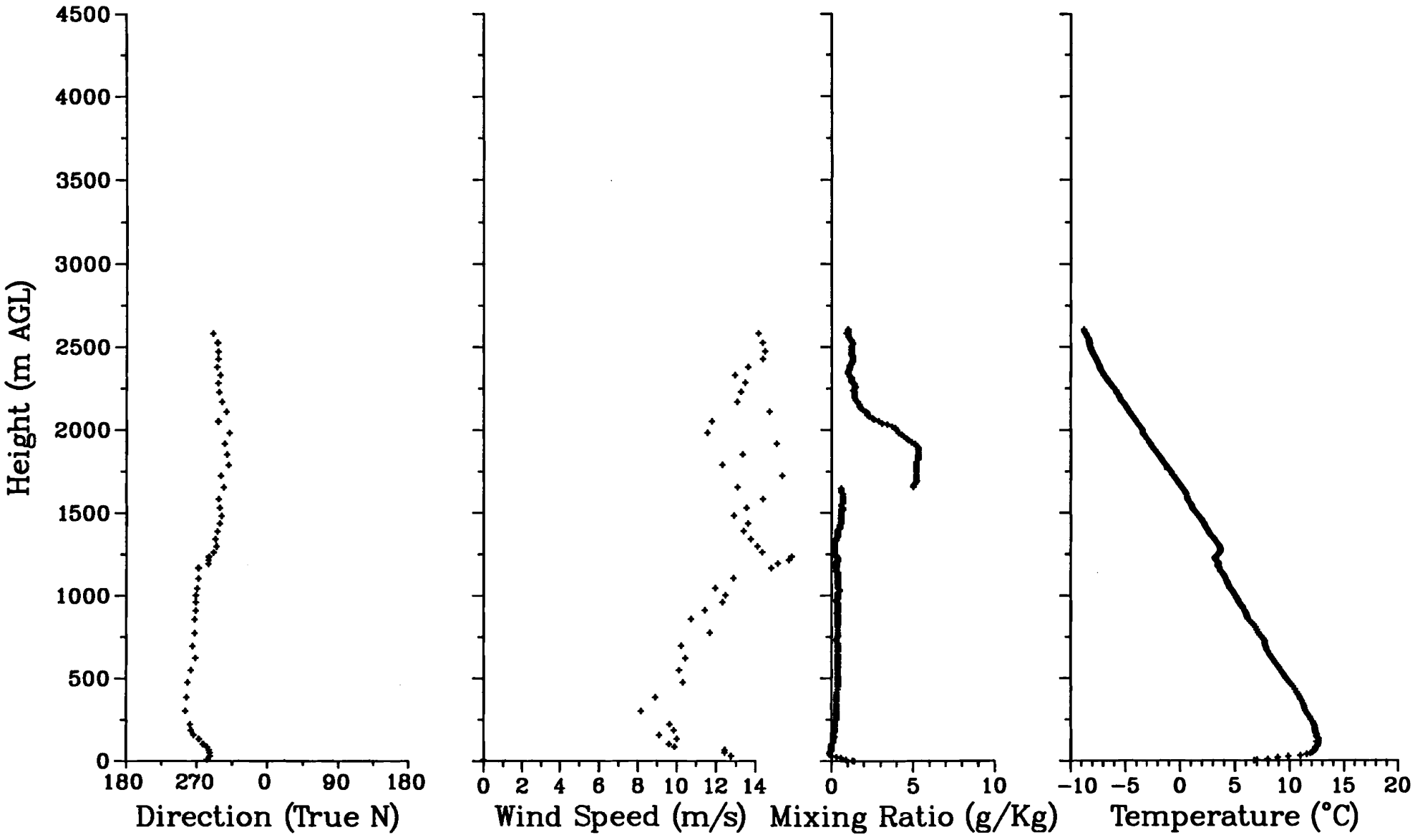
Standard ASCOT Plots

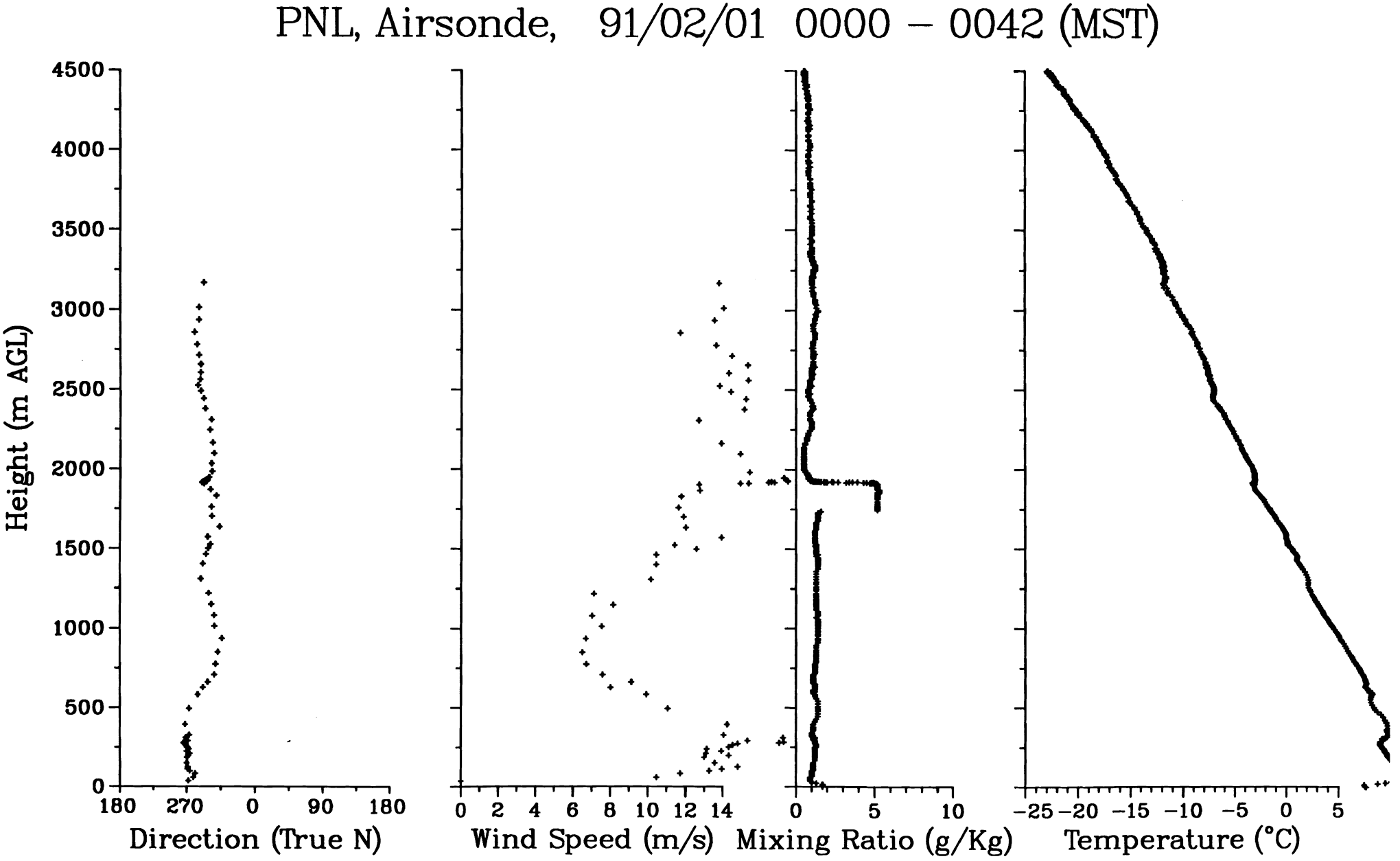

PNL, Airsonde, 91/01/29 1802 – 1903 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180
270
0
90
180
Direction (True N)
0
2
4
6
8
10
12
14
Wind Speed (m/s)
0
5
10
Mixing Ratio (g/Kg)
−30
−25
−20
−15
−10
−5
0
Temperature (°C)

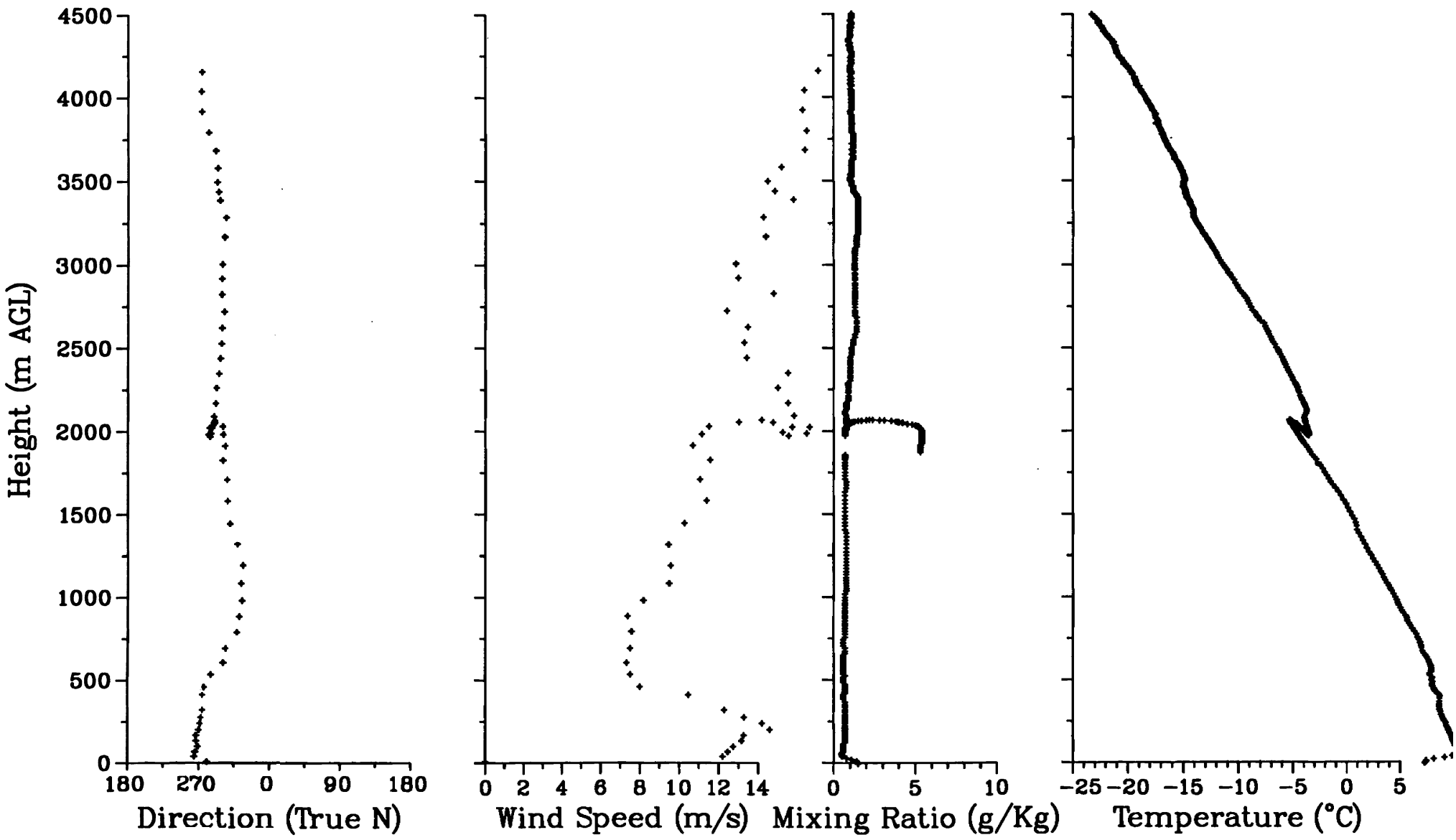

PNL, Airsonde, 91/01/29 2007 – 2107 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−30 −25 −20 −15 −10 −5 0
Temperature (°C)


PNL, Airsonde, 91/01/29 2202 – 2313 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−30 −25 −20 −15 −10 −5 0
Temperature (°C)


PNL, Airsonde, 91/01/31 2003 – 2118 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)


PNL, Airsonde, 91/01/31 2200 – 2221 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−10 −5 0 5 10 15 20
Temperature (°C)


PNL, Airsonde, 91/02/01 0000 – 0042 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)


PNL, Airsonde, 91/02/01 0200 – 0259 (MST)
Height (m AGL)
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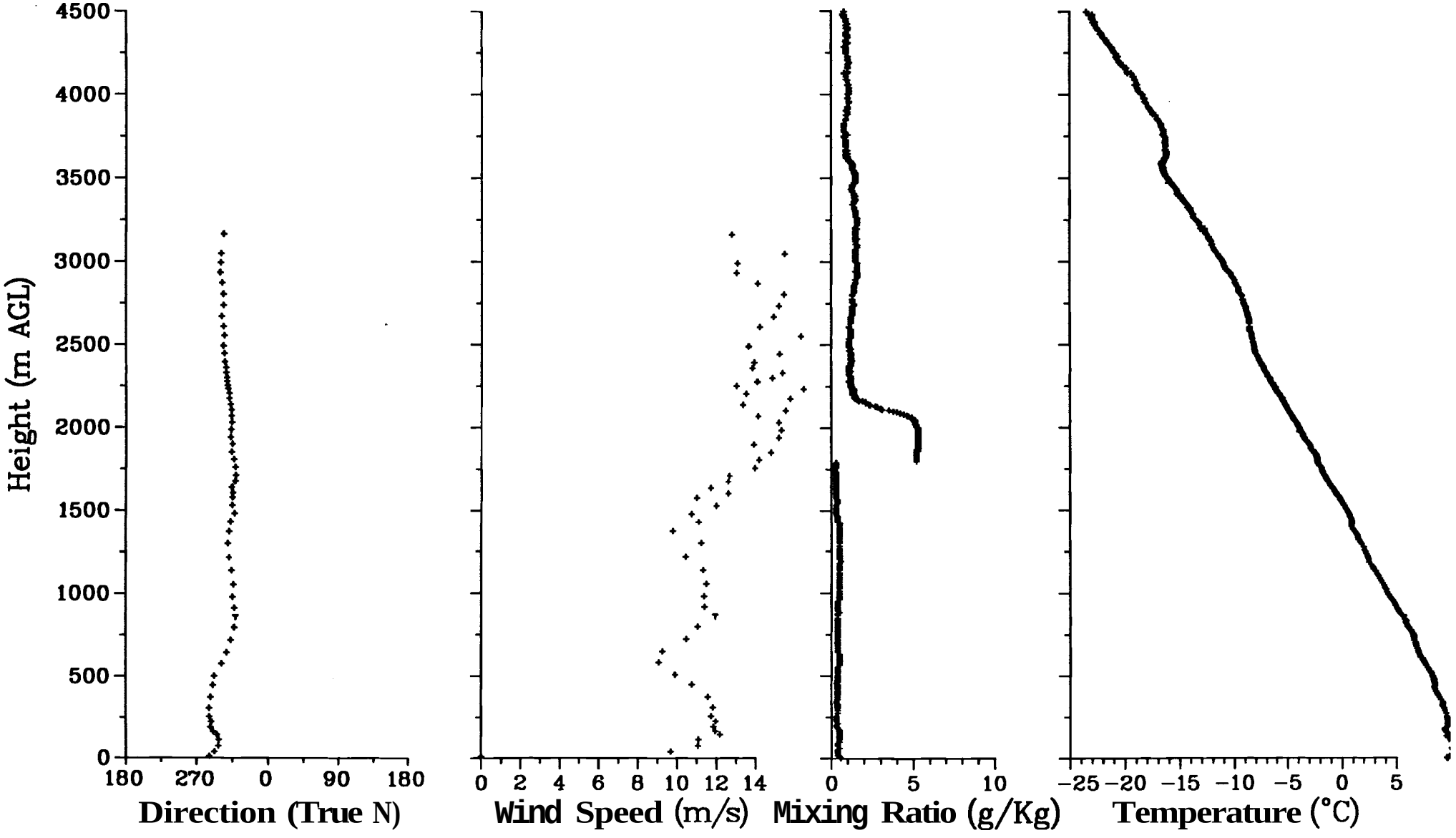
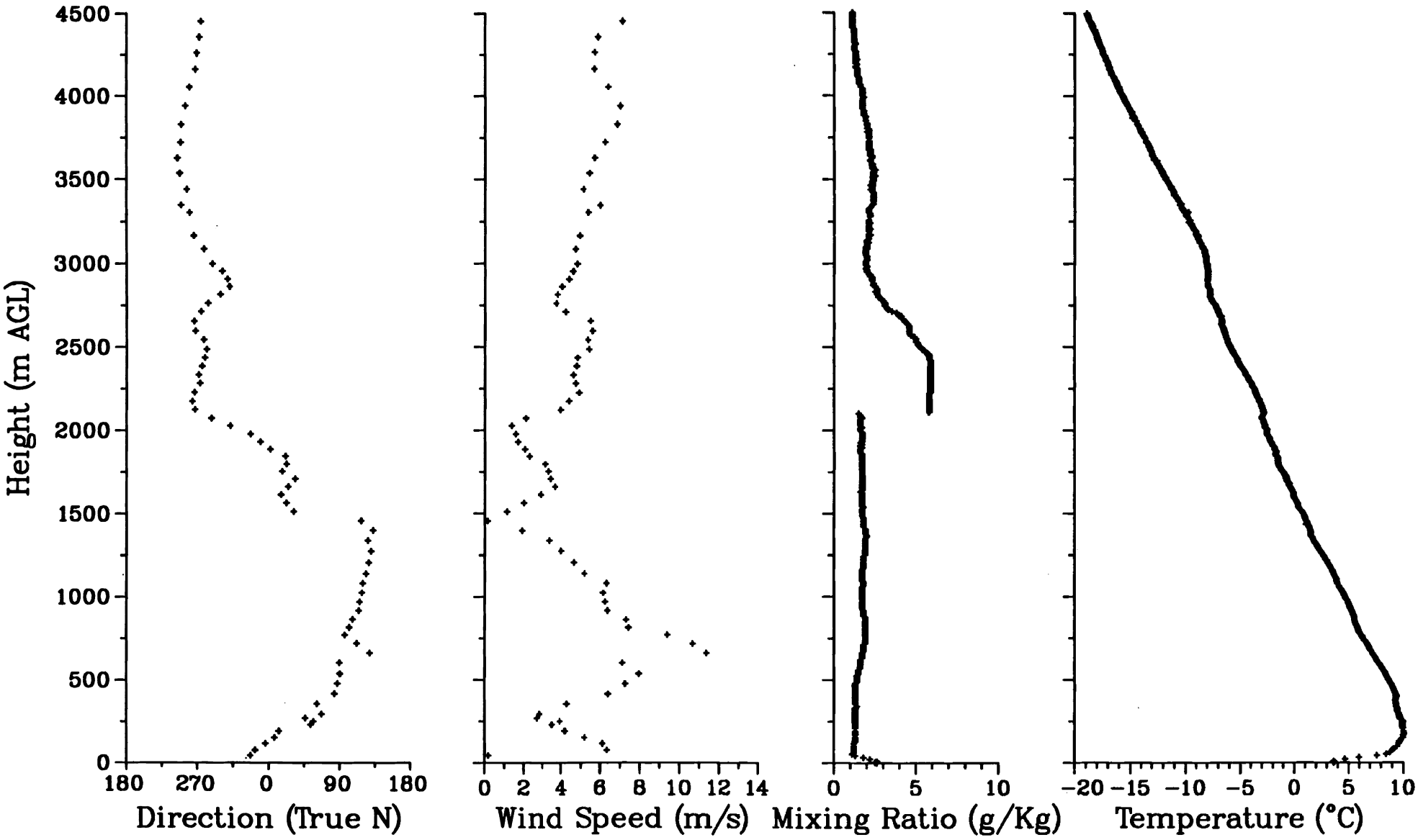
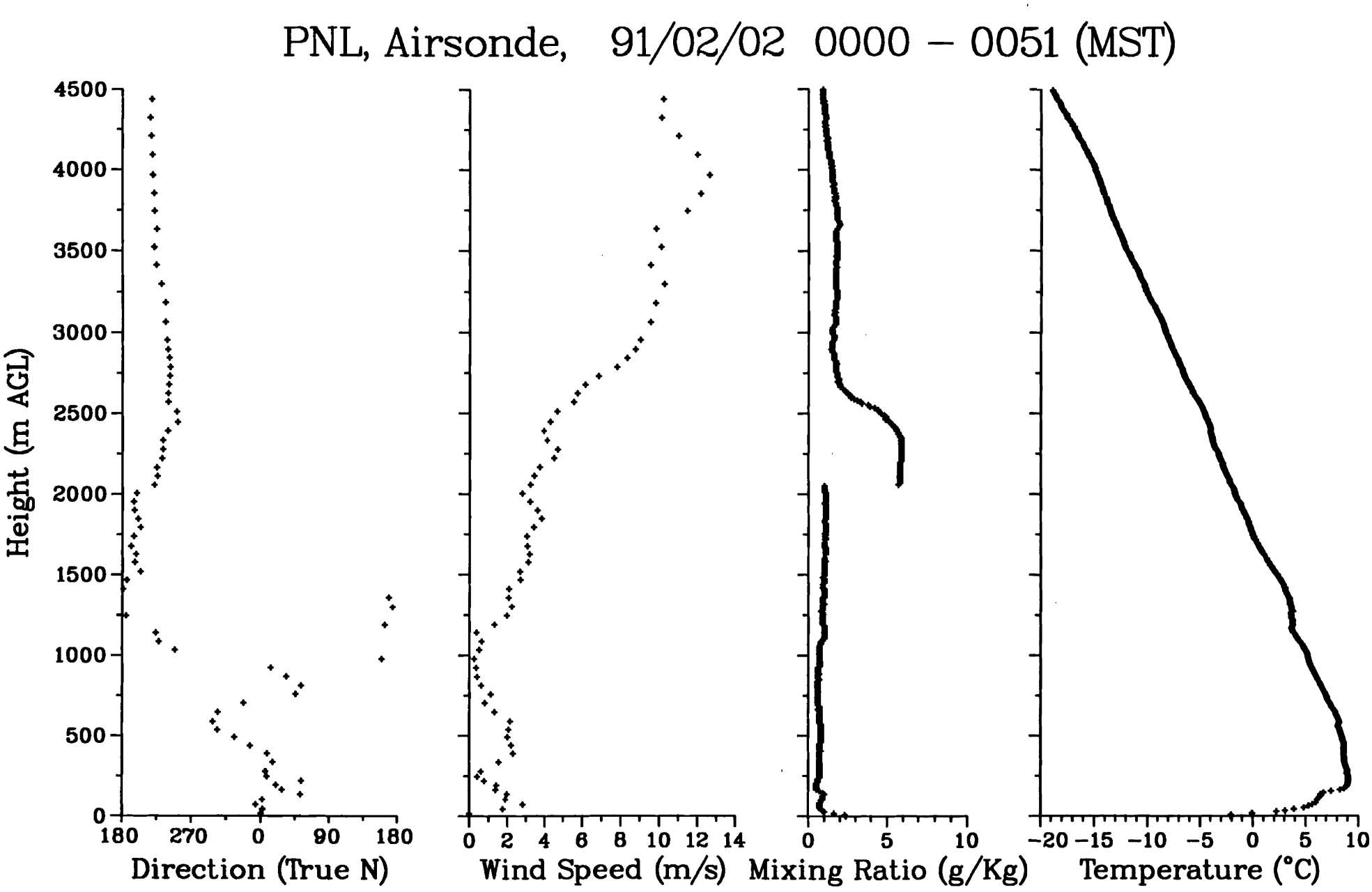
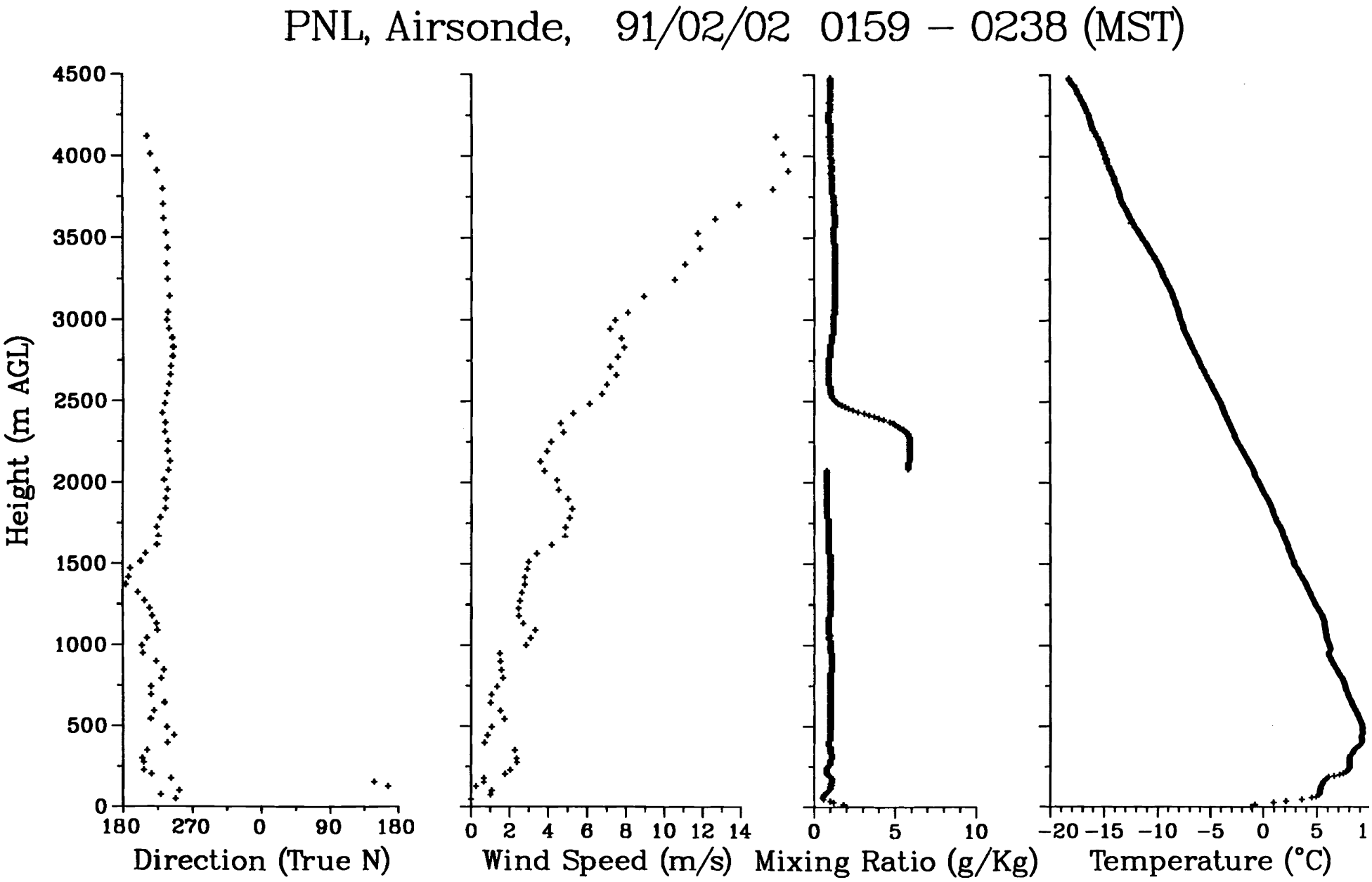
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
-25 -20 -15 -10 -5 0 5
Temperature (°C)

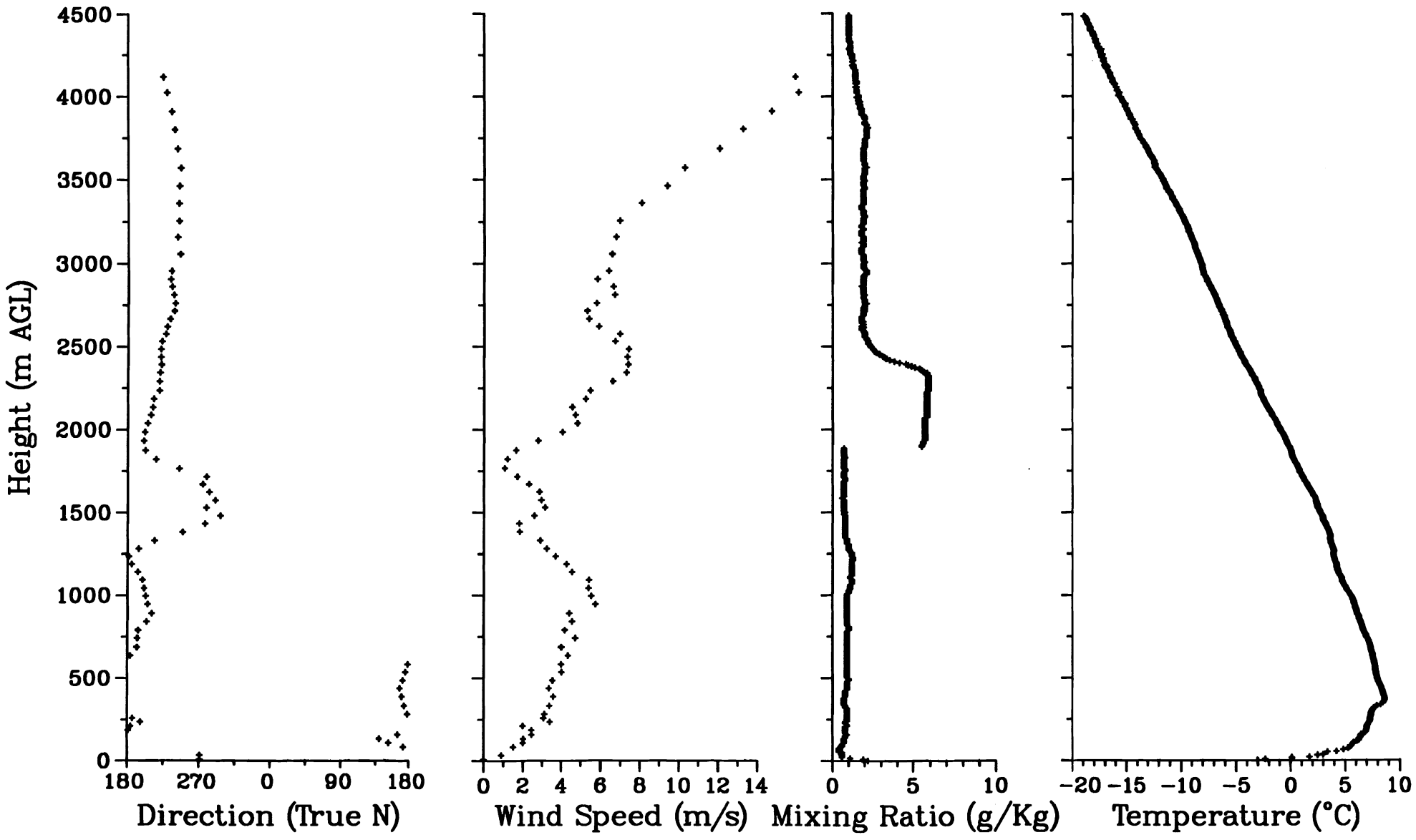
PNL, Airsonde, 91/02/01 0358 – 0443 (MST)

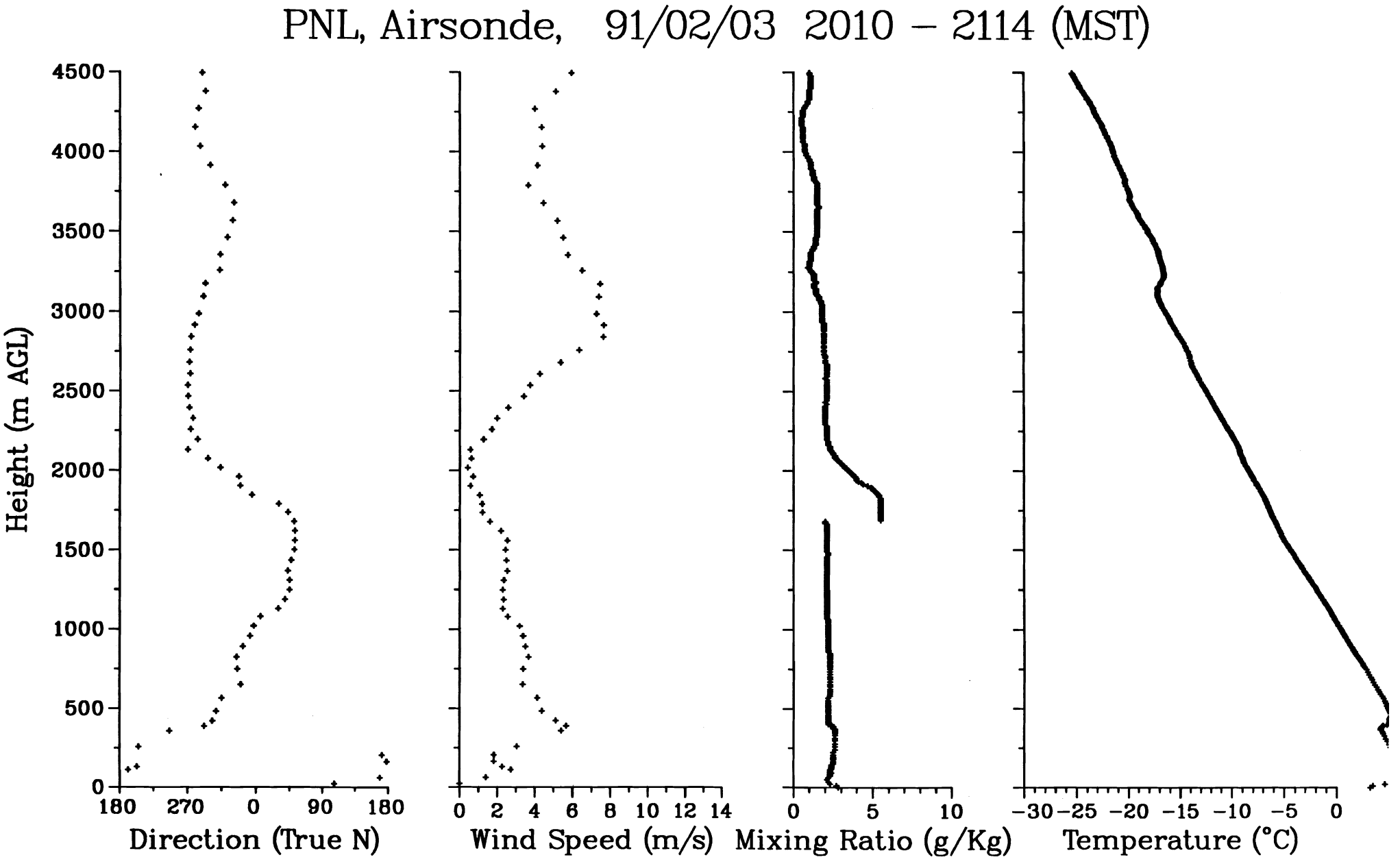


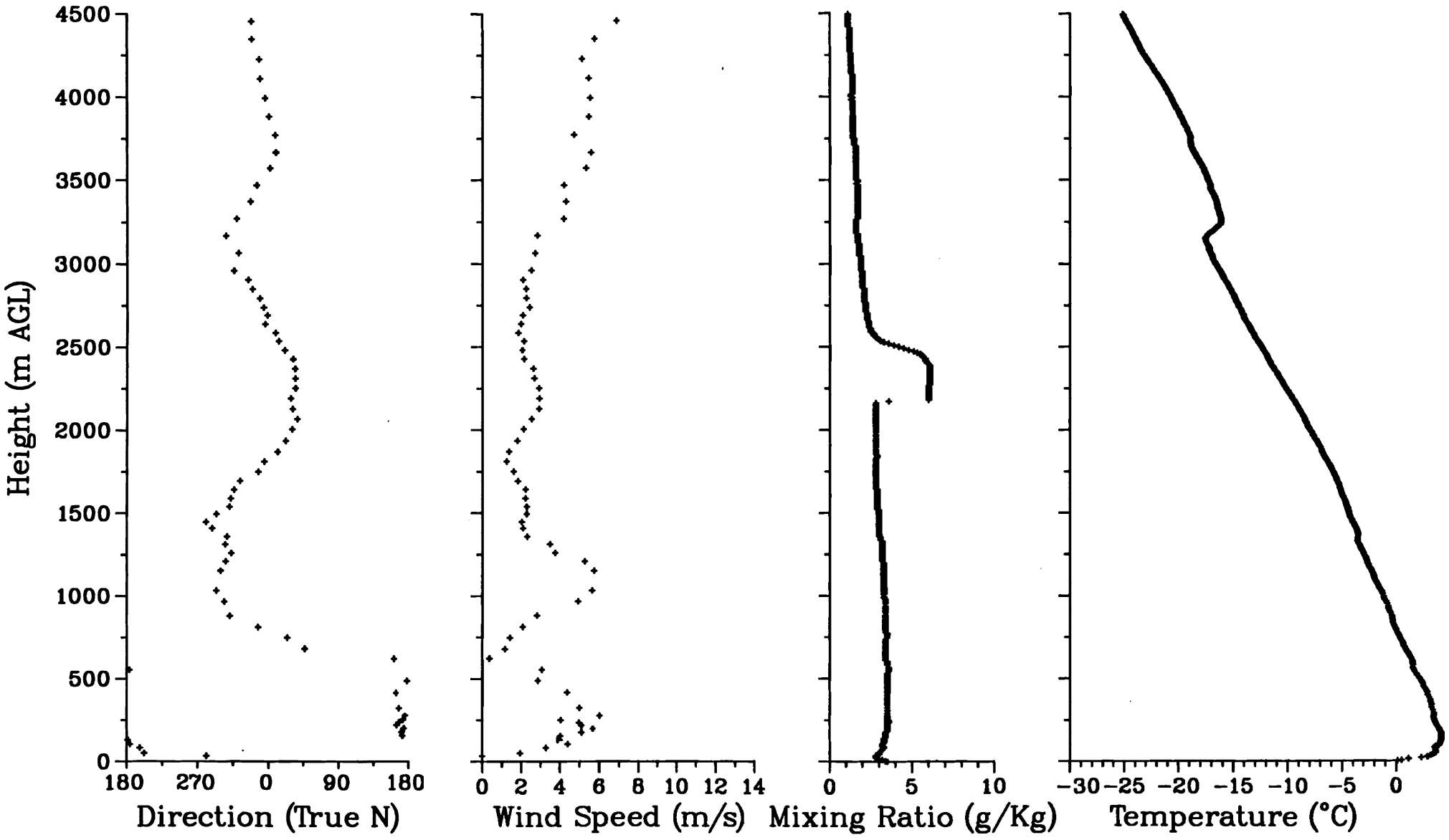

PNL, Airsonde, 91/02/01 1800 – 1916 (MST)
Height (m AGL)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
180
270
0
90
180
Direction (True N)
0
2
4
6
8
10
12
14
Wind Speed (m/s)
0
5
10
Mixing Ratio (g/Kg)
−20
−15
−10
−5
0
5
10
Temperature (°C)

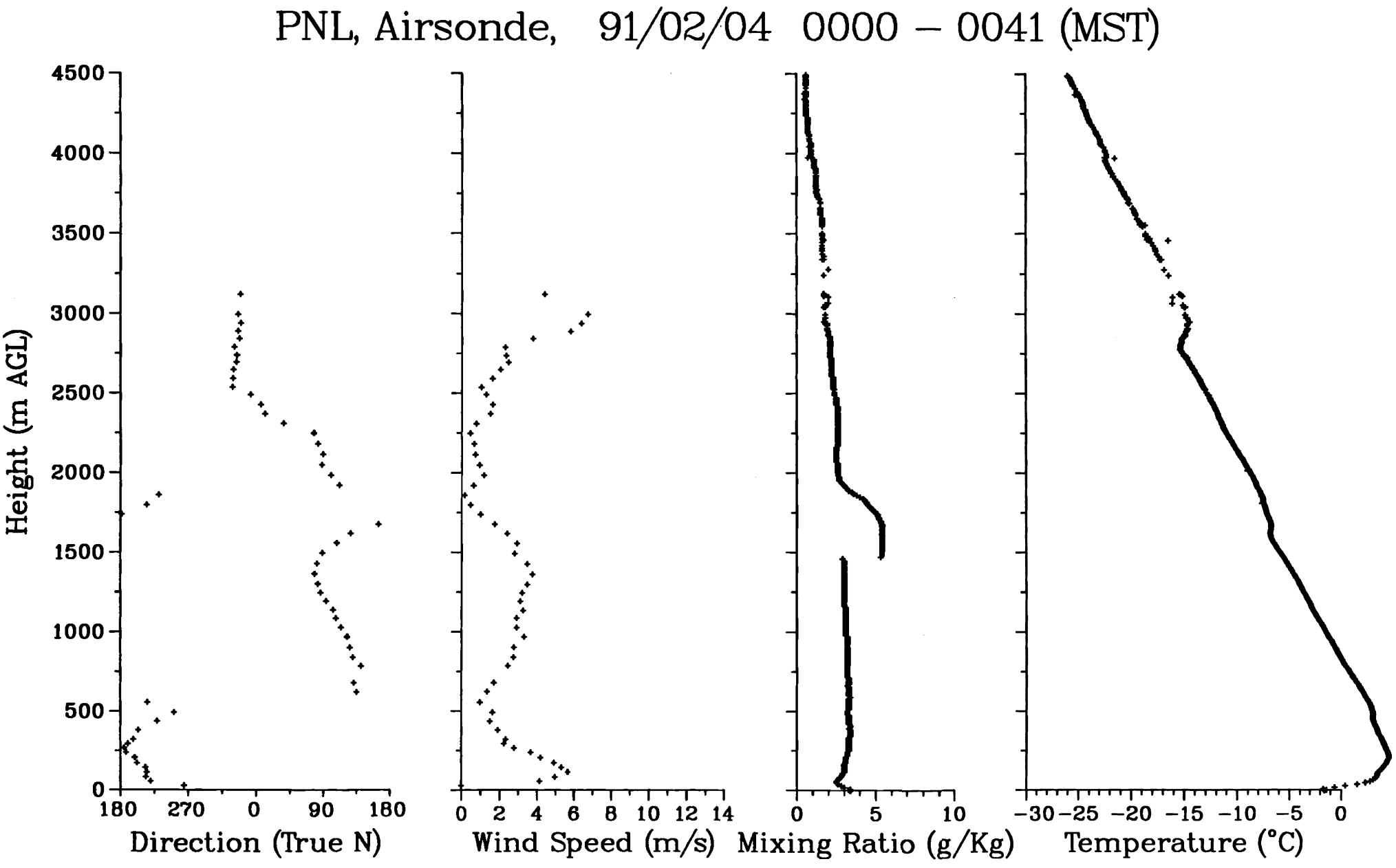

PNL, Airsonde, 91/02/02 0000 – 0051 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−20 −15 −10 −5 0 5 10
Temperature (°C)


PNL, Airsonde, 91/02/02 0159 – 0238 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−20 −15 −10 −5 0 5 1
Temperature (°C)


PNC. Airsonde, 91/02/02 0355 – 0437 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−20 −15 −10 −5 0 5 10
Temperature (°C)


PNL, Airsonde, 91/02/03 2010 – 2114 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−30 −25 −20 −15 −10 −5 0
Temperature (°C)


PNL, Airsonde, 91/02/03 2200 – 2247 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−30 −25 −20 −15 −10 −5 0
Temperature (°C)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Height (m AGL)
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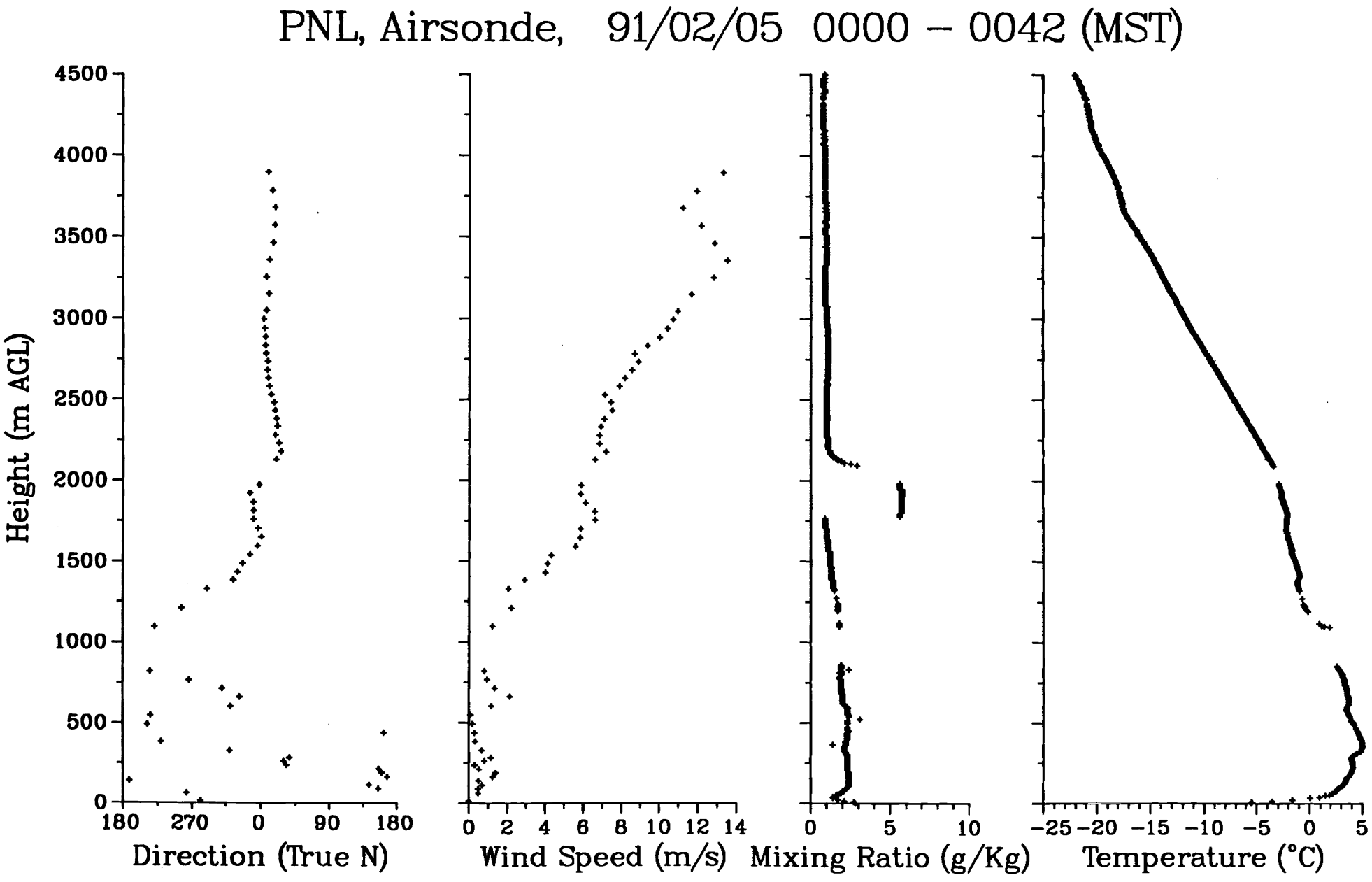
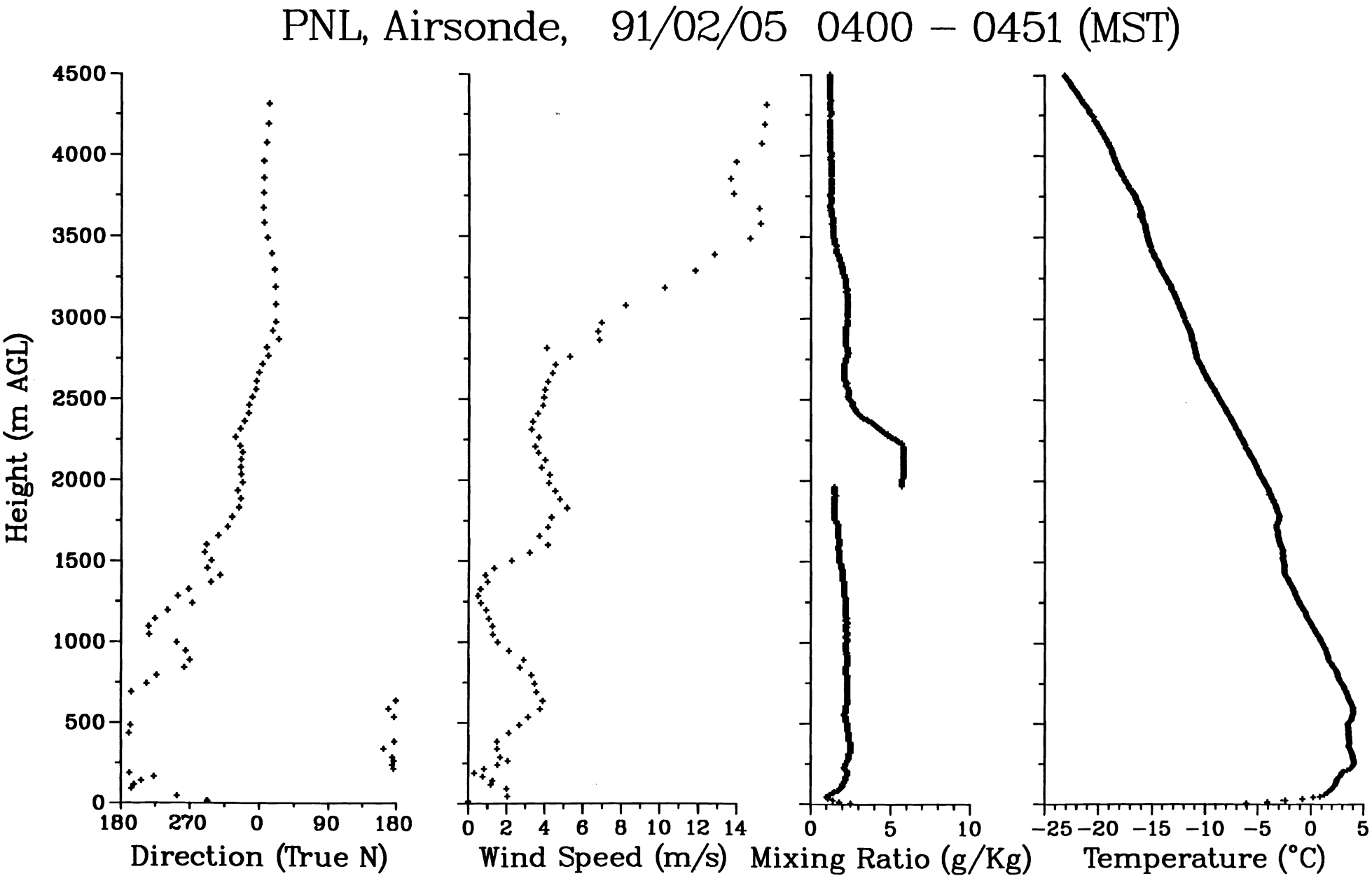
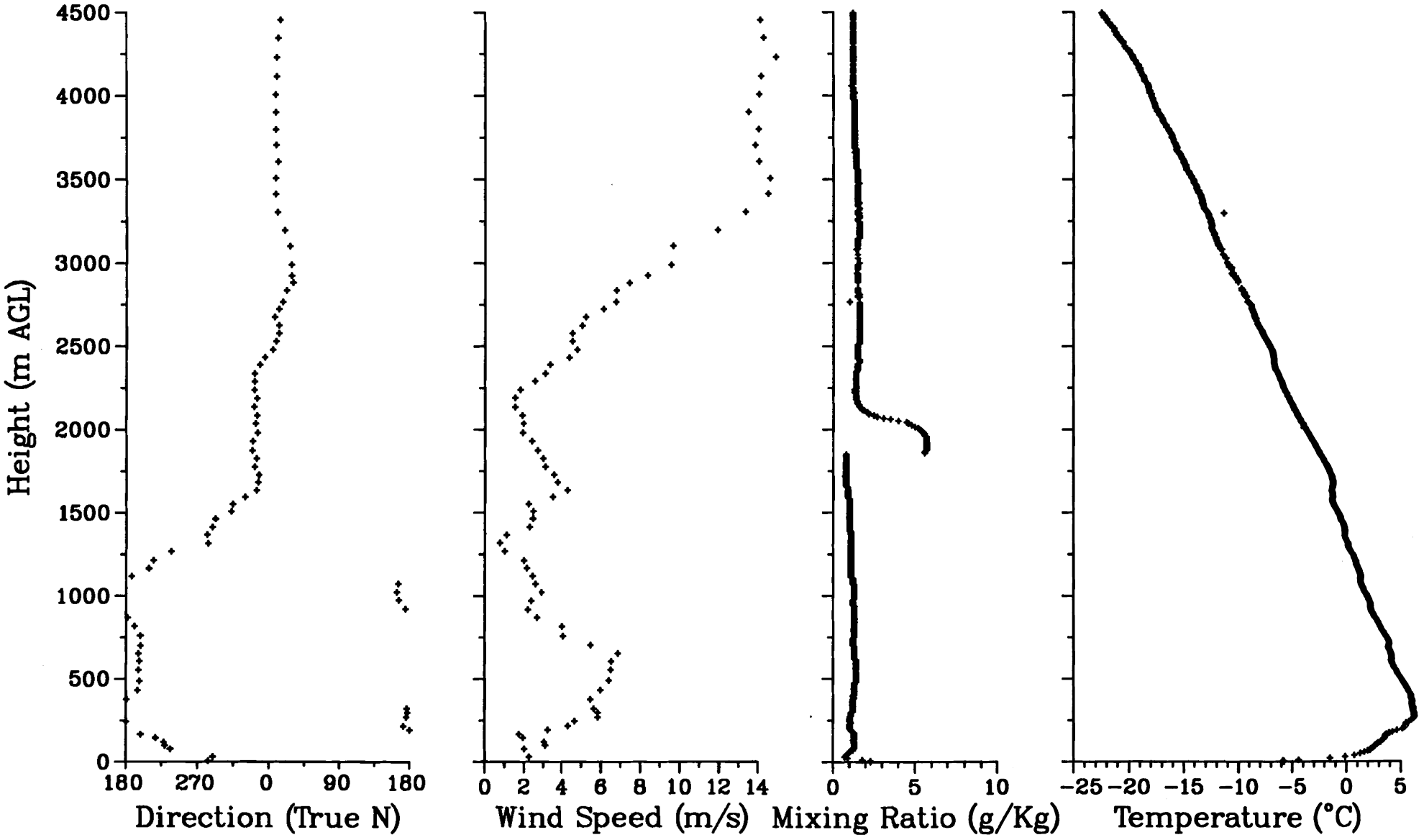
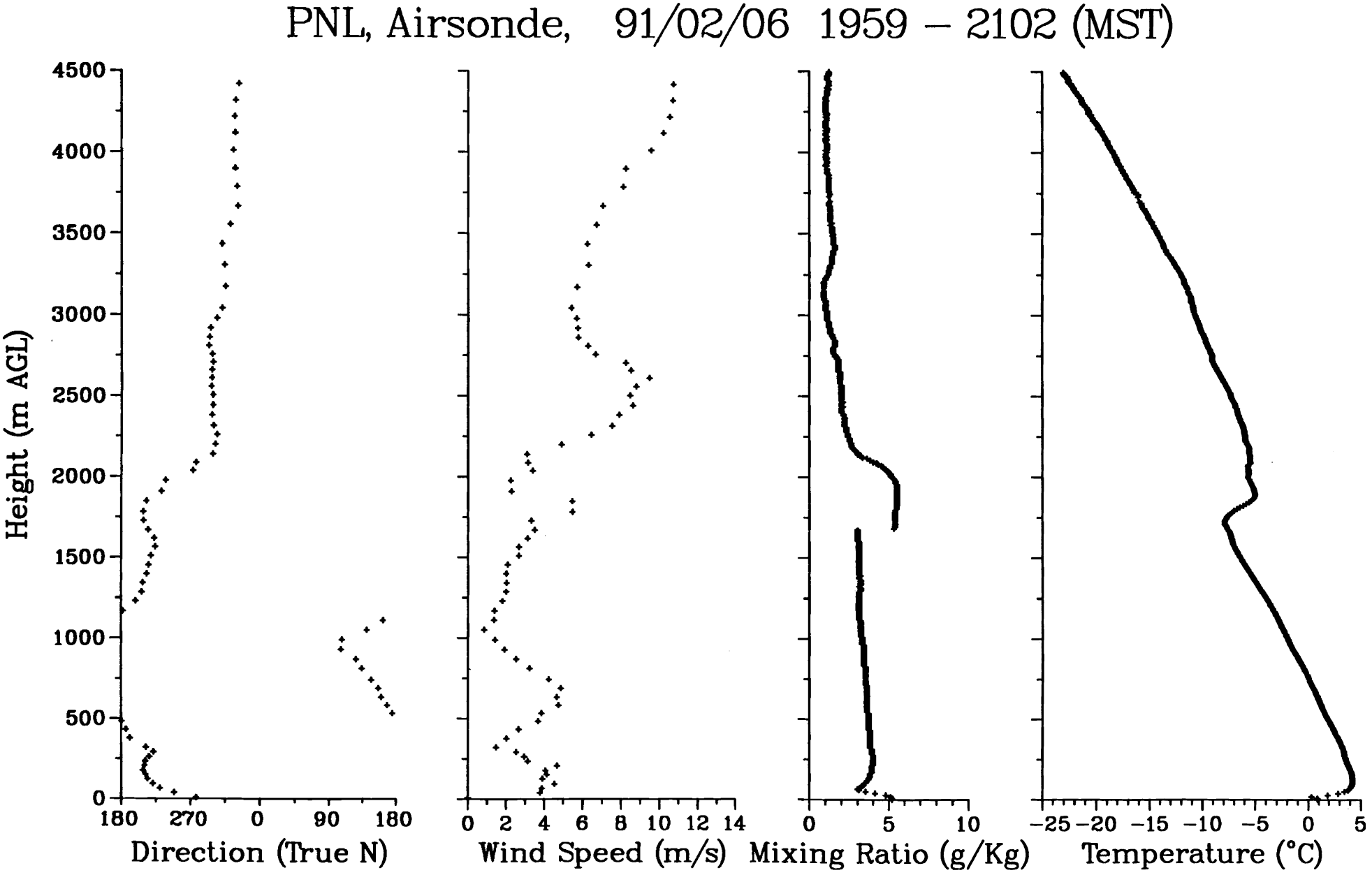
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−30 −25 −20 −15 −10 −5 0
Temperature (°C)

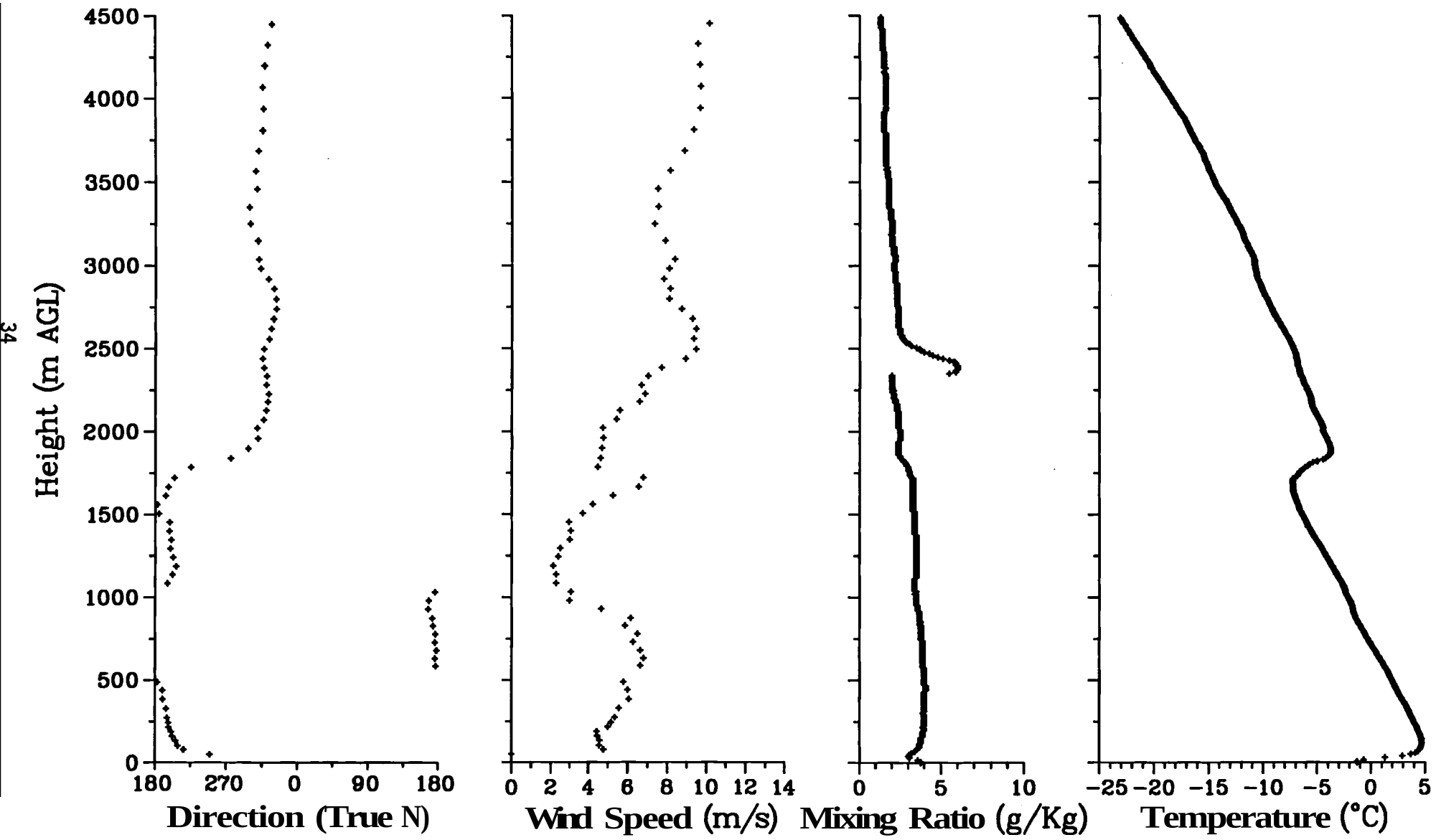

PNL, Airsonde, 91/02/05 0000 – 0042 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
–25 –20 –15 –10 –5 0 5
Temperature (°C)

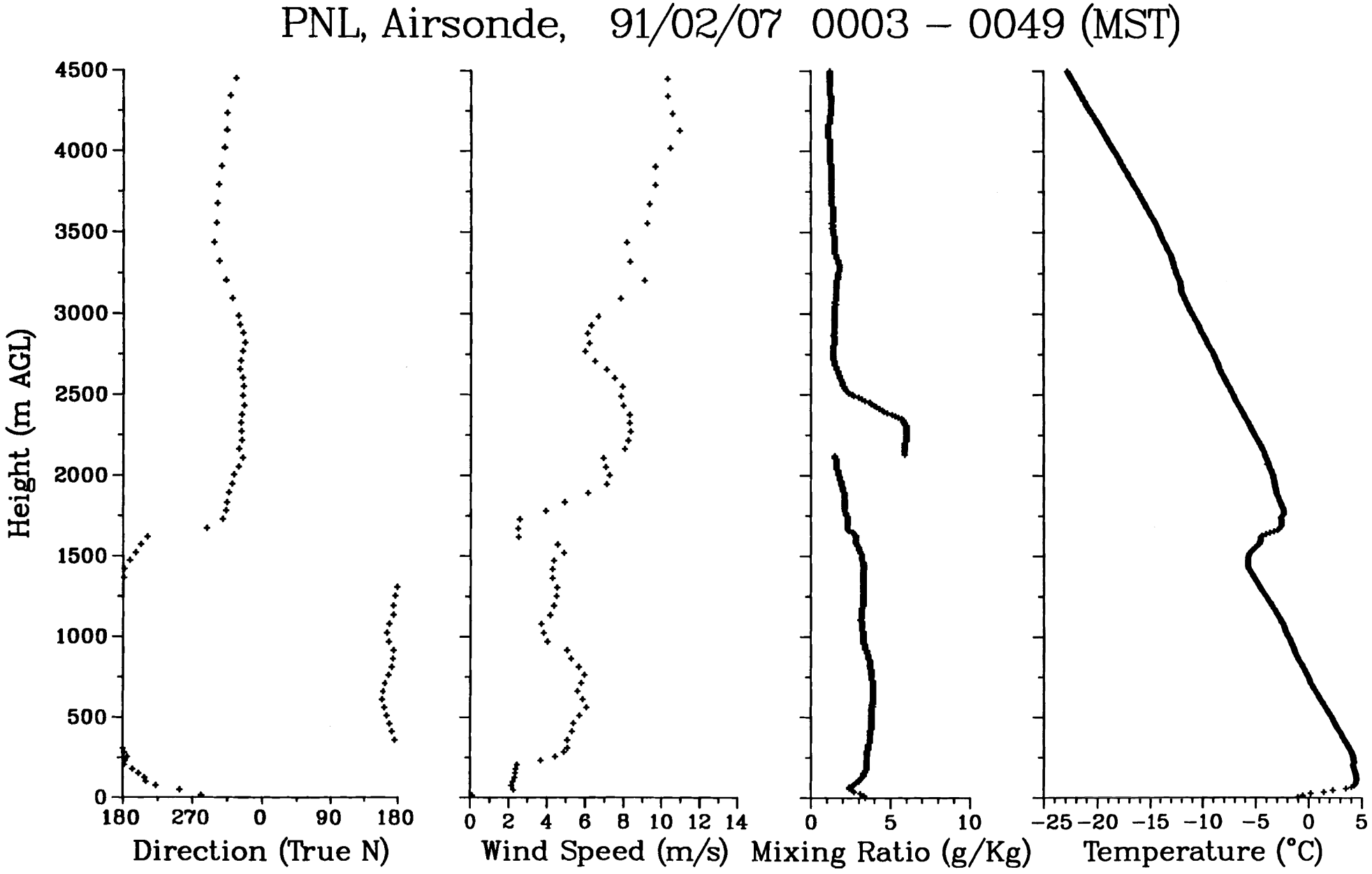

PNL, Airsonde, 91/02/05 0400 – 0451 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)


PNL, Airsonde, 91/02/05 0529 – 0631 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)

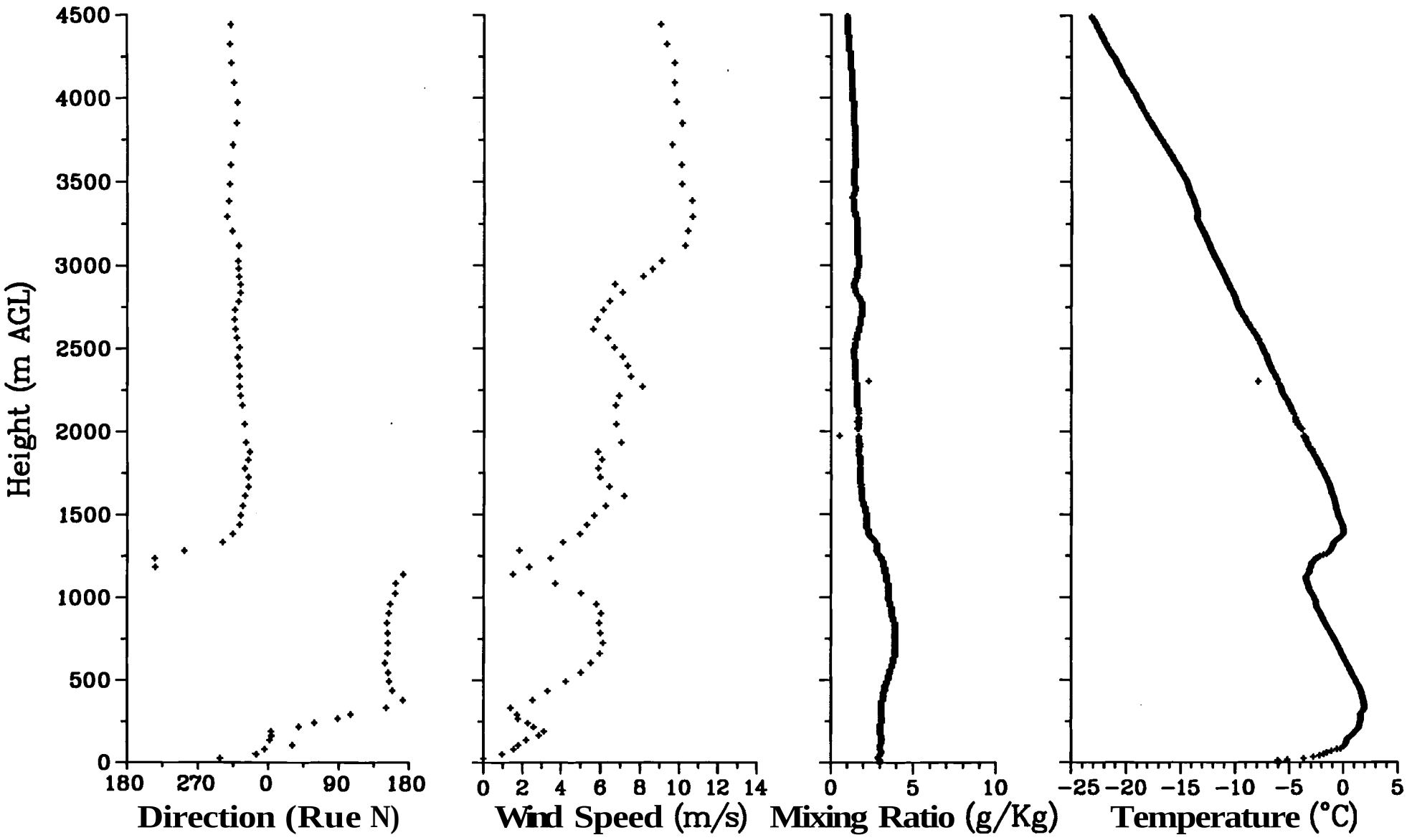

PNL, Airsonde, 91/02/06 1959 – 2102 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)

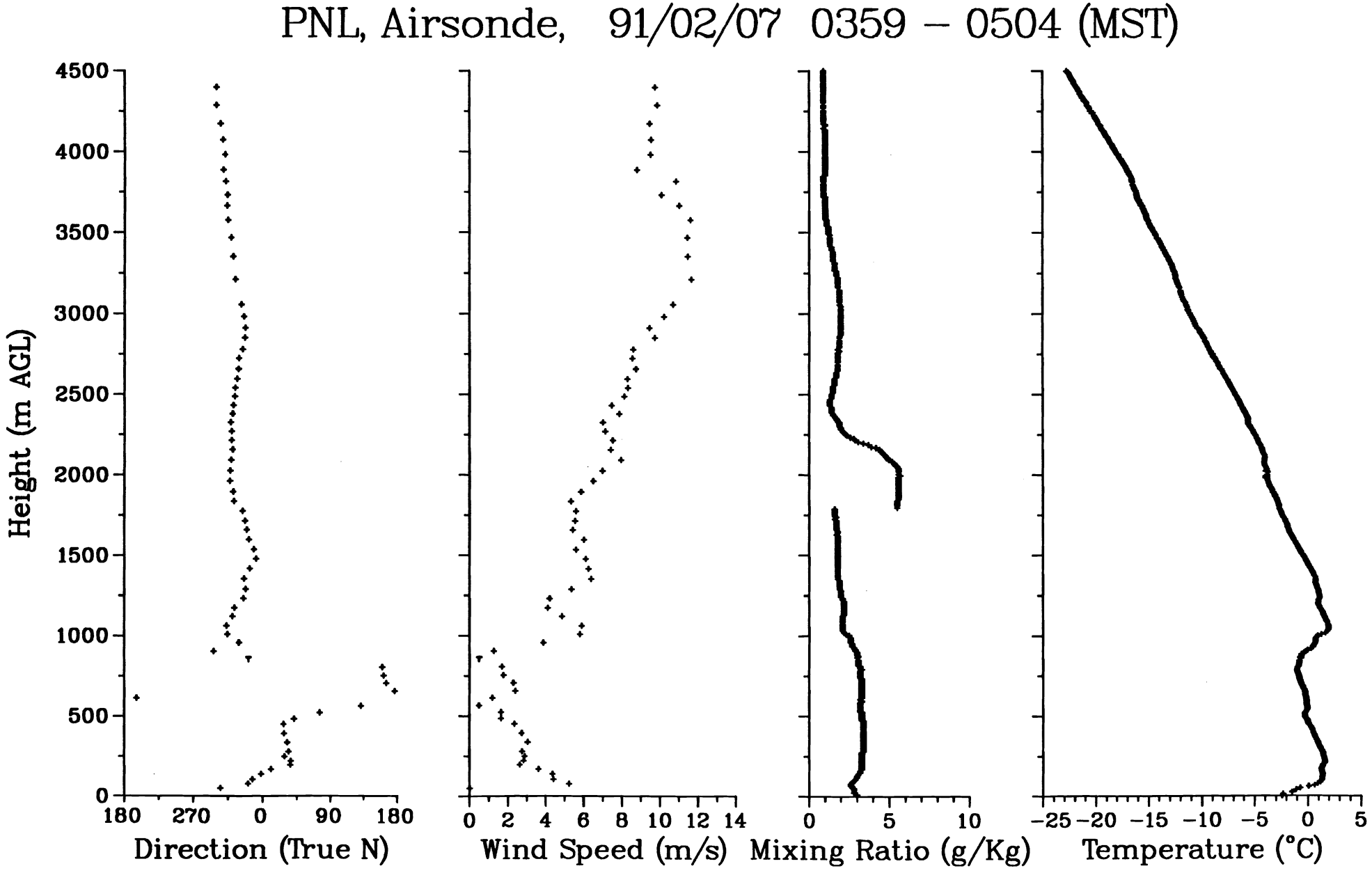
PNL, Airsonde, 91/02/06 2203 – 2312 (MST)

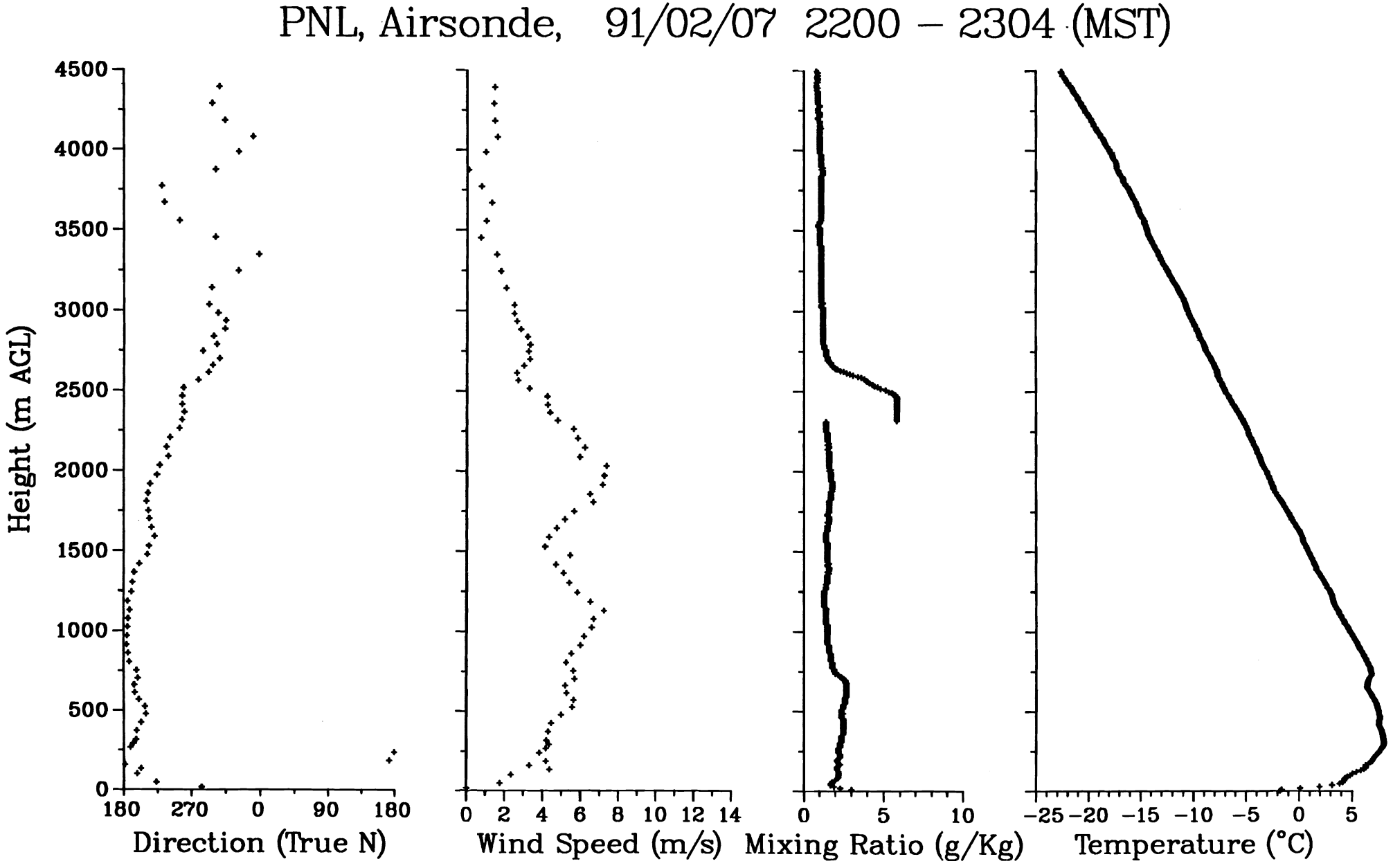


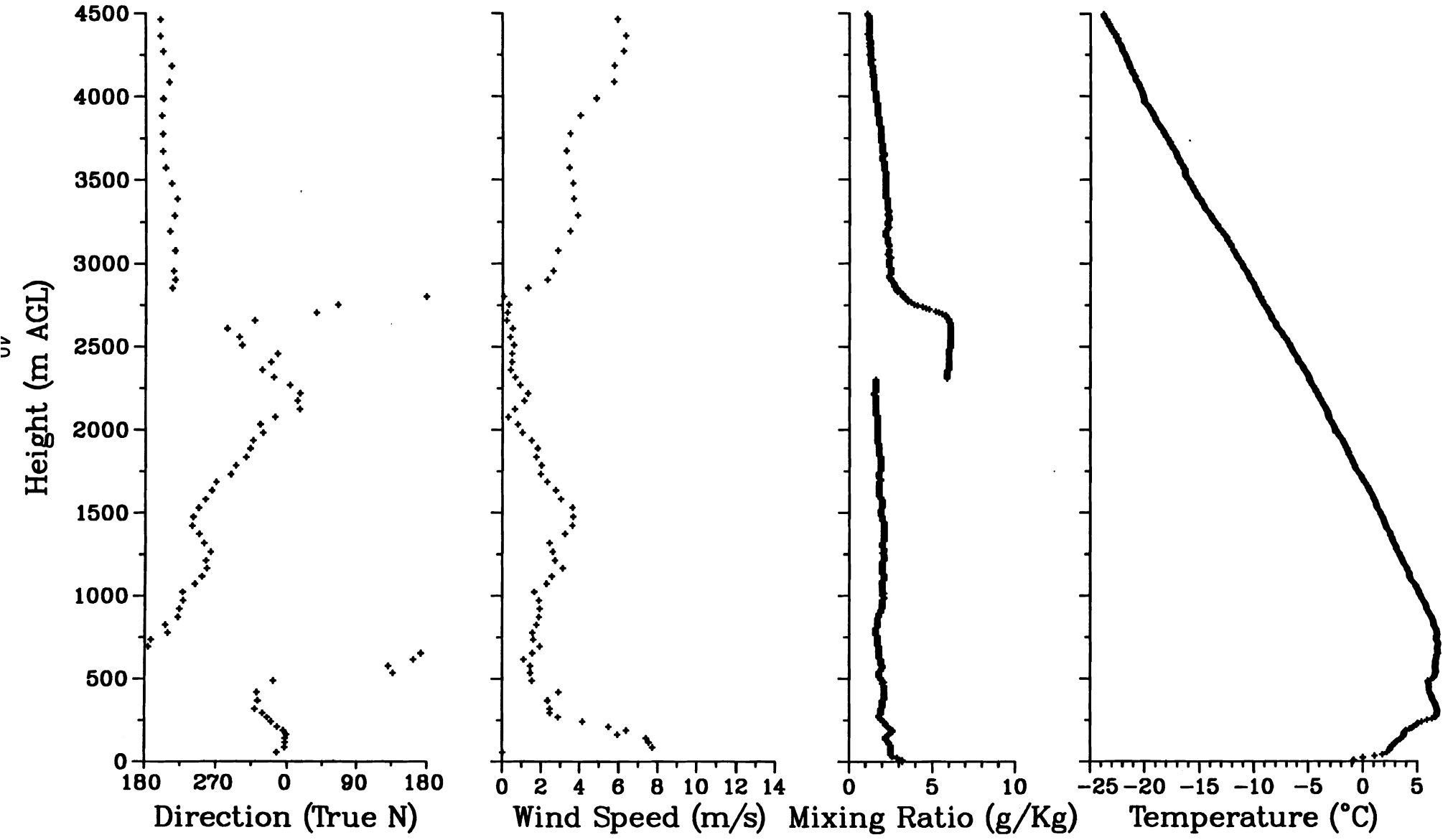

PNL, Airsonde, 91/02/07 0003 – 0049 (MST)
Height (m AGL)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
180
270
0
90
180
Direction (True N)
0
2
4
6
8
10
12
14
Wind Speed (m/s)
0
5
10
Mixing Ratio (g/Kg)
−25
−20
−15
−10
−5
0
5
Temperature (°C)

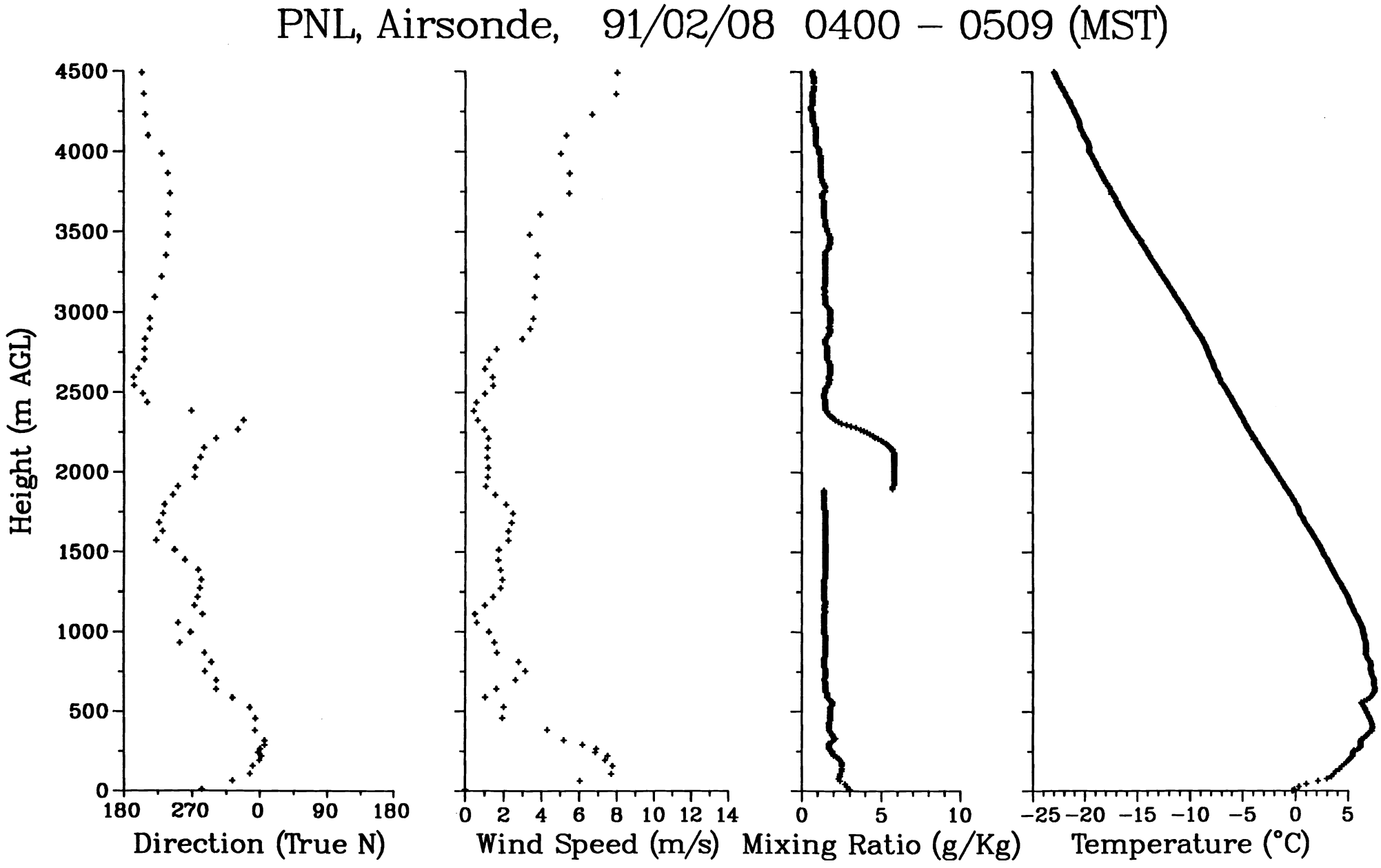
PNL, Airsonde, 91/02/07 0210 – 0311 (MST)

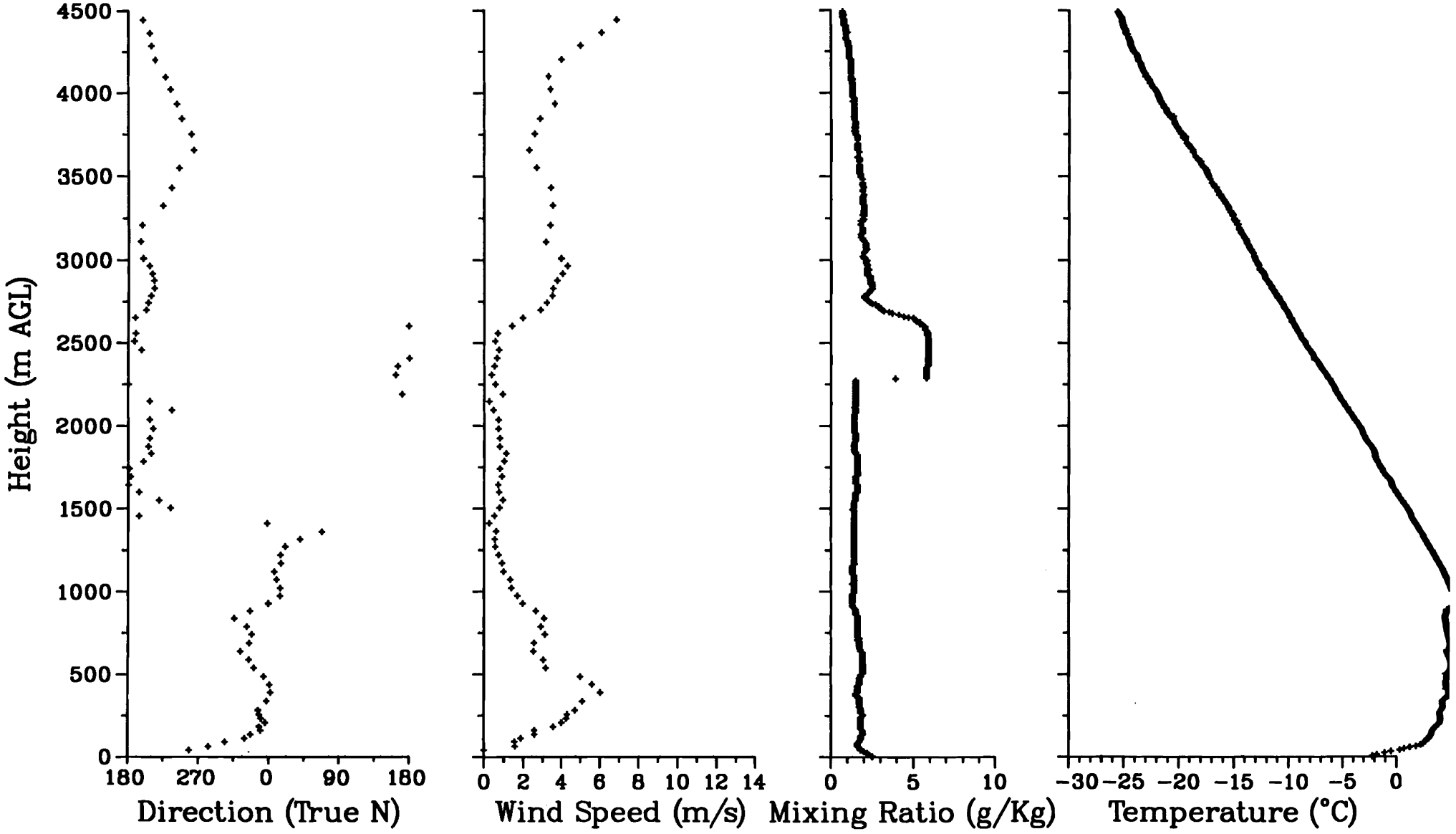



PNL, Airsonde, 91/02/07 0359 – 0504 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)


PNL, Airsonde, 91/02/07 2200 – 2304 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)


PNL, Airsonde, 91/02/08 0203 – 0301 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
-25 -20 -15 -10 -5 0 5
Temperature (°C)


PNL, Airsonde, 91/02/08 0400 – 0509 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−25 −20 −15 −10 −5 0 5
Temperature (°C)

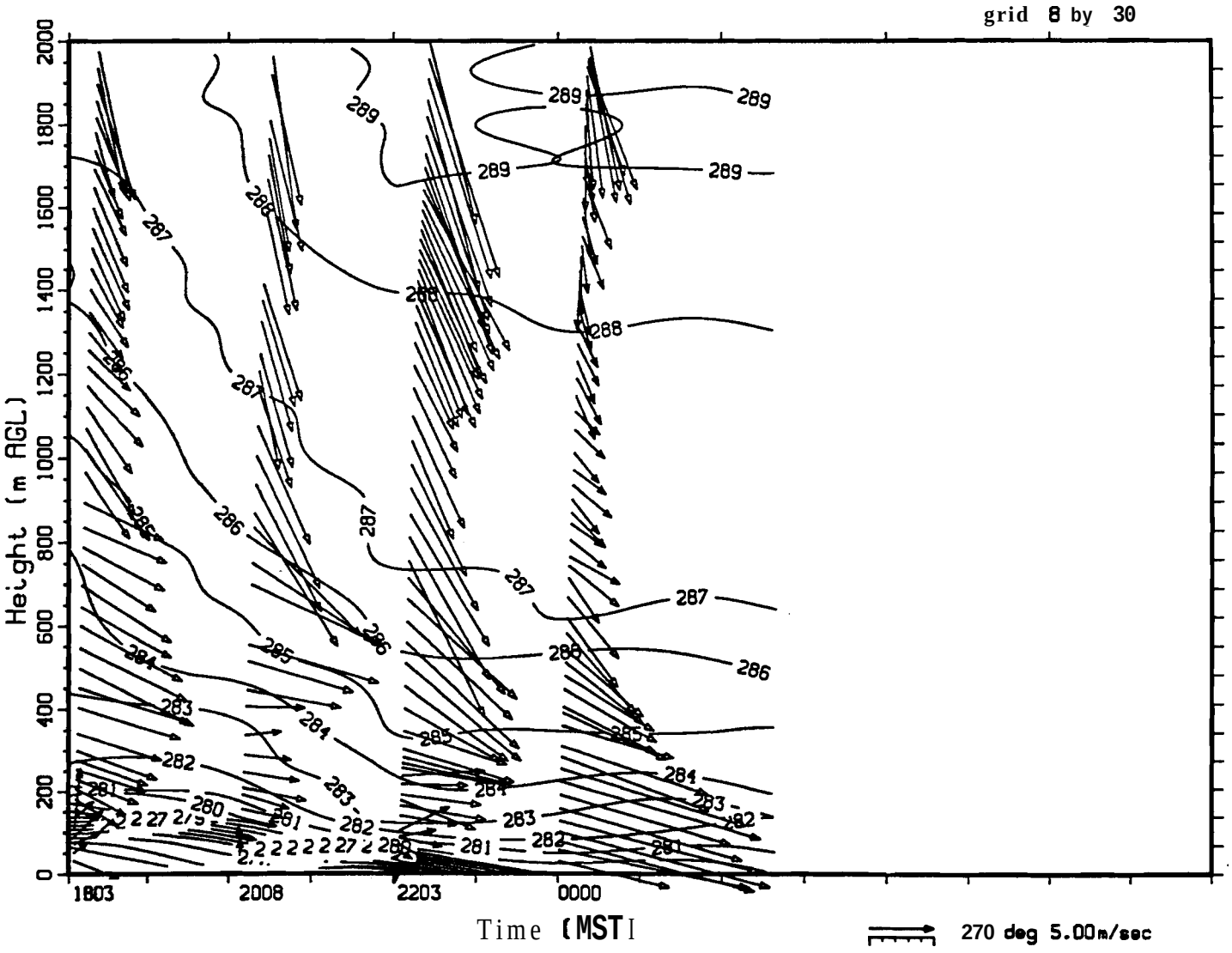

PNL, Airsonde, 91/02/08 0530 – 0625 (MST)
Height (m AGL)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
180 270 0 90 180
Direction (True N)
0 2 4 6 8 10 12 14
Wind Speed (m/s)
0 5 10
Mixing Ratio (g/Kg)
−30 −25 −20 −15 −10 −5 0
Temperature (°C)

APPENDIX C

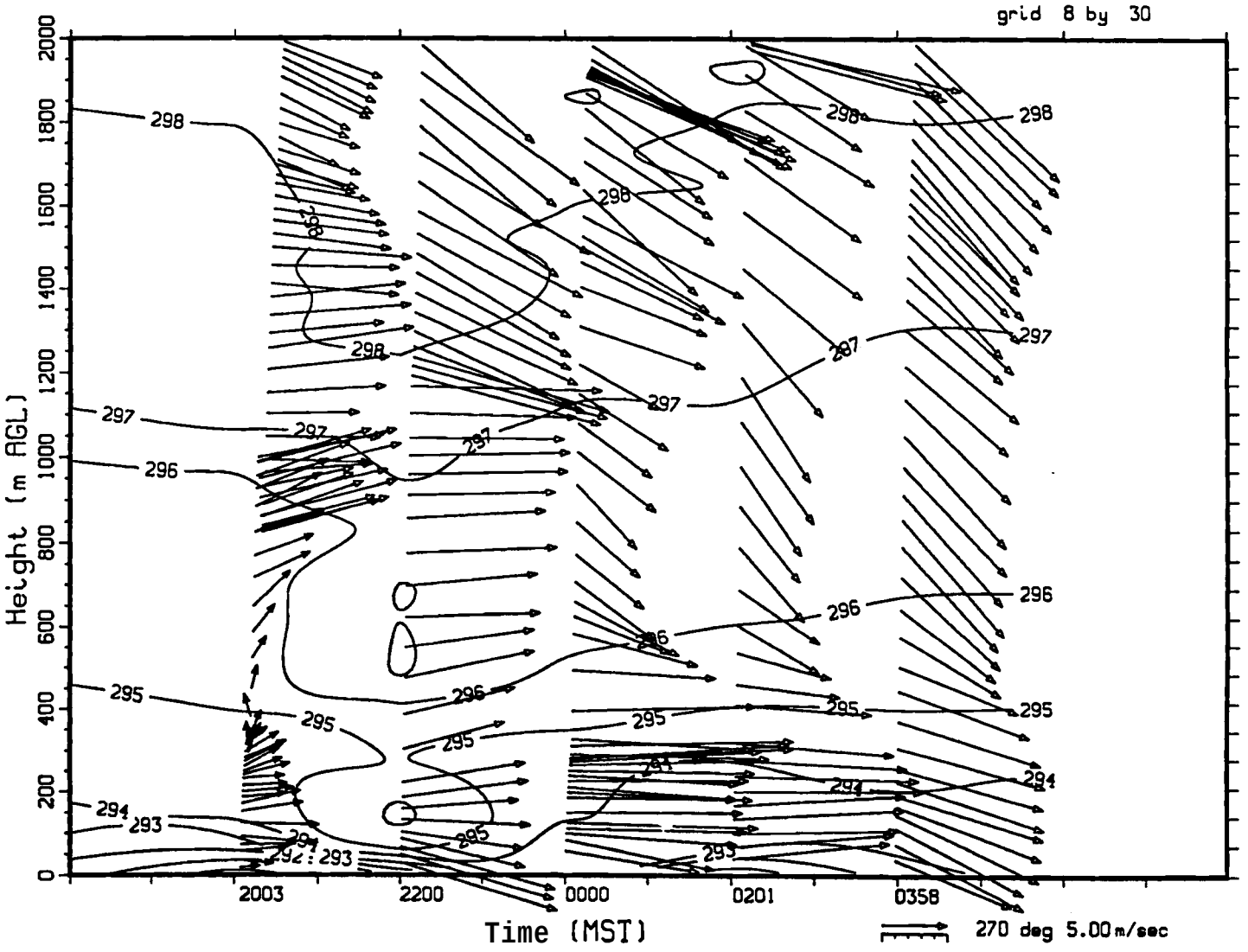
Time/Height Plots

PNL FP Airsonde

1/29 - 1/30 **1991 Winds & Potential Temperature**

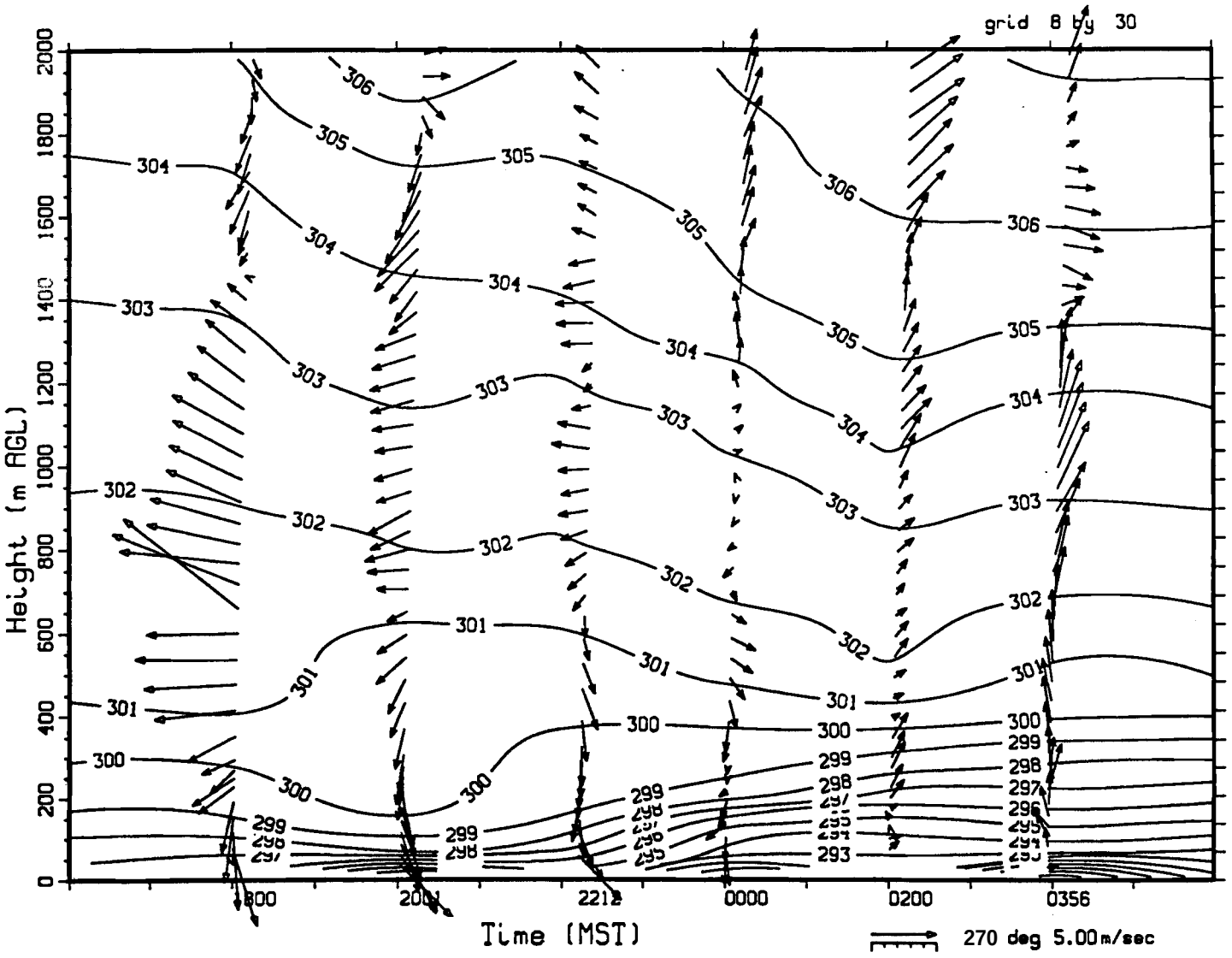


PNL FP Airsonde
1/31 - 2/1 1991 Winds & Potential Temperature

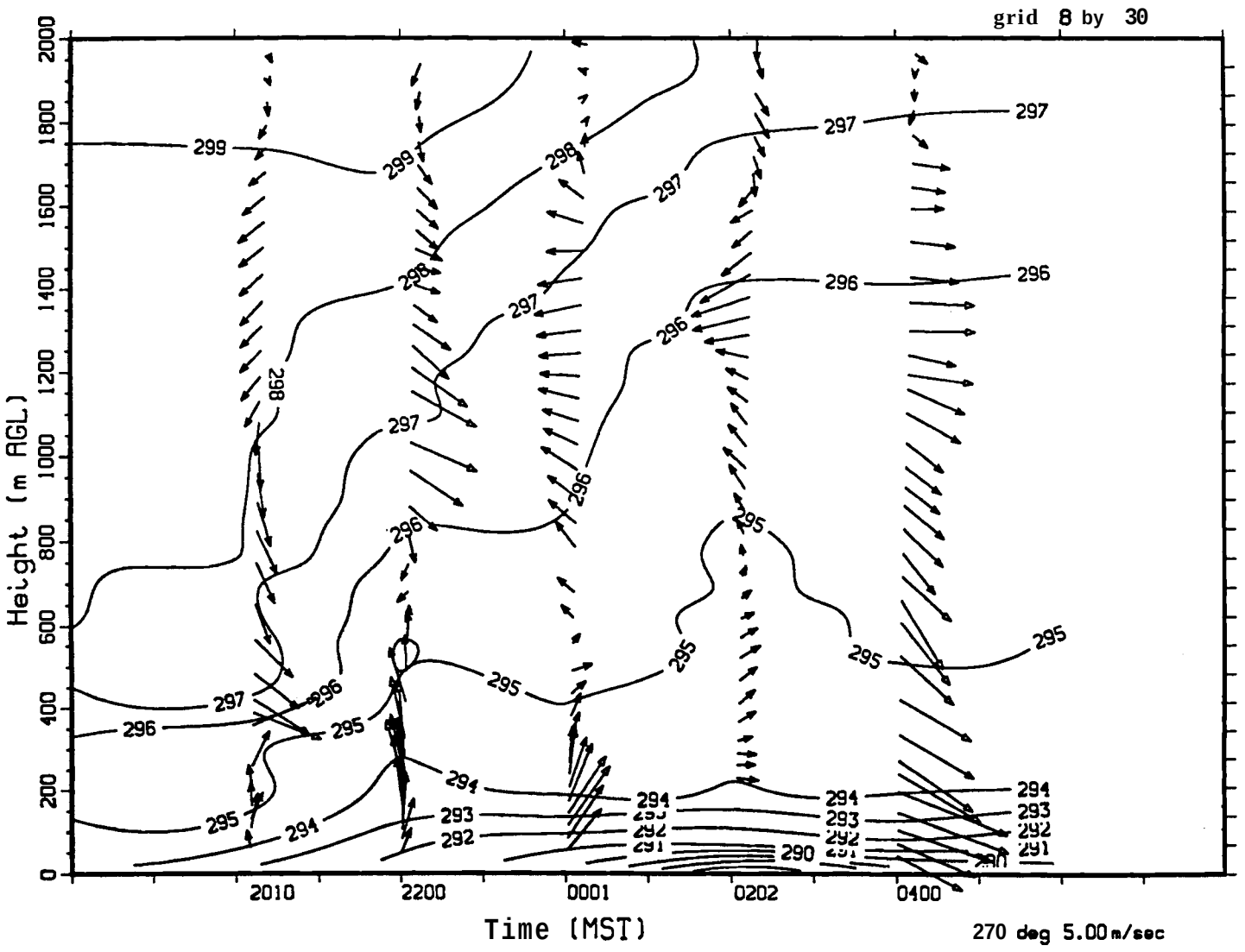


PNL FP Airsonde

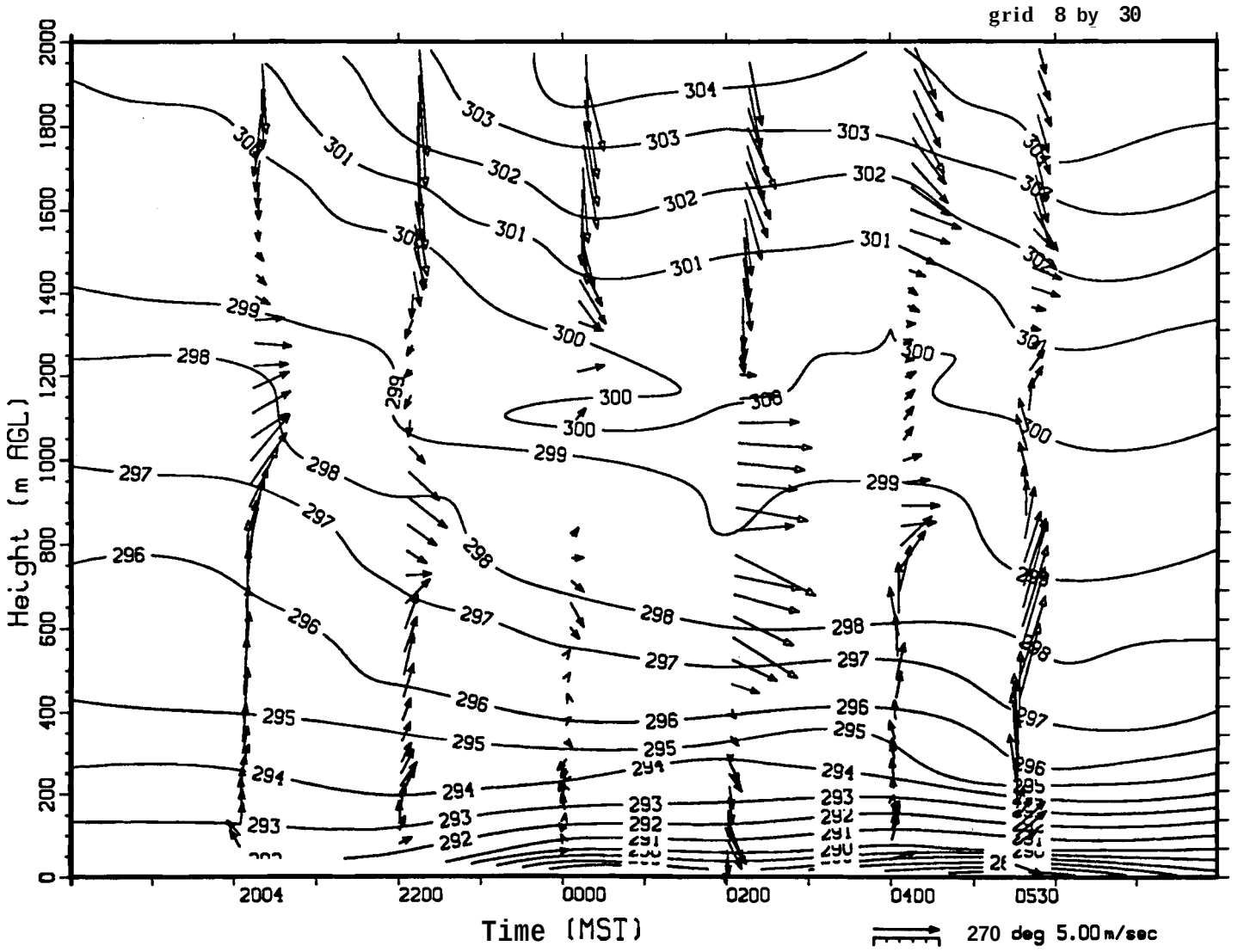
2/1 - [redacted] 1991 Winds & Potential Temperature



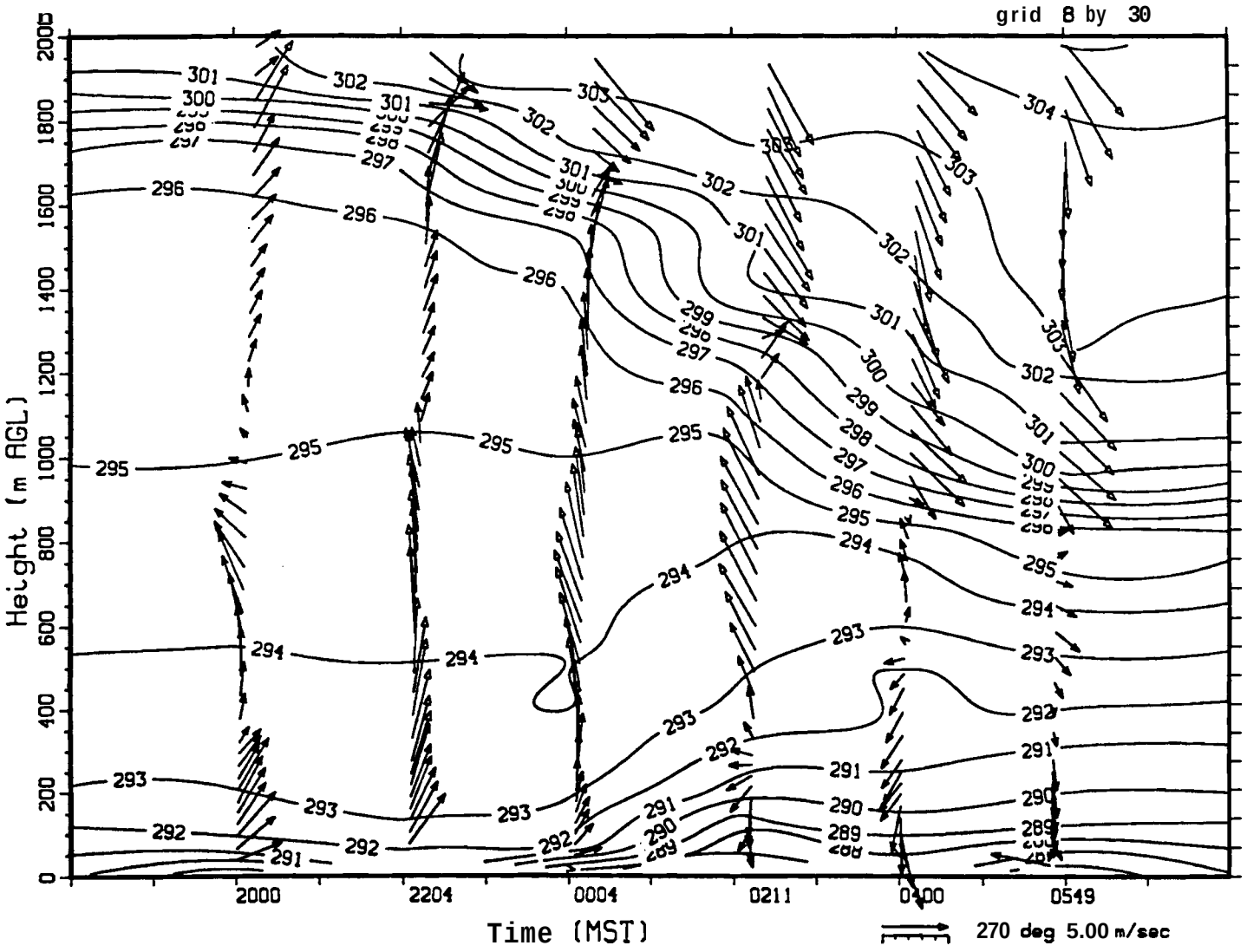
PNL FP Airsonde
2/3 - 2/4 1991 Winds & Potential Temperoture



PNL FP Airsonde
2/4 - 2/51 1991 Winds & Potential Temperature



PNL FP Airsonde
2/6 - 2/7 1991 Winds & Potential Temperature



PNL FP Airsonde
2/7 - 2/8 1991 Winds & Potential Temperature