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13. ABSTRACT *(Maximum 200 words)*

A 924-MHz wind-profiling Doppler radar is a candidate for incorporation into a Mobile Profiler System (MPS) being developed at White Sands Missile Range (WSMR), NM. The MPS must acquire wind data that are comparable (within 2 m/s in speed and within 10° in direction) to rawinsonde data in generating an upper-air meteorological message for the field artillery. To determine whether the 924-MHz system could meet this requirement, a measurement program was conducted at the Atmospheric Profiler Research Facility (APRF) at WSMR from 24 March to 26 August 1992. Selected wind data from the profiler were compared with rawinsonde data in the range from 600 m above ground level (AGL) to 2538 m AGL. For comparison of winds in the first 600 m AGL, an Enterprise WF-100 Wind-Finding Radar system was used. In general, the wind data from the 924-MHz profiler system met the criterion. The wind data from the 924-MHz profiler were also compared to wind data from anemometers mounted on a fixed tower, a sodar, and a 404-MHz wind-profiling Doppler radar.

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Executive Summary

A 924-MHz Boundary Layer Radar is a candidate for incorporation into the Mobile Profiler System (MPS) being developed by the Battlefield Environment Directorate (BED) of the Army Research Laboratory (ARL). One requirement of the MPS is to provide wind data during 15-min sampling periods at least comparable to the data obtained by rawinsondes. To evaluate the 924-MHz radar, the radar was operated at the Atmospheric Profiler Research Facility (APRF) at the High Energy Laser Instrumentation Development Laboratory (HIDL) during the spring and summer of 1992. APRF is an appropriate location for evaluation because the facility includes fixed-tower anemometers and 404-MHz, 50-MHz, and sodar wind profilers. Moreover, a rawinsonde and WF-100 wind-finding radar site (Oasis) is located relatively close to APRF.

The evaluation period ran from 24 March to 26 August 1992. For this report, 23 days with apparently uniform winds in the White Sands Missile Range air shed and 14 days when WF-100 data were available were selected for evaluation of the 924-MHz profiler.

Extensive efforts were expended to establish consistent data formats among the systems and ensure that nearly identical sampling volumes were used for the graphical and statistical evaluation.

The comparison of the 924-MHz profiler with the five other systems is quite good on days with uniform winds and minimal convective activity, but sporadic on days that do not meet this criterion. It should be noted that (1) the profiler data have been consensus averaged; (2) the data have been corrected for vertical motion, the correction being negligible at low vertical wind speeds; and (3) the statistical comparisons encompass temporally equivalent periods.

Particularly curious is the fact that the U components agreed well in some cases while the V components did not and vice versa. Results of paired t-tests and correlation and regression analyses are included. The role of meteorological factors, spatial separation, and differences in temporal resolution as they affect the comparisons, particularly between the 924-MHz and rawinsonde data, are addressed.

The conclusion is that when the complete set of evaluation data are considered, the wind data from 924-MHz profiler system agrees with the wind data from the other systems to within 2 m/s in wind speed and to within 10° in direction, although there are much larger variations found in individual data sets. Some of the large discrepancies found in the individual data sets can be traced to meteorological factors; in other cases determining the reason for discrepancies will require further study.

1. Introduction

A small, portable 924-MHz wind-profiling Doppler radar, developed at, and provided by, the National Oceanic and Atmospheric Administration's (NOAA) Aeronomy and Wave Propagation Laboratories in Boulder, CO, is a candidate for incorporation into the Mobile Profiler System (MPS) being developed by the U.S. Army Research Laboratory's (ARL) Battlefield Environment Directorate (BED) at White Sands Missile Range (WSMR), NM. The MPS must acquire sufficient wind data, comparable to rawinsonde data, during a 15-min period to generate an upper-air meteorological (MET) message for the field artillery. The wind speeds measured with the 924-MHz system had to be within ±2 m/s and the wind directions within ±10° of those measured with the rawinsonde system.

To determine whether the 924-MHz system meets this specific requirement, a measurement program was conducted at WSMR during the spring and summer of 1992. The 924-MHz system operated virtually continuously during the 155-day period from 24 March to 26 August 1992 at the Atmospheric Profiler Research Facility (APRF). Selected wind data from this period were compared with data from aperiodic launches of rawinsondes from Oasis, located about 6 km southwest of APRF.

An Omega-based Vaisala rawinsonde served as a major basis of comparison. However, this particular Vaisala system in a stand-alone mode uses an Ekman spiral to approximate the winds for the first 600 m above the surface. Thus, comparisons of rawinsonde and 924-MHz data were made only in the range of 600 m above ground level (AGL) to 2538 m AGL, the latter being the upper limit of the test 924-MHz system operating in the low mode.

Because of the spatial separation of Oasis and APRF, the comparisons were limited to 23 rawinsonde runs when the wind field appeared to be uniform and a reasonably complete set of wind data was available from the 924-MHz profiler.

An Enterprise WF-100 Wind-Finding Radar system was used to facilitate comparison of winds in the lower 600 m. However, the WF-100 system was not incorporated into the measurement program until 17 June, and it was only used on portions of 14 days. For those 14 periods, the 924-MHz data were also compared to wind data from collocated sodar and 404-MHz wind profiler systems and nearby tower-mounted anemometers. Comparison statistics may be degraded because the presence of a uniform wind field was not a criterion for data selection.

Also illustrative of the quality of the wind data from the surface to 600 m AGL are comparisons among the 924-MHz, anemometer, and sodar systems. As an example of such comparisons, a single day, 15 April, was selected.

Finally, data from the 924- and 404-MHz profilers were compared.

This report contains brief descriptions of the instrumentation, discussions of the comparison techniques, and comparisons of the results in figures and tables.

In addition to the wind comparison, temperature data acquired with a Radio Acoustic Sounding System (RASS) attached to the 924-MHz profiler are compared to temperature data acquired with radiosondes launched from Oasis.

Appendix A provides information on the range gates for the 924-MHz profiler, the sodar, and the 404-MHz profiler. Appendix B lists range-gate data for RASS virtual temperature profiles, and appendix C provides supplemental information on the rawinsonde and WF-100 systems. Appendix D lists sample statistics, and appendix E shows sample regression line plots.

2. Measurement Sites

The 924-MHz, 404-MHz, and sodar measurements were made at APRF, the anemometer measurements at the 150-m tower at LC-35 (immediately adjacent to APRF), and the balloon measurements at Oasis. The relative positions of APRF and Oasis are shown in figure 1.

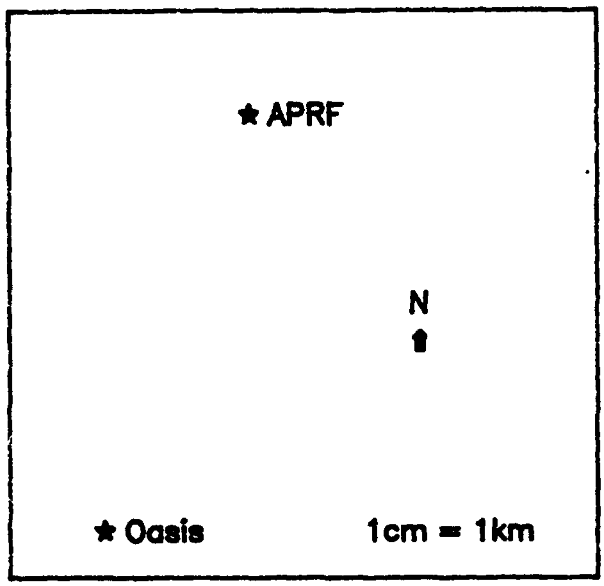


Figure 1. Relative locations of sampling sites.

3. Wind

3.1 Instrumentation

The wind measurement systems selected for this study were the 924-MHz wind profiler; two free-balloon tracking systems, an Omega rawinsonde and a wind-finding radar; a 404-MHz wind profiler; a sodar; and anemometers at multiple levels of a 150-m tower. These systems and certain performance characteristics are summarized in table 1. More complete information is provided in Hines, et al. [1]

Table 1. Wind measurement systems used in the 924-MHz profiler evaluation

System	Manufacturer	Mode	Height Range (m AGL)	Vertical Resolution (m)	Averaging Interval (min)
924 MHz	NOAA	Low	120-2500	100	30 or 15
		High	127-5000	200	30 or 15
Rawin	Vaisala	N/A	<30,000	1200	4
WF-100	Enterprise	N/A	<6000	50 or 150	0.17
404 MHz	UNISYS	Low	500-9250	335	60
		High	7500-16250	1000	60
Sodar	Radian	N/A	50-525	25	15
U-V	R. M. Young	N/A	7.6-152.4	8 lvls	1

The temperature measurement systems were limited to the virtual temperature measured by the RASS system associated with the 924-MHz wind profiler and the air temperature and moisture measured with the radiosonde system.

3.1.1 924-MHz Profiler System

The 924-MHz profiler system includes three antenna beams. In order of sampling sequence, the antenna beam orientations are as follows:

1. Vertical
2. 75° azimuth, tilted 20° off vertical
3. 345° azimuth, tilted 20° off vertical

The 924-MHz profiler has two modes: low and high. The low mode consists of 25 gates and has a vertical resolution of about 100 m from 70 to 2538 m AGL. The gates and corresponding altitude ranges are listed in appendix A.

As shown in table 2, both low- and high-mode data were acquired over 30- and 15-min sampling intervals. However, only the low-mode data are used for this report.*

Table 2. System configurations for the 924-MHz wind profiler

Date (1992)	Mode	Sampling Interval (min)	Dwell Time (s/beam)
24 Mar - 5 June	Low and high	30	30
5 June - 25 June	Low only	15	30
26 June - 26 Aug	Low or high	15	20

In addition to the wind data, virtual temperature data were acquired with an RASS system. RASS data were acquired during the first 6 min of the 30-min sampling intervals and during the first 3 min of the 15-min sampling intervals.

* *As suggested in table 2, there were insufficient high-mode data to extend the comparison to higher altitudes.*

Each of the three 924-MHz beams was on for either 30 or 20 s, requiring 90 s or 1 min, respectively, to obtain one sample. A maximum of 8 low- and 8 high-mode samples were obtained during the 30-min sampling period. A maximum of 8 or 12 low-mode samples, depending on the dwell time, were obtained during the 15-min sampling periods.

Because of the RASS data acquisition, low-mode wind data were acquired during only 12 min of the 30-min sampling periods and low- or high-mode wind data were acquired during only 12 min of the 15-min sampling periods.

The time assigned to a 30- or 15-min period refers to the start of the period.

The horizontal wind data are corrected for vertical motion.

3.1.2 Rawinsonde

Although rawinsonde data are acquired from a number of sites at WSMR, only those from Oasis are used in this study because it is closest to APRF.

The rawinsonde system used in this evaluation is an Omega-based Vaisala navigation aid (NAVAID) system. Relative position data are acquired every 10 s with the Vaisala system. Four-min averages are used for wind measurement because the Omega system has an inherent noise in differential position measurements of 200 m.

For an approximate balloon rise rate of 300 m/min, 4 min translates to a vertical displacement of approximately 1200 m. Thus, the first valid average wind data apply to the 600 m AGL level (about 2 min into the flight). For the rawinsondes released at Oasis during the summer of 1992, the winds below 600 m (except for the surface wind) were estimated proprietarily using an Ekman spiral. Above 600 m, the wind data are reported at 10-s intervals and represent a cubic spline fit to the data from 600 m below to 600 m above the 10-s point.

Additional information on the Vaisala rawinsonde systems used at WSMR is presented in appendix C.

3.1.3 WF-100 Radar

The Enterprise WF-100 Wind-Finding Radar System is designed to provide elevation angle, azimuth angle and range data at 1-s intervals. In reality, the 1-s data represent averages over either 10 s (5 s on either side of the 1-s point) or 30 s (15 s on either side of the 1-s point). For a balloon rise rate of 300 m/min, the 10-s and 30-s data correspond to approximate averaging intervals of 50 m and 150 m, respectively.

The WF-100 wind data were acquired at ½-h intervals during 2- to 5-h periods on each of 14 days (see table 3 for specific information on the dates and times of these wind soundings and availability of corresponding 924-MHz data).

The 150-m layer data were available for the June and July data and the 50-m layer data for the August data. The difference in vertical resolution is taken into account in the comparisons with the 924-MHz data.

Detailed information on the WF-100 system is provided in appendix C.

Table 3. Availability of WF-100 and corresponding 924-MHz data

Date (1992)	Time Interval[a] (MST)	Corresponding 924-MHz Data	Vertical Averaging Interval (m)
17 June	0730-1030	yes	150
18 June	1330-1830	yes	150
24 June	0730-1030	yes	150
25 June	1430-1830	yes	150
1 July	0130-0430	yes	150
2 July	0330-0630	yes	150
8 July	1330-1630	yes	150
9 July	1600-1830	yes	150
18 August	1600-1800	yes	50
19 August	1600-1800	yes	50
20 August	1600-1800	partial	50
21 August	1600-1800	yes	50
24 August	1500-1700	yes	50
25 August	1500-1700	yes	50

[a]During the specified time intervals, balloons were released at 30-min intervals.

3.1.4 404-MHz Profiler

The 404-MHz profiler consists of three antenna beams. In order of sampling sequence, the antenna beam orientations are as follows:

1. 90° (±3°) azimuth, tilted 16.1° off vertical
2. 360° (±3°) azimuth, tilted 16.1° off vertical
3. Vertical

The 404-MHz profiler has two modes: low and high. The data acquisition proceeds as follows:

Low mode: 1 min/antenna beam for a total of 3 min
High mode: 1 min/antenna beam for a total of 3 min

A maximum of 10 low-mode and 10 high-mode profiles occur within a 60-min period.

Although the profiler data were acquired in both the low and high modes, only low-mode data were used in this evaluation. The gates and corresponding altitude ranges are listed in appendix A.

The time assigned to a 1-h average refers to the start of the hour.

The horizontal wind data are corrected for vertical motion.

3.1.5 Sodar

The sodar consists of three horns. The horns were pulsed every 5 s for 125 ms. Values of the U component, V component, and resultant wind speeds were determined every 15 s. A maximum of 60 samples were obtained every 15 min. Only 15-min average data are available for the analyses.

The single mode of the sodar consists of 20 gates and spans an altitude range from 37.5 to 537.5 m AGL. The gates and corresponding altitude ranges are listed in appendix A.

The time assigned to a 15-min period refers to the end of that period.

3.1.6 Tower-Mounted UV Anemometers

A 150-m tower is located at LC-35, approximately 0.5 km southeast of APRF. The tower has a triangular cross section with 1.2-m-wide sides. The booms that support R. M. Young Model 27106 anemometers are 3.6-m long and oriented at an azimuth of 210° from the tower. Little effect of tower shadow on the data is expected.

The U and V probes are mounted at eight levels on the 150-m tower at LC-35. The eight levels are 7.6, 22.9, 38.1, 53.3, 68.6, 91.4, 121.9, and 152.4 m AGL. The U probe is oriented toward the east. A positive U indicates a wind component blowing from the east toward the west, i.e., an east wind component. The V probe is oriented toward the north. A positive V indicates a wind component blowing from the north toward the south (i.e., a north wind component).

The data were acquired at a rate of 1 sample every 10 s. The 10-s data were averaged over 1 min and the original 10-s data were purged. The 1-min data were averaged over the appropriate 15- or 30-min period.

The time assigned to a period refers to the end of that period.

3.2 Analysis

The data were ingested and archived at the Microhub/Meteorological Atmospheric Sensing System (MHUB/MASS) facility at APRF. Data analyses were produced with the Statistical Analysis Software (SAS) package on the High Energy Laser Systems Test Facility (HELSTF) μVax and APRF 730 work-station. The majority of the effort documented in a preliminary report was to establish consistent data formats and units from the widely disparate data formats used by the various systems and ensure that similar volumes were compared to minimize differences in the vertical and temporal resolution of the various systems. [2]

For this report, no quality control algorithms are applied other than an internal consensus provided by the system's manufacturer.

Wind barbs and line plots are used to show the comparisons graphically. The conversion of wind barb to wind speed is illustrated in figure 2.

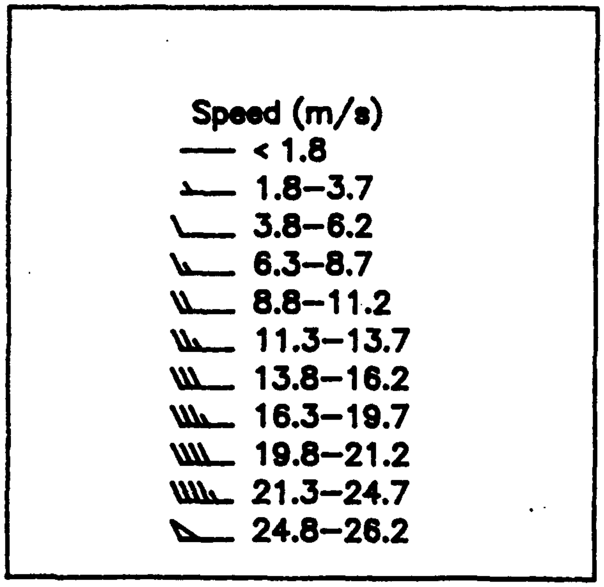


Figure 2. Wind barb to wind speed conversion.

For the comparison, differences in the volume (vertical) and temporal resolution of the various systems are minimized.

3.2.1 *Volume Averaging*

Because of the disparity in vertical resolution of the five systems, volume averaging was used to approximately equate the sampling volumes when comparing the results from two systems.

Figure 3 shows the gates and gate ranges for the 924-MHz profiler and the four other systems throughout the vertical range of the 924-MHz system.

Figure 4 illustrates the relative vertical sampling volumes normalized to the low-mode sampling volume of the 924-MHz system.

Vector averaging of the wind data is used to equate sampling volumes in the vertical. For example, figure 5 shows that four sodar gates and the top three tower levels approximately equate to the lowest 924-MHz gate. Therefore, the wind data from the four sodar gates are vectorially averaged

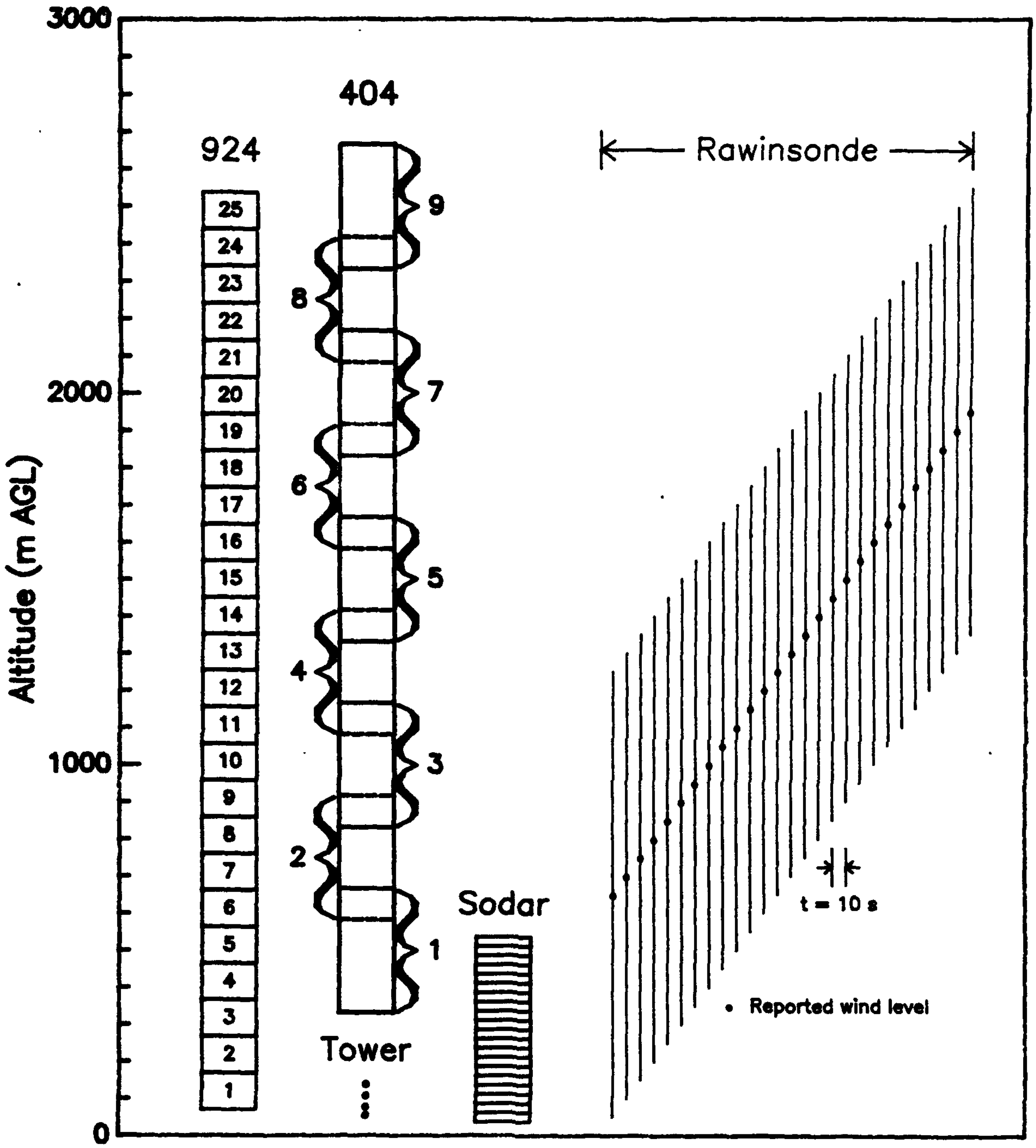


Figure 3. Relative vertical sampling volumes of the 404-MHz wind profiler, tower, sodar, and rawinsonde normalized to the low-mode sampling volume of the 924-MHz wind profiler.

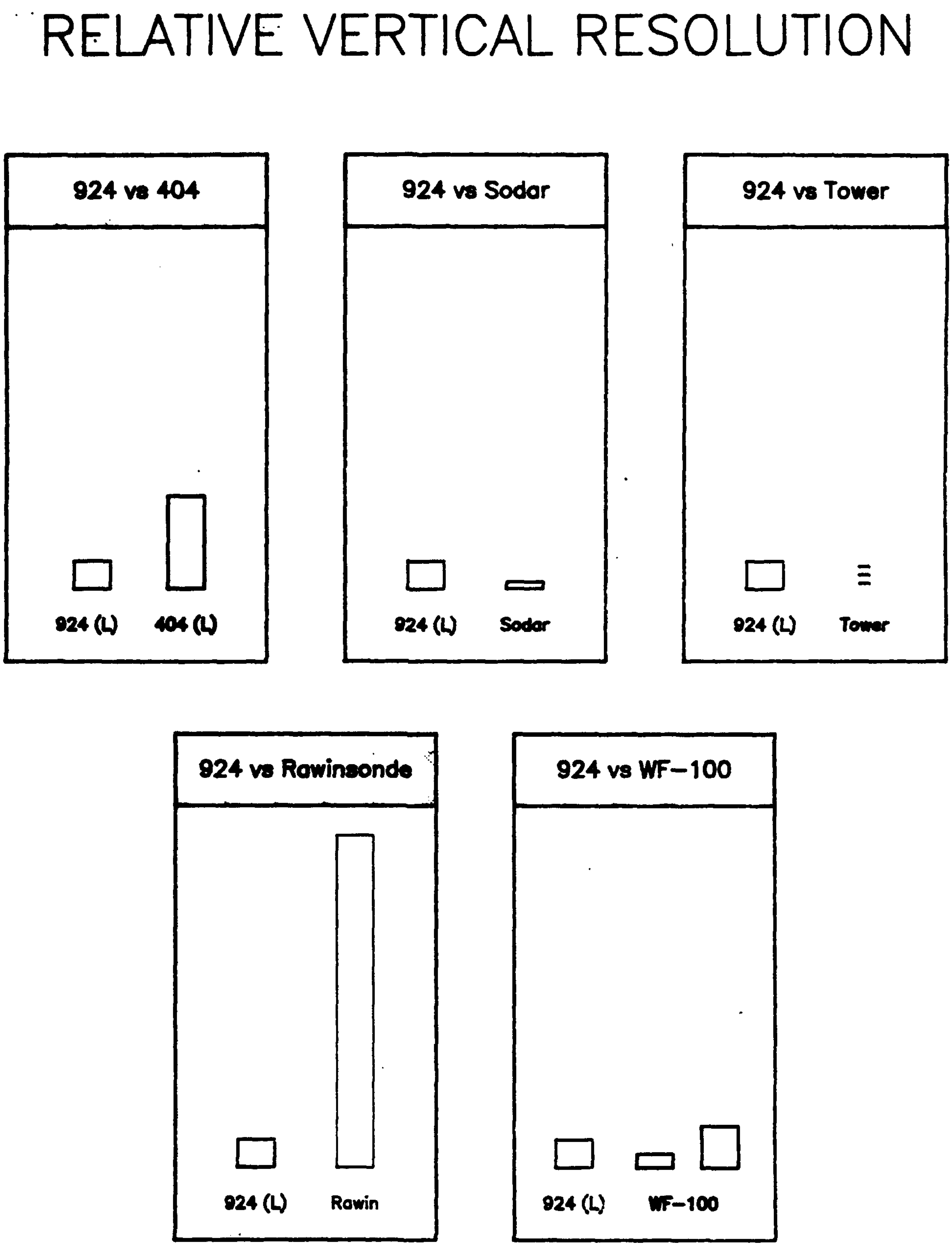


Figure 4. Relative vertical resolution of the six wind measurement systems used in the comparative evaluation.

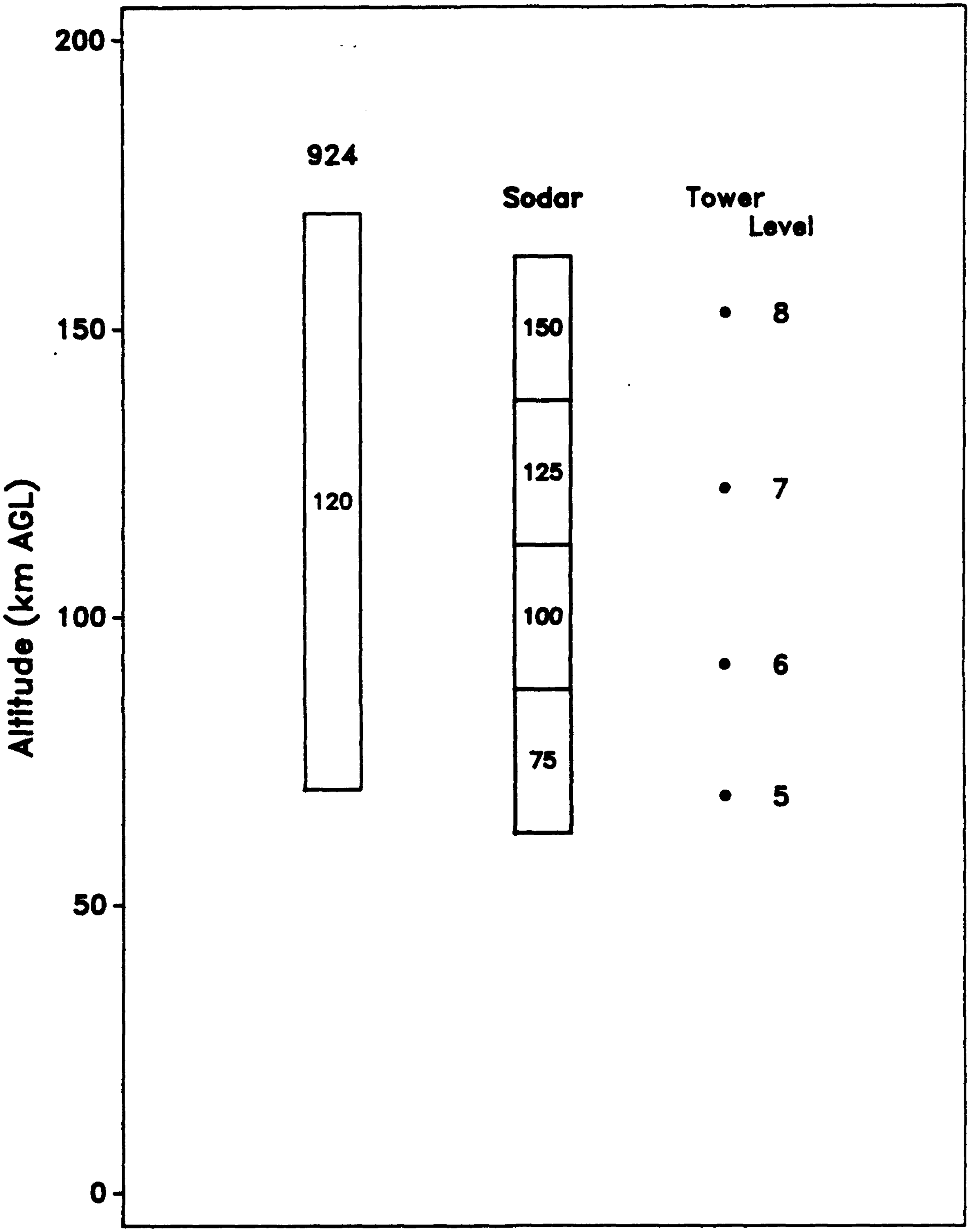


Figure 5. Example of volume averaging for the 924-MHz, sodar, and tower data.

and compared to the wind data from the corresponding single 924-MHz gate. The same vectorial averaging is applied to the wind data from tower levels 6, 7, and 8.

For 404-MHz data, at least three 924-MHz gates must be combined to compare with a single 404-MHz gate.

For rawinsonde data, it must be reiterated that the vertical resolution of the Vaisala system is a 4-min average. The resolution is dependent on the rise rate of the balloon and, in general, is equivalent to about 1200 m.

As shown in table 2, the vertical resolution of the WF-100 is either 150 or 50 m with two WF-100 gates approximately corresponding to three 924-MHz gates, and two WF-100 gates approximately corresponding to a single 924-MHz gate, respectively.

3.2.2 *Temporal Averaging*

Table 1 shows the temporal resolution of the three profiling systems ranging from 15 min for the sodar to 60 min for the 404-MHz system. The 924-MHz system occupies an intermediate position with the temporal resolution ranging from 30 min until 5 June and 15 min after 5 June. Once again, vector averaging is used to approximately equate sampling intervals to the largest common denominator.

The balloon was within the low-mode vertical range of the 924-MHz system for only 2 to 5 min, depending on the rise rate of the balloon, for the rawinsonde and WF-100 systems. The 15- or 30-min period overlapping the time that the balloon was within the sampling volume of the 924-MHz is used to compare the balloon data with the 924-MHz system data.

The 1-min tower data were vectorially averaged over 15 or 30 min corresponding 924-MHz averaging interval in effect at the time.

3.2.3 *Spatial Separation*

The balloons associated with the rawinsonde and WF-100 systems were released from Oasis as previously mentioned. Although Oasis is located about 6 km southwest of APRF, it is reasonably well situated with respect to APRF, especially during spring with the prevailing southwesterly flow and summer with the prevailing southeasterly flow.

Figure 6 shows individual examples and a composite example of selected rawinsonde balloon surface projections of trajectories from the point of release through the brief period (less than 5 min) that the balloons were within the altitude range of the 924.

No attempt is made to compensate for spatial separation of the measurement points. However, the spatial separation is taken into account in the qualitative descriptions of the comparisons.

3.2.4 *Statistics*

Wind data analyses were produced using the SAS commercial statistics package. The statistical comparison involves the Pearson product-moment (correlation) coefficient (ρ),

$$\rho = \frac{\sum_{0}^{n} (x_{924} - \overline{x_{924}})(x_{oms} - \overline{x_{oms}})}{\sqrt{\sum_{0}^{n} (x_{924} - \overline{x_{924}})^2 \sum_{0}^{n} (x_{oms} - \overline{y_{oms}})^2}} \qquad (1)$$

where
oms = other measurement system,

the root mean square error (root MSE),

$$root\ MSE = \sqrt{\left(\frac{\sum_{0}^{n} [(x_{924} - x_{oms}) - B]^2}{n - p} \right)} \qquad (2)$$

where
n = number of observations
p = number of parameters (in this case 2)
B = bias or expected value of the difference (E[x_{924} - x_{oms}])

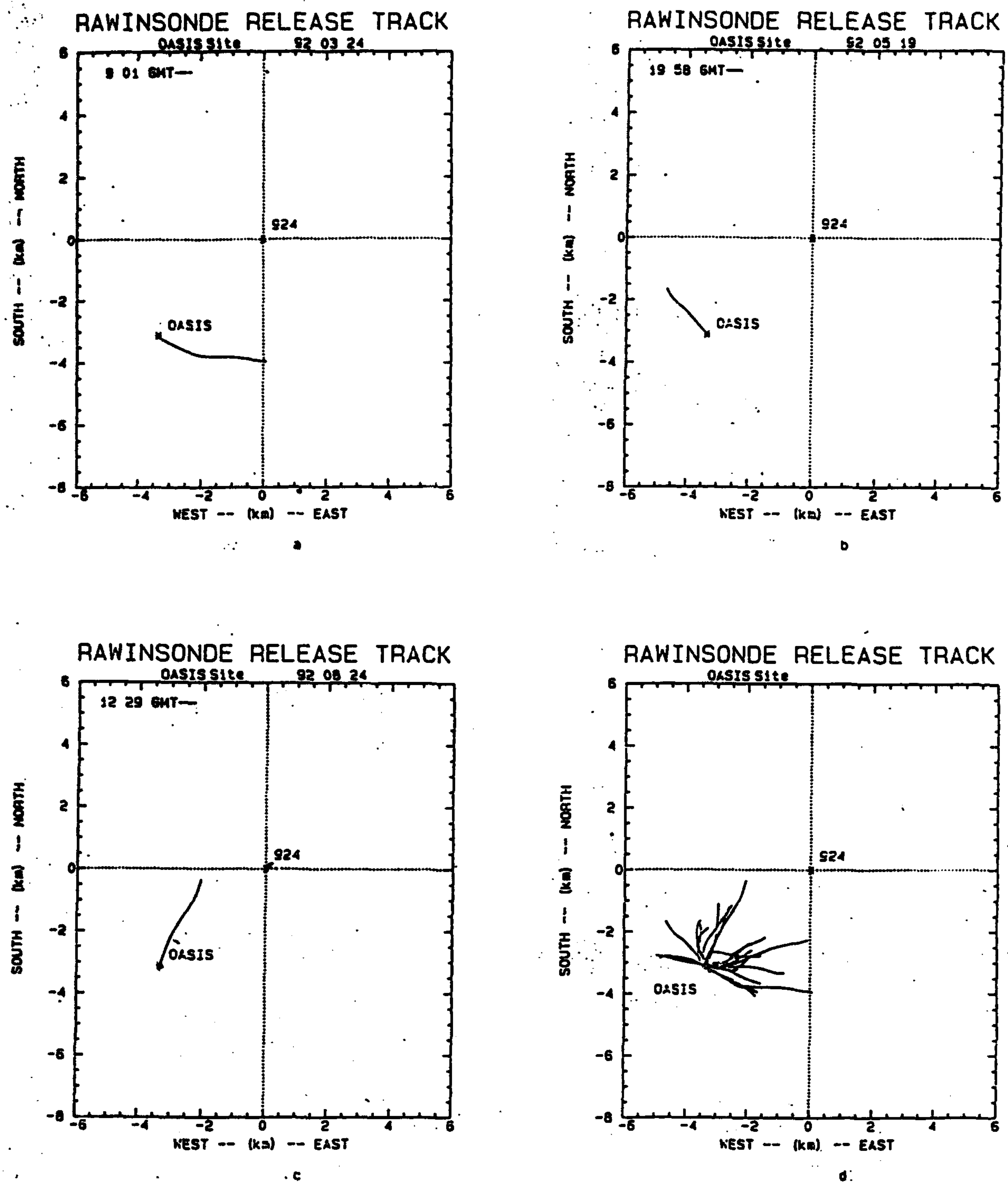


Figure 6. Horizontal projection of the trajectory of rawinsondes released from Oasis during the spring and summer of 1992: (a) 24 March, 0201 MST, (b) 19 May, 1258 MST, (c) 24 August, 0529 MST, and (d) composite of all 23 rawinsondes (924 = APRF complex).

$$B = E(x_{924} - x_{\text{[illegible]}}) = \frac{\sum_{0}^{n} (x_{924} - x_{\text{[illegible]}})}{n} \tag{3}$$

and the paired Student's t-test probability (Prob > |t|)

$$t = \frac{B\sqrt{n}}{S} \tag{4}$$

where
S = standard deviation

$$S = \sqrt{\left(\frac{\sum_{0}^{n} [(x_{924} - x_{\text{[illegible]}}) - B]^{2}}{n}\right)} \tag{5}$$

The paired Student's t-test probability and the Pearson product-moment (correlation) coefficient are discussed in more detail in the following two sections.

3.2.4.1 *Student's t-test.*--To investigate whether there is a significant difference between the wind speed measured over approximately equal time intervals and height ranges by the 924-MHz profiler as compared to the other instrumentation (i.e., the tower anemometers, the sodar, the 404-MHz profiler, the rawinsondes, and the WF-100), the paired Student's t-test was selected to compare the U and V components and resultant wind speeds. Although this test is reasonably informative with regard to nonnormal distributions, the Wilcoxon rank test also could be used in this case.

Analyses of speed and direction measurement differences between the 924-MHz system and the other four systems indicate that the data are from normally distributed populations; therefore, the t-test is a valid test. The t-statistic, the t probability, and the Wilcoxon probability are computed for each data set. Appendix D contains sample output.

The standard null hypothesis is that the differences between means of the paired profiler speed populations are not significantly different from zero. The significance of this hypothesis is tested. If a 5 percent significance level is chosen as the measure of rejection (at least a 5 percent chance the results are not random), then the probability (Prob > $|t|$) is compared with 0.05. If the probability is greater than 0.05, then the null hypothesis is not rejected. In other words, the probability is the observed significance level, the probability that the observed difference in means between the two populations would occur if, in fact, the difference in means of the population is not significantly different from zero.

3.2.4.2 *Regression/Correlation.*--To investigate linear relationships, or offsets, between the profilers, the SAS package was used to compute regression coefficients and the standard Pearson product-moment (correlation) coefficient, ρ , on individual days, as well as summary data sets of all days. A sample output is included in appendix D. Sample scatter plots are shown in appendix E. Standard least squares regression is used rather than the median of least squares regression because significance tests indicate that parametric statistics are appropriate.

3.3 Comparisons

This section on comparisons is divided into three parts.

The first part investigates whether wind speeds, measured with the 924-MHz system, were within ± 2 m/s and whether wind directions were within $\pm 10°$ of the rawinsonde system measurements.

The second part investigates the 14 days of WF-100 data, emphasizing the region from the surface to nominally 600 m AGL, not covered by the rawinsonde data from Oasis.

The third part is an example of a graphical comparison of wind speed and direction throughout the course of one day as measured by tower-mounted anemometers, sodar, and the 924-MHz profiler.

3.3.1 924-MHz versus Rawinsonde Wind Data

To minimize the effect of the 6 km separation of APRF and Oasis on the comparison of the 924-MHz and rawinsonde data, only the periods when the air-shed wind field appeared to be uniform and the wind speeds moderate were included.

In addition, there would have to be reasonably complete vertical 924-MHz profiles attending a rawinsonde flight.

The period from 24 March through 25 August 1992 represented 155 days of potential 924-MHz data. There were a total of 301 rawinsonde runs on 101 of the 155 days. The 924-MHz data acquired during that 101-day period were screened for periods displaying uniform wind fields and rawinsonde data available during the same periods. This process reduced the original 301 rawinsonde profiles to 23.

The comparisons of the 924-MHz and rawinsonde data are shown in figures 7 to 14. Most of the expected uniform wind fields, based on the 924-MHz data, were confirmed by the rawinsonde data.

Tables 4 and 5 show comparison statistics {correlation coefficient (ρ), the t probability (Prob > $|t|$), the root mean square error (root MSE), and the expected value of the difference of the two means [$E(\bar{\chi} - \bar{\chi})$]}. Corresponding statistics for a 924- and 404-MHz comparison are listed in tables 6 and 7.

Low and negative correlation coefficients appeared on some days. The surface weather data were examined for evidence of convective activity that might disturb an otherwise apparently uniform wind field.

3.3.2 WF-100 Periods

In contrast to the rawinsonde data, WF-100 data were acquired at ½-h intervals over 2- to 5-h periods on 14 days. The evolution of the wind field could be viewed, but the wind field might not be uniform.

Also, during the 14 days of 924-MHz low-mode and WF-100 data, reasonably complete data sets were acquired from the tower (except for July), sodar, 404-MHz (except for July), and rawinsonde systems.

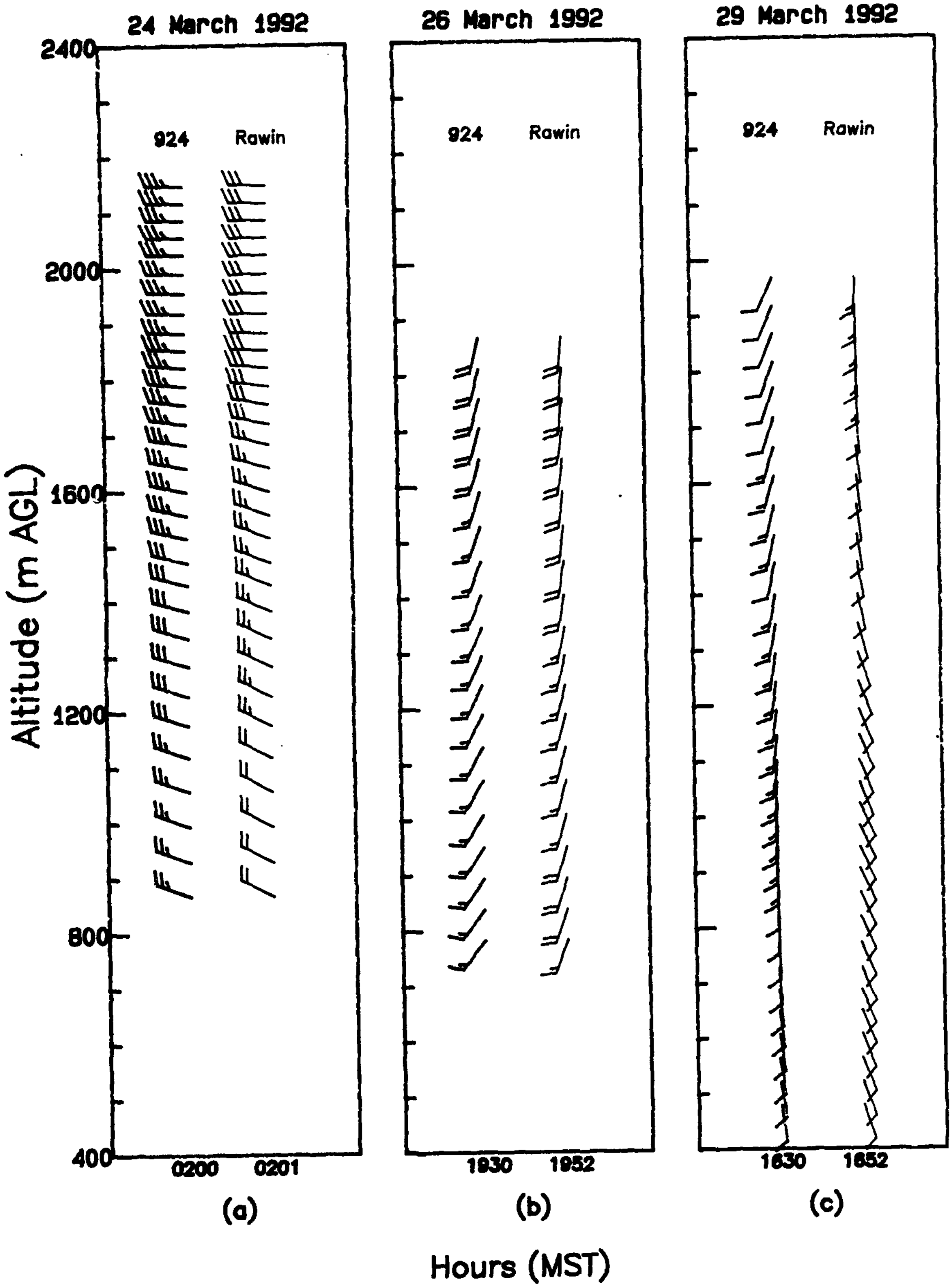


Figure 7. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 24 March 1992, 0200-0230 MST, (b) 26 March 1992, 1930-2000 MST, and (c) 29 March 1992, 1630-1700 MST.

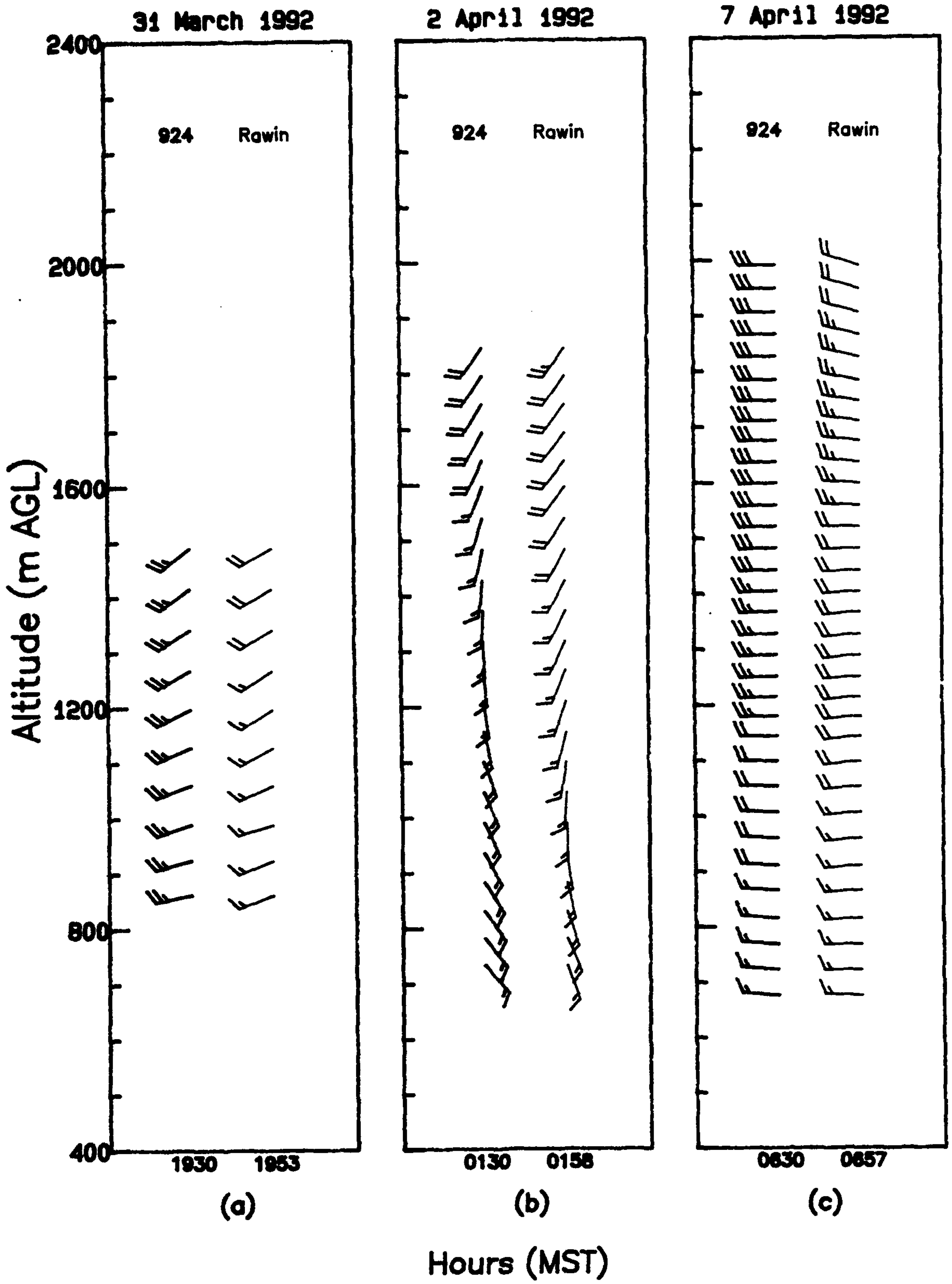


Figure 8. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 31 March 1992, 1930-2000 MST, (b) 2 April 1992, 0130-0200 MST, and (c) 7 April 1992, 0630-0700 MST.

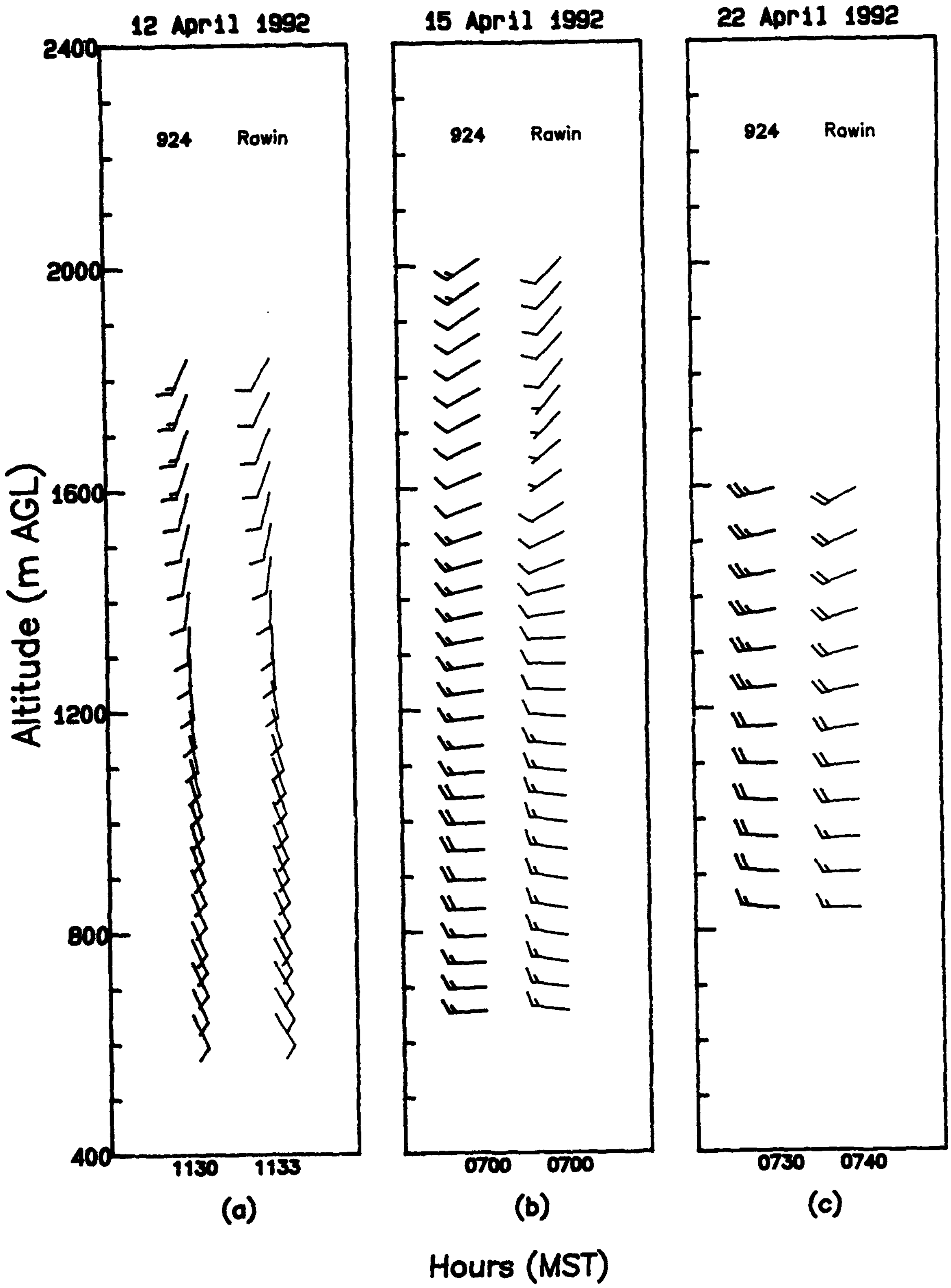


Figure 9. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 12 April 1992, 1130-1200 MST, (b) 15 April 1992, 0700-0730 MST, and (c) 22 April 1992, 0730-0800 MST.

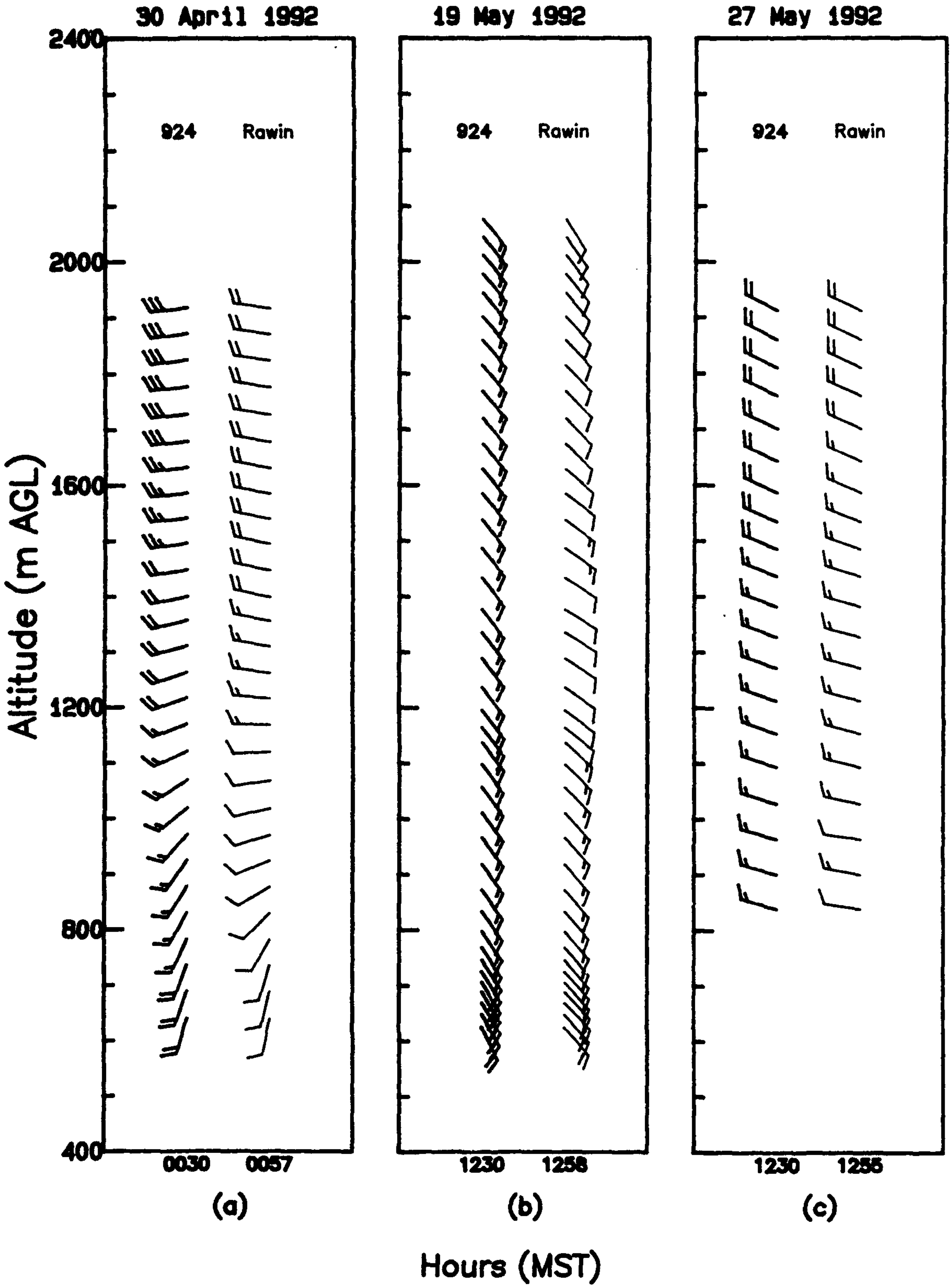


Figure 10. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 30 April 1992, 0030-0100 MST, (b) 19 May 1992, 1230-1300 MST, and (c) 27 May 1992, 1230-1300 MST.

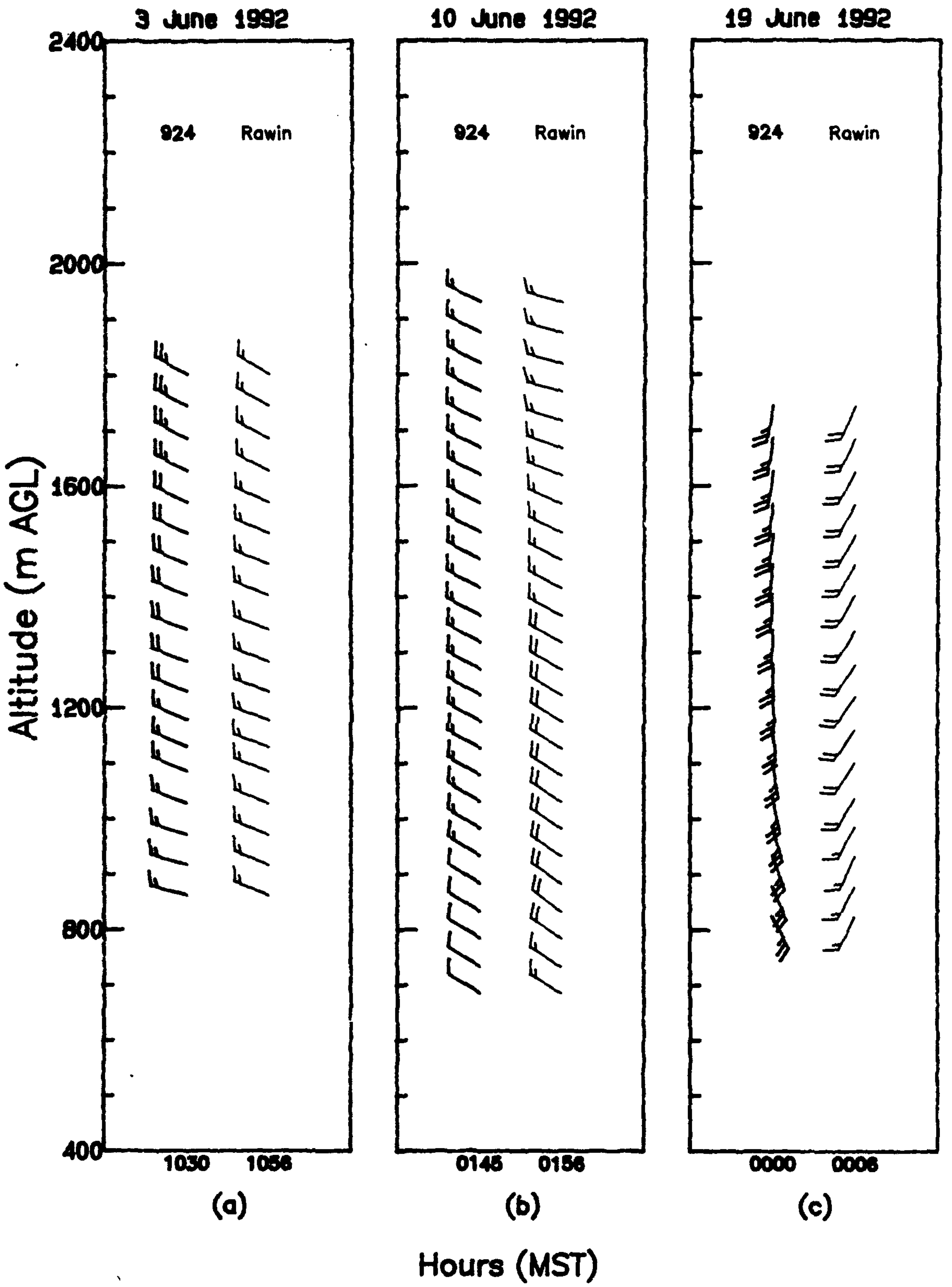


Figure 11. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 3 June 1992, 1030-1100 MST, (b) 10 June 1992, 0145-0200 MST, and (c) 19 June 1992, 0000-0015 MST.

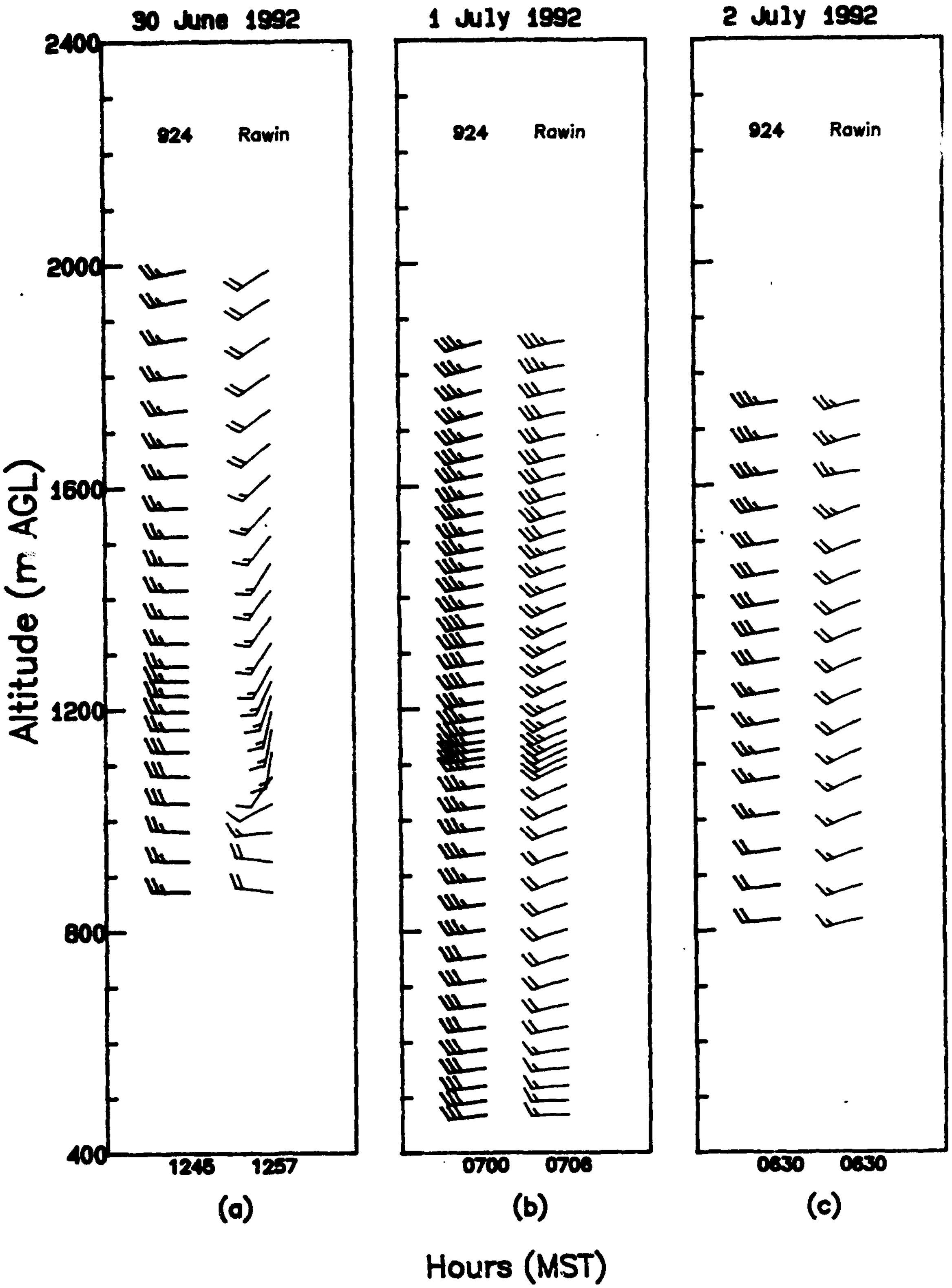


Figure 12. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 30 June 1992, 1245-1300 MST, (b) 1 July 1992, 0700-0715 MST, and (c) 2 July 1992, 0630-0645 MST.

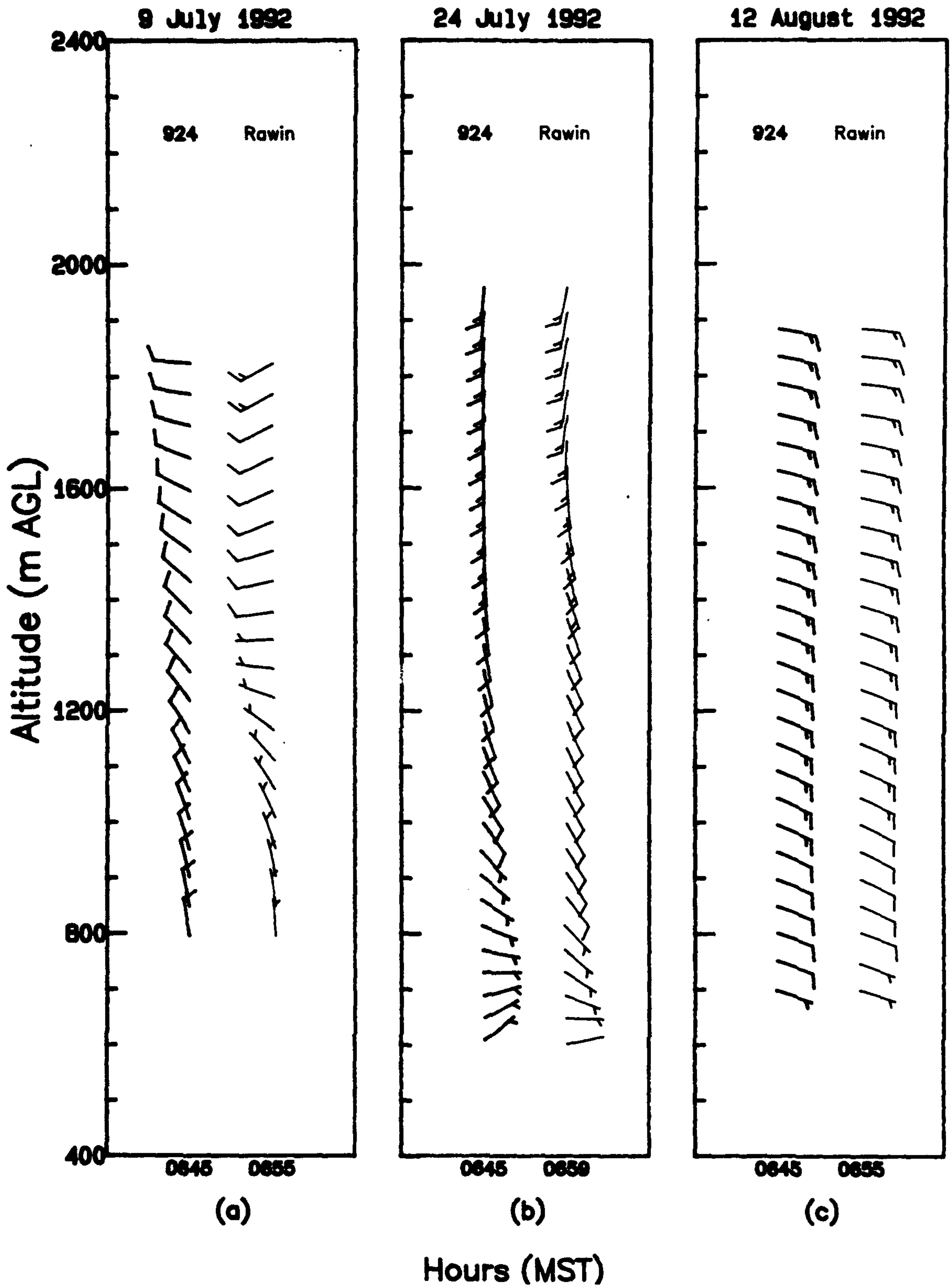


Figure 13. **Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 9 July 1992, 0645-0700 MST, (b) 24 July 1992, 0645-0700 MST, and (c) 12 August 1992, 0645-0700 MST.**

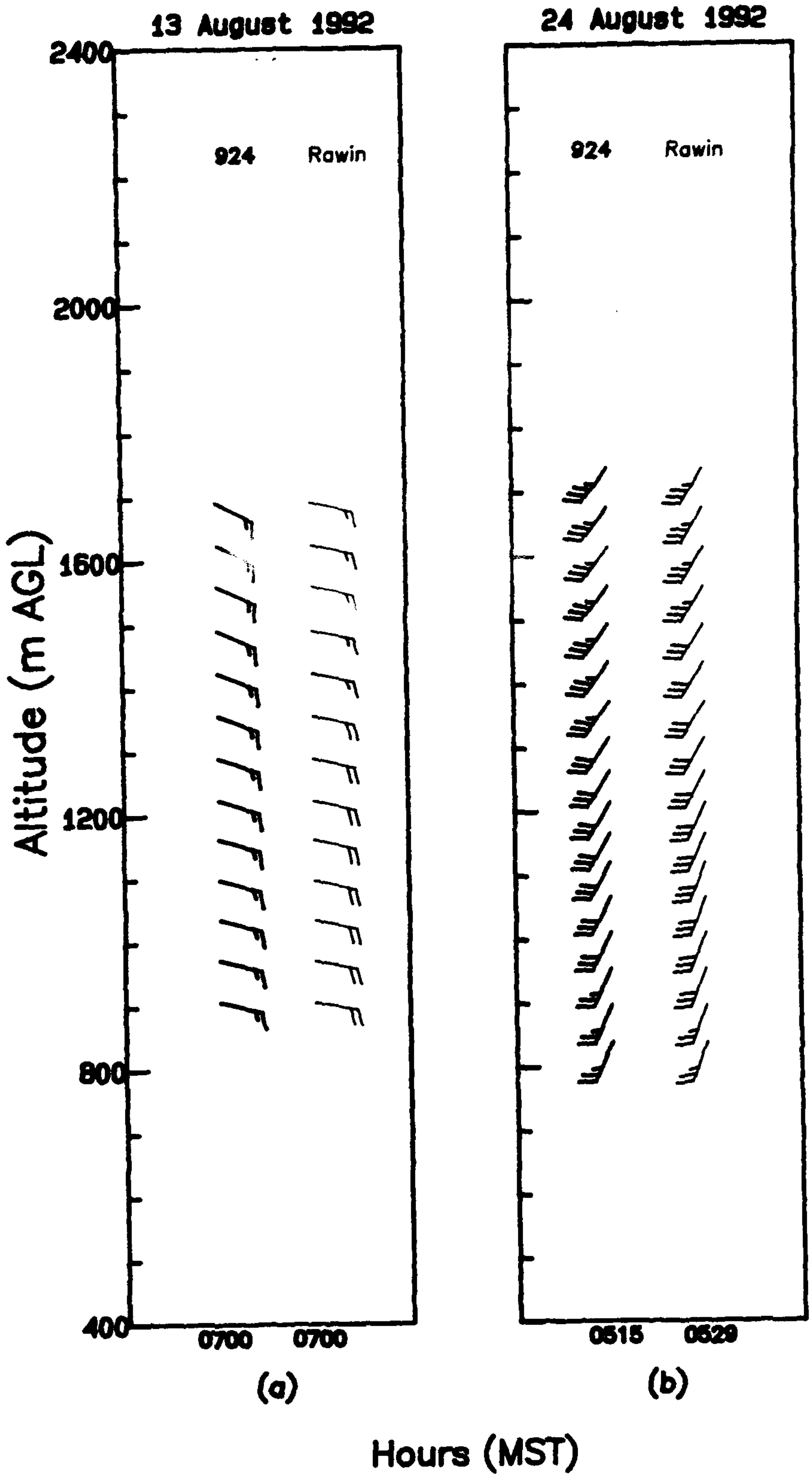


Figure 14. Comparison of volume-averaged wind profiles based on 924-MHz wind profiler and rawinsonde data during apparently uniform wind field conditions: (a) 13 August 1992, 0700-0715 MST, and (b) 24 August 1992, 0515-0530 MST.

Table 4. Correlation coefficients (ρ) of 924-MHz and rawinsonde wind speed and wind direction data

Date	Time[a]	Q[b]	Correlation Coefficients (ρ) S[c]	U[d]	V[d]	D[e]	Comments
24 March	0201	4	0.87	0.91	0.99	0.99	NCA[f]
26 March	1952	3	0.92	0.98	0.94	0.97	NCA
29 March	1652	3	0.29	0.85	0.00	0.86	Towering cumulus clouds & rain showers east
31 March	1953	3	-0.88	-0.22	0.86	0.77	Convective activity earlier in the day: cumulonimbus clouds and distant rain showers
2 April	0158	2 3	0.97	0.96	0.79	0.94	Lite rain shower
7 April	0657	3	0.99	0.97	-0.24	0.67	NCA
12 April	1133	2 3	0.27	0.99	-0.20	0.99	Convective clouds north
15 April	0700	3	0.93	0.96	0.99	0.99	NCA
22 April	0730	3	0.90	0.39	1.00	1.00	NCA
30 April	0057	3	0.89	0.96	0.99	0.95	NCA
19 May	1258	2	0.82	0.46	0.73	0.15	Cumulonimbus clouds W-NW
27 May	1255	4	0.98	0.97	0.99	0.99	Cumulonimbus clouds in all quadrants moving SE

[a]Release time of rawinsonde
[b]Quadrant from which wind was blowing through vertical extent of the comparison (2 = 90° to 180°, 3 = 180° to 270 °, 4 = 270° to 360°)
[c]Resultant horizontal wind speed
[d]Wind-speed components
[e]Direction
[f]No convective activity

Table 4. Correlation coefficients of 924-MHz and rawinsonde wind speed and wind direction data (continued)

Date	Time[a]	Q[b]	Correlation Coefficients (ρ) S[c]	U[d]	V[d]	D[e]	Comments
3 June	1056	4	0.98	0.86	0.85	0.66	NCA
10 June	0156	4	-0.68	-0.66	-0.52	0.90	Convective activity including virga previous evening
19 June	0006	2	0.89	0.75	0.93	0.07	Convective activity previous evening
		3					
30 June	1257	3	-0.52	-0.45	0.33	-0.18	Late afternoon cumulus clouds
1 July	0706	3	0.84	0.71	0.41	-0.13	NCA
2 July	0630	3	0.99	0.96	0.56	0.32	NCA
9 July	0655	4	0.88	0.99	0.93	0.94	NCA
24 July	0659	2	0.96	0.88	0.99	0.95	NCA
		3					
12 August	0655	2	0.99	0.99	0.91	0.97	NCA
13 August	0700	2	0.75	0.94	-0.33	0.21	Previous evening: rain showers, cumulonimbus clouds, and virga
24 August	0529	3	0.99	0.95	0.90	0.97	NCA
All 23 days			0.85	0.93	0.90	0.96	
NCA days			0.89	0.96	0.93	0.97	

[a]Release time of rawinsonde
[b]Quadrant from which wind was blowing through vertical extent of the comparison (2 = 90° to 180°, 3 = 180° to 270 °, 4 = 270° to 360°)
[c]Resultant horizontal wind speed
[d]Wind-speed components
[e]Direction
[f]No convective activity

Table 5. Statistical summary of the 924-MHz and rawinsonde wind speed comparisons during uniform wind field periods

Date (1992)	Time (MST)	Prob > |t| U[a]	V[a]	S[b]	MSE	root E[x_9 - x_R]
24 Mar	0201	0.0001	0.0011	0.0001	0.90	2.66
26 Mar	1952	0.0001	0.0001	0.0001	0.18	-0.40
29 Mar	1652	0.0001	0.0001	0.0001	0.53	0.60
31 Mar	1953	0.0001	0.0001	0.0001	0.19	3.31
2 Apr	0158	0.0001	0.0421	0.0001	0.27	-0.44
7 Apr	0657	0.0001	0.0320	0.0001	0.46	2.46
12 Apr	1133	0.0001	0.0001	0.0001	0.46	0.69
15 Apr	0700	0.0001	0.0001	0.0001	0.43	1.75
22 Apr	0730	0.0001	0.0001	0.0001	0.64	2.23
30 Apr	0057	0.0001	0.0001	0.0001	1.21	3.10
19 May	1258	0.9422	0.0001	0.0001	0.49	1.28
27 May	1255	0.0001	0.0001	0.0001	0.23	1.00
3 June	1056	0.0021	0.0108	0.0025	0.41	1.32
10 June	0156	0.0549	0.5107	0.1043	0.93	-0.76
19 June	0006	0.0001	0.0001	0.0001	0.25	2.75
30 June	1257	0.0001	0.0001	0.0001	0.30	5.61
1 July	0706	0.0001	0.0095	0.0001	1.04	6.36
2 July	0630	0.0001	0.0001	0.0001	0.43	4.12
9 July	0655	0.0069	0.0001	0.0001	0.20	1.32
24 July	0659	0.2551	0.1255	0.8985	0.55	-0.01
12 Aug	0655	0.2024	0.0376	0.2894	0.17	-0.05
13 Aug	0700	0.0001	0.0008	0.0001	0.13	-1.33
24 Aug	0529	0.0001	0.0100	0.0102	0.25	0.45
Composite		0.0001	0.2307	0.0001	2.20	1.79

[a]Wind-speed components
[b]Resultant horizontal wind speed

Table 6. Correlation coefficients of 924- and 404-MHz wind speeds during the uniform wind field periods

Date (1992)	Time (MST)	ρ U[a]	ρ V[a]	ρ S[b]
24 Mar	0201	0.995	0.931	0.994
26 Mar	1952	0.121	0.789	0.357
29 Mar	1652	0.851	0.450	0.459
31 Mar	1953	0.188	0.967	0.036
2 Apr	0158	0.615	-0.099	-0.264
7 Apr	0657	0.984	0.614	0.986
12 Apr	1133	0.844	-0.049	0.264
15 Apr	0700	0.688	0.775	0.675
22 Apr	0730	0.939	0.989	0.981
30 Apr	0057	0.983	0.922	0.878
19 May	1258	-0.033	-0.423	-0.279
27 May	1255	0.828	0.916	0.922
3 June	1056	0.975	0.780	0.972
10 June	0156	0.958	0.884	0.980
19 June	0006	0.908	0.712	0.379
30 June	1257	0.532	0.745	0.708
1 July	0706	NA	NA	NA
2 July	0630	NA	NA	NA
9 July	0655	NA	NA	NA
24 July	0659	NA	NA	NA
12 Aug	0655	0.997	0.989	0.990
13 Aug	0700	0.513	0.918	0.469
24 Aug	0529	0.953	0.758	0.920
Composite		0.928	0.920	0.825

[a]Wind-speed components
[b]Resultant horizontal wind speed

Table 7. Statistical summary of the 924- and 404-MHz wind profiler wind speed comparisons during uniform wind field periods

Date (1992)	Time (MST)	Prob > |t| U[a]	Prob > |t| V[a]	Prob > |t| S[b]	root MSE	$E[x_9 - x_R]$
24 Mar	0201	0.0043	0.9999	0.0037	0.48	1.46
26 Mar	1952	0.0092	0.3539	0.0551	1.48	1.41
29 Mar	1652	0.2110	0.0034	0.0025	0.45	1.02
31 Mar	1953	0.1343	0.0771	0.1313	2.23	2.52
2 Apr	0158	0.8366	0.7453	0.7934	3.88	-0.48
7 Apr	0657	0.0001	0.0772	0.0001	0.59	2.17
12 Apr	1133	0.8143	0.0118	0.0080	1.94	2.58
15 Apr	0700	0.1281	0.5973	0.0946	1.78	1.46
22 Apr	0730	0.0209	0.7182	0.0038	0.77	2.07
30 Apr	0057	0.0016	0.1513	0.0191	2.27	2.08
19 May	1258	0.2567	0.1024	0.1035	1.69	1.87
27 May	1255	0.0114	0.3775	0.0084	0.87	1.76
3 June	1056	0.0007	0.0215	0.0004	0.92	1.68
10 June	0156	0.0019	0.0059	0.0001	0.50	1.10
19 June	0006	0.9387	0.1850	0.0452	1.28	1.13
30 June	1257	0.0407	0.1617	0.0259	1.38	2.84
1 July	0706	NA	NA	NA	NA	NA
2 July	0630	NA	NA	NA	NA	NA
9 July	0655	NA	NA	NA	NA	NA
24 July	0659	NA	NA	NA	NA	NA
12 Aug	0655	0.0001	0.0311	0.0001	0.30	0.88
13 Aug	0700	0.0735	0.0152	0.0182	1.04	1.67
24 Aug	0529	0.0089	0.0654	0.0371	0.94	3.13
Composite		0.0001	0.0017	0.0001	2.24	1.70

[a] Wind-speed components
[b] Resultant horizontal wind speed

Two types of plots show data comparisons: (1) the diurnal variation at fixed levels and (2) vertical wind-barb plots that compare wind speed and direction at the lowest gate of the 924-MHz system with the vector average of the wind at the top three levels of the tower. The various comparisons are shown in figures 15 through 83.

Comparison and composite statistics for the individual WF-100 period are shown in tables 8 through 11 and table 12, respectively.

3.3.2.1 *17-18 June 1992.*--Seventeen June was a typical premonsoon season day with clear skies, light winds, and low moisture levels. Dewpoints in the low 20's late in the morning were attributed to the passage of a weak cold front. As the day progressed dewpoints rose. By sunrise on 18 June, dewpoints were in the 40's. Winds remained light, but low and high clouds appeared and weak convective activity occurred to the northeast.

3.3.2.2 *24-25 June 1992.*--Scattered to broken, low and high clouds and light winds occurred throughout the sampling period. Dewpoints in the upper 50's dropped abruptly to levels in the low to mid 40's after 1000 MST on 24 June. Very little convective activity occurred on 24 June, but virga were reported in all quadrants late in the afternoon.

3.3.2.3 *1-2 July 1992.*--On 1 and 2 July, premonsoonal conditions prevailed with few clouds and dewpoints in the 30's and 40's. Gusty surface winds were reported the afternoon and early evening of 1 July and the late morning of 2 July.

3.3.2.4 *8-9 July 1992.*--On 8 and 9 July, monsoon conditions occurred with clear skies, dewpoints ranging from the mid 50's to low 60's, and light winds in the early morning hours. As low clouds began to develop shortly after sunrise, dewpoints began to drop. By afternoon, general convective activity occurred over the area, and dewpoints ranged from the mid 30's to low 50's. The convective activity dissipated by 2300 MST.

3.3.2.5 *18-21 August 1992.*--South central New Mexico was under the influence of weak monsoonal flow from the Gulf of Mexico 18 through 21 August. Dewpoints were generally in the mid 50's. Skies were cloudy with convective activity each afternoon. On 19 August the convective activity reached its peak with rain being reported at Oasis from 2000 MST until just after midnight.

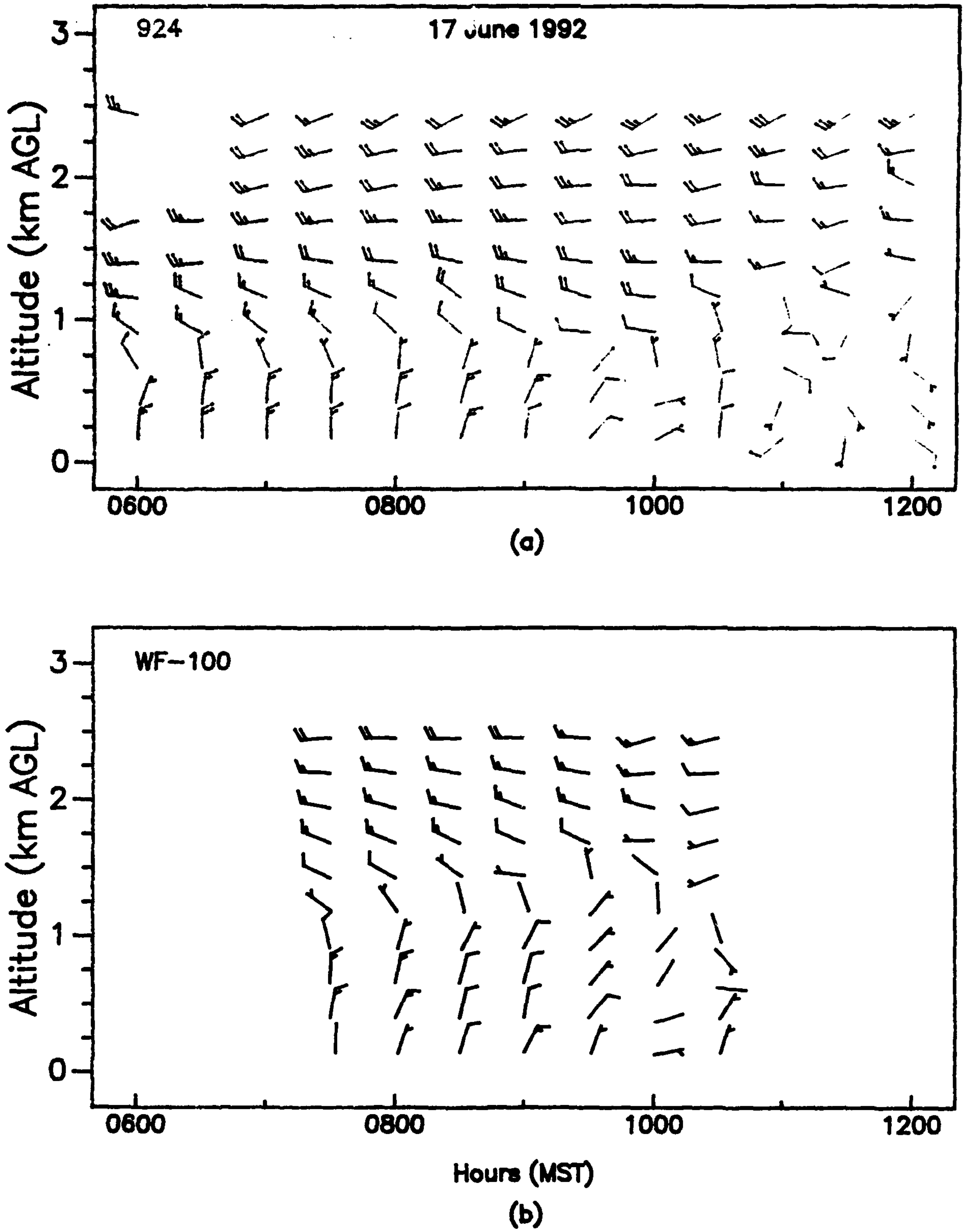


Figure 15. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 0000 to 1200 MST, 17 June 1992 (15-min averages for the 924 data).

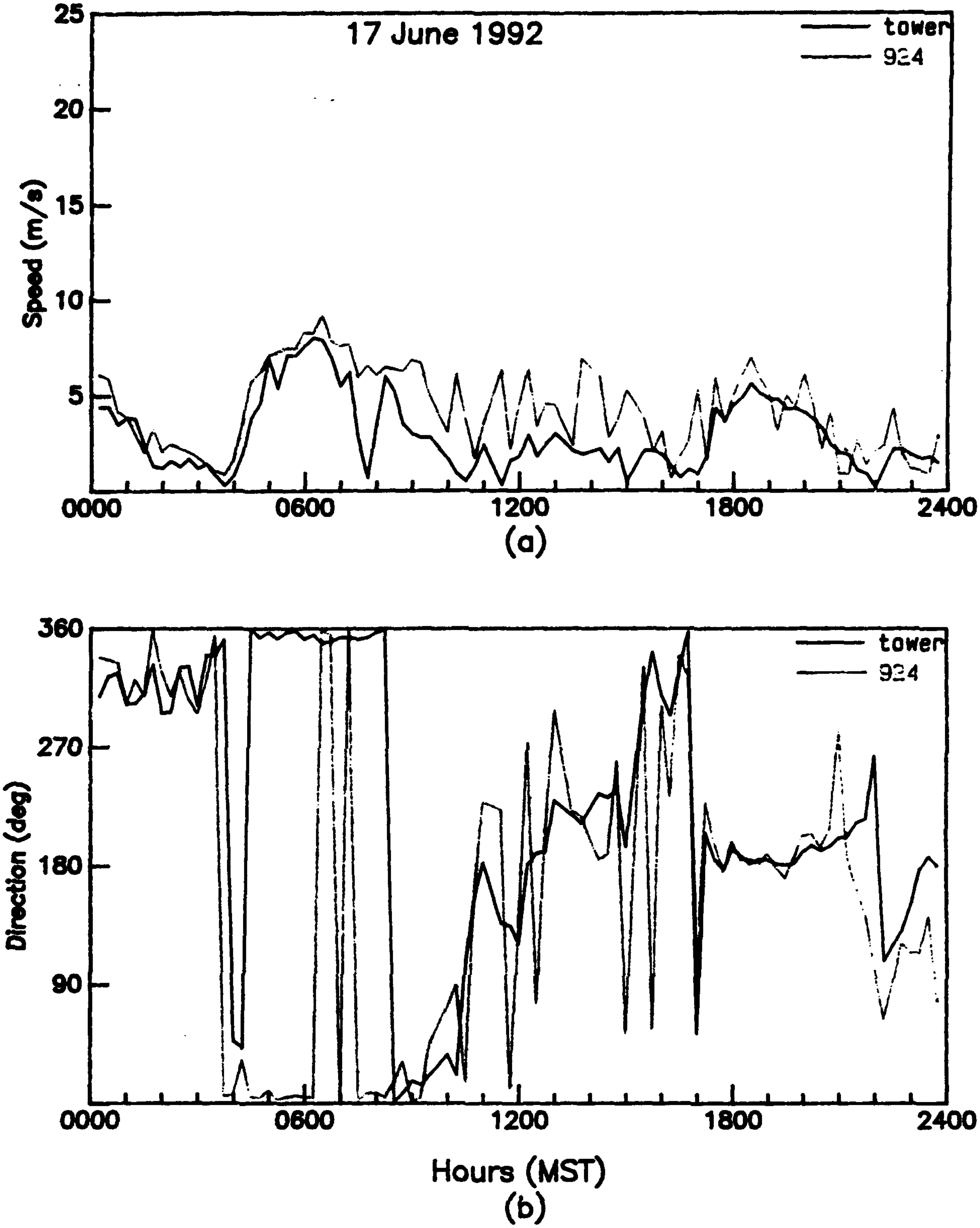


Figure 16. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 17 June 1992 (15-min averages).

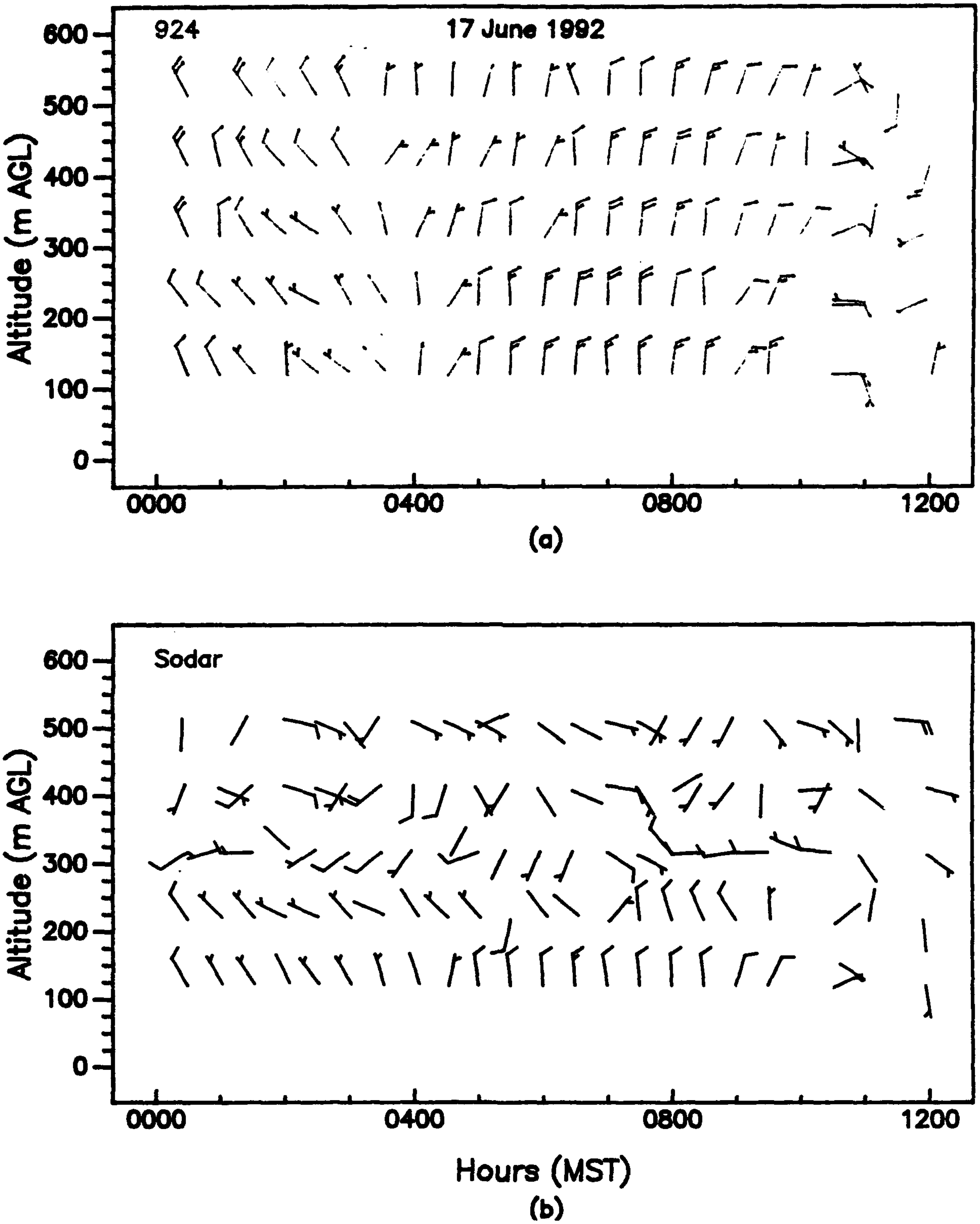
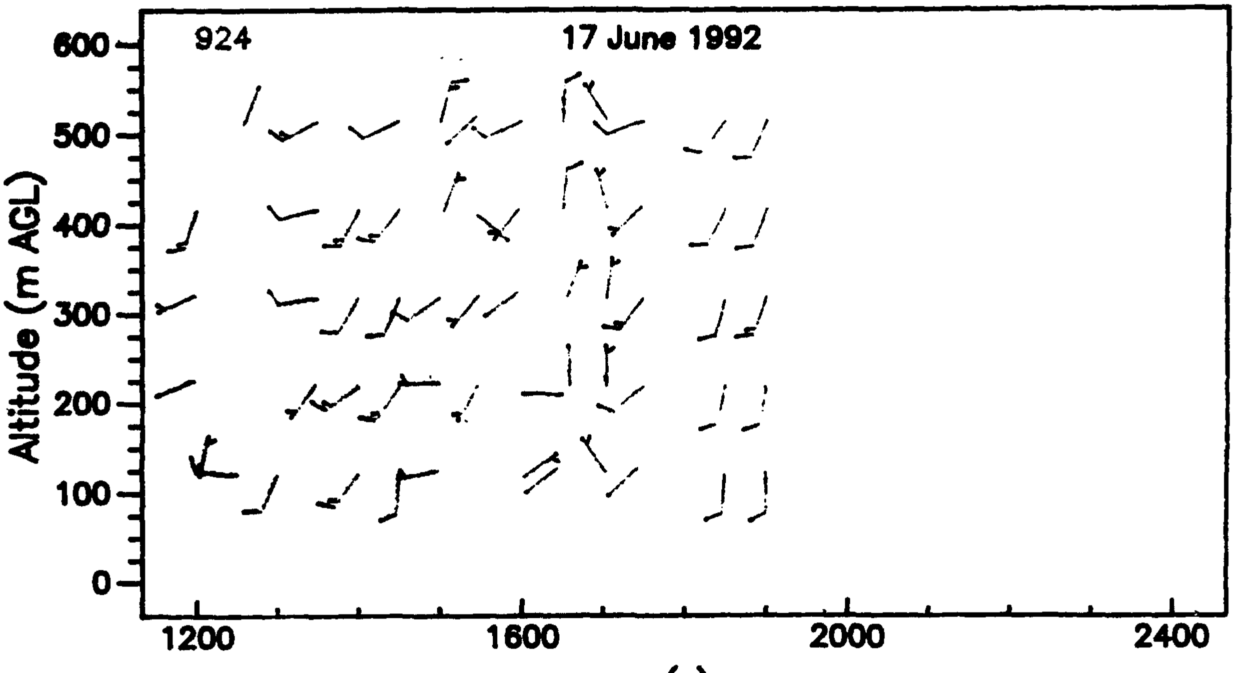
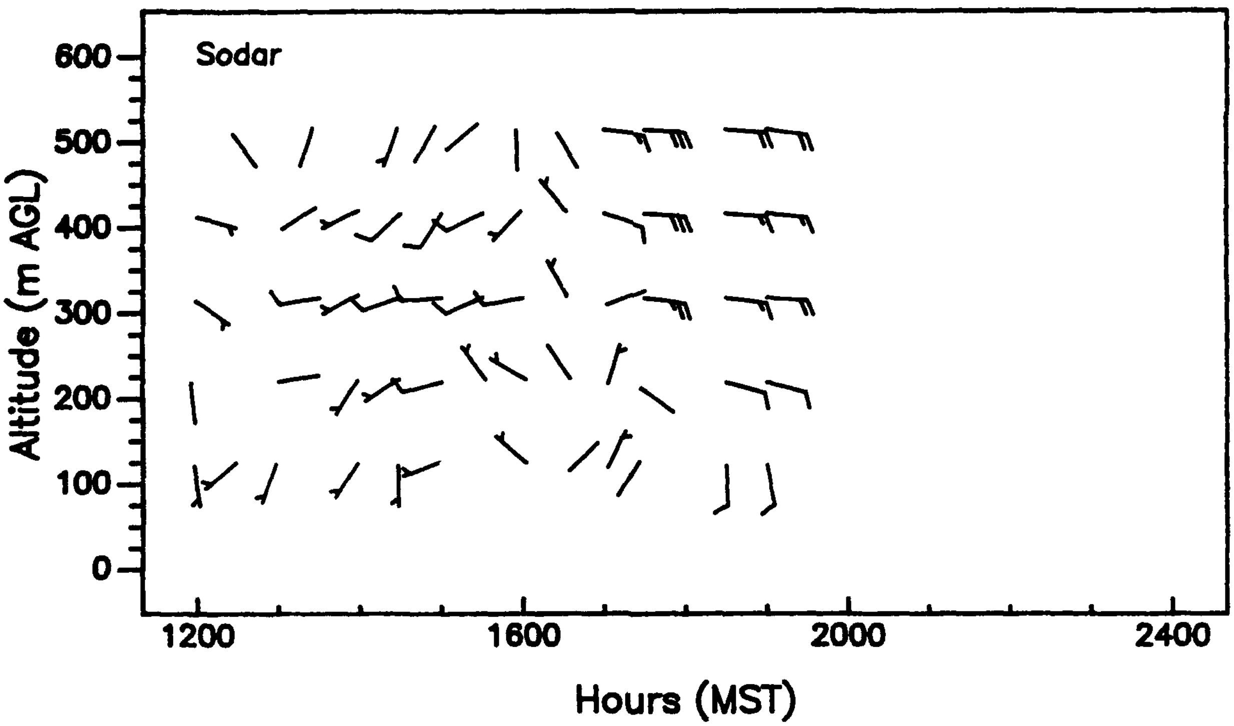


Figure 17. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 17 June 1992 (15-min averages).



(a)



(b)

Figure 18. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 17 June 1992 (15-min averages).

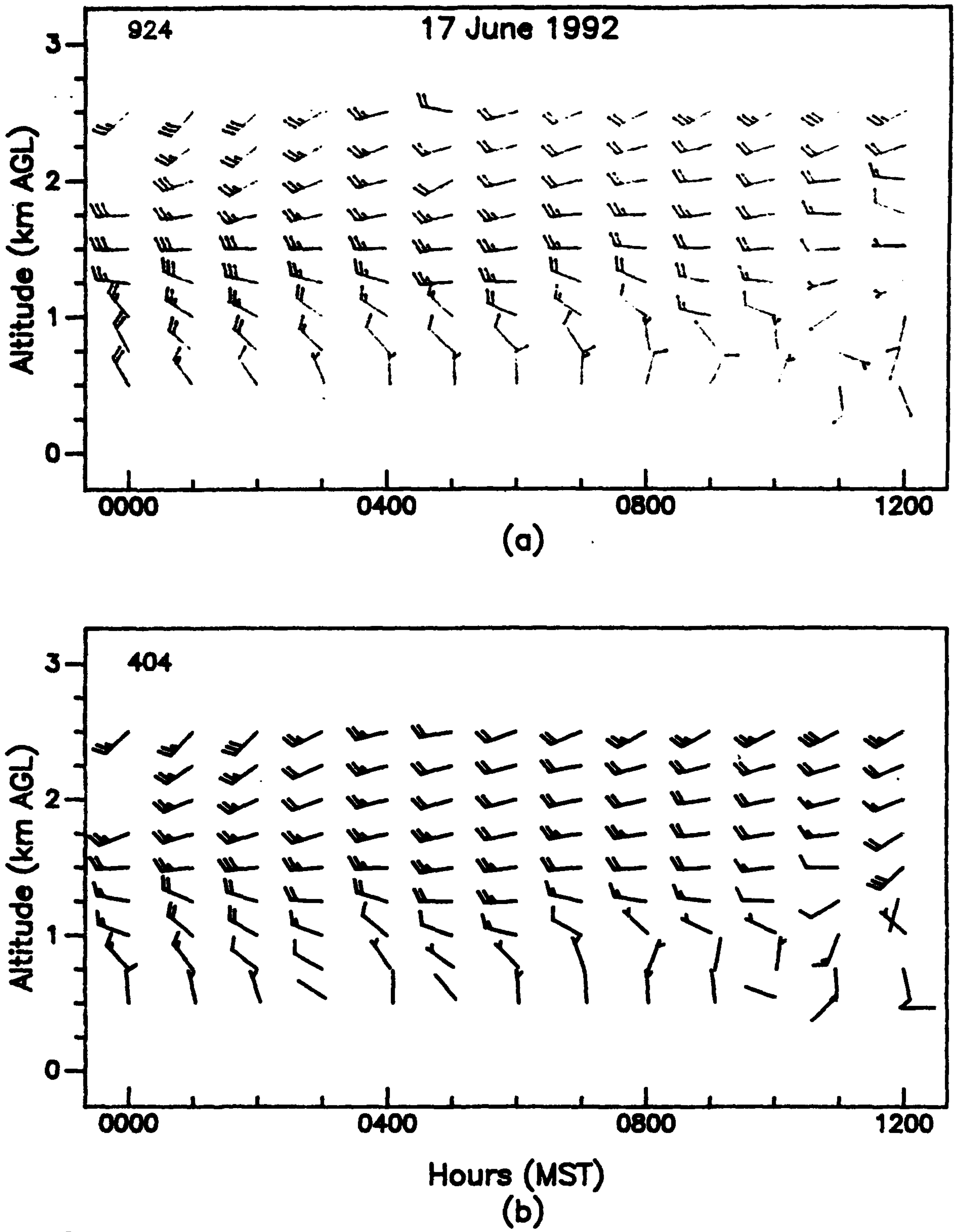


Figure 19. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 17 June 1992 (1-h averages).

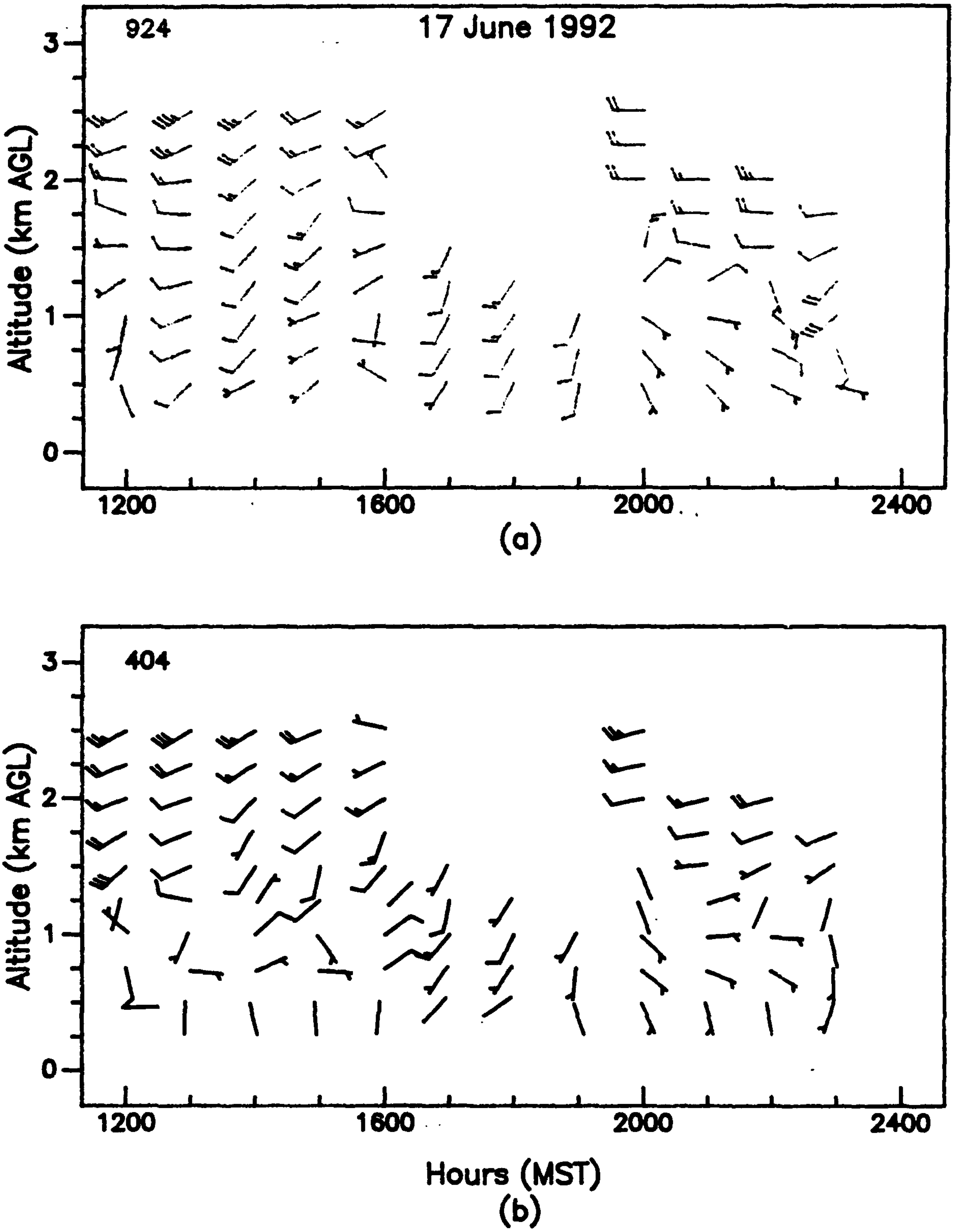


Figure 20. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 17 June 1992 (1-h averages).

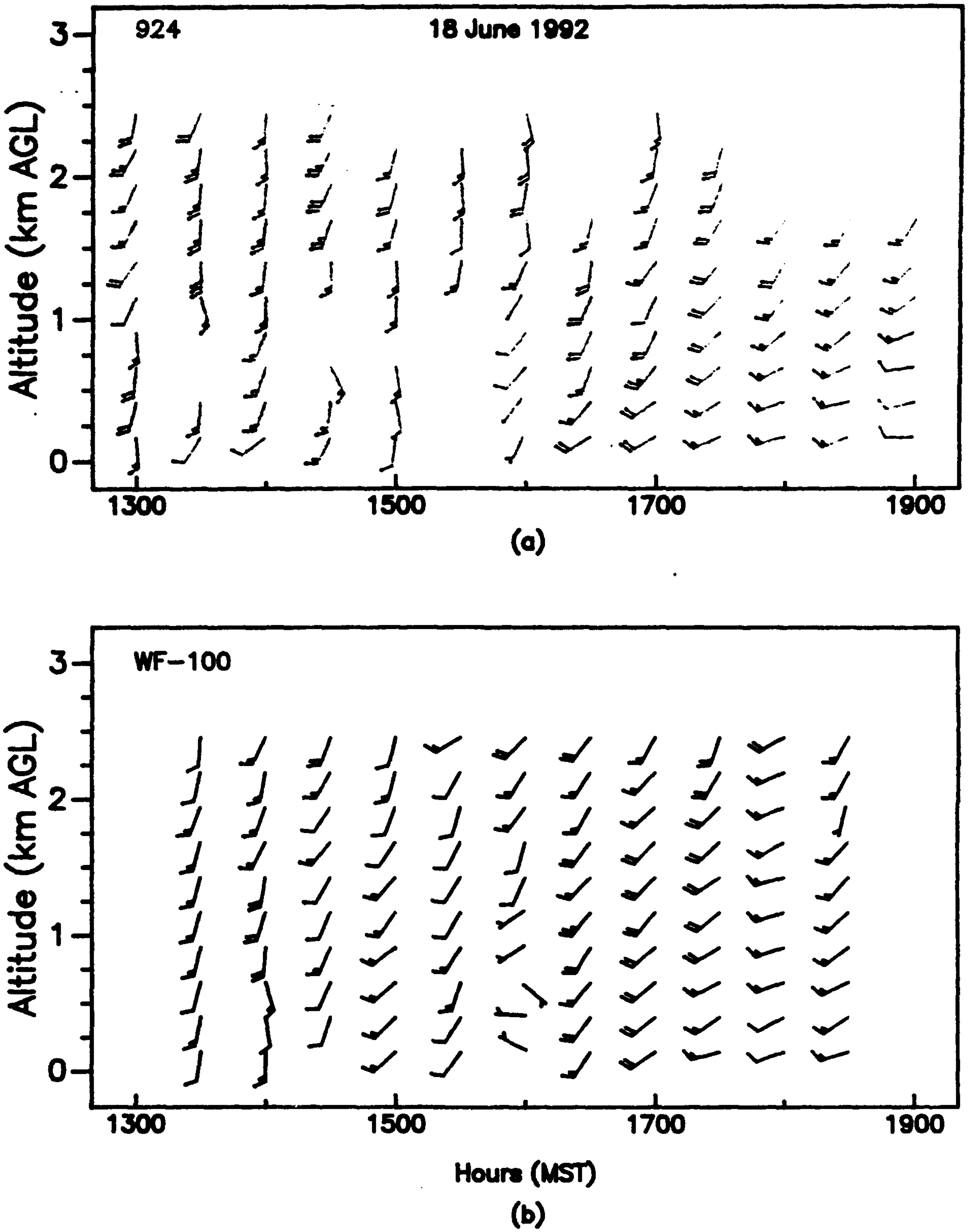


Figure 21. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1300 to 1900 MST, 18 June 1992 (15-min averages for the 924 data).

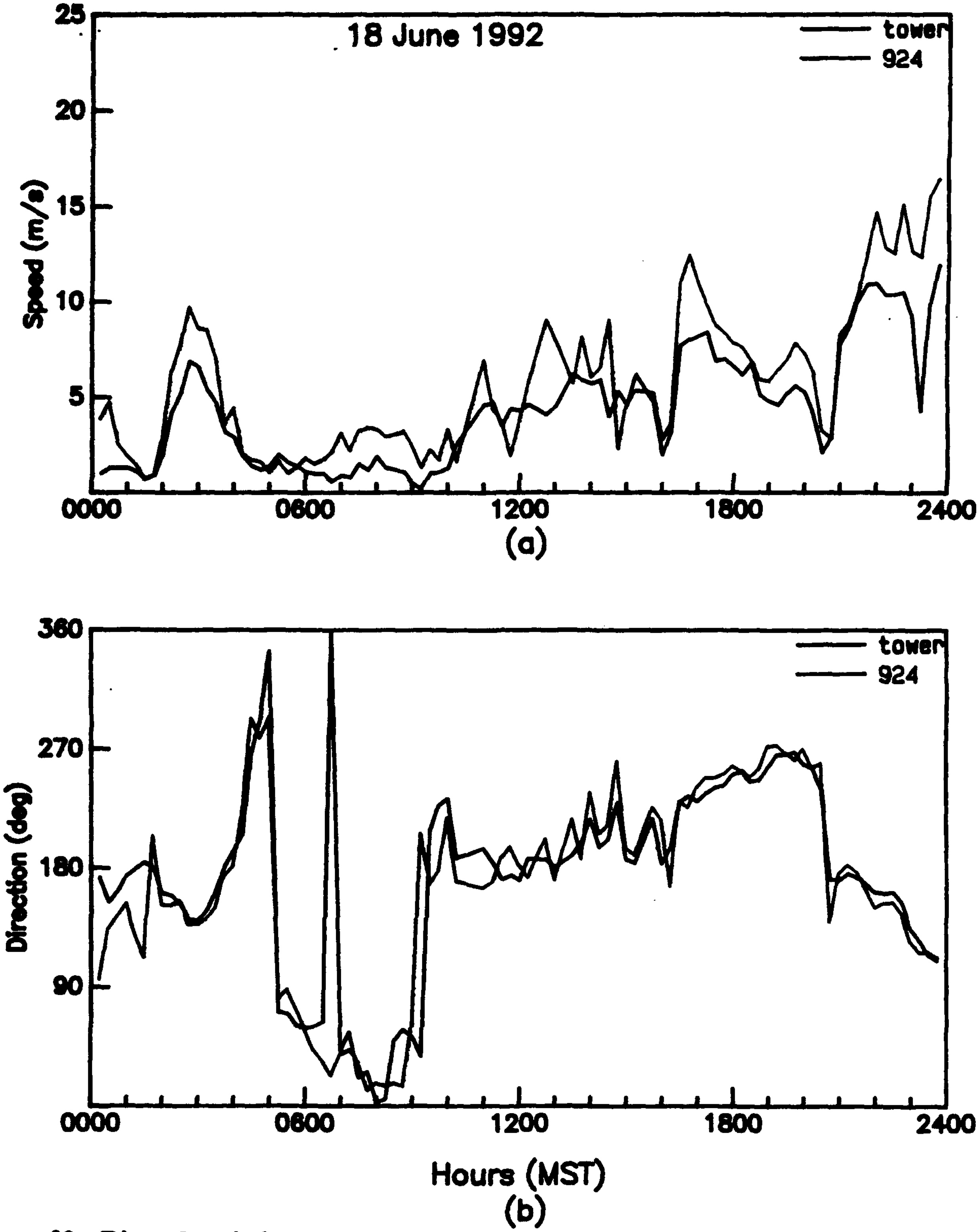


Figure 22. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 18 June 1992 (15-min averages).

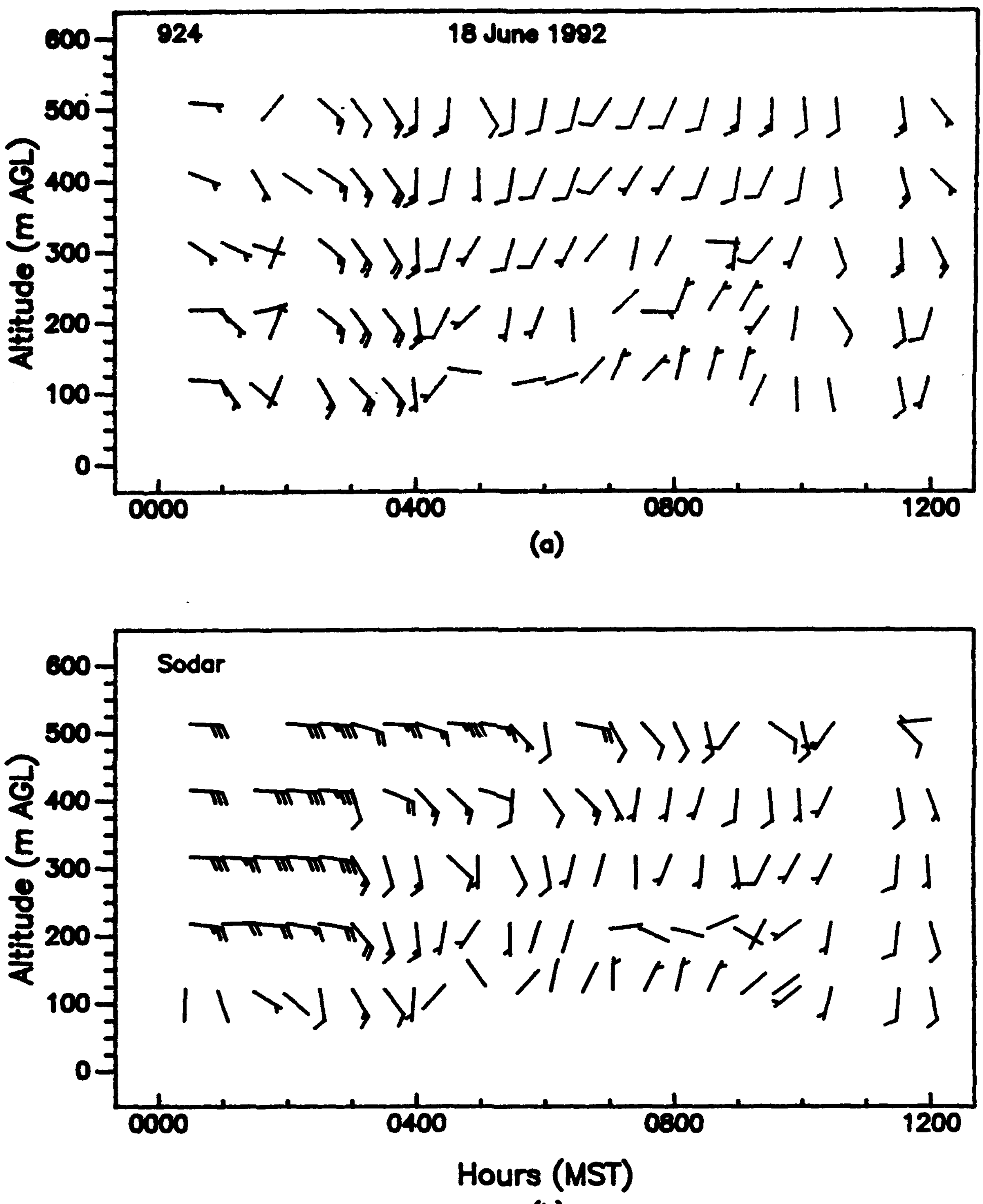


Figure 23. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 18 June 1992 (15-min averages).

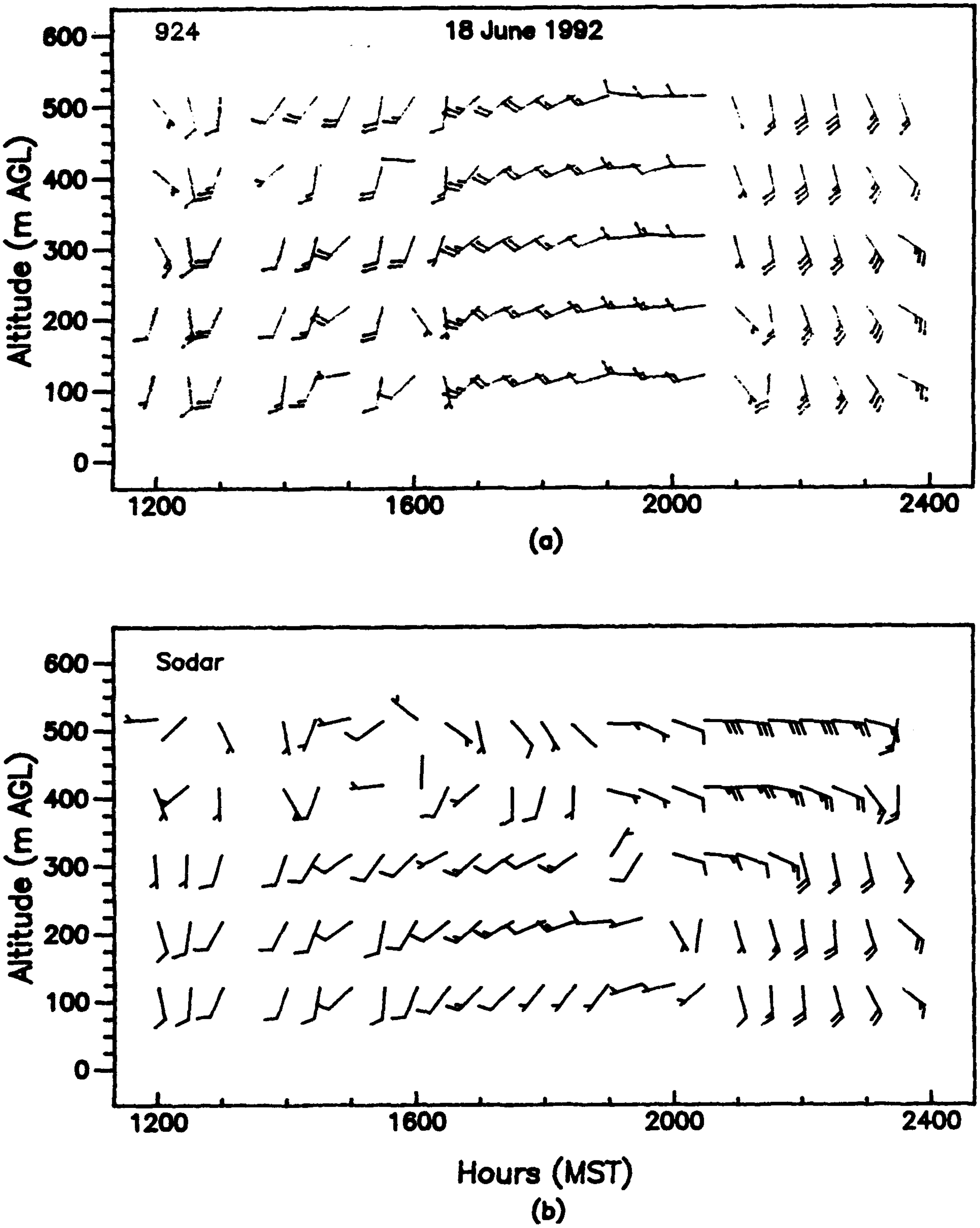


Figure 24. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 18 June 1992 (15-min averages).

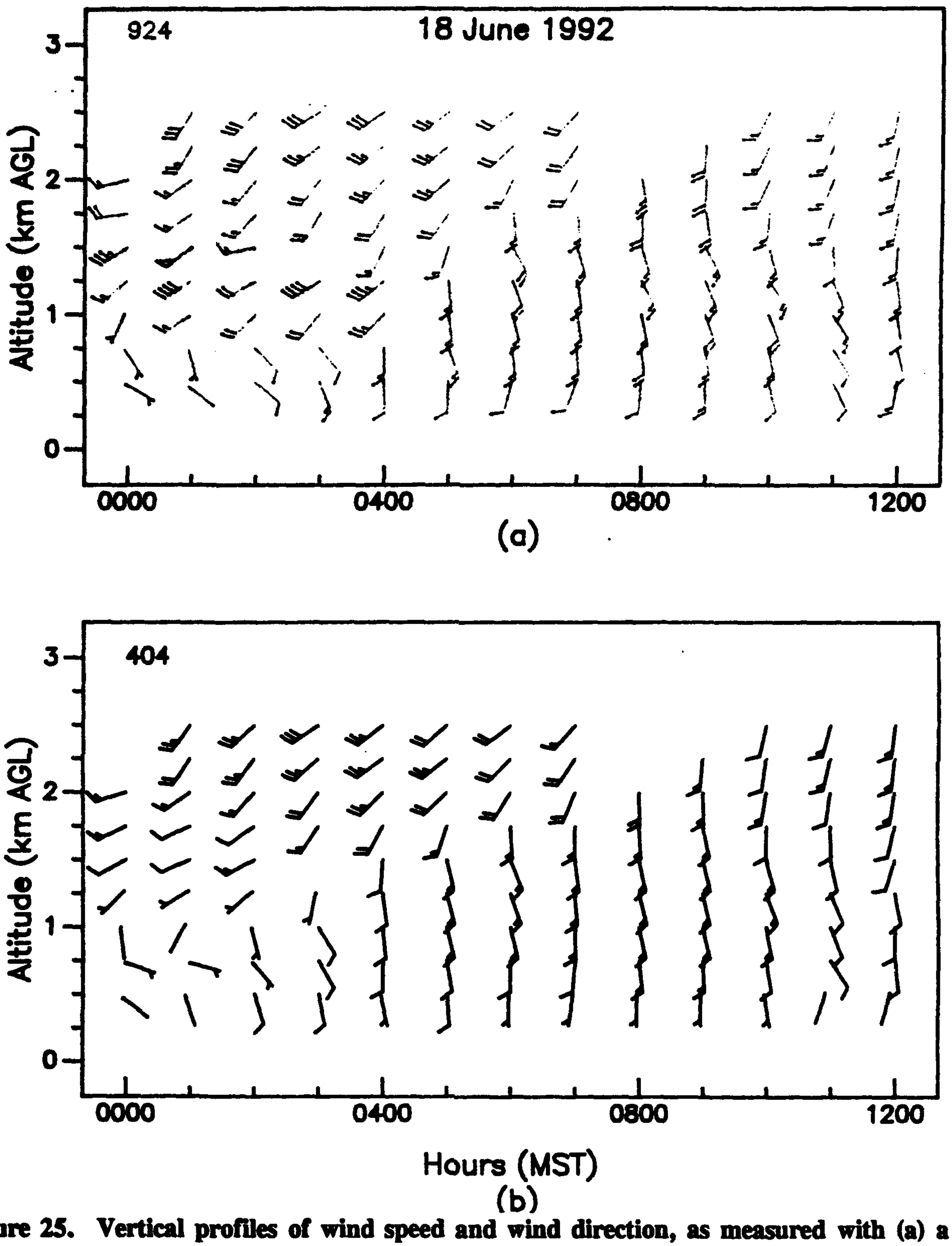


Figure 25. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 18 June 1992 (1-h averages).

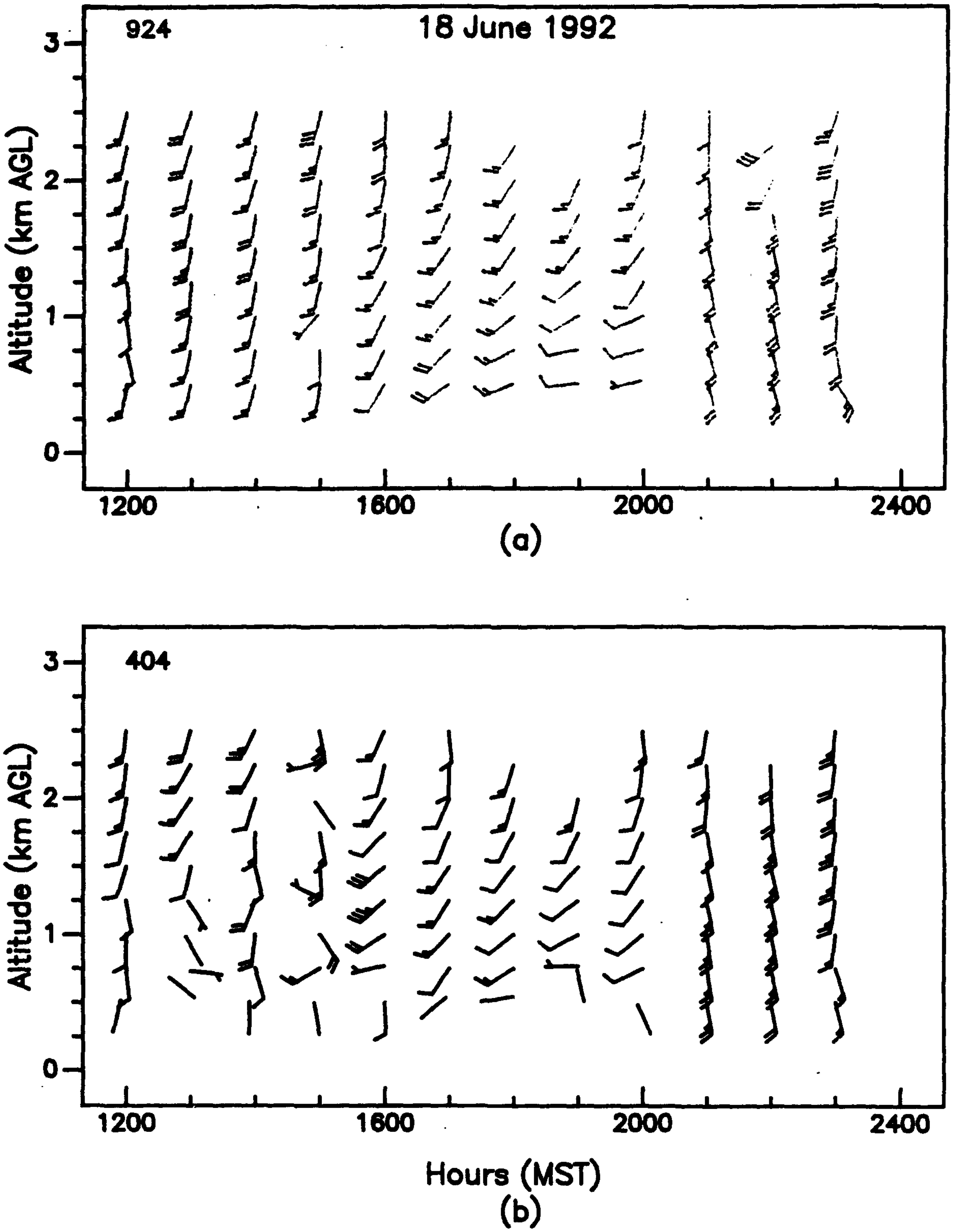


Figure 26. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 18 June 1992 (1-h averages).

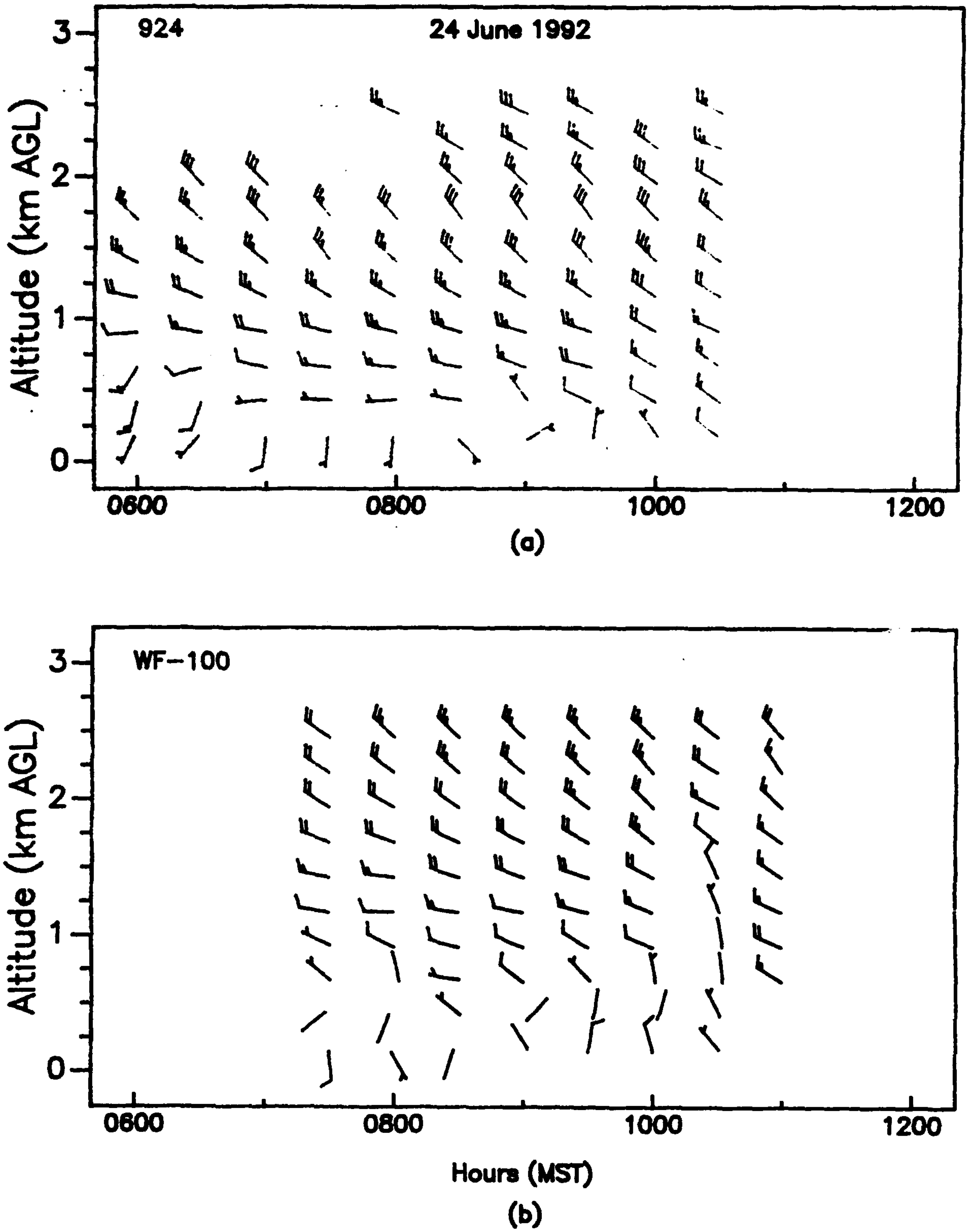


Figure 27. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 0600 to 1200 MST, 24 June 1992 (15-min averages for the 924 data).

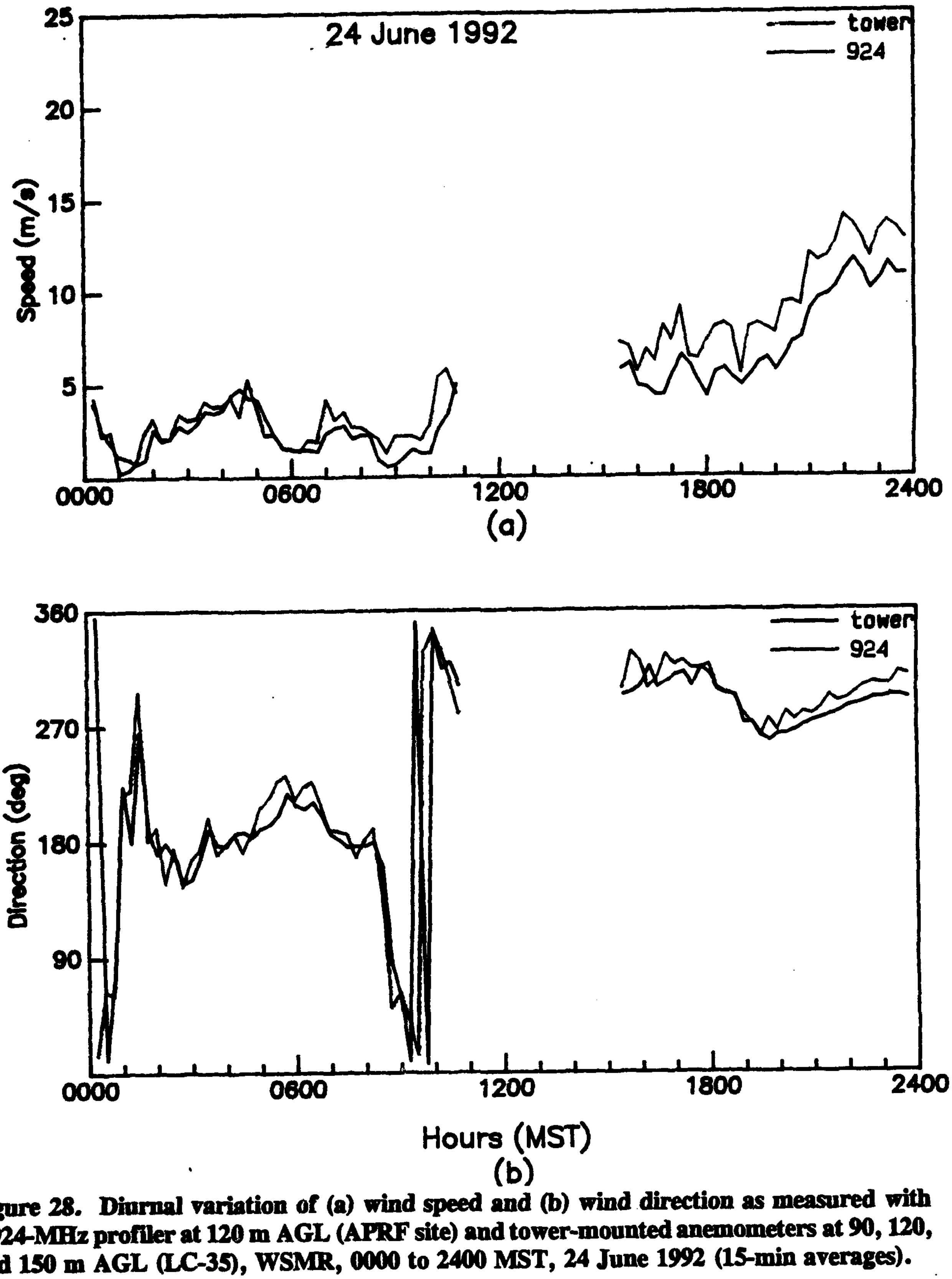


Figure 28. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 24 June 1992 (15-min averages).

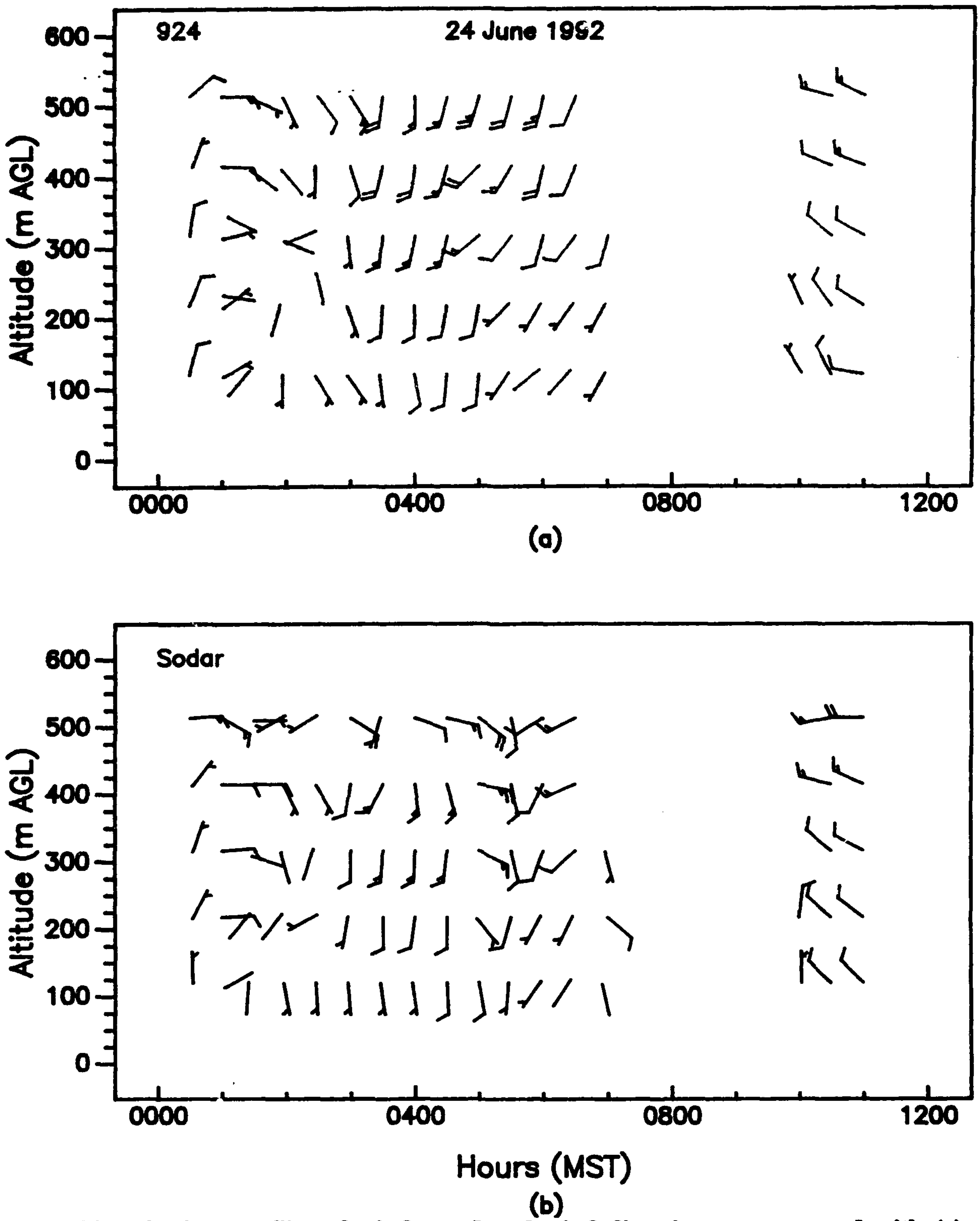


Figure 29. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 24 June 1992 (15-min averages).

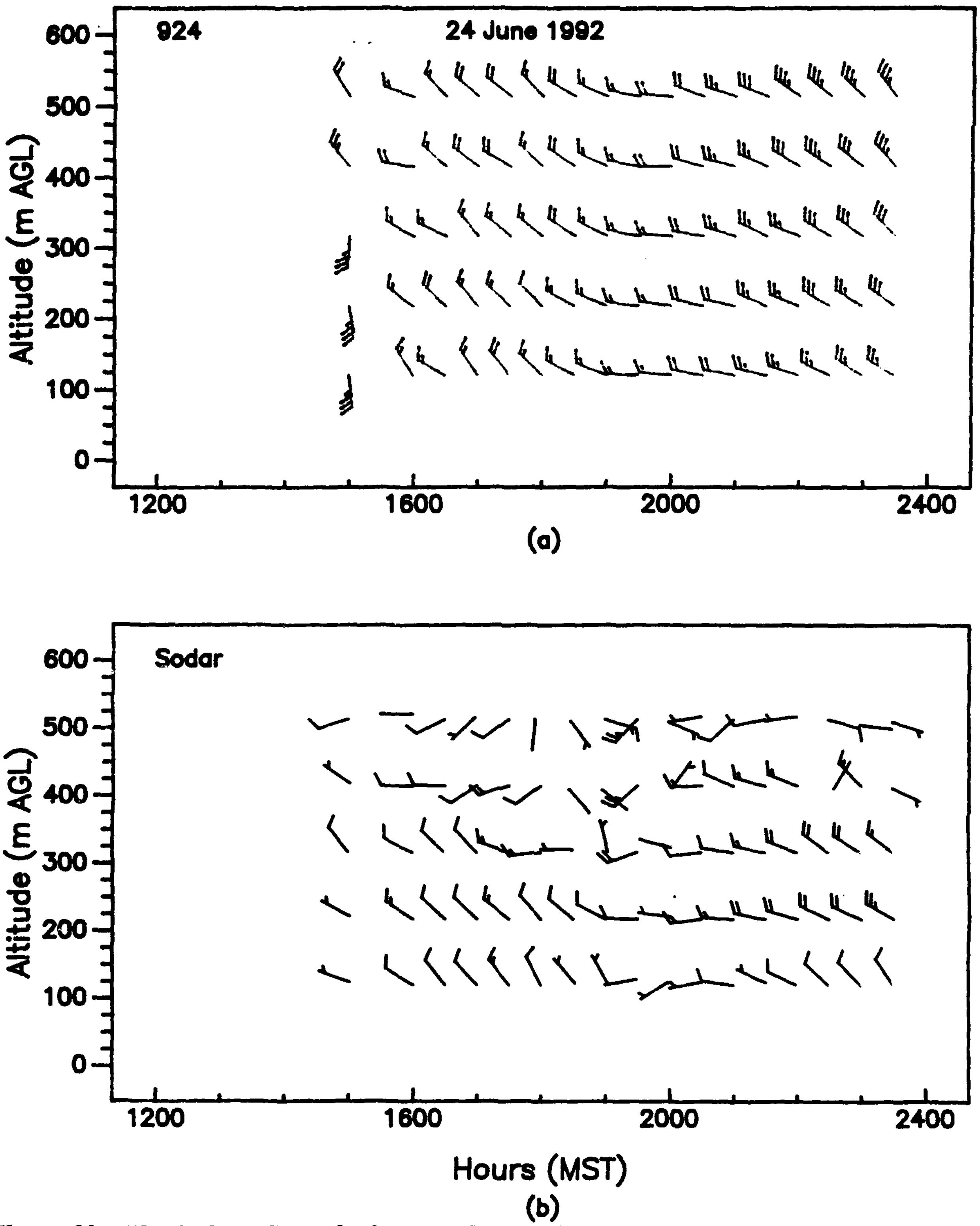


Figure 30. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 24 June 1992 (15-min averages).

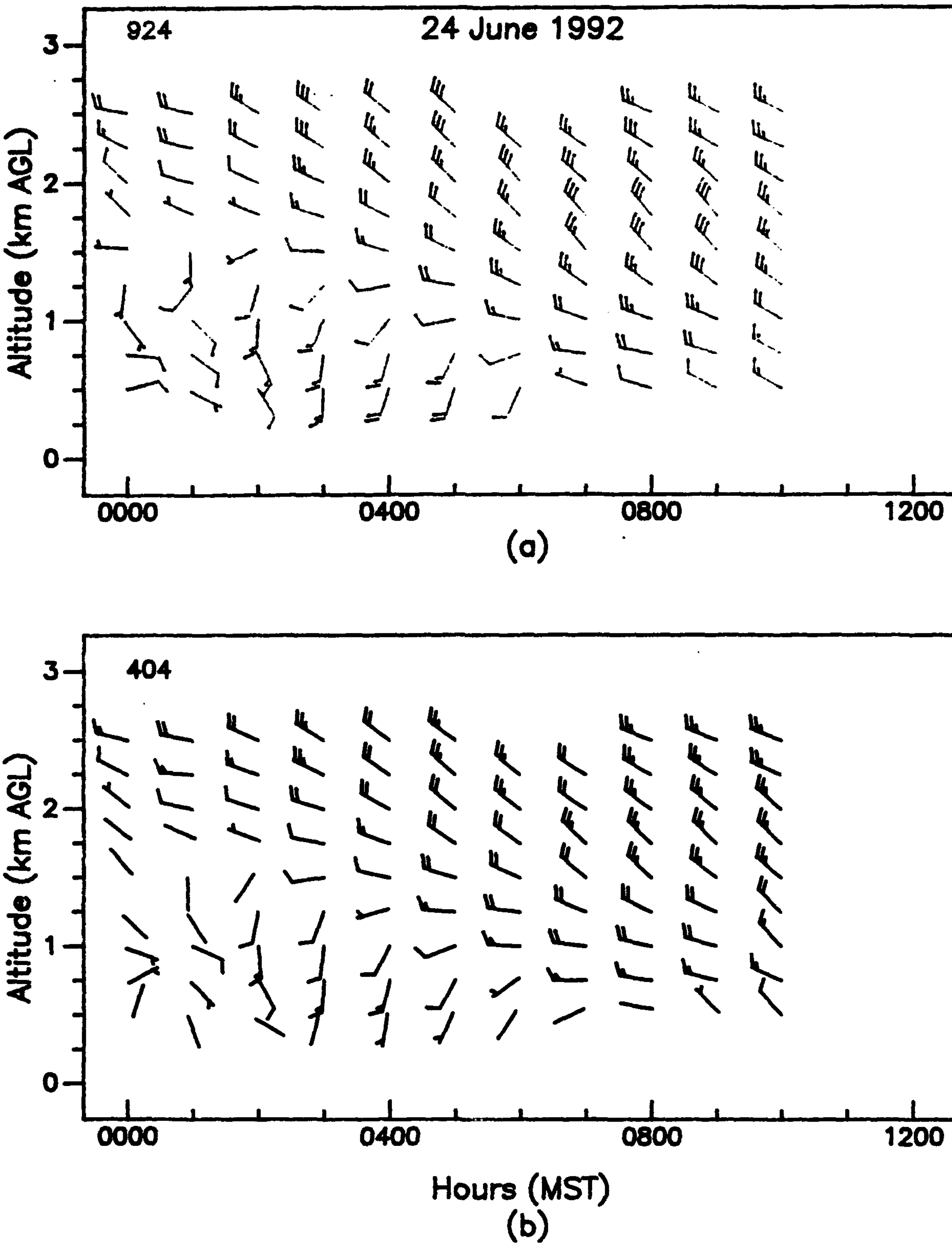


Figure 31. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 24 June 1992 (1-h averages).

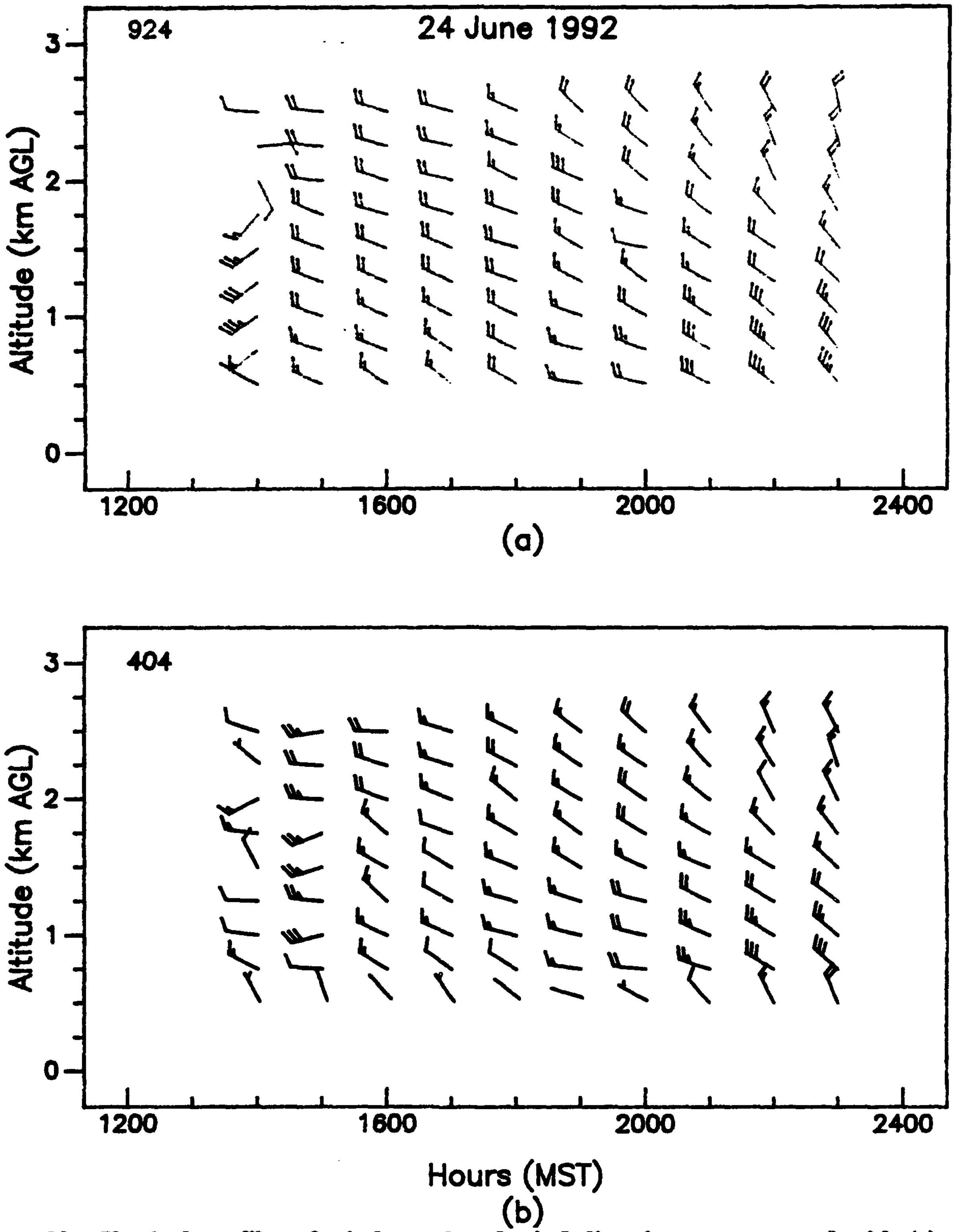
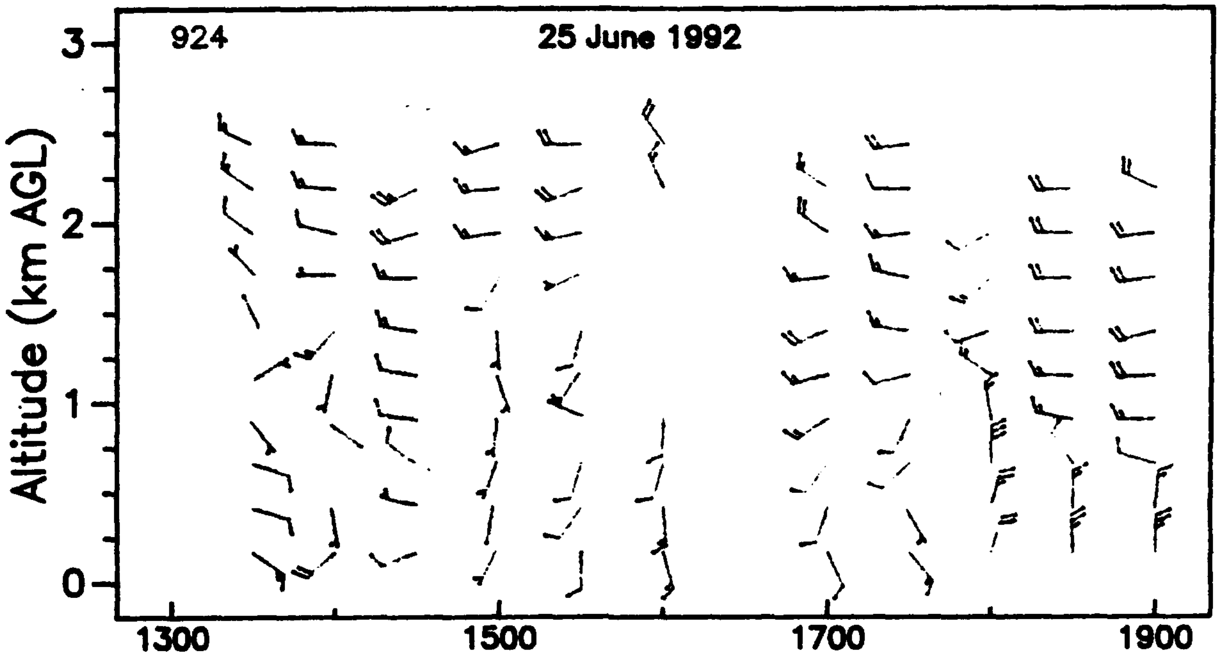
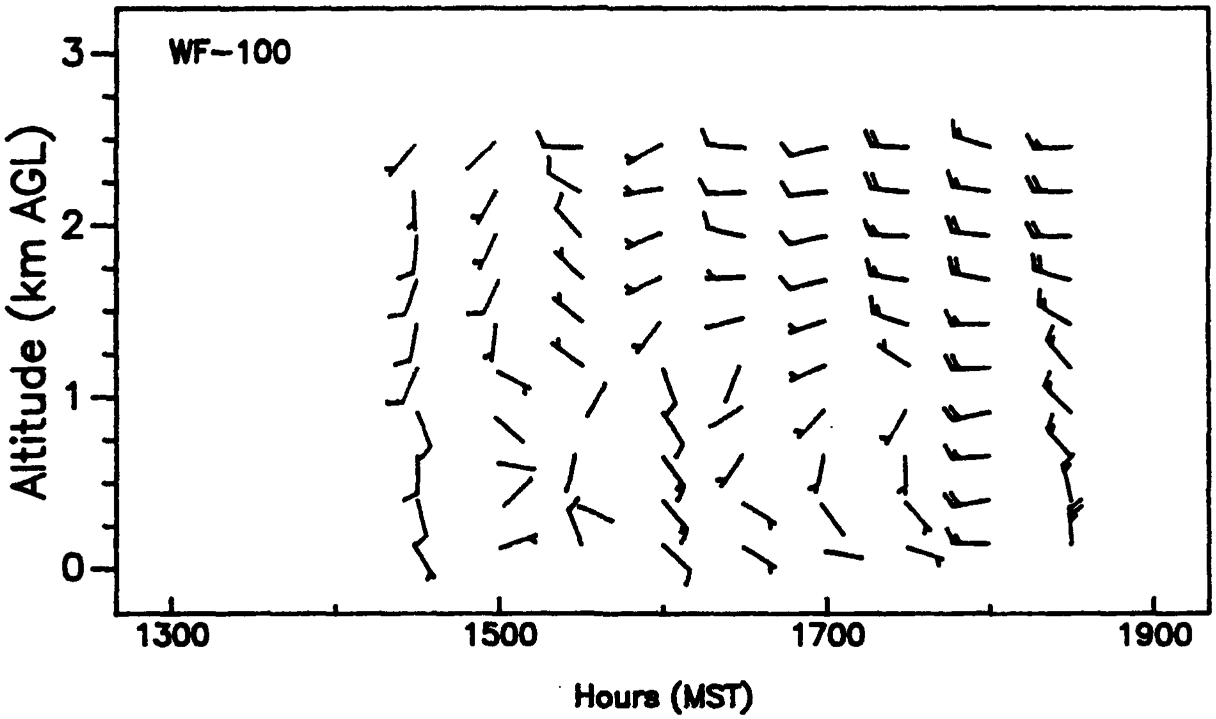


Figure 32. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 24 June 1992 (1-h averages).



(a)



(b)

Figure 33. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1300 to 1900 MST, 25 June 1992 (15-min averages for the 924 data).

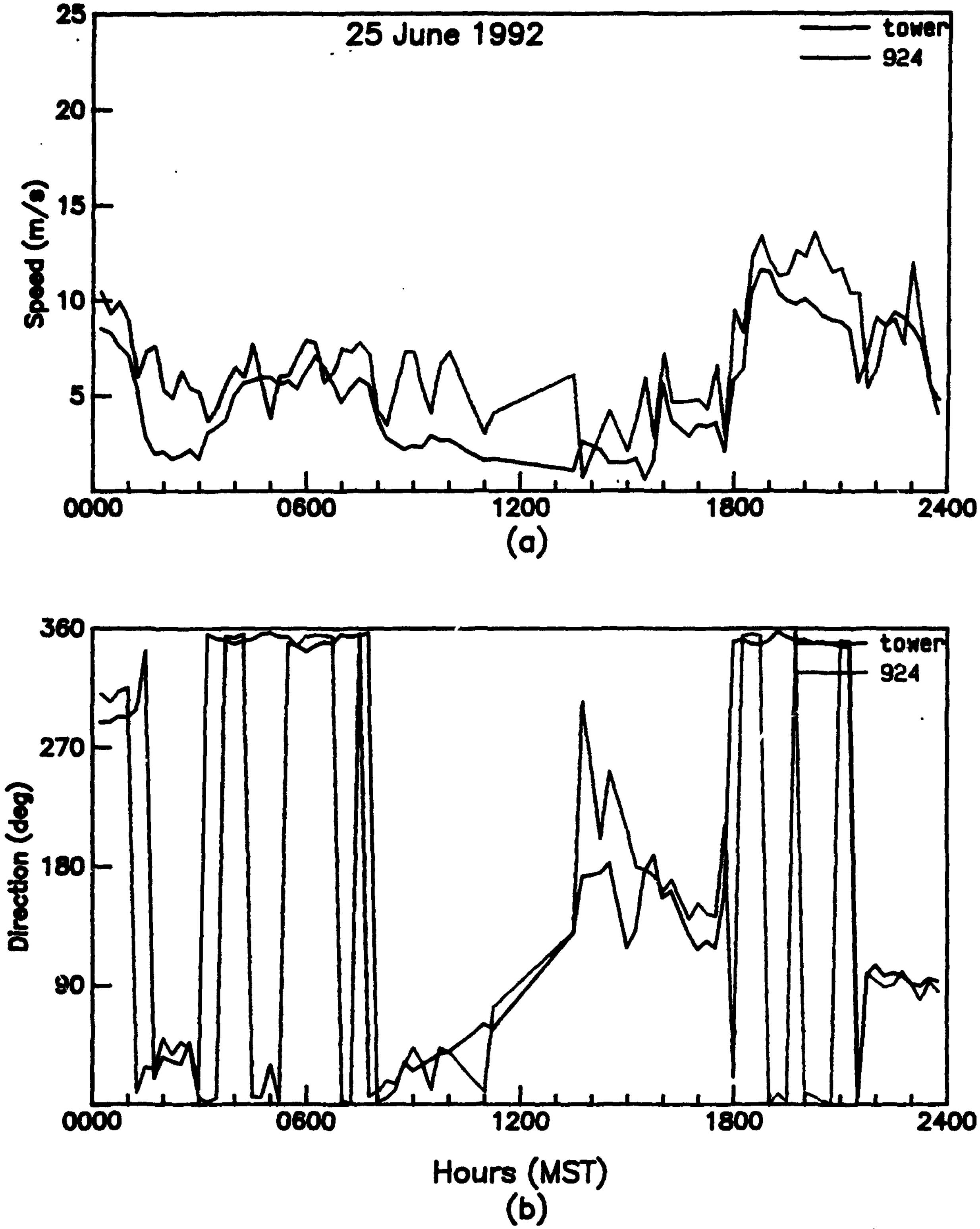


Figure 34. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 25 June 1992 (15-min averages).

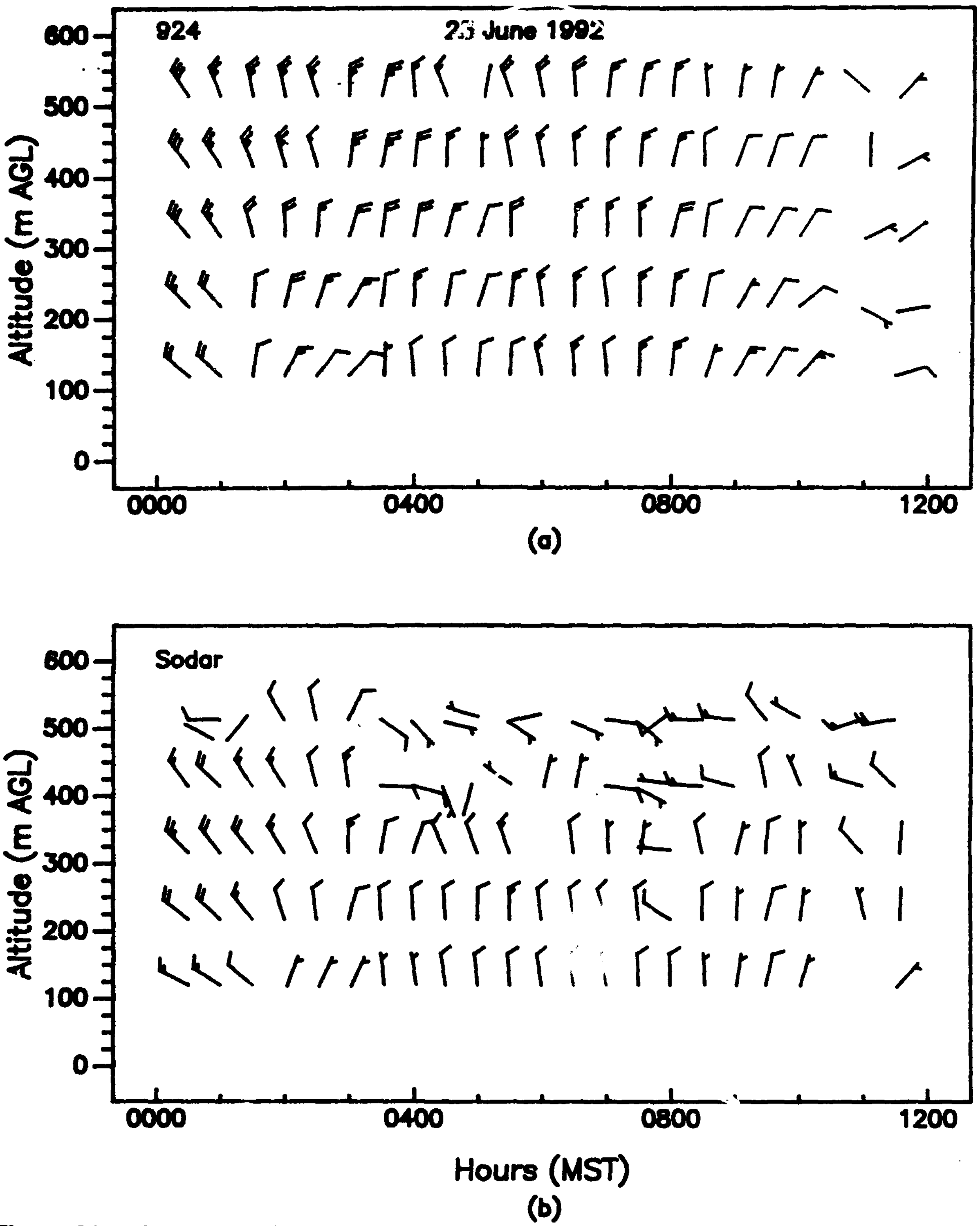


Figure 35. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 25 June 1992 (15-min averages).

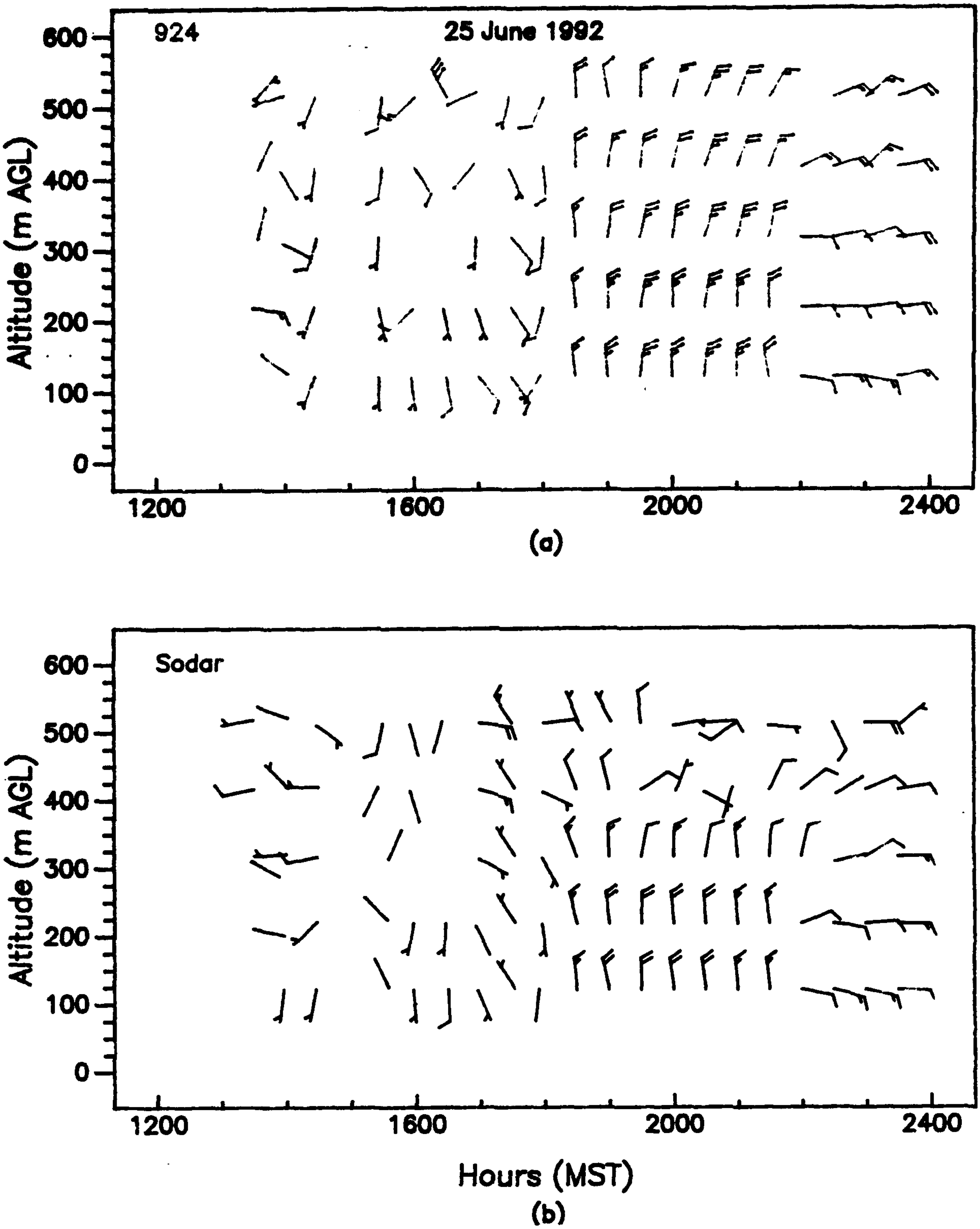


Figure 36. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 25 June 1992 (15-min averages).

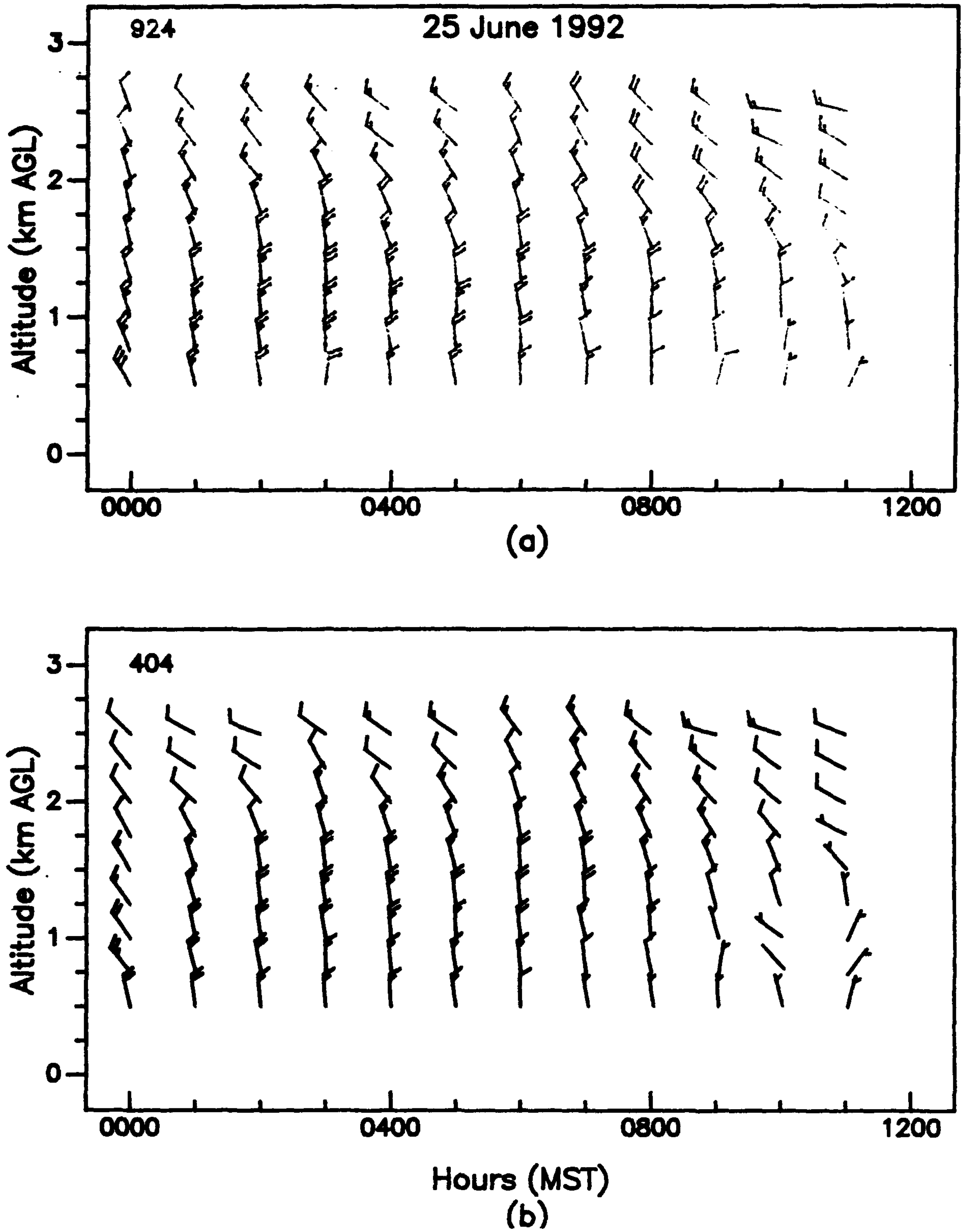
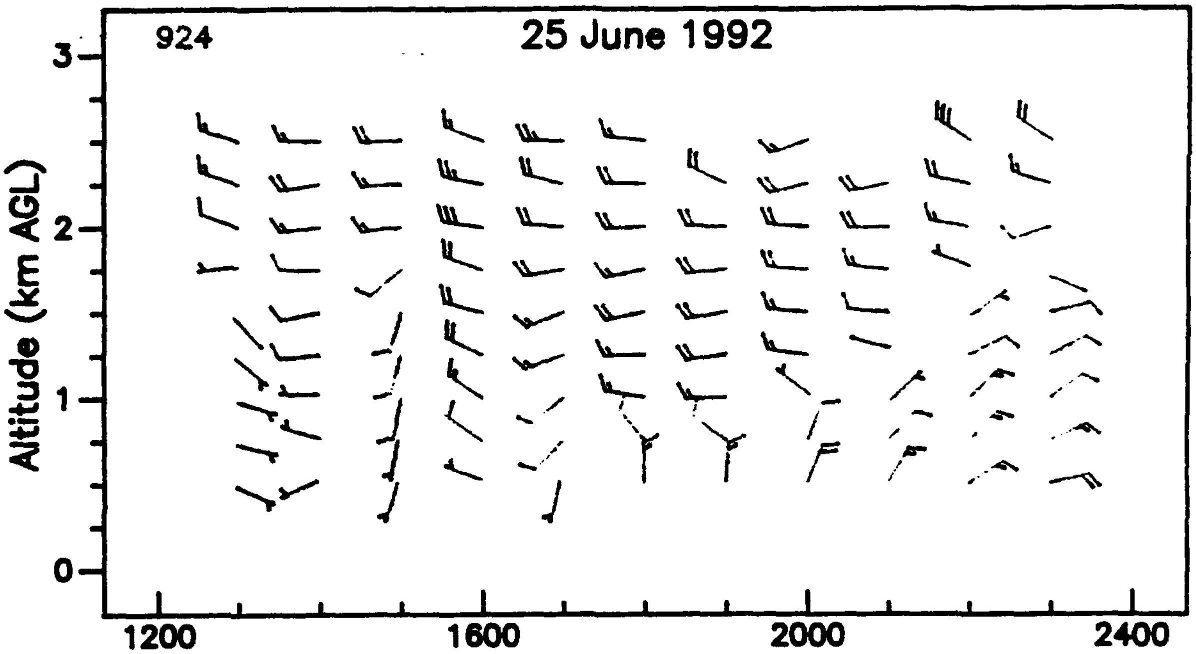
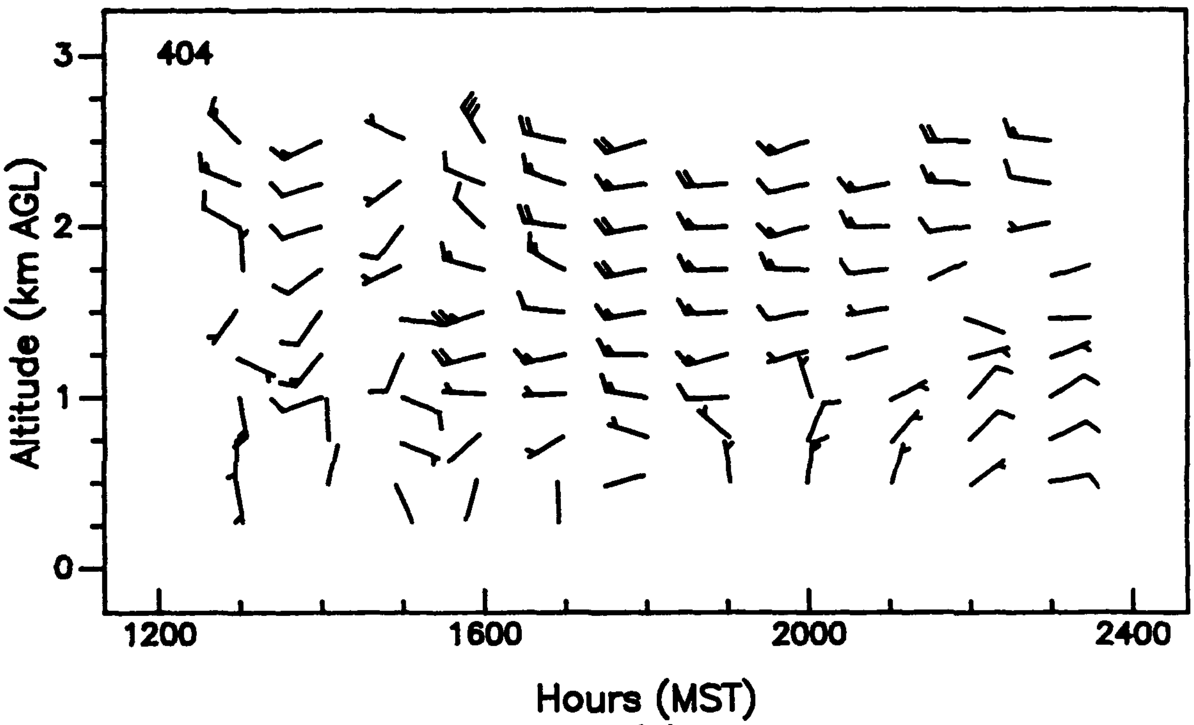


Figure 37. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 25 June 1992 (1-h averages).



(a)



(b)

Figure 38. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 25 June 1992 (1-h averages).

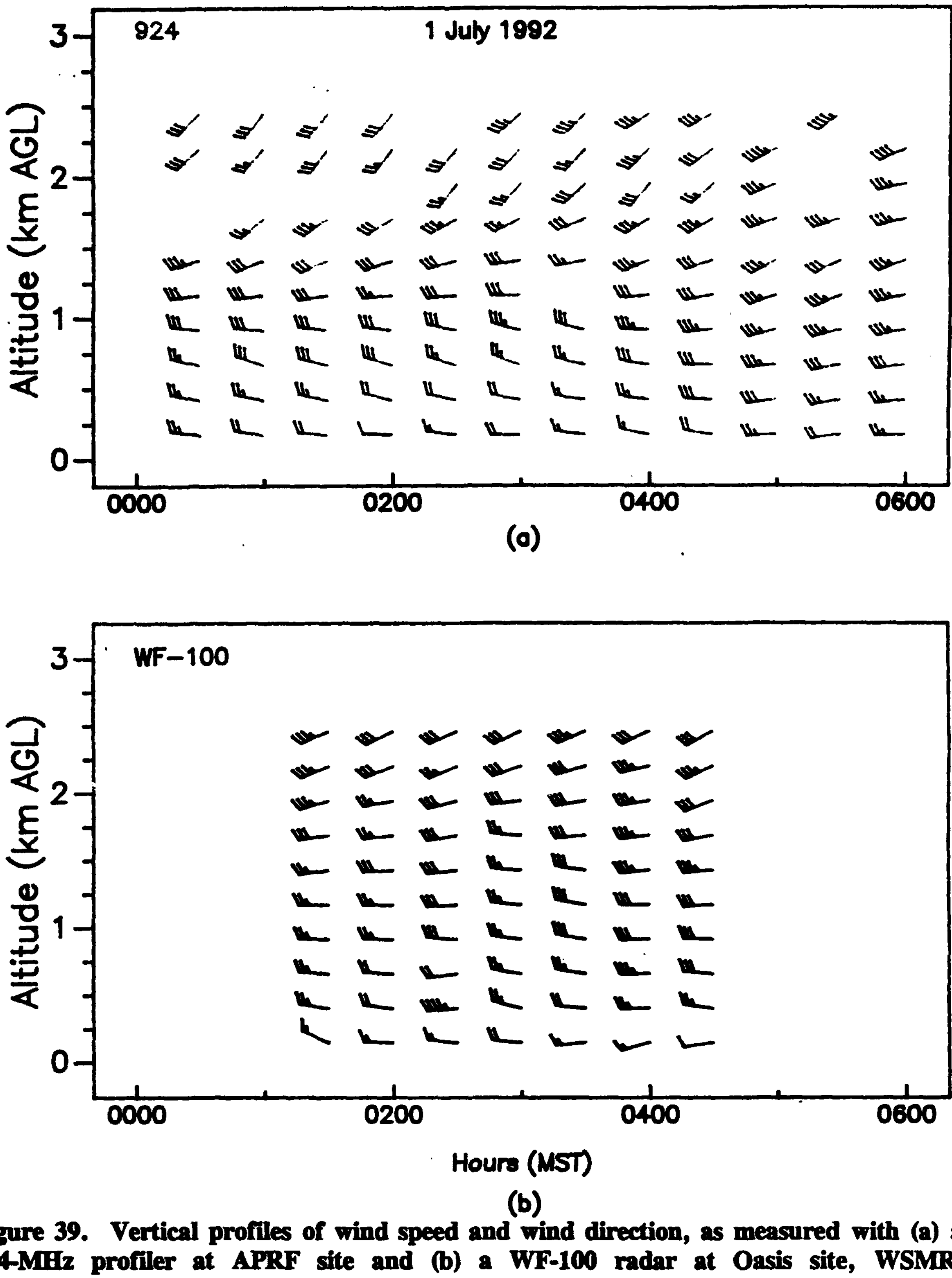


Figure 39. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 0000 to 0600 MST, 1 July 1992 (15-min averages for the 924 data).

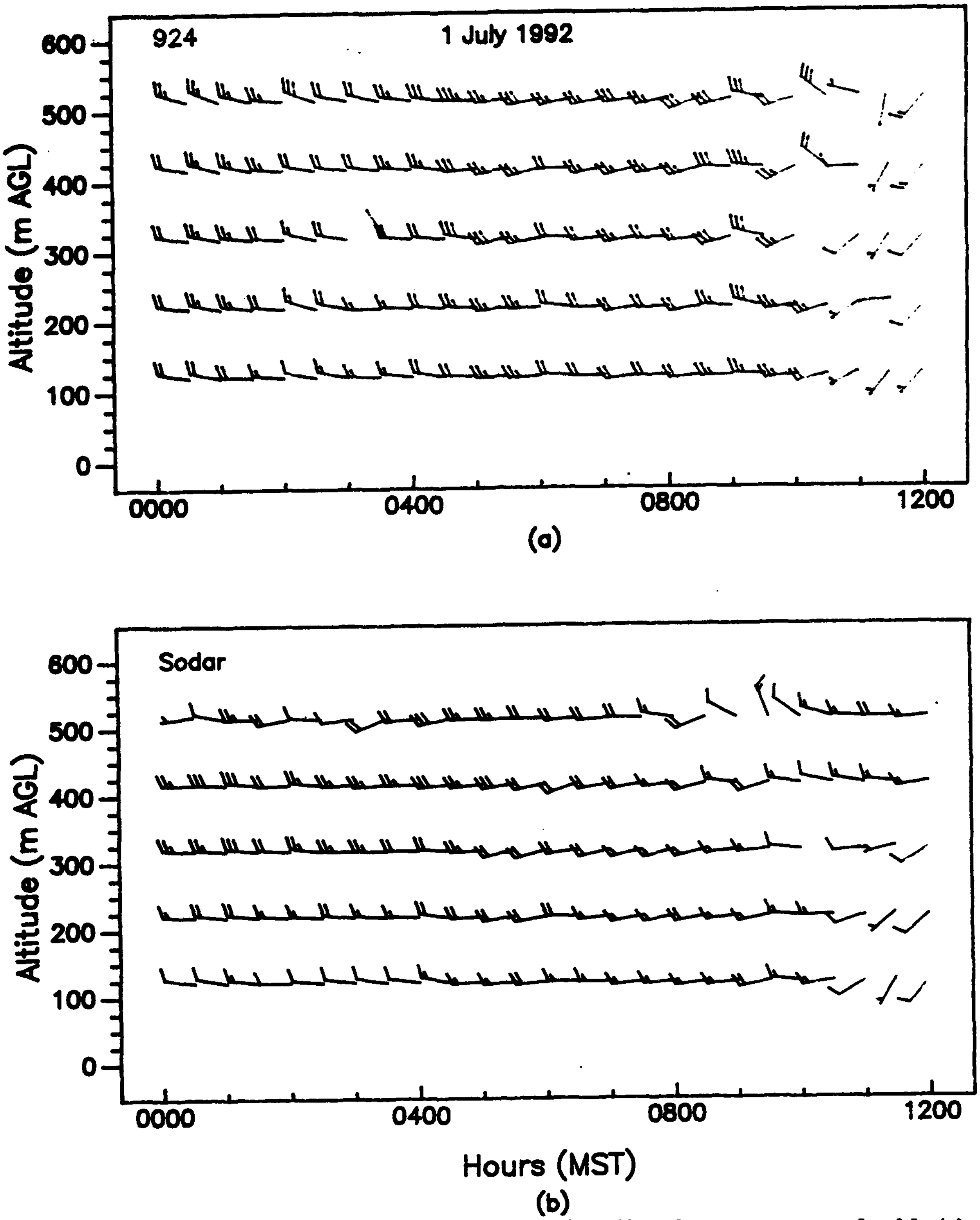


Figure 40. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 1 July 1992 (15-min averages).

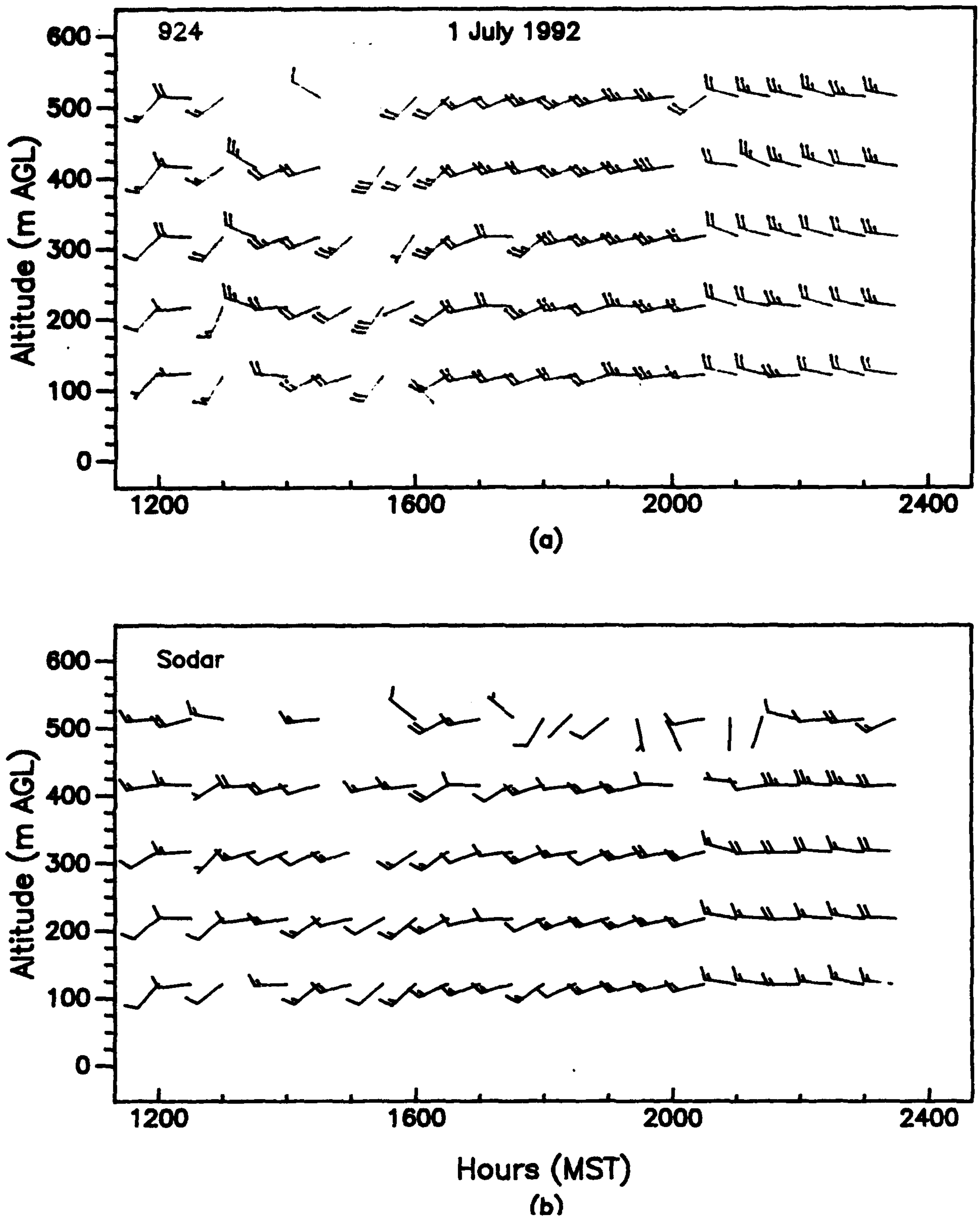


Figure 41. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 1 July 1992 (15-min averages).

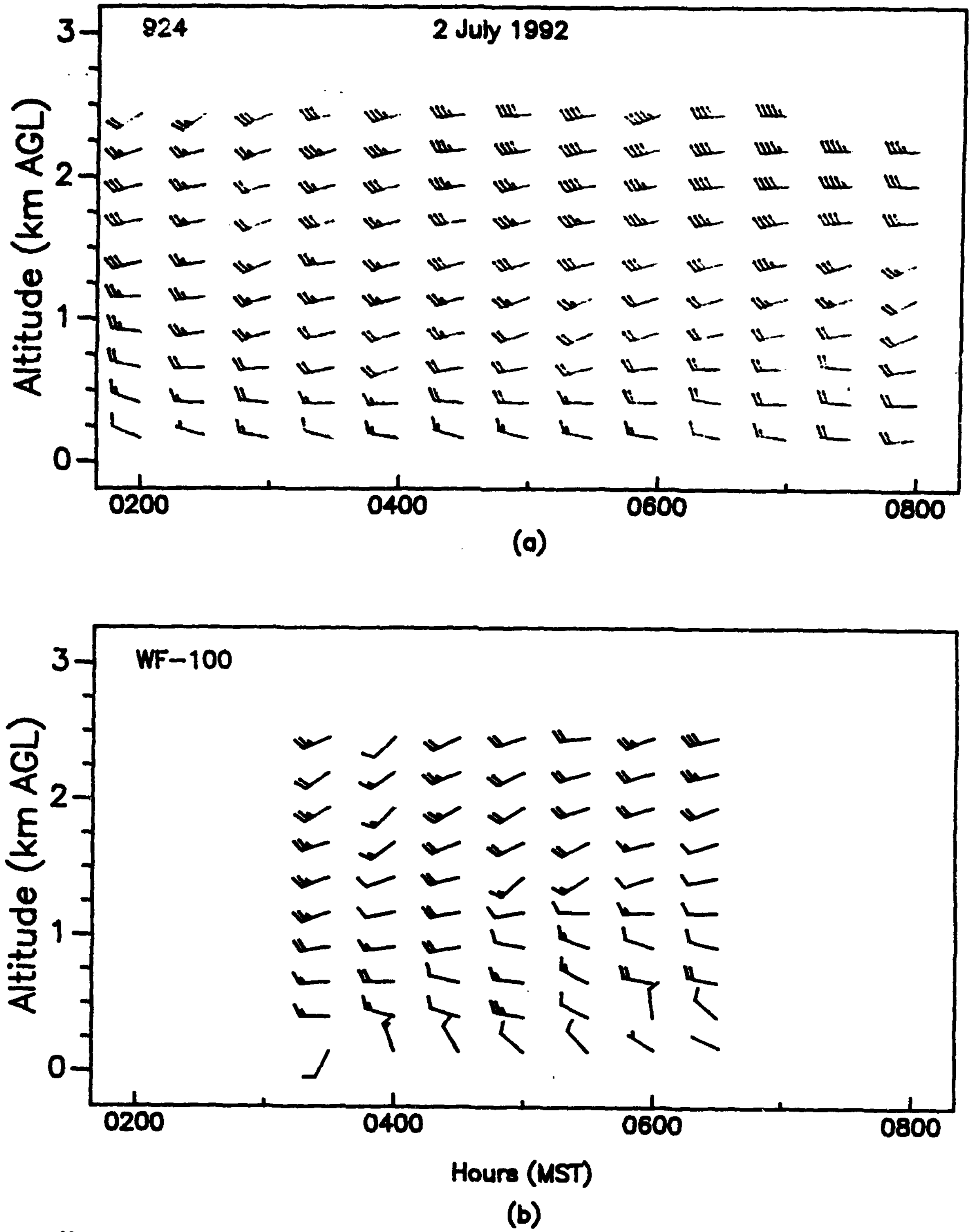


Figure 42. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 0200 to 0800 MST, 2 July 1992 (15-min averages for the 924 data).

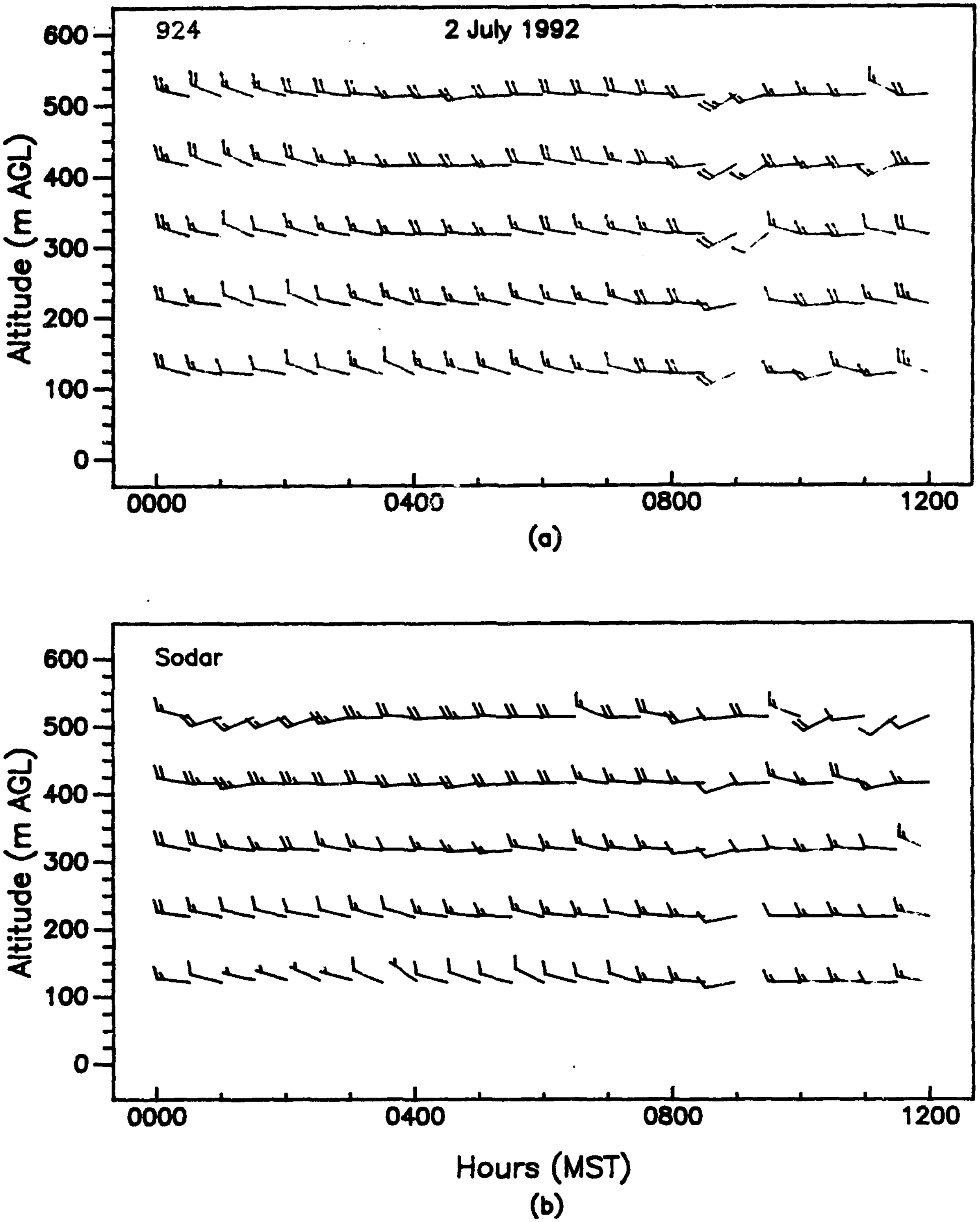
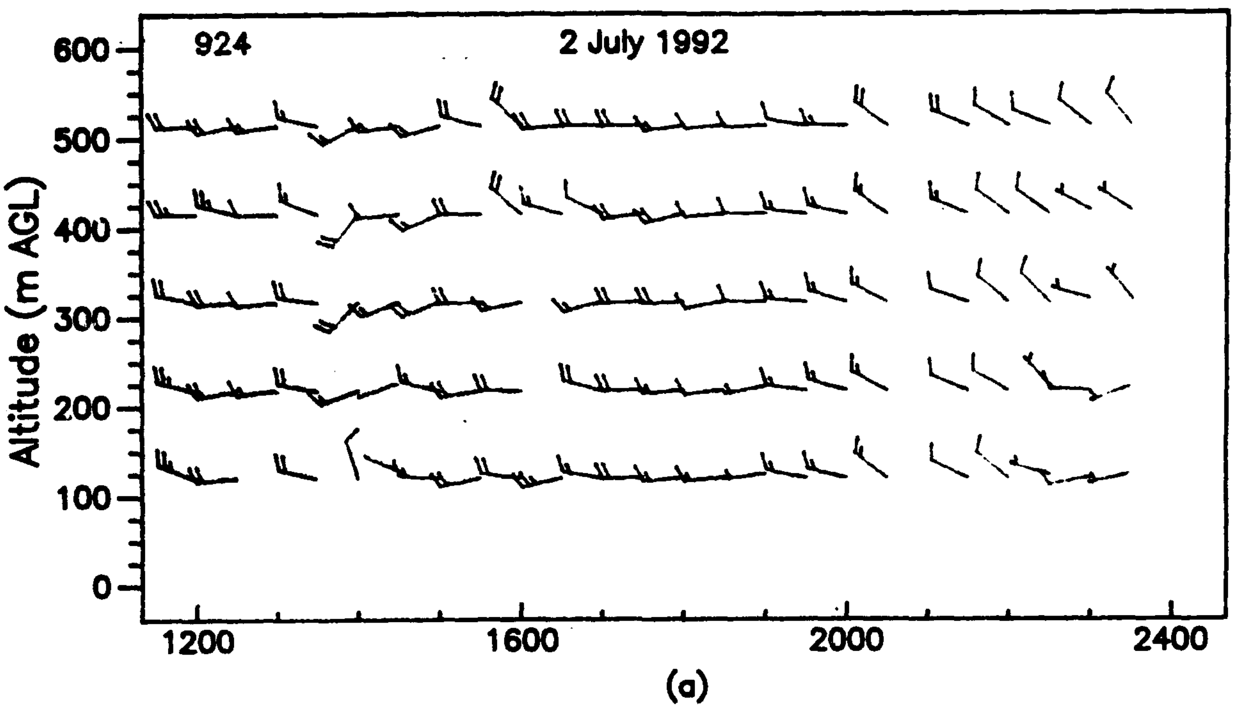


Figure 43. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 2 July 1992 (15-min averages).



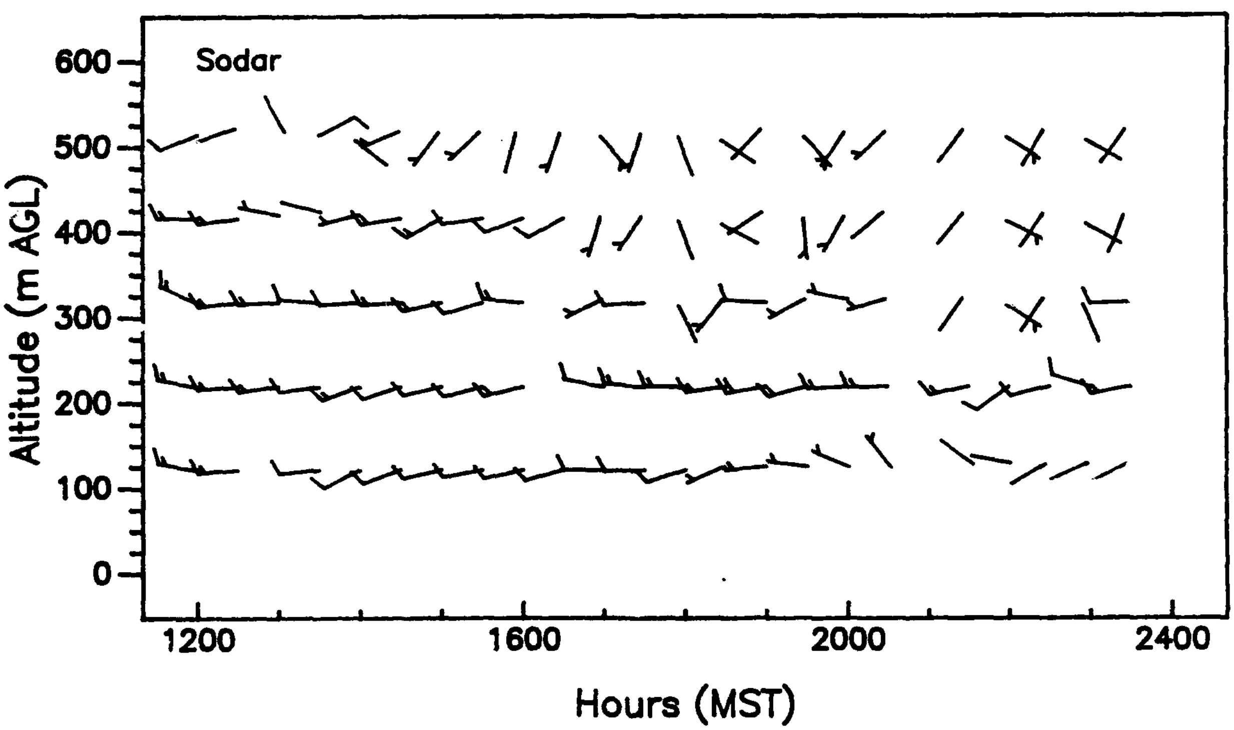
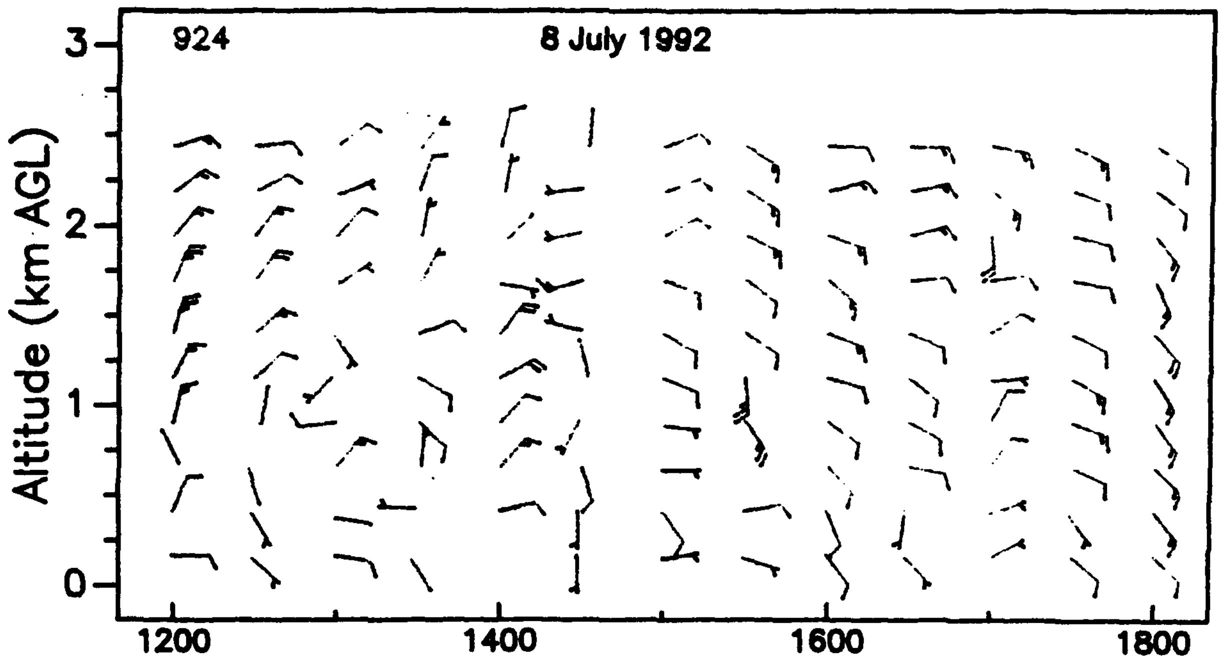
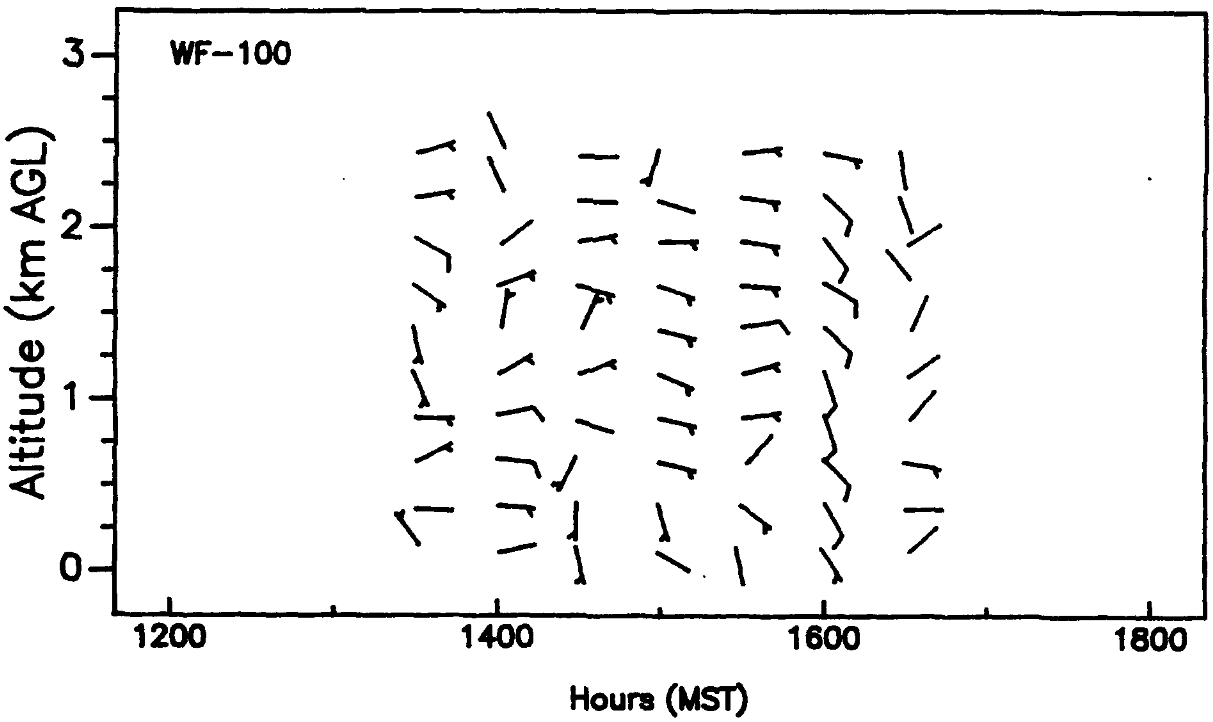


Figure 44. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 2 July 1992 (15-min averages).



(a)



(b)

Figure 45. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1200 to 1800 MST, 8 July 1992 (15-min averages for the 924 data).

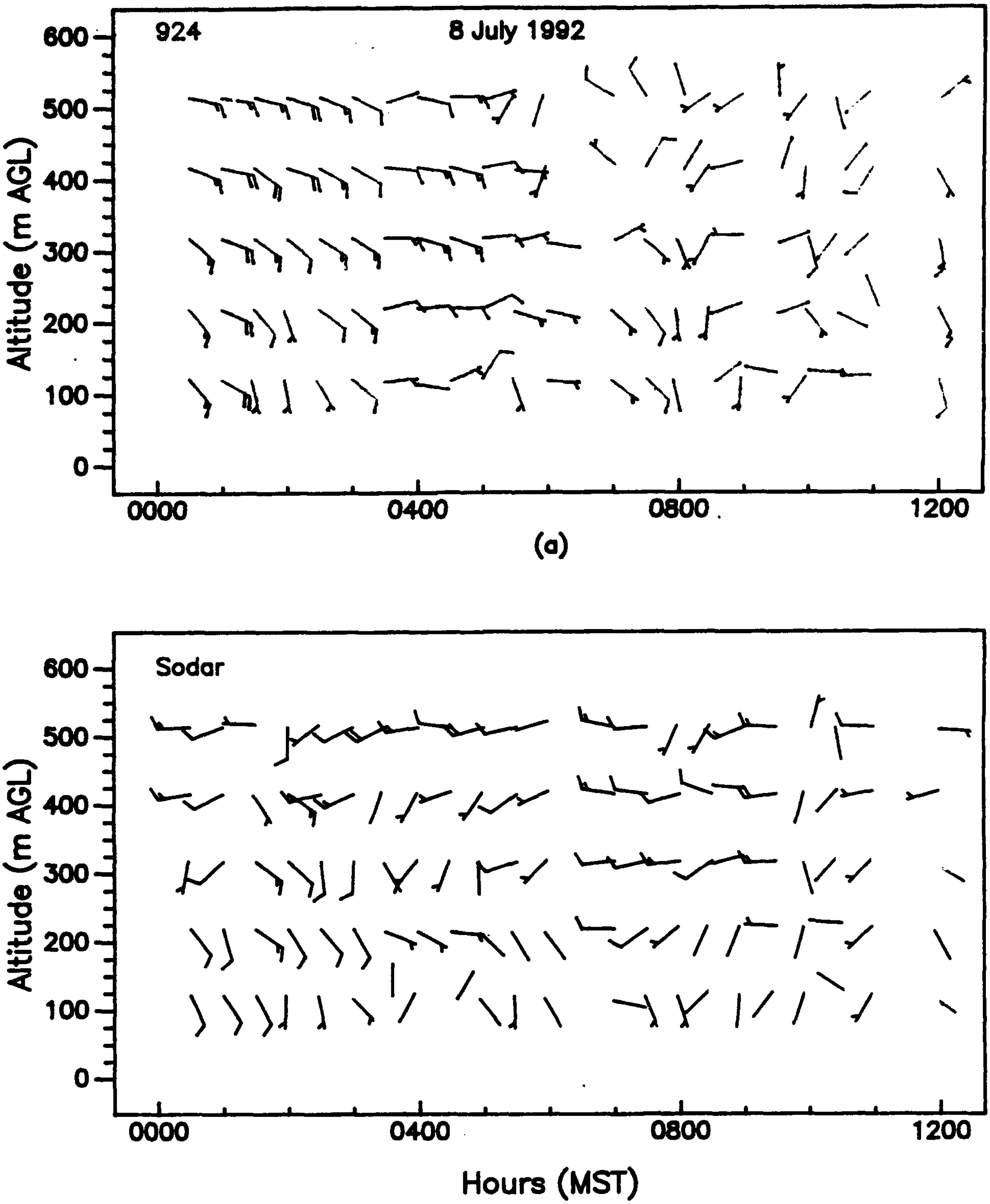


Figure 46. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 8 July 1992 (15-min averages).

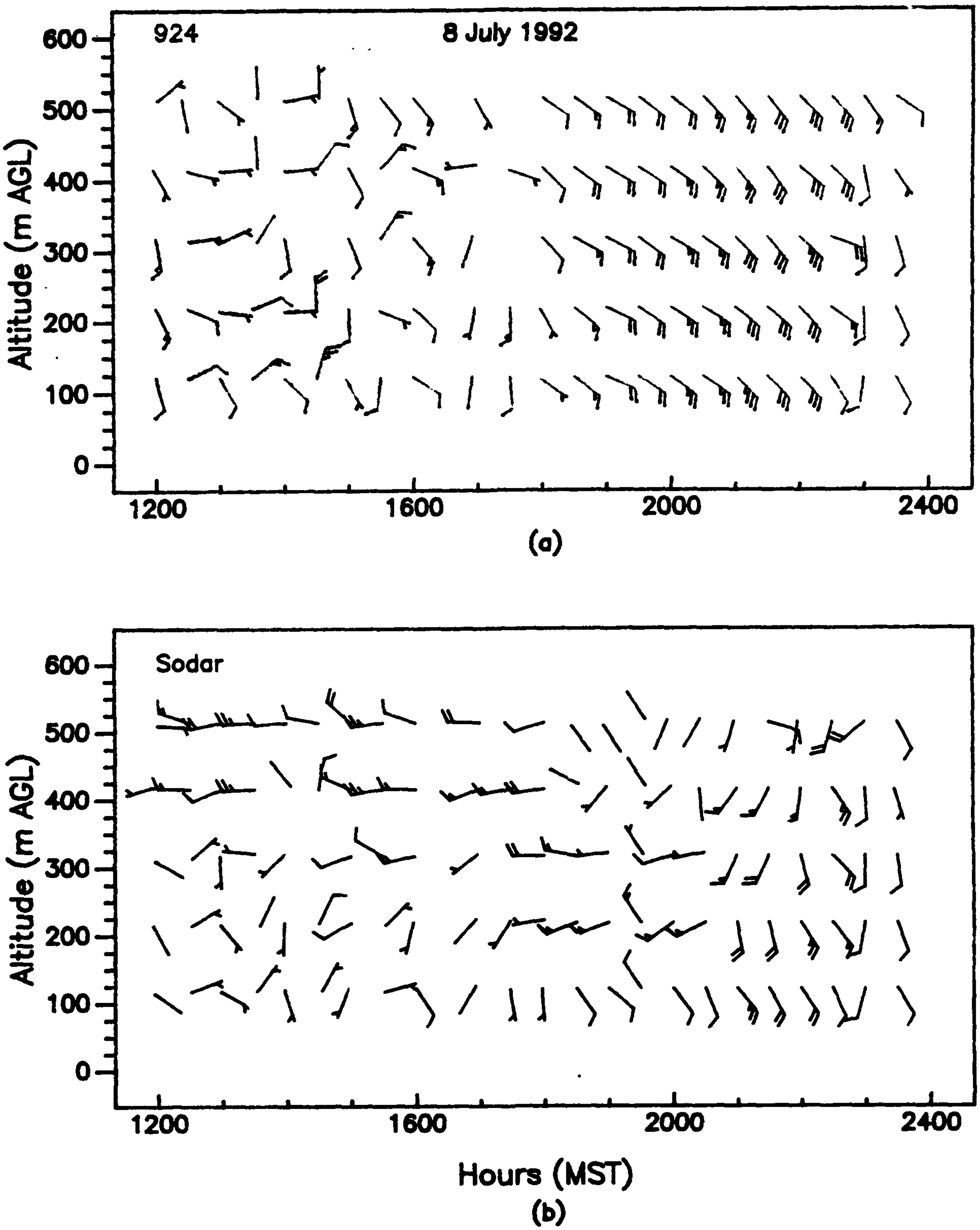
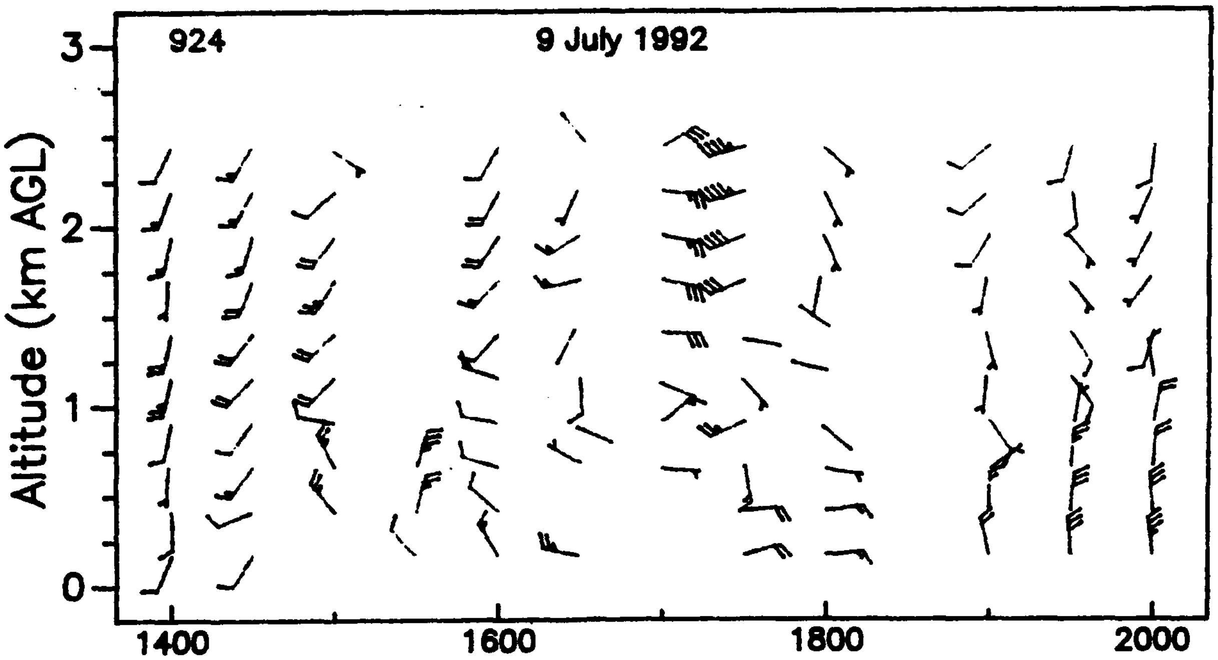
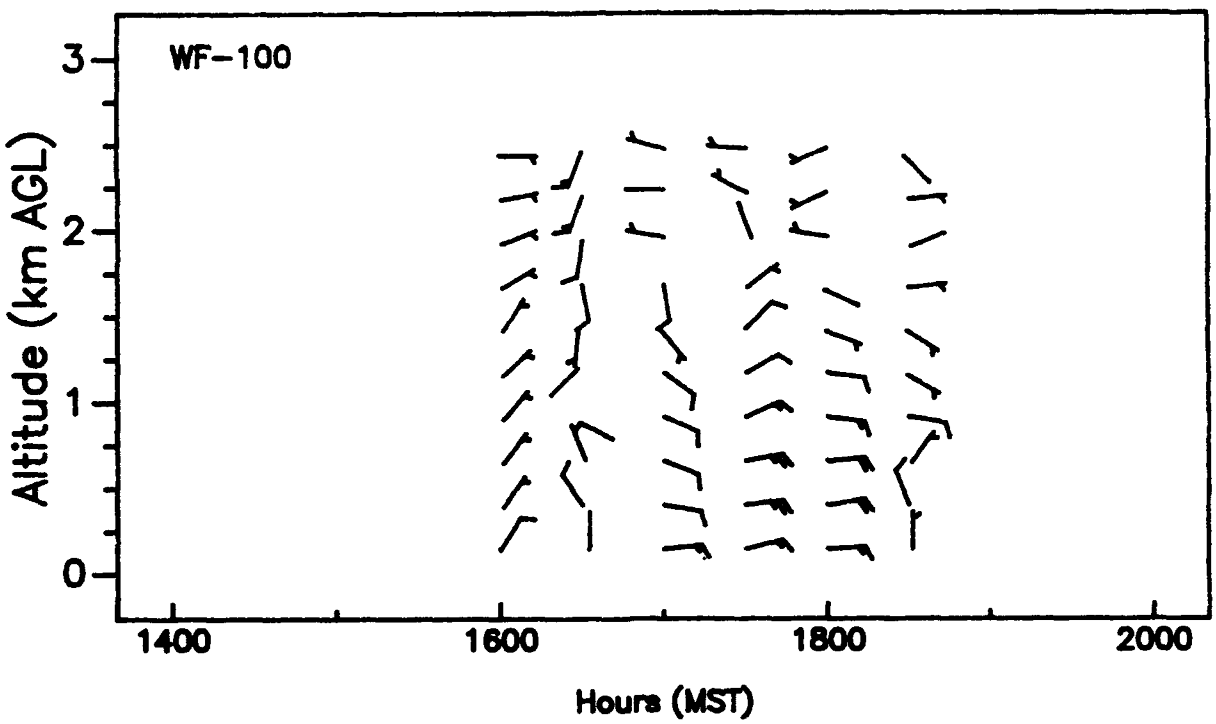


Figure 47. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 8 July 1992 (15-min averages).

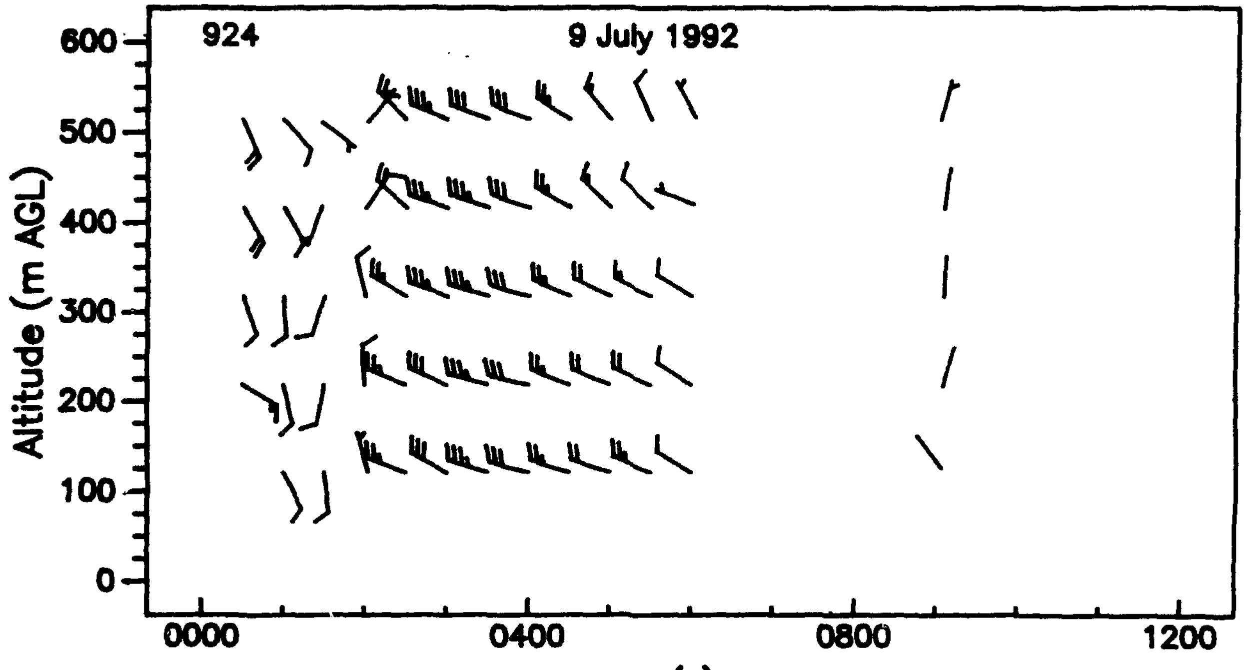


(a)

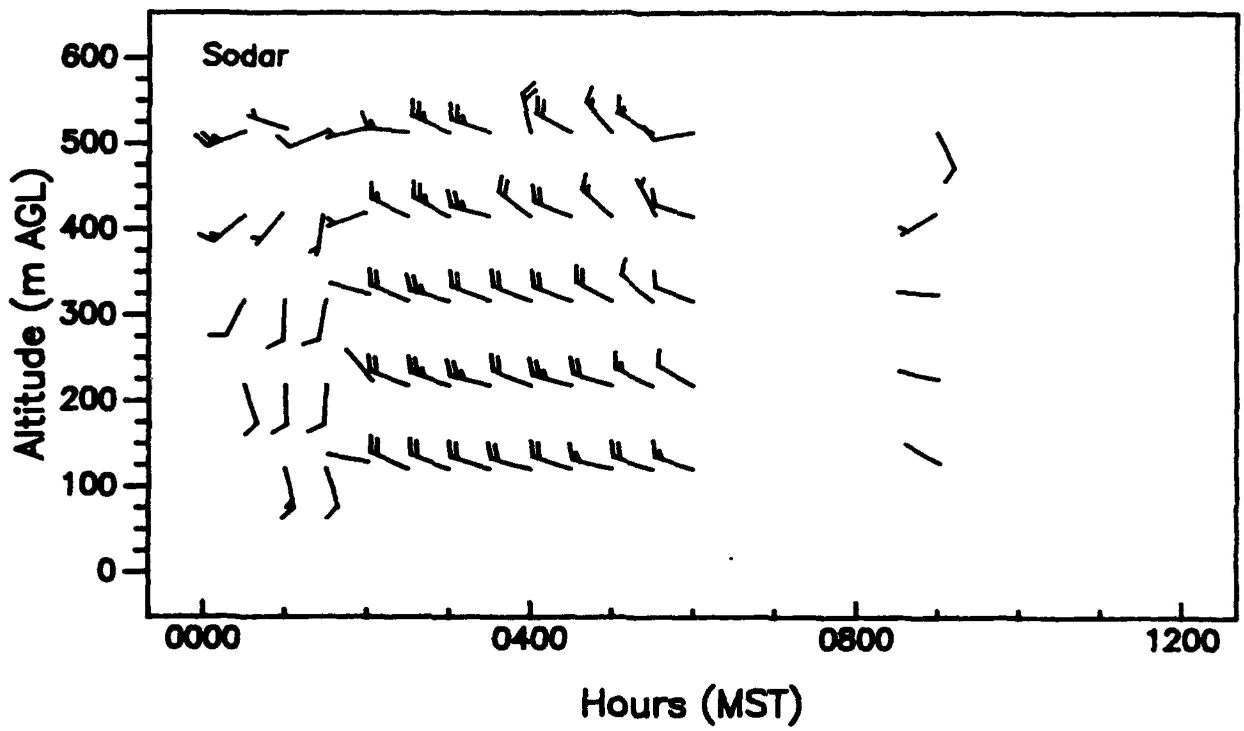


(b)

Figure 48. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1400 to 2000 MST, 9 July 1992 (15-min averages for the 924 data).



(a)



(b)

Figure 49. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRt site, WSMR, 0000 to 1200 MST, 9 July 1992 (15-min averages).

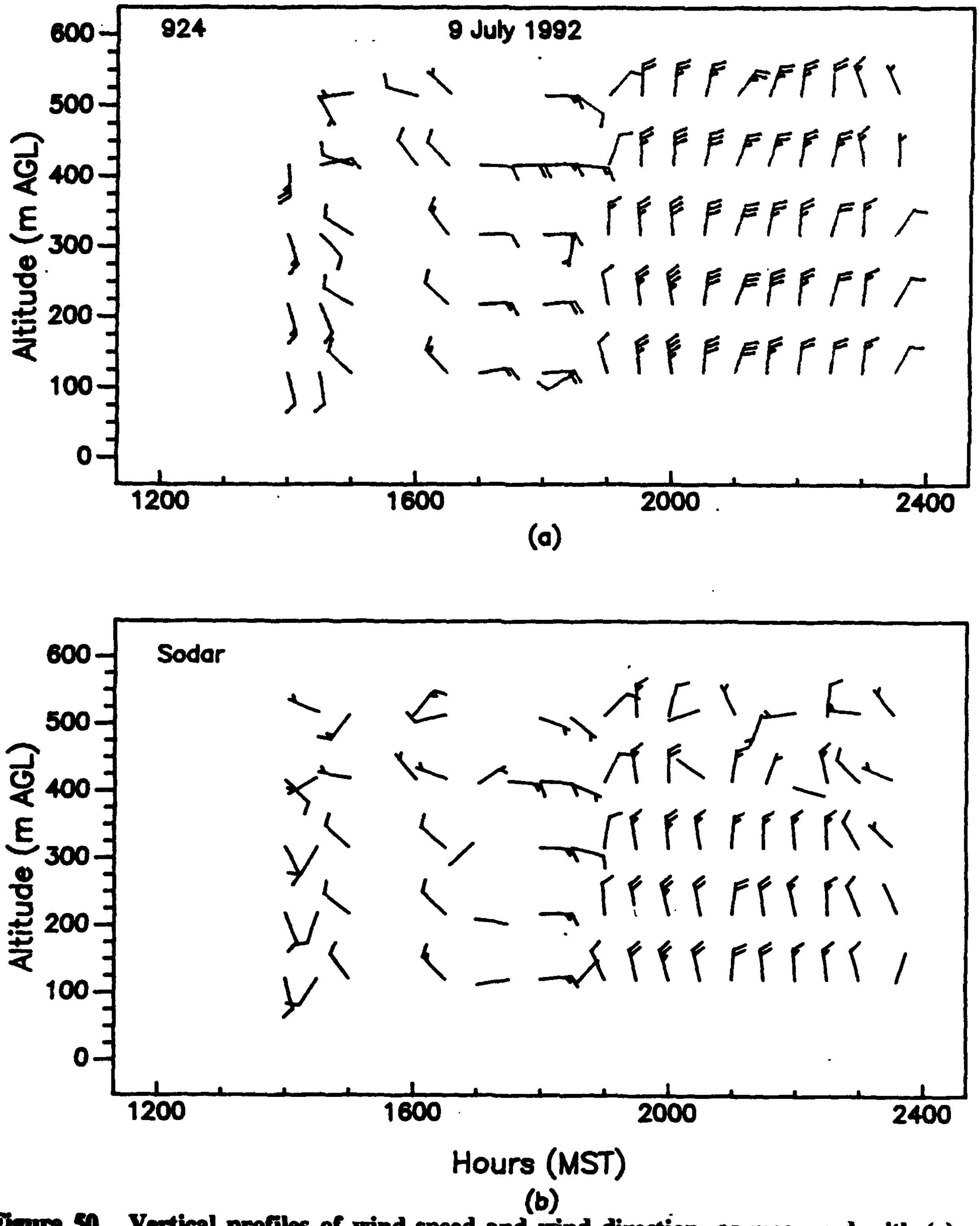
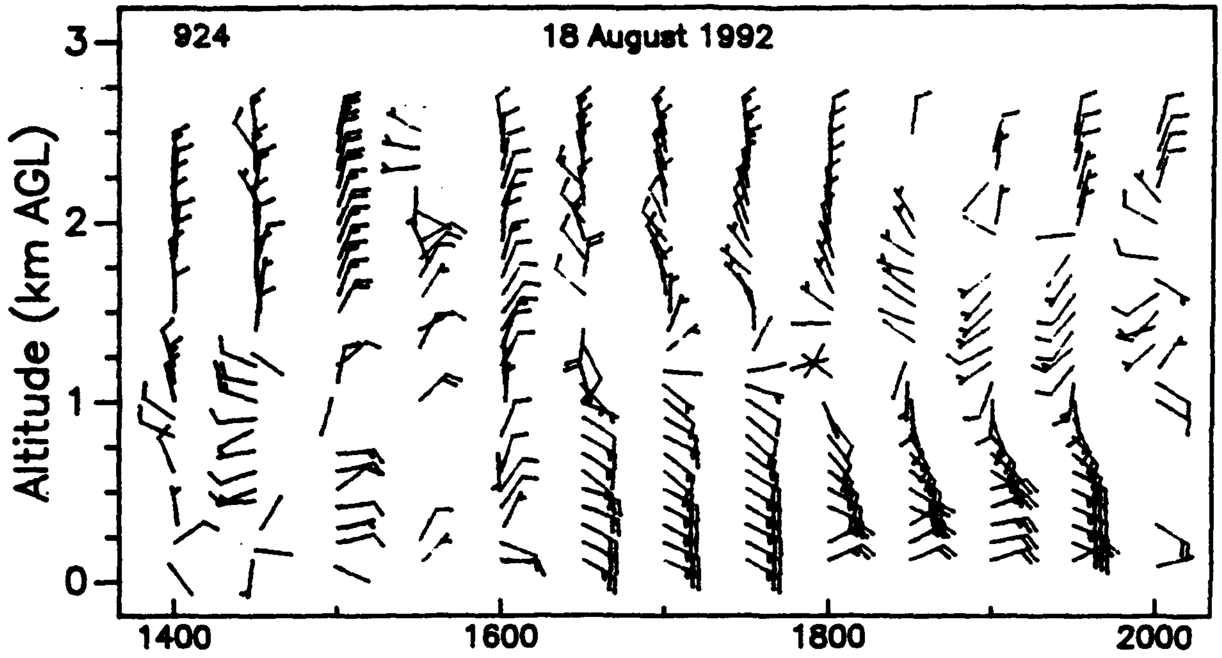
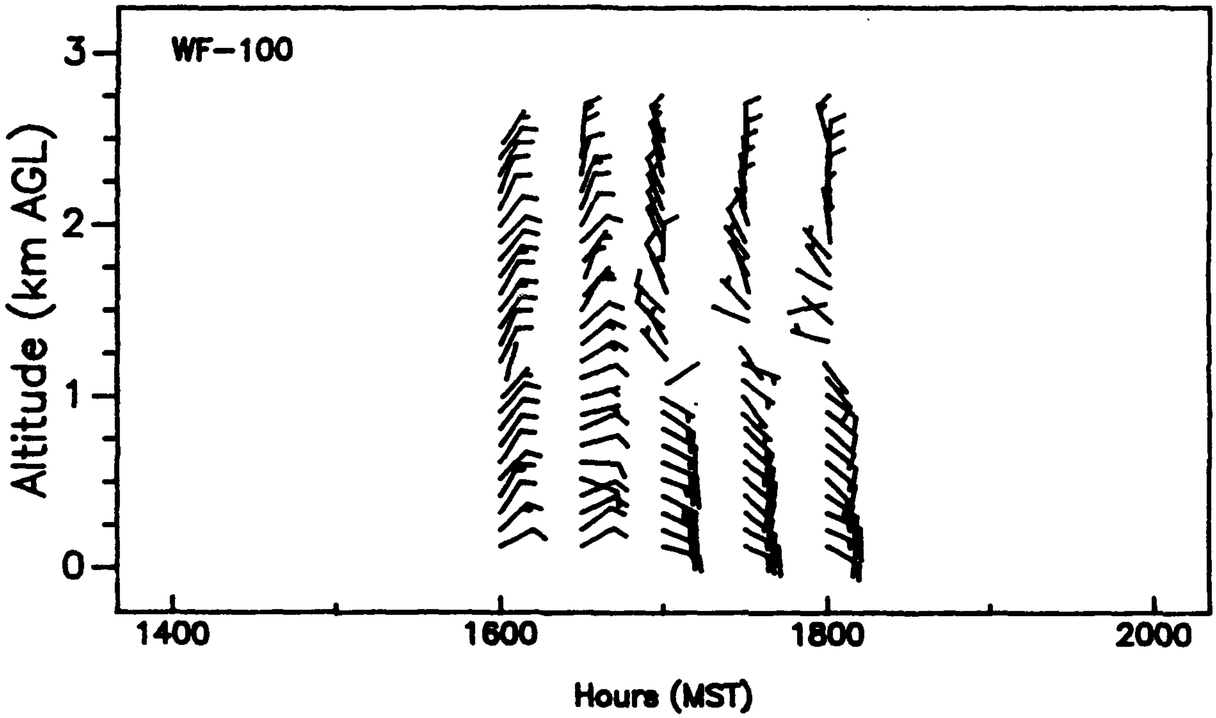


Figure 50. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 9 July 1992 (15-min averages).



(a)



(b)

Figure 51. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1400 to 2000 MST, 18 August 1992 (15-min averages for the 924 data).

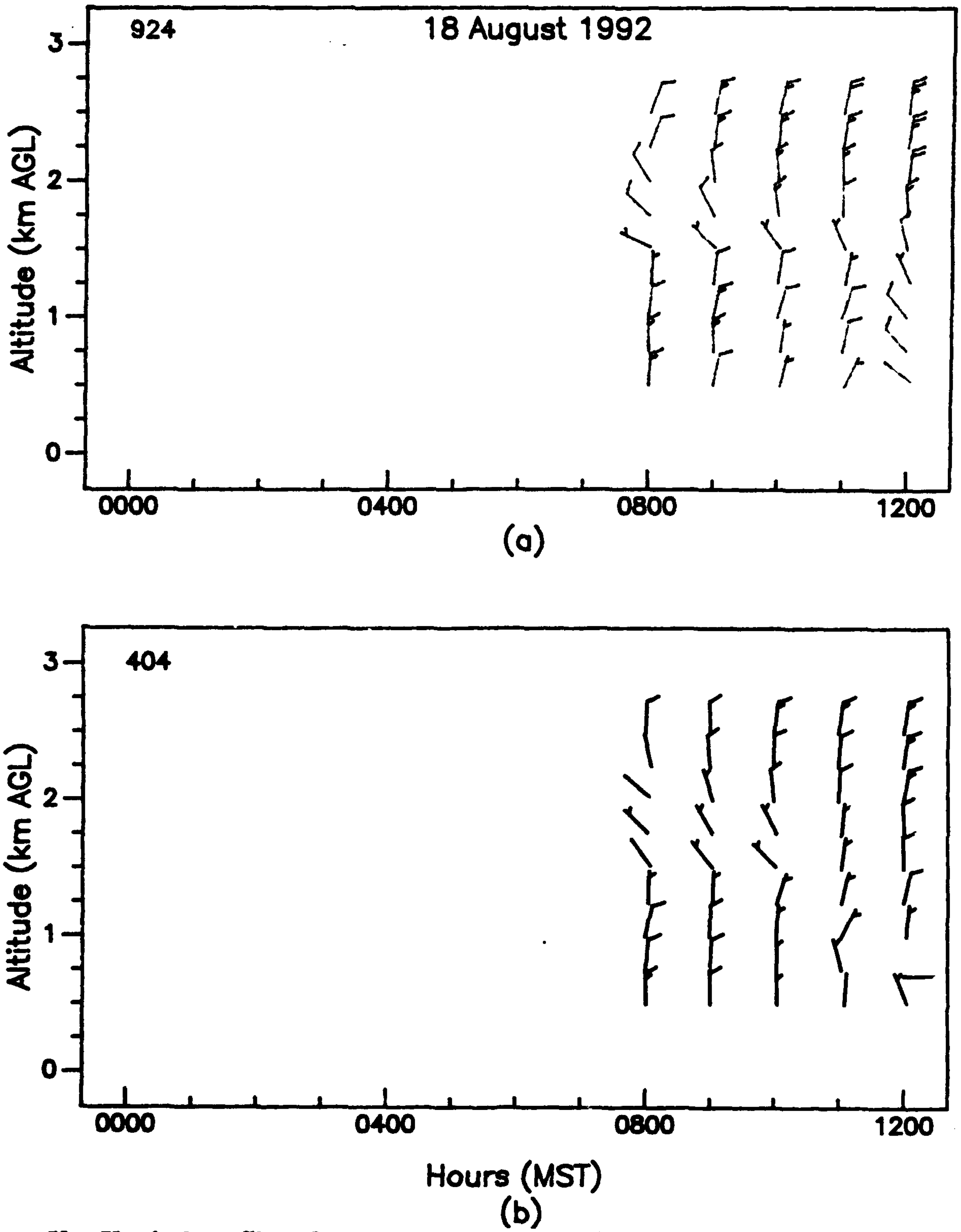


Figure 52. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 18 August 1992 (1-h averages).

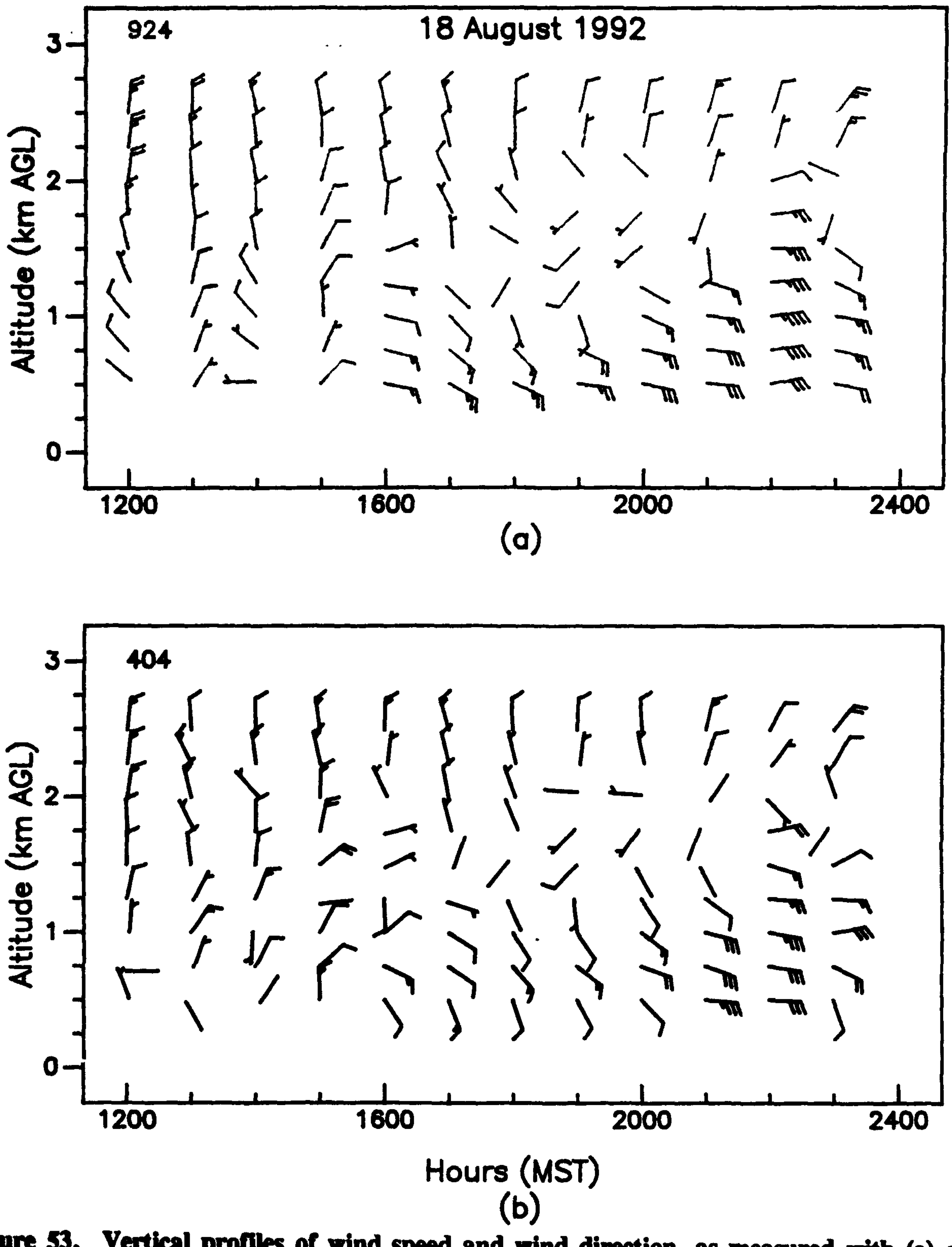
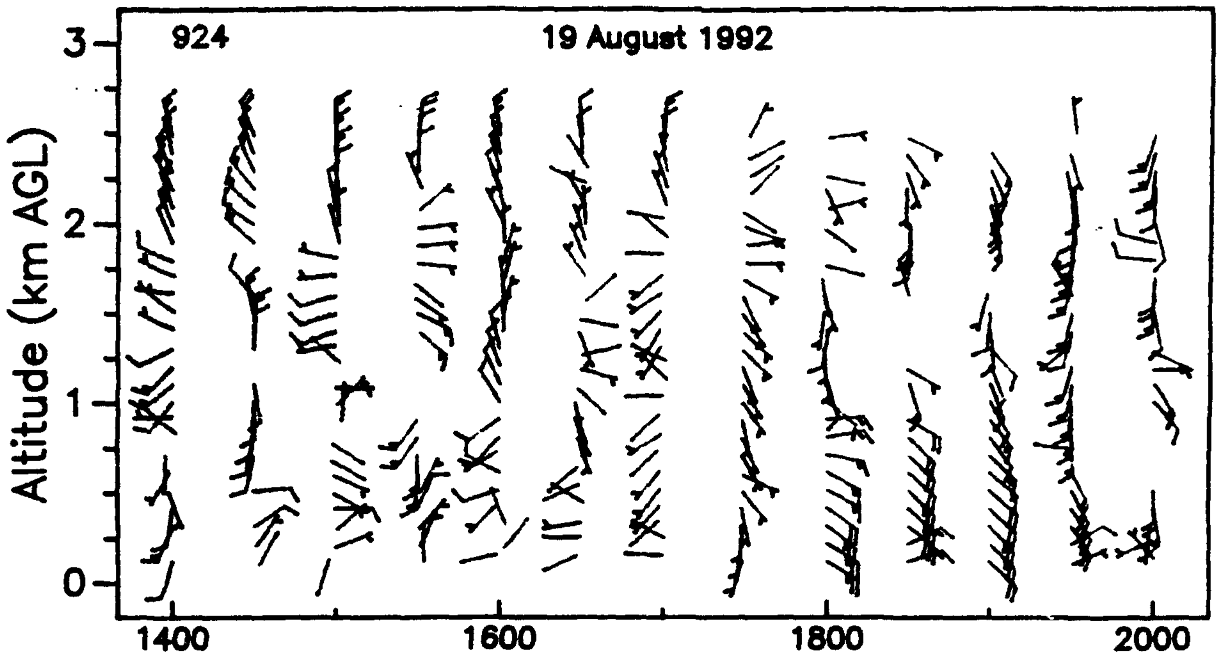
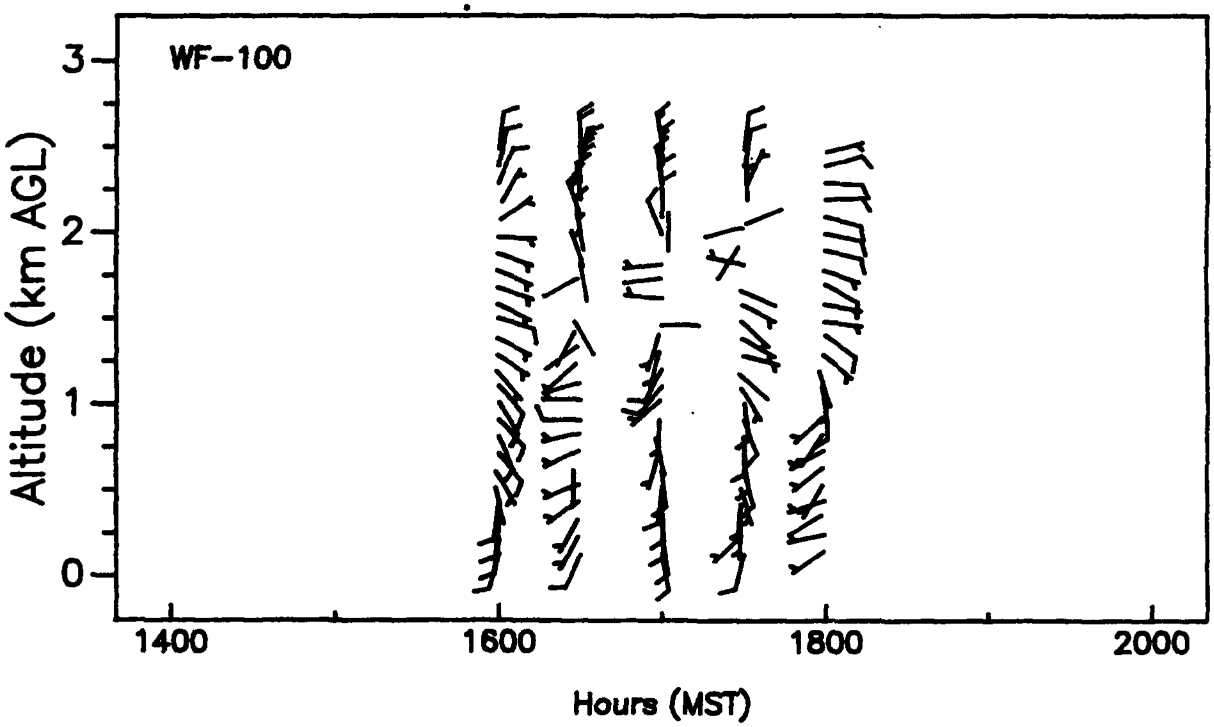


Figure 53. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 18 August 1992 (1-h averages).



(a)



(b)

Figure 54. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1400 to 2000 MST, 19 August 1992 (15-min averages for the 924 data).

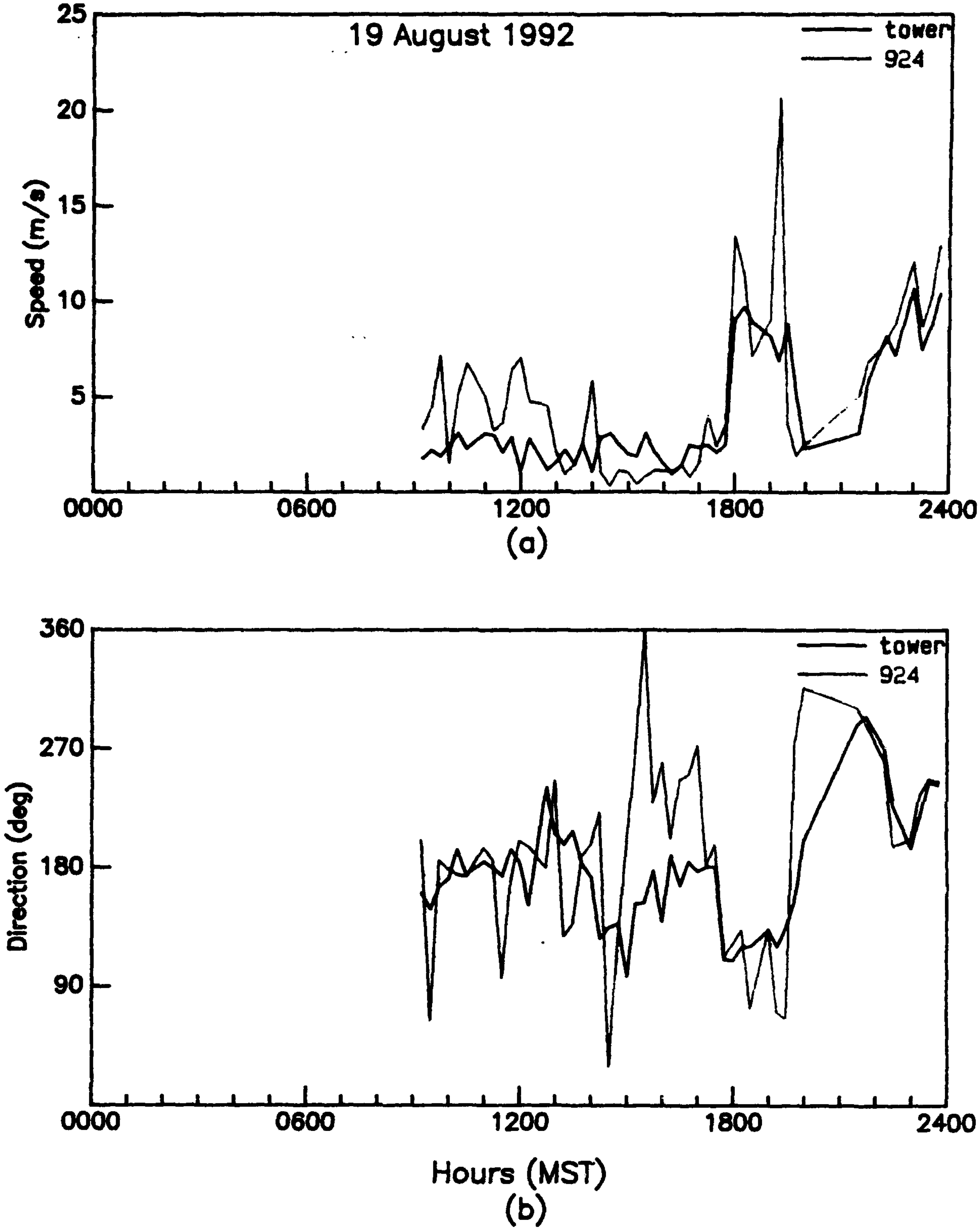


Figure 55. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 19 August 1992 (15-min averages).

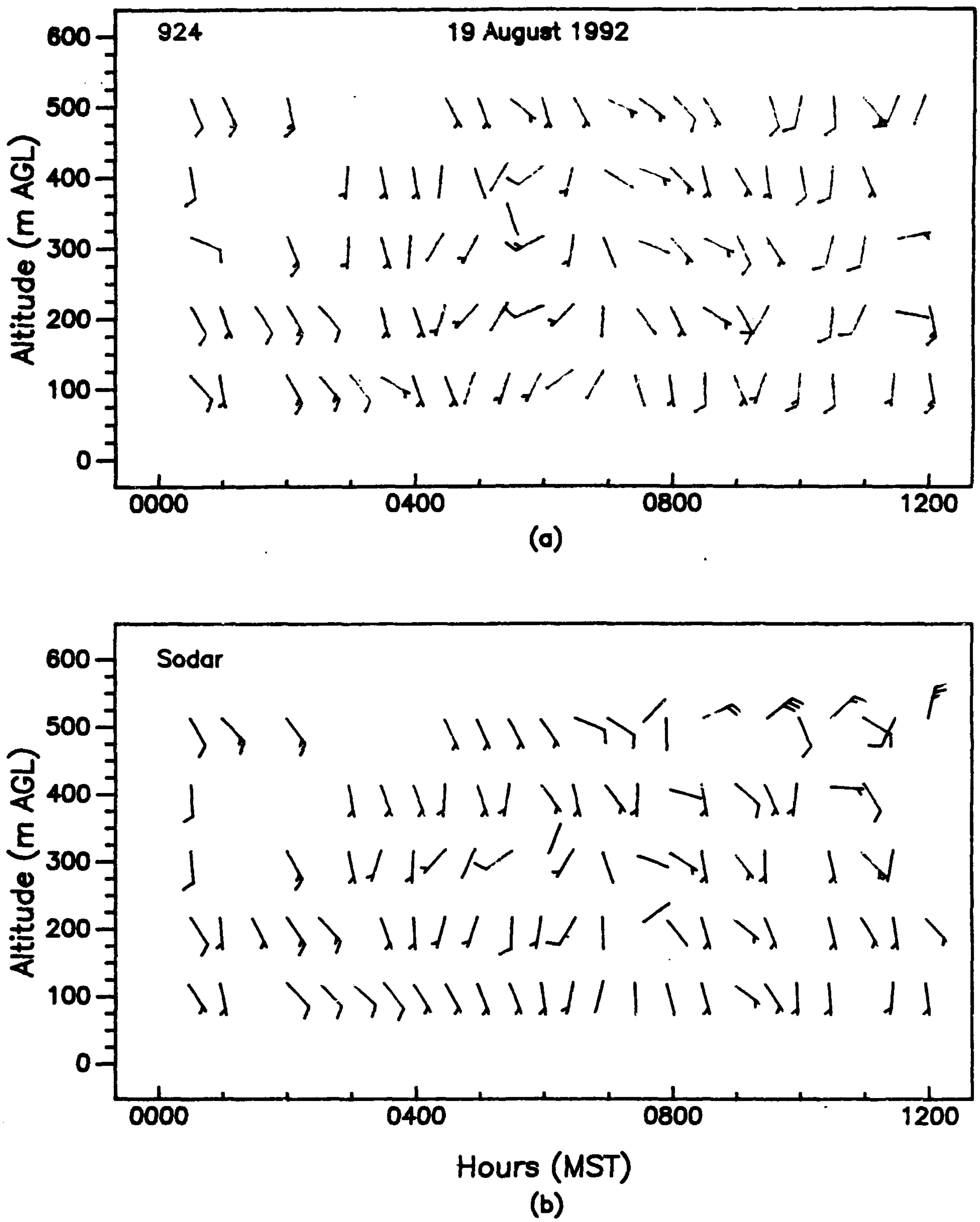
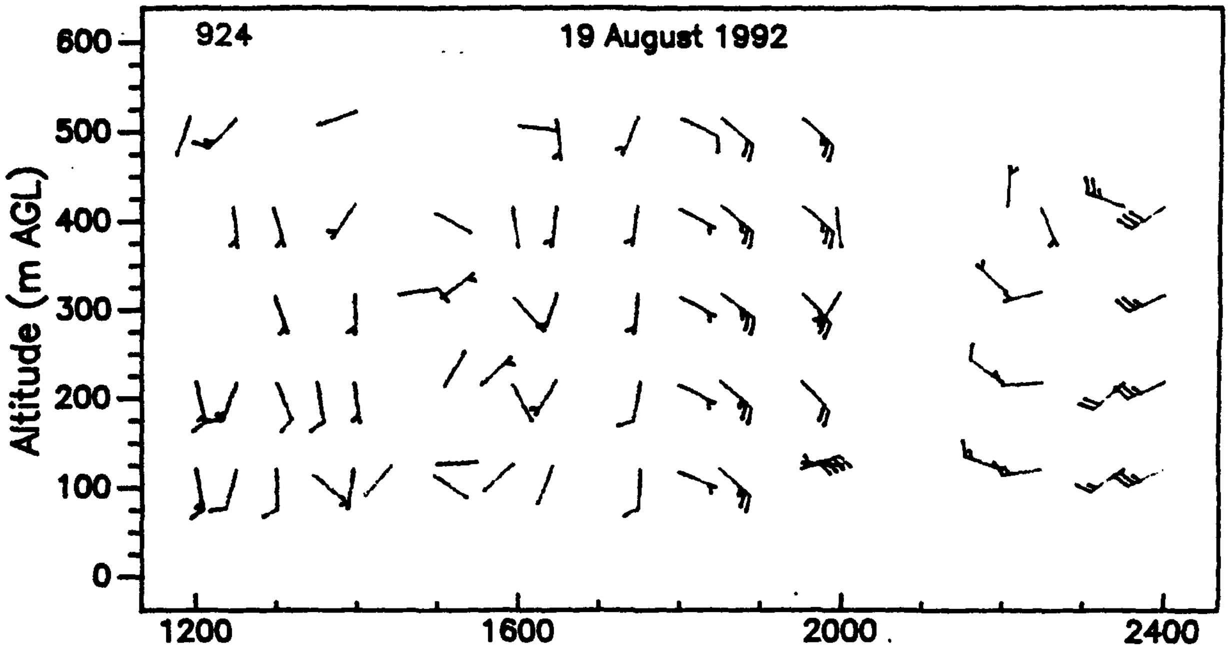
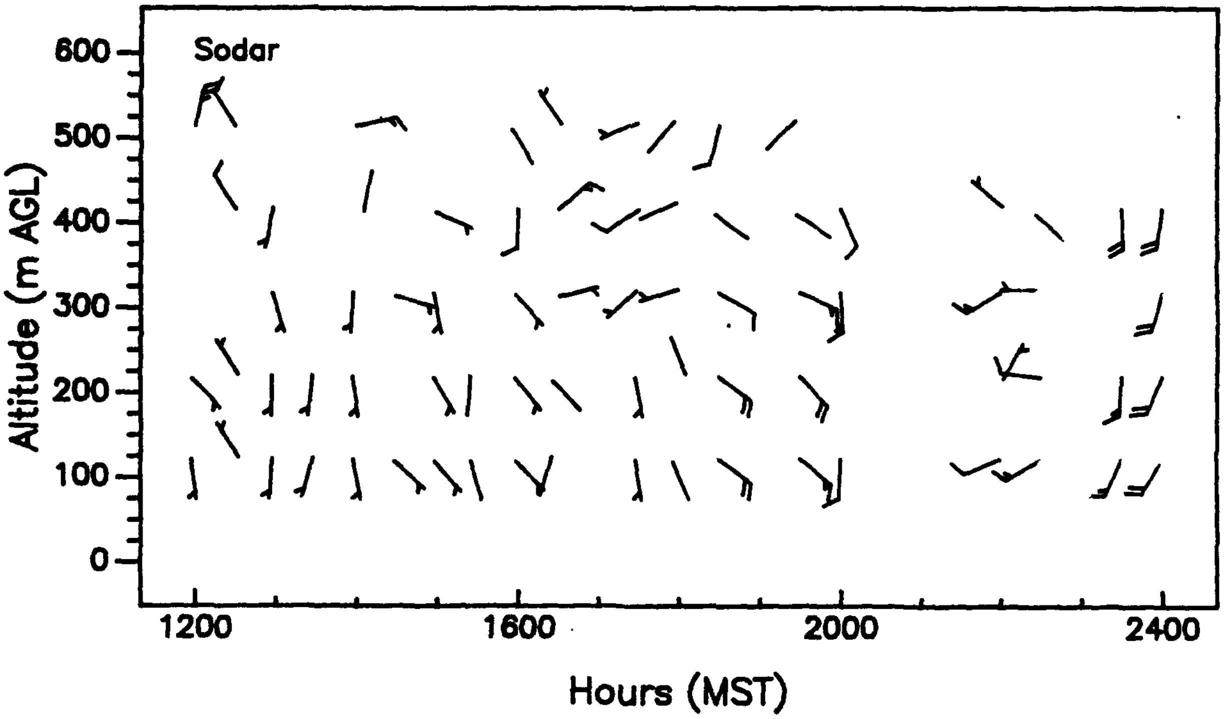


Figure 56. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 19 August 1992 (15-min averages).



(a)



(b)

Figure 57. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 19 August 1992 (15-min averages).

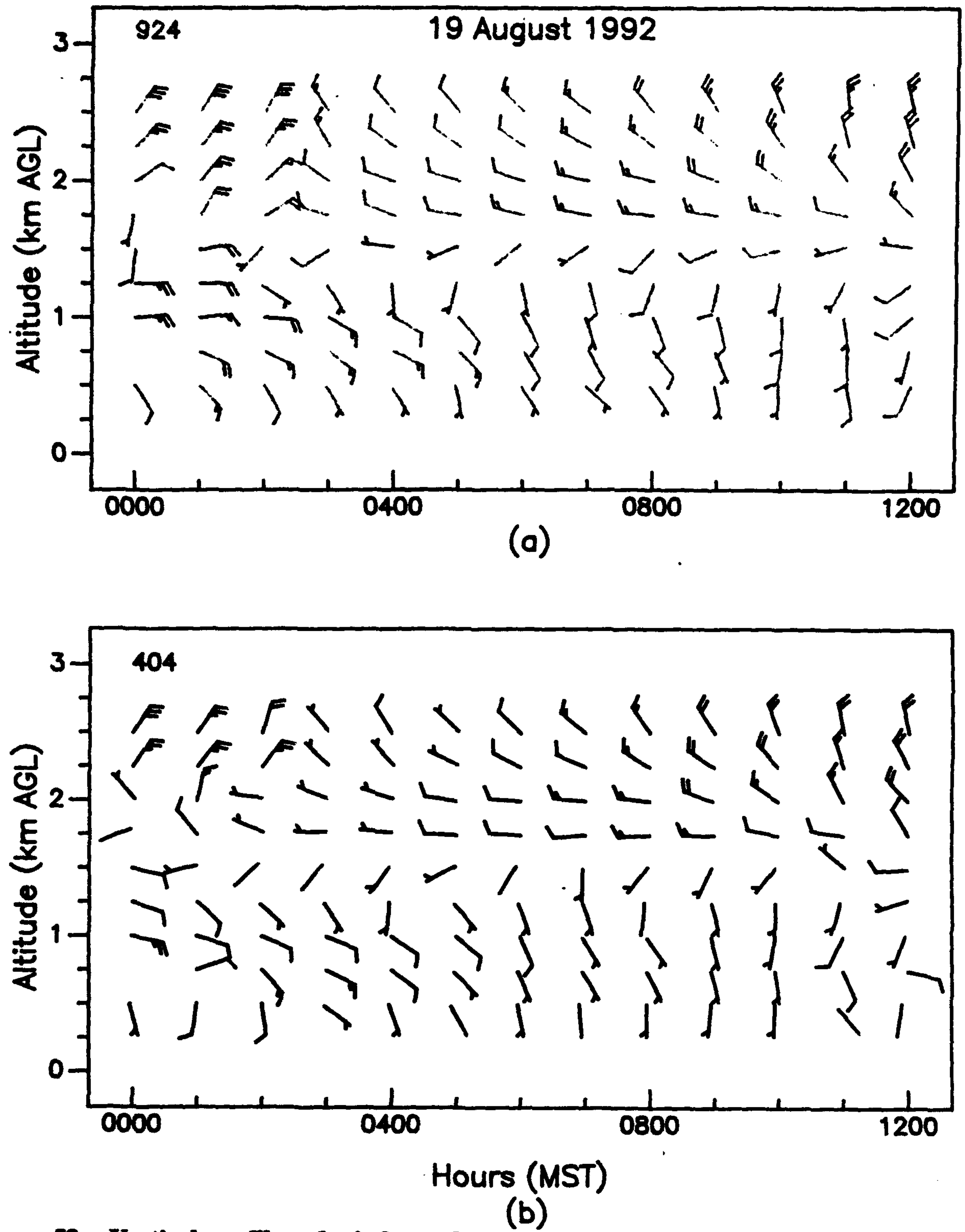


Figure 58. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 19 August 1992 (1-h averages).

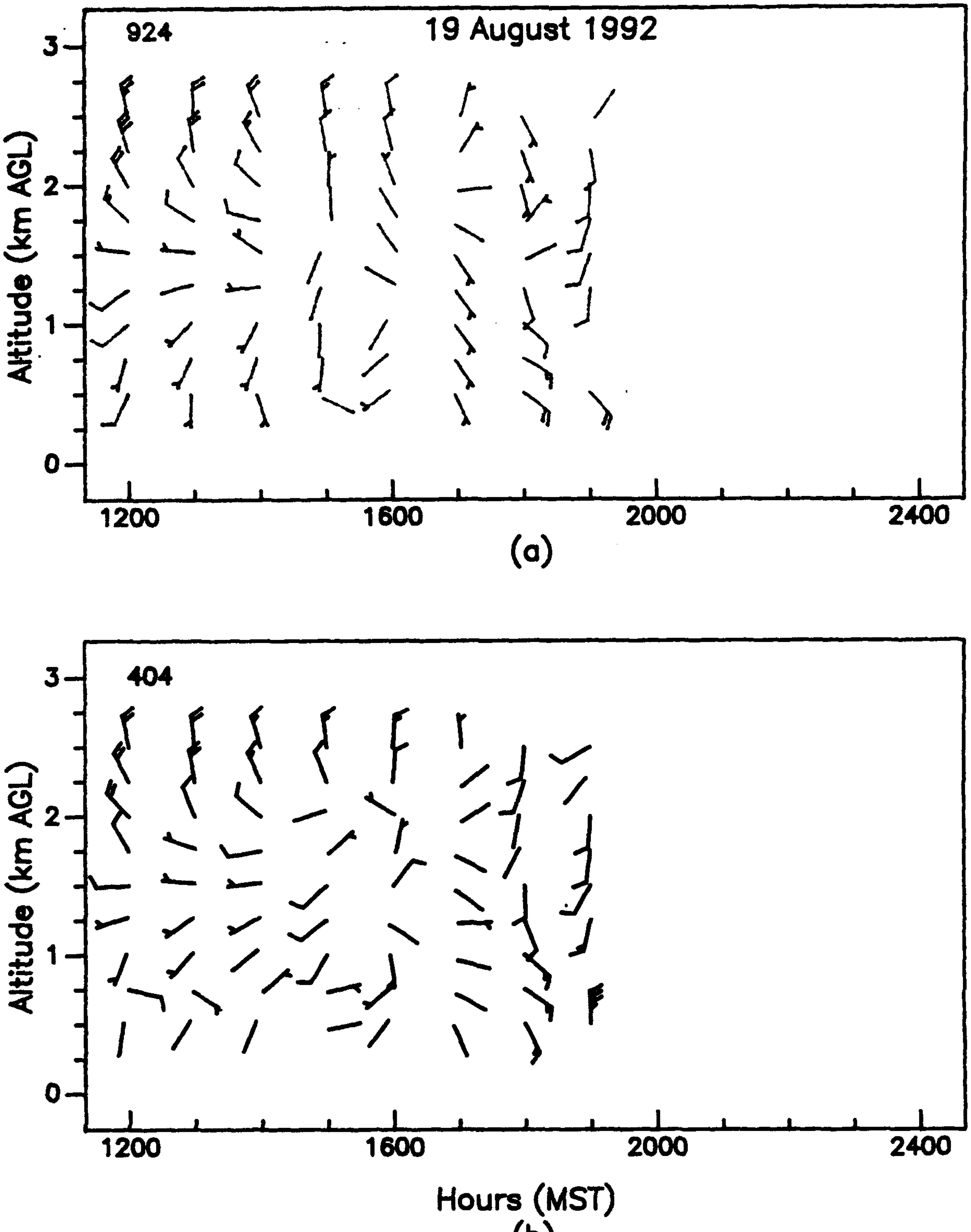


Figure 59. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 19 August 1992 (1-h averages).

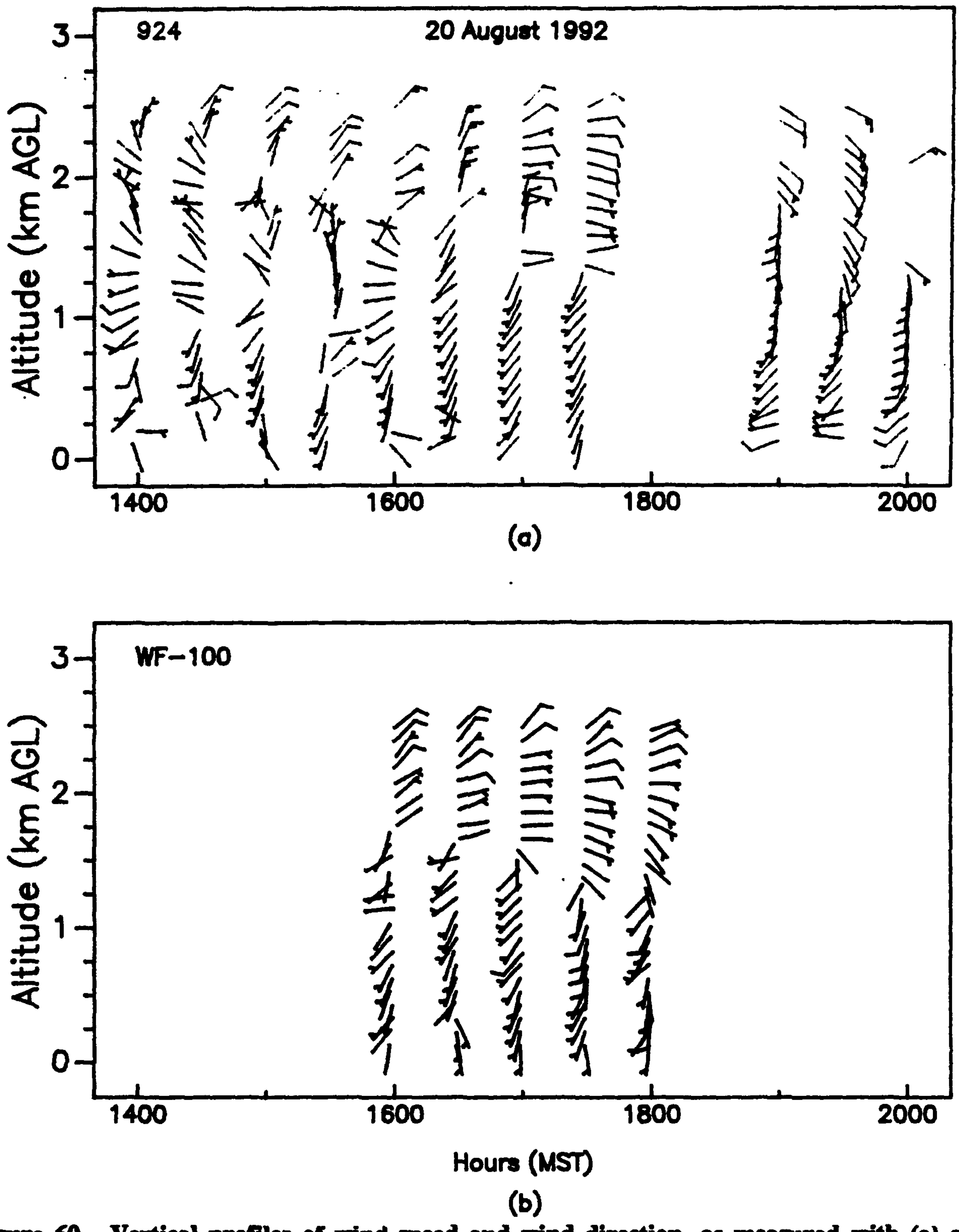


Figure 60. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1400 to 2000 MST, 20 August 1992 (15-min averages for the 924 data).

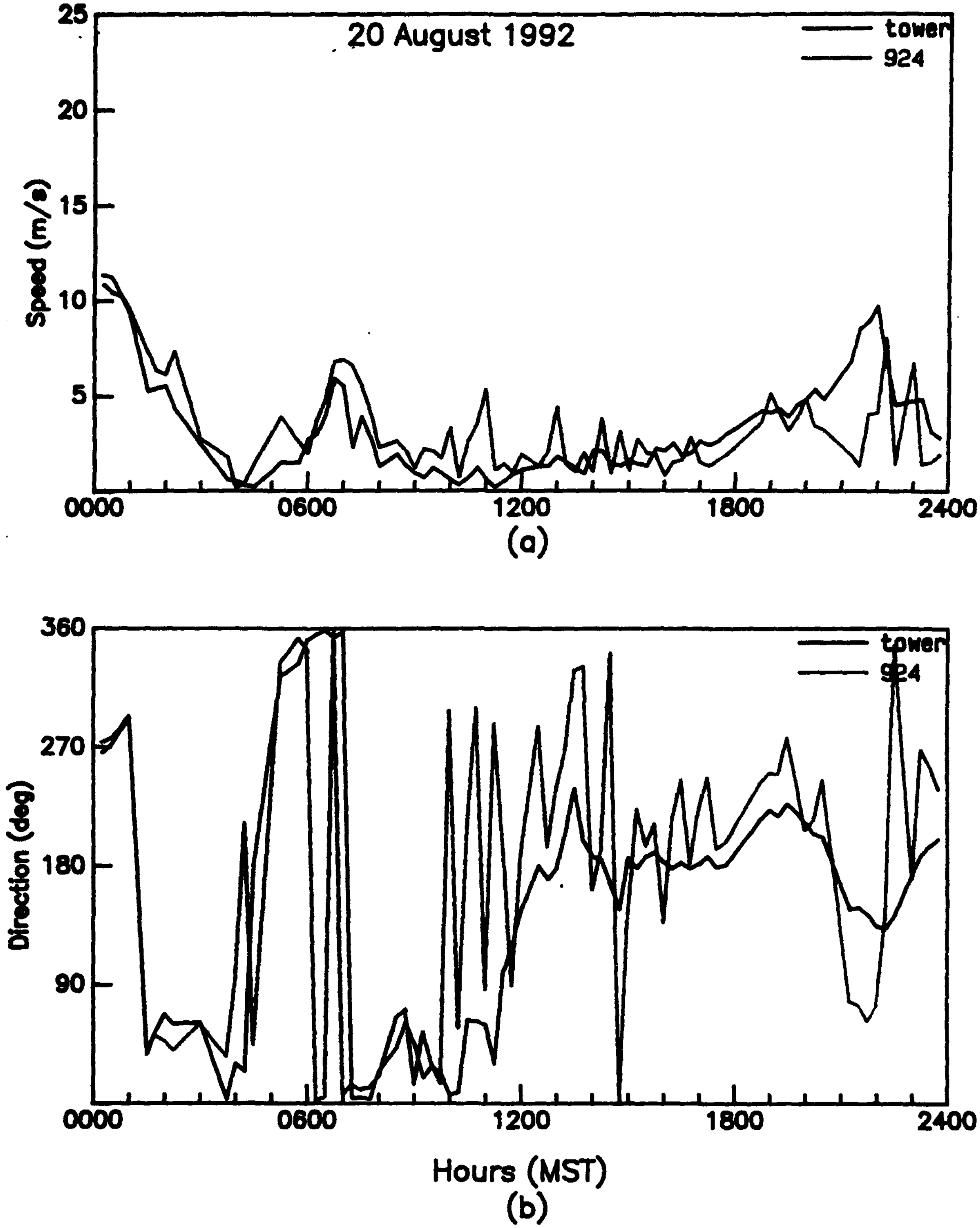


Figure 61. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 20 August 1992 (15-min averages).

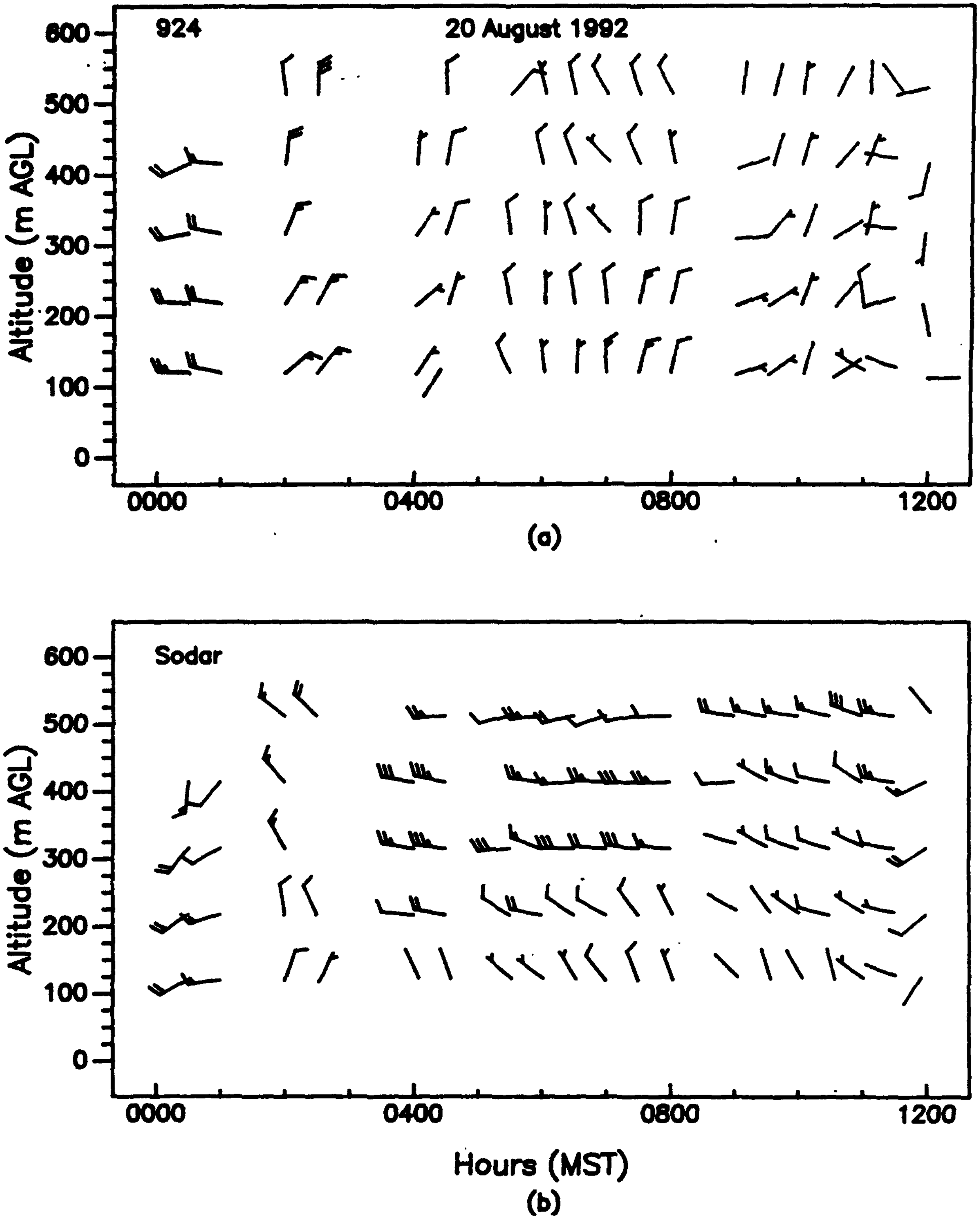
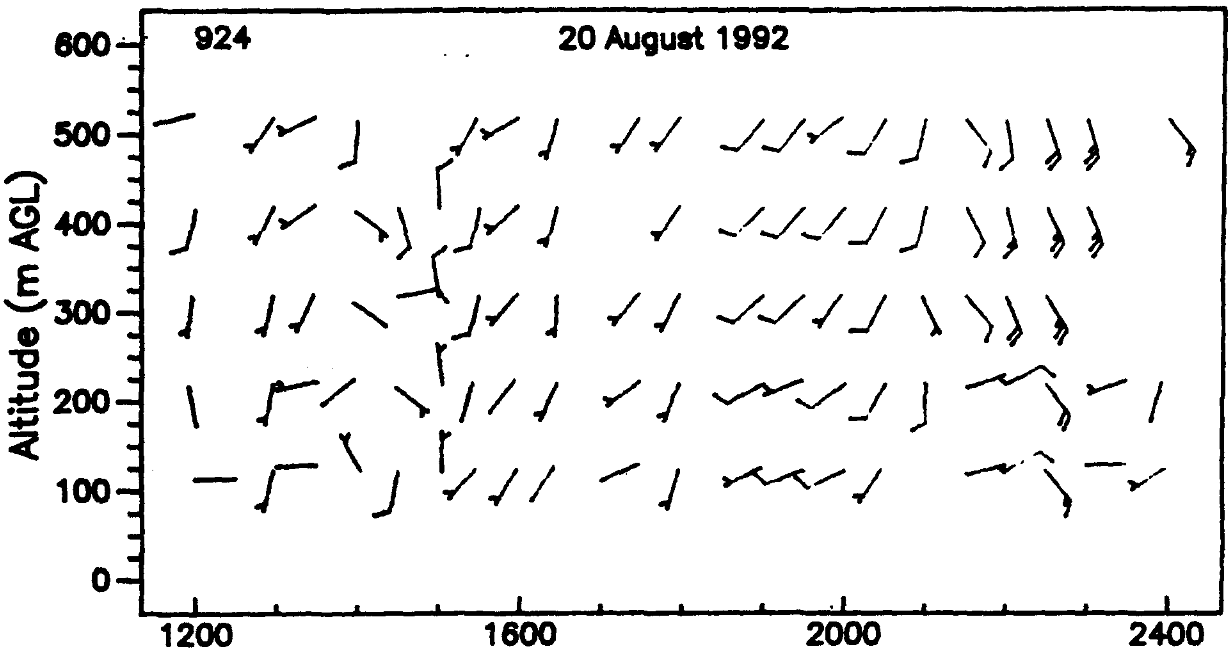
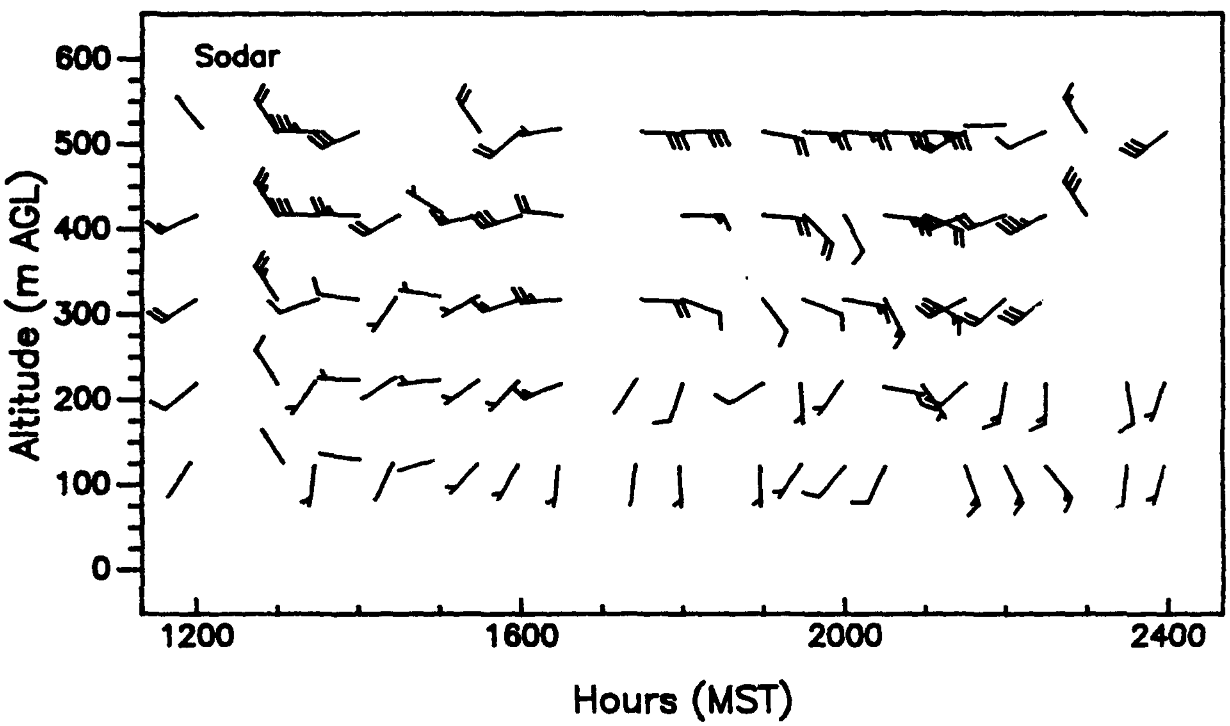


Figure 62. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 20 August 1992 (15-min averages).



(a)



(b)

Figure 63. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 20 August 1992 (15-min averages).

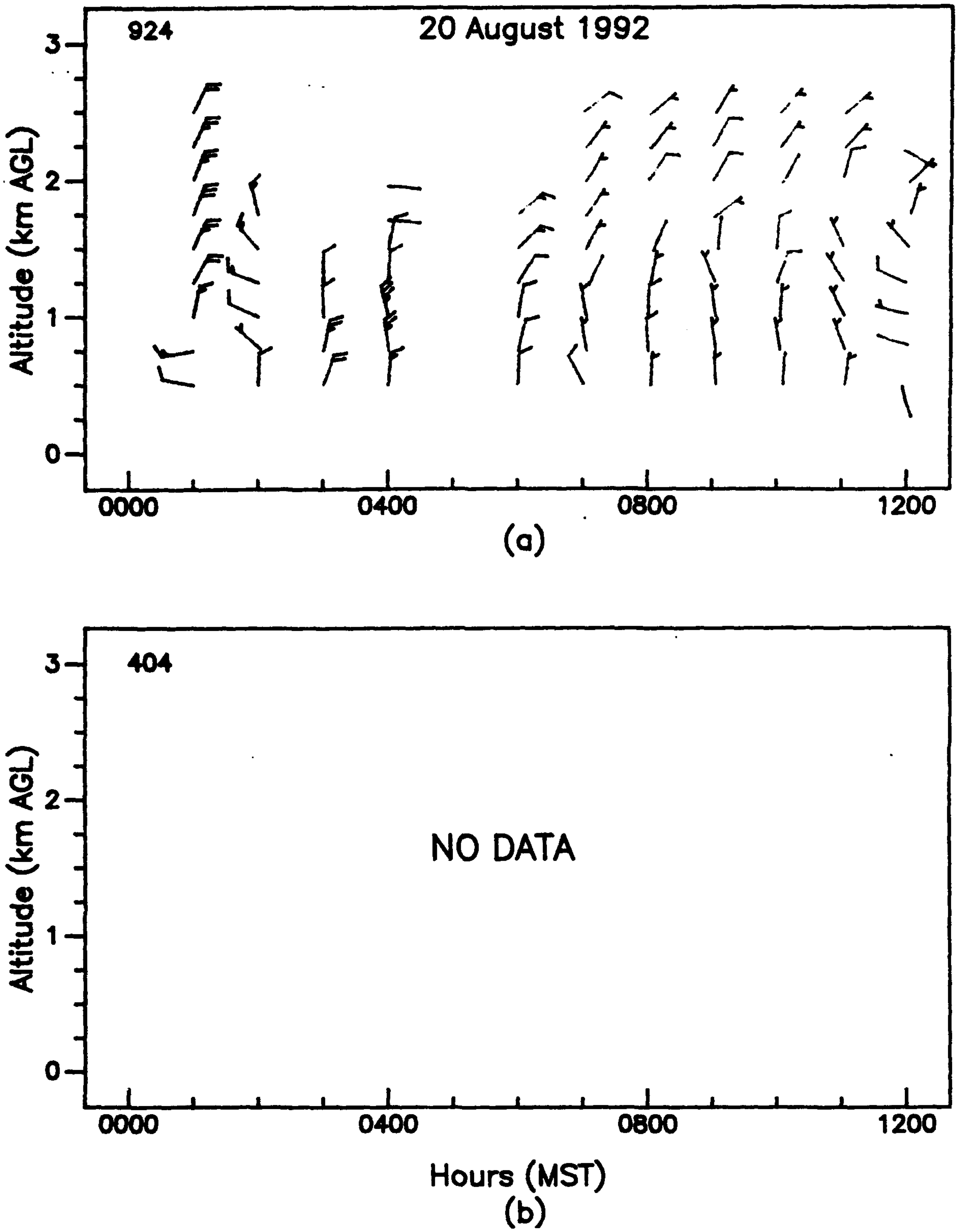
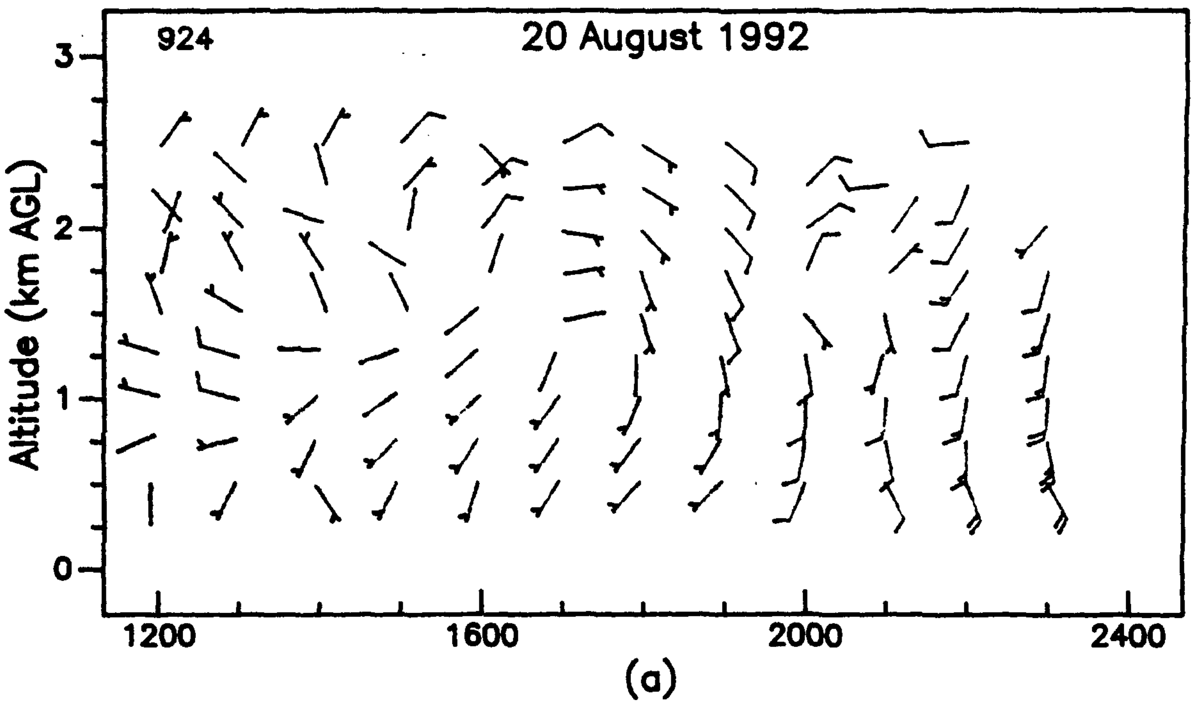


Figure 64. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 20 August 1992 (1-h averages).



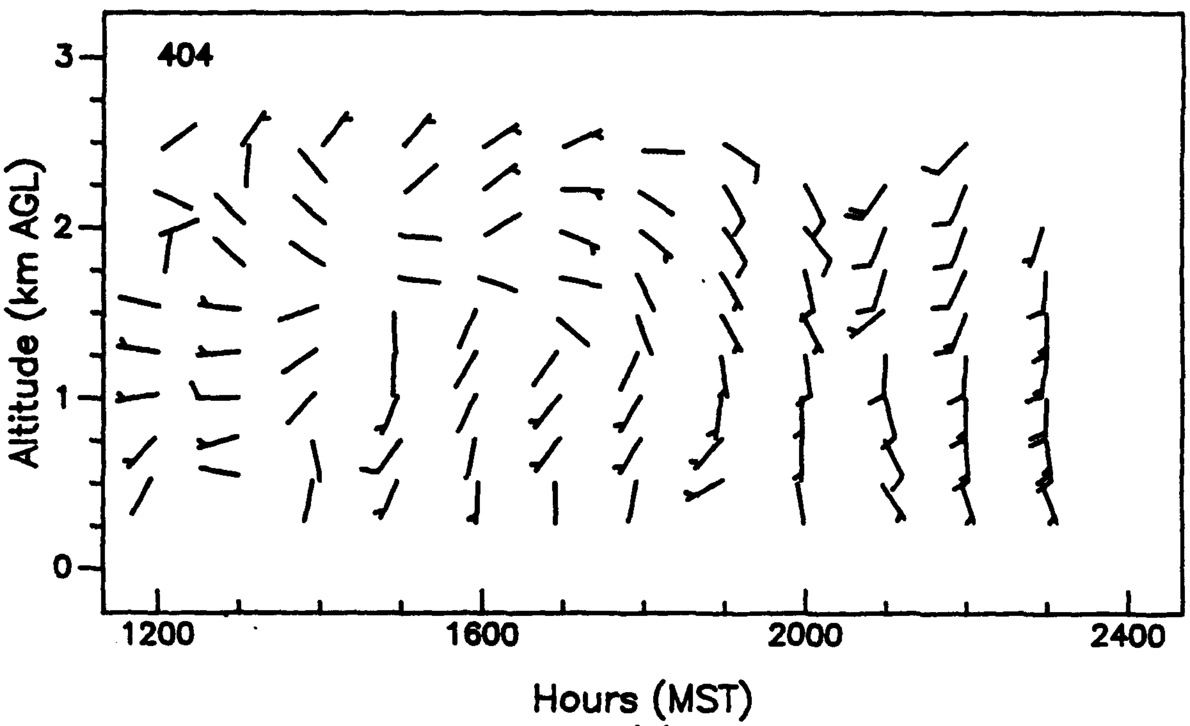


Figure 65. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 20 August 1992 (1-h averages).

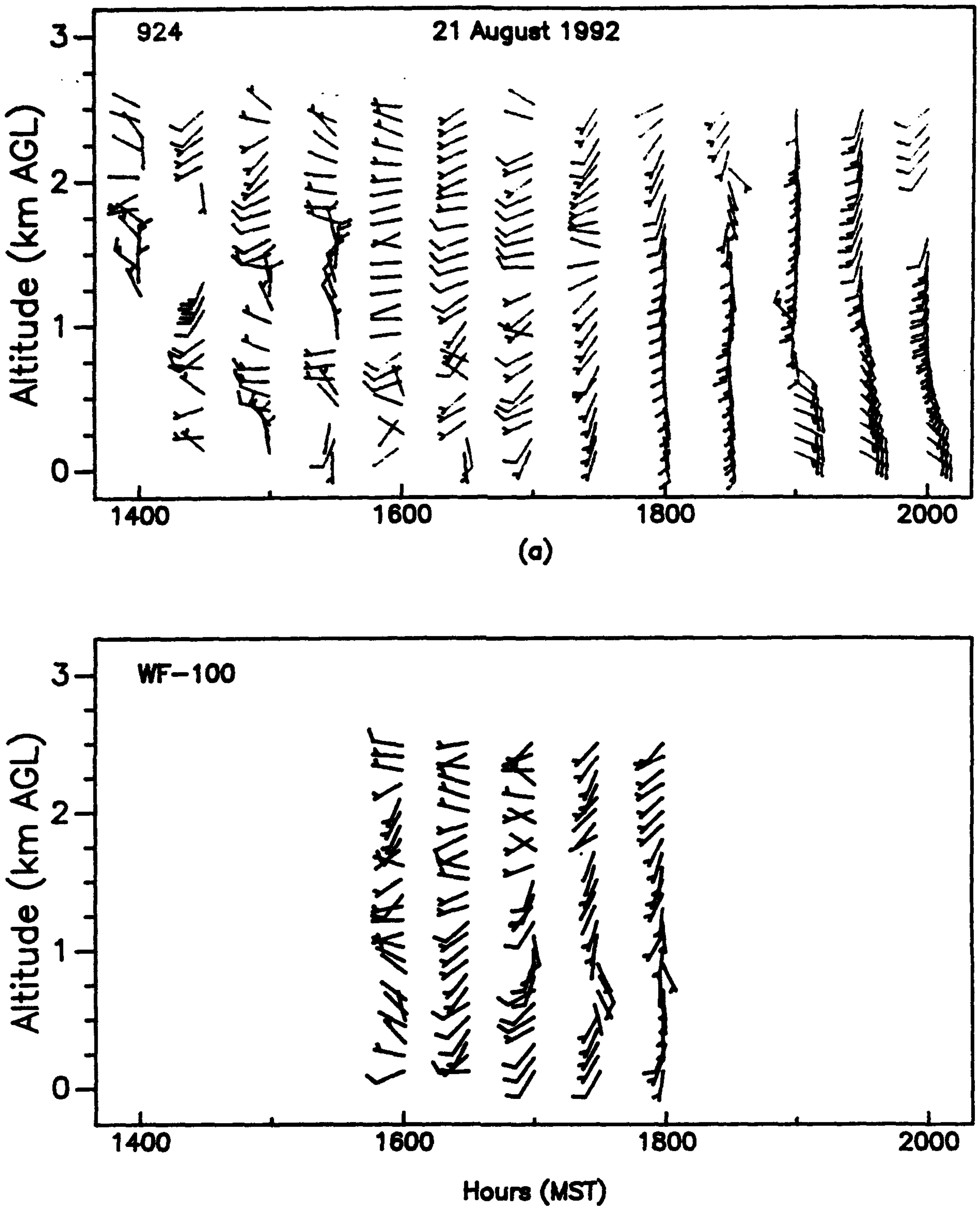


Figure 66. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1400 to 2000 MST, 21 August 1992 (15-min averages for the 924 data).

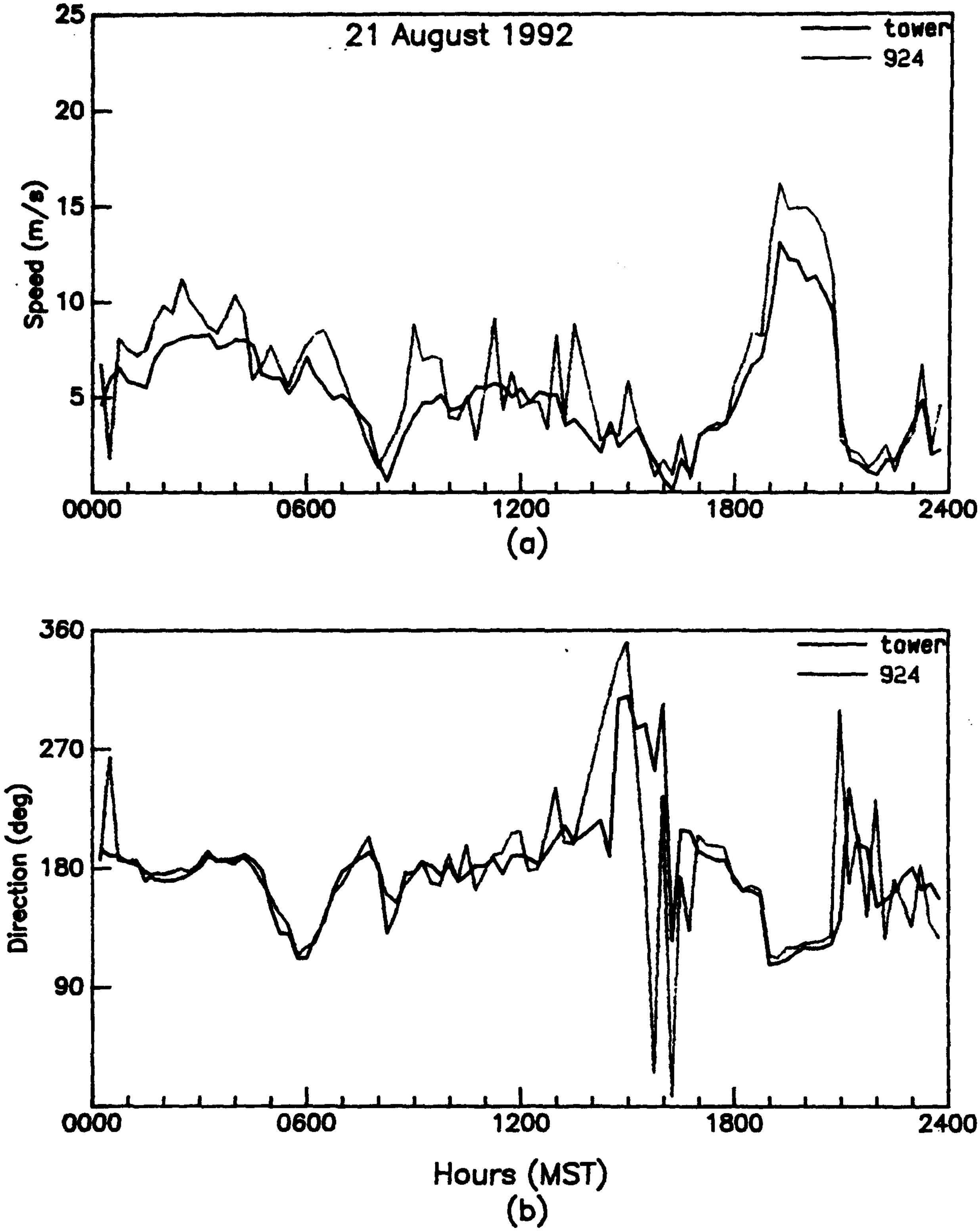


Figure 67. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 21 August 1992 (15-min averages).

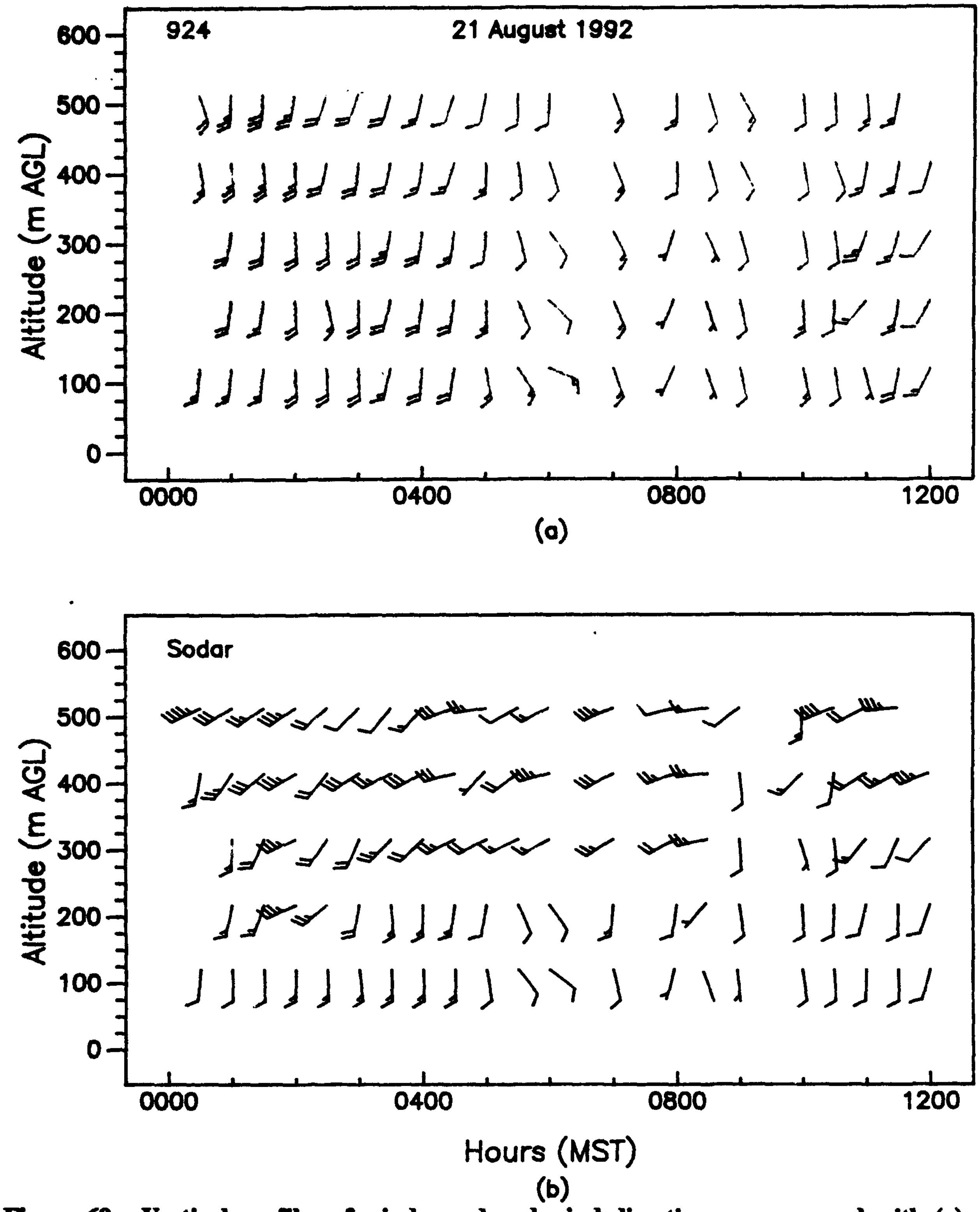


Figure 68. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 21 August 1992 (15-min averages).

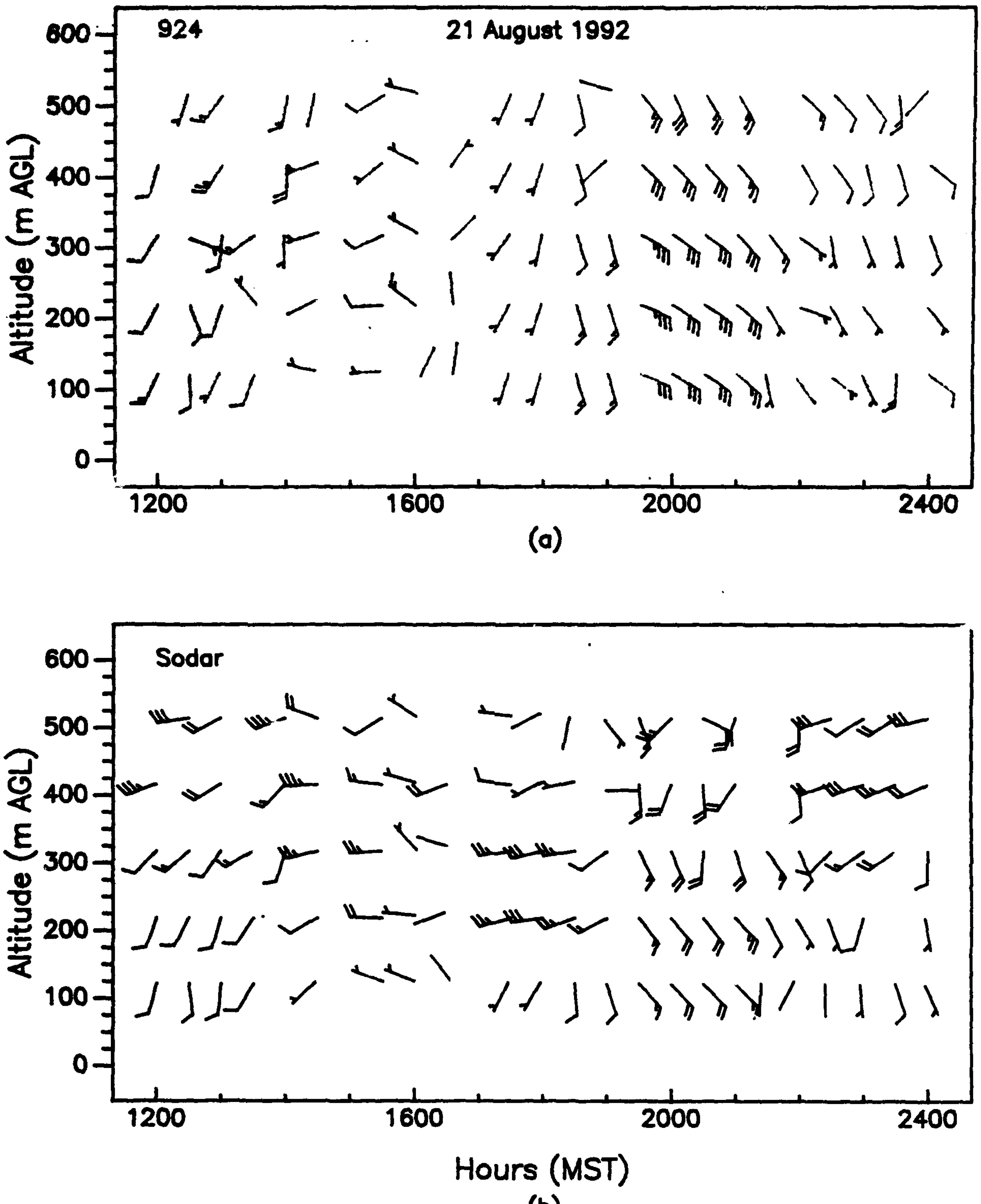


Figure 69. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 21 August 1992 (15-min averages).

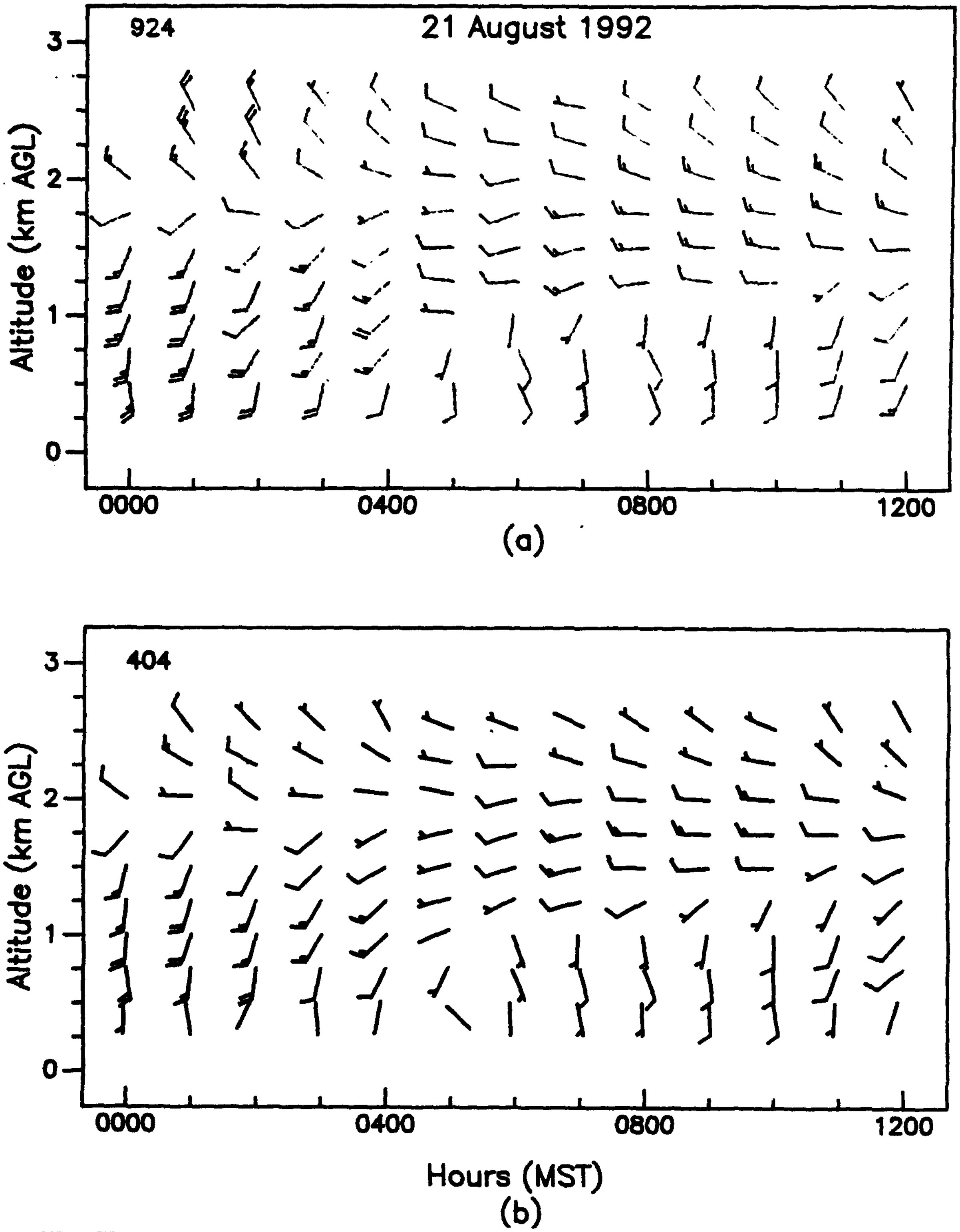


Figure 70. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 21 August 1992 (1-h averages).

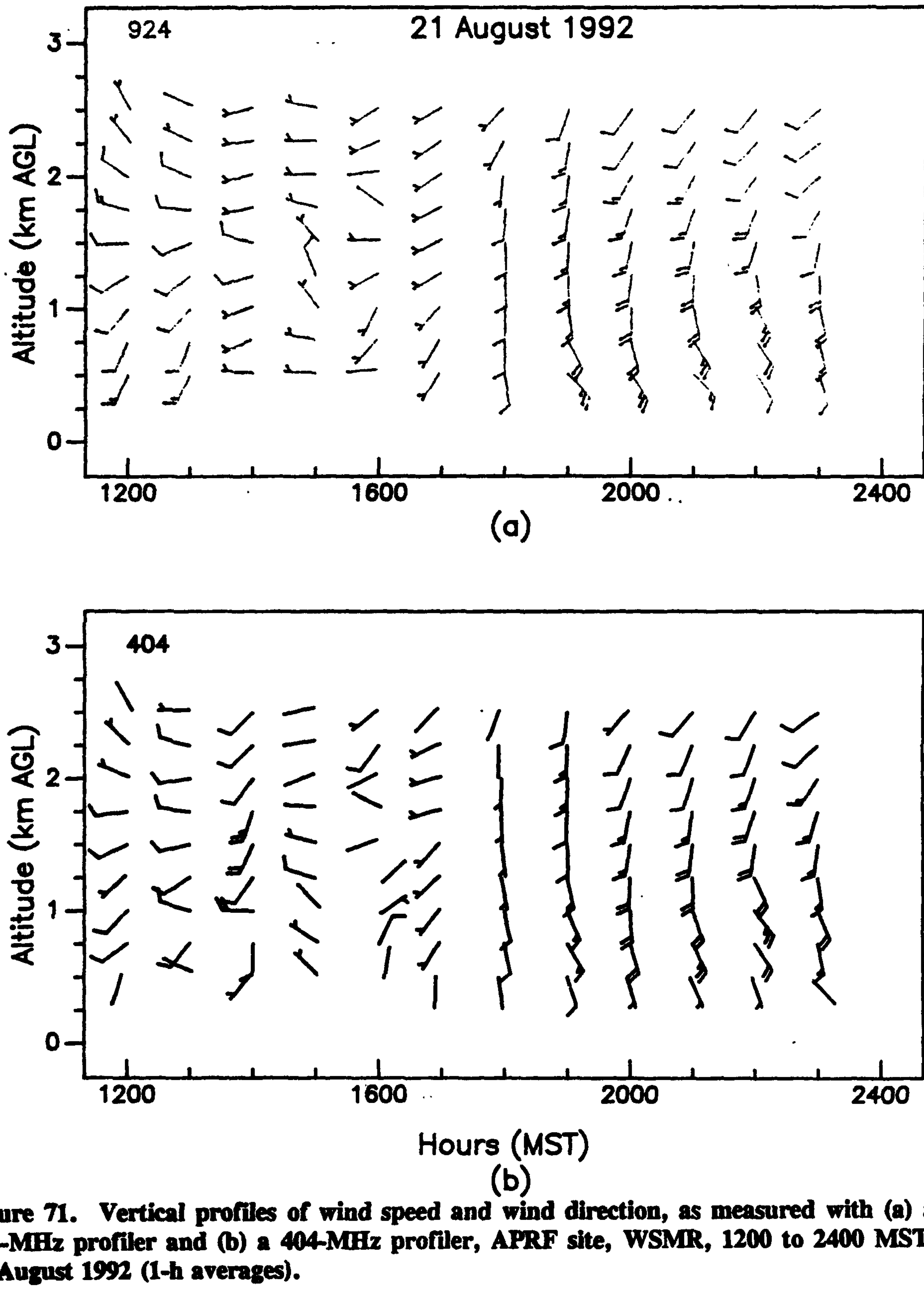
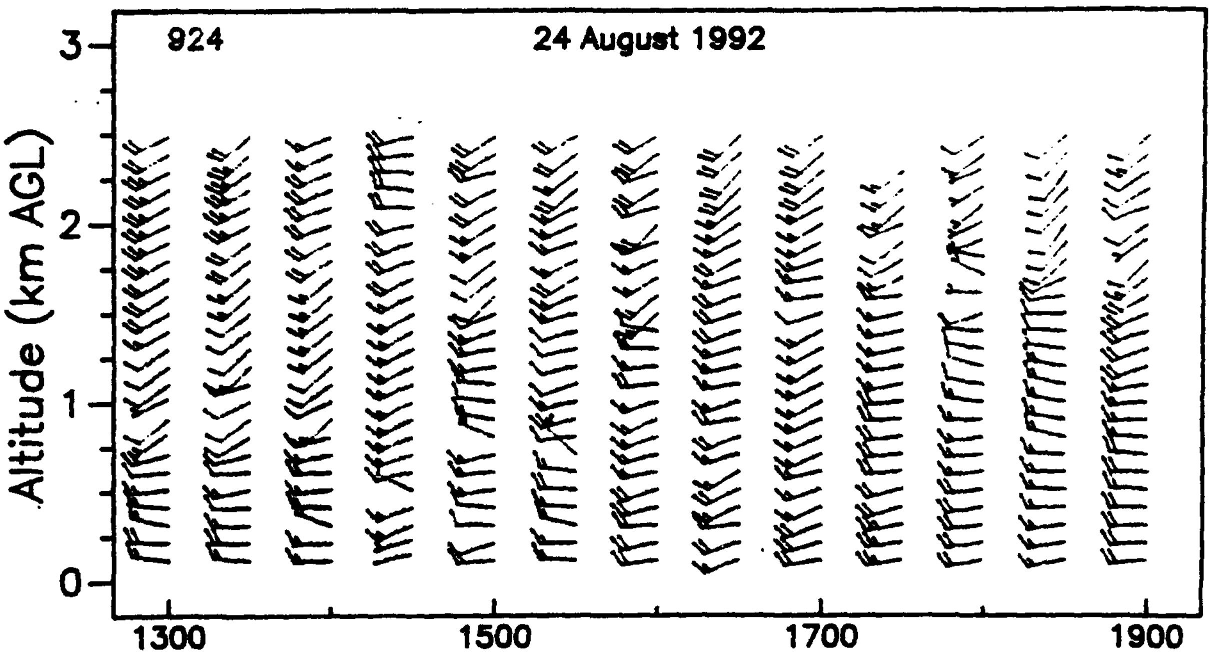
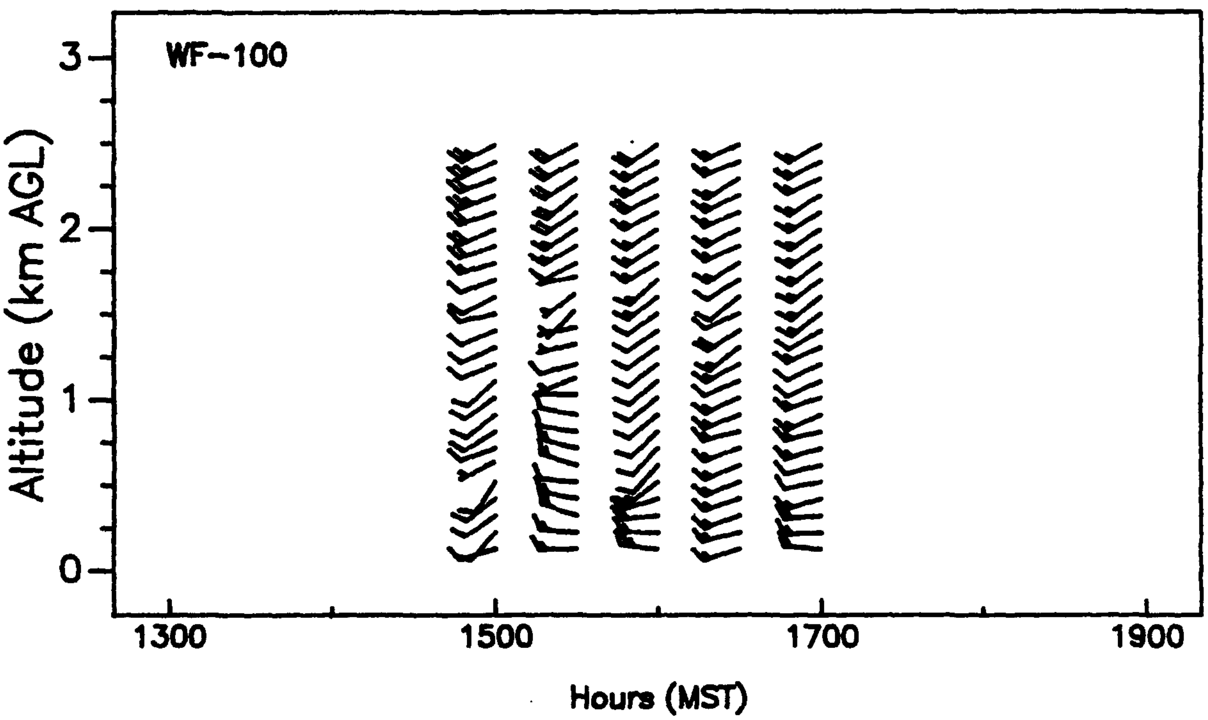


Figure 71. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 21 August 1992 (1-h averages).



(a)



(b)

Figure 72. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1300 to 1900 MST, 24 August 1992 (15-min averages for the 924 data).

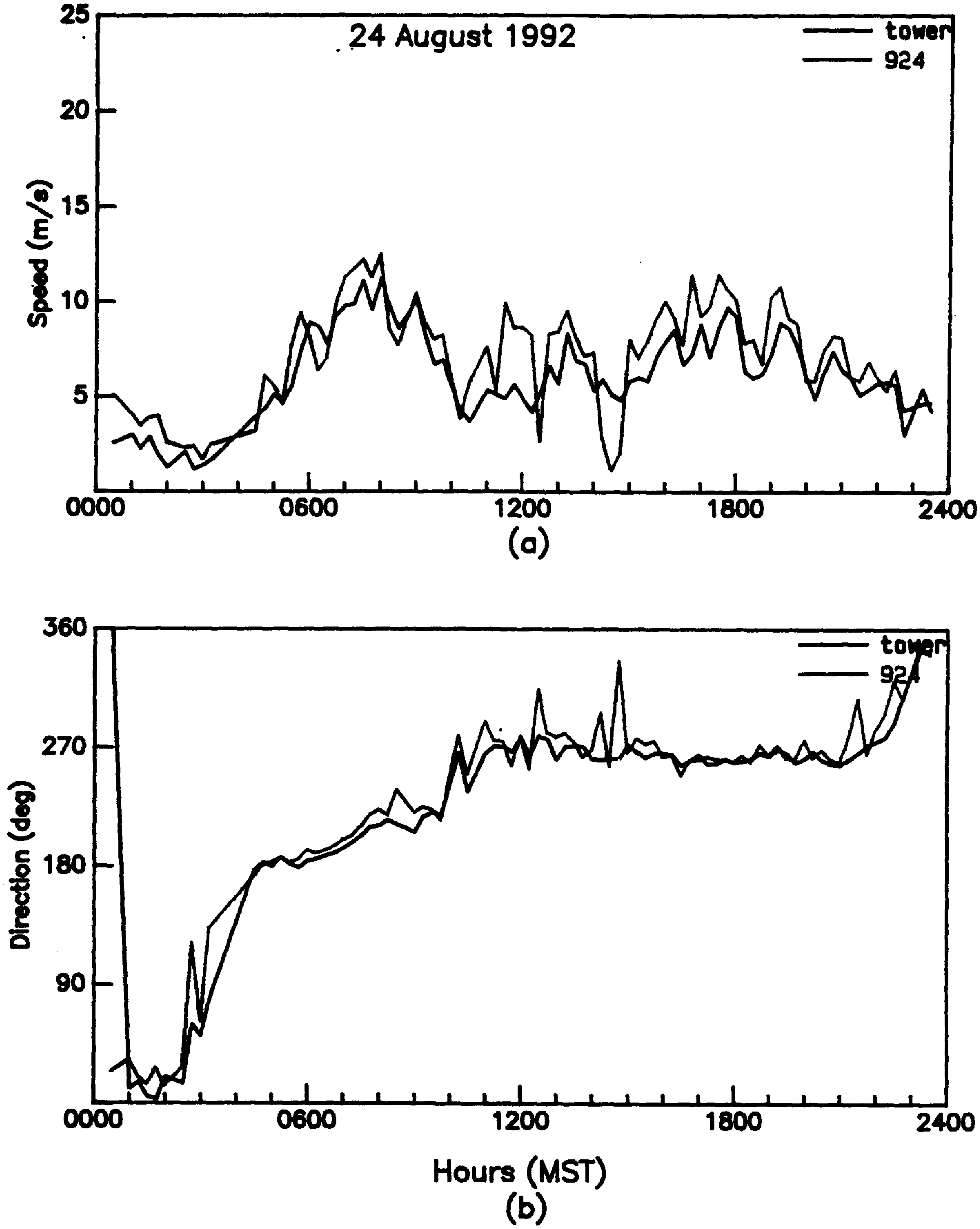


Figure 73. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 24 August 1992 (15-min averages).

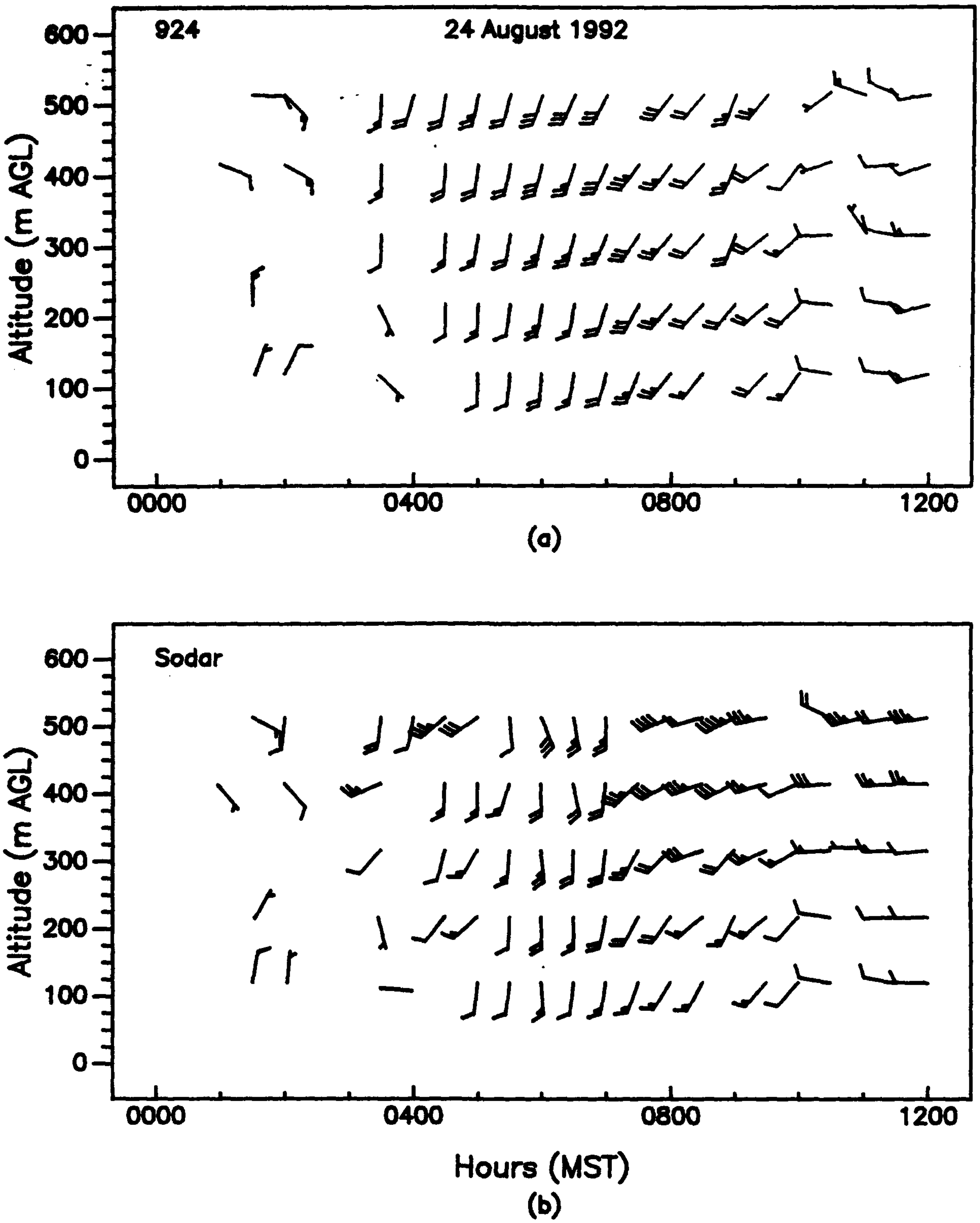


Figure 74. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 24 August 1992 (15-min averages).

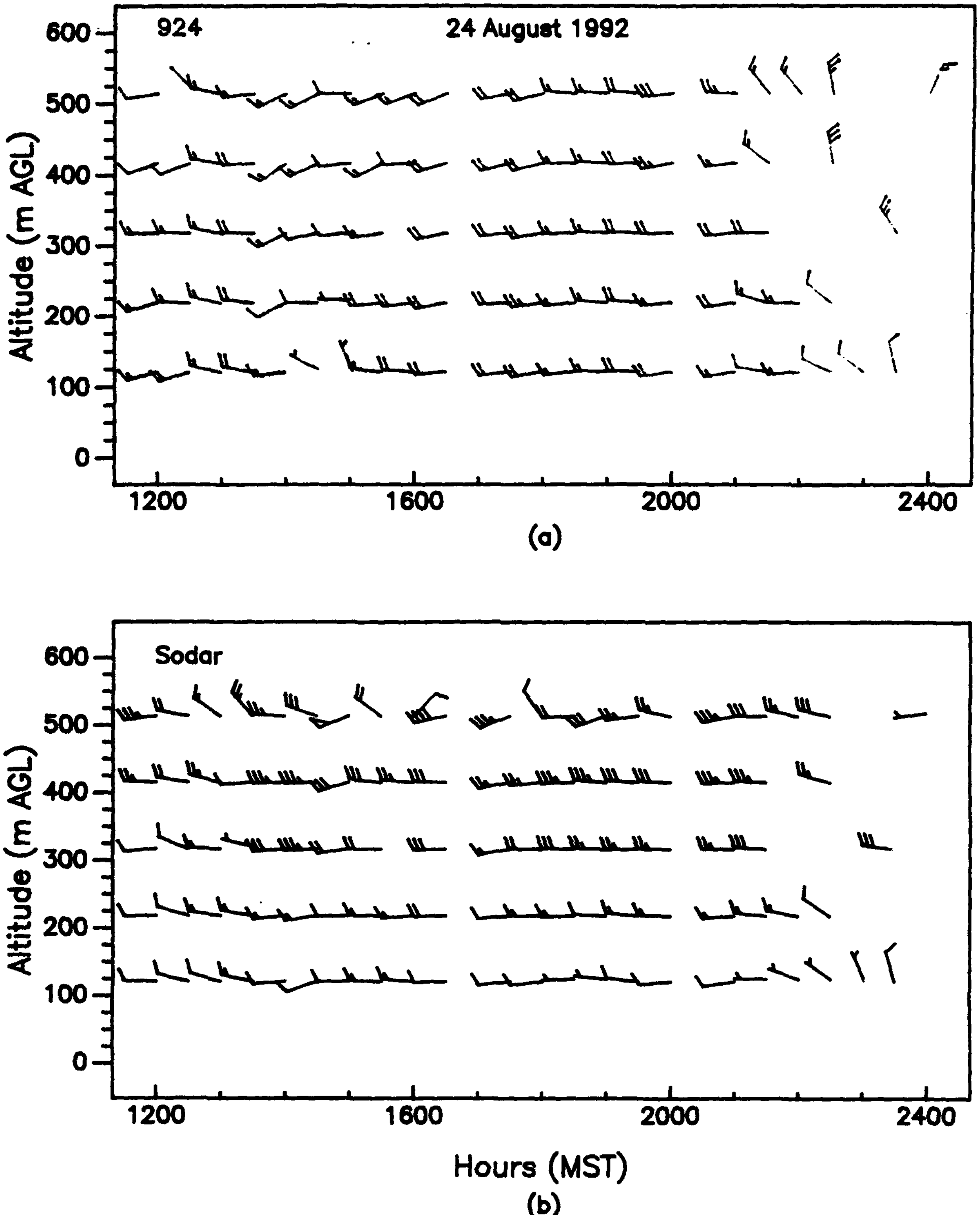


Figure 75. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 24 August 1992 (15-min averages).

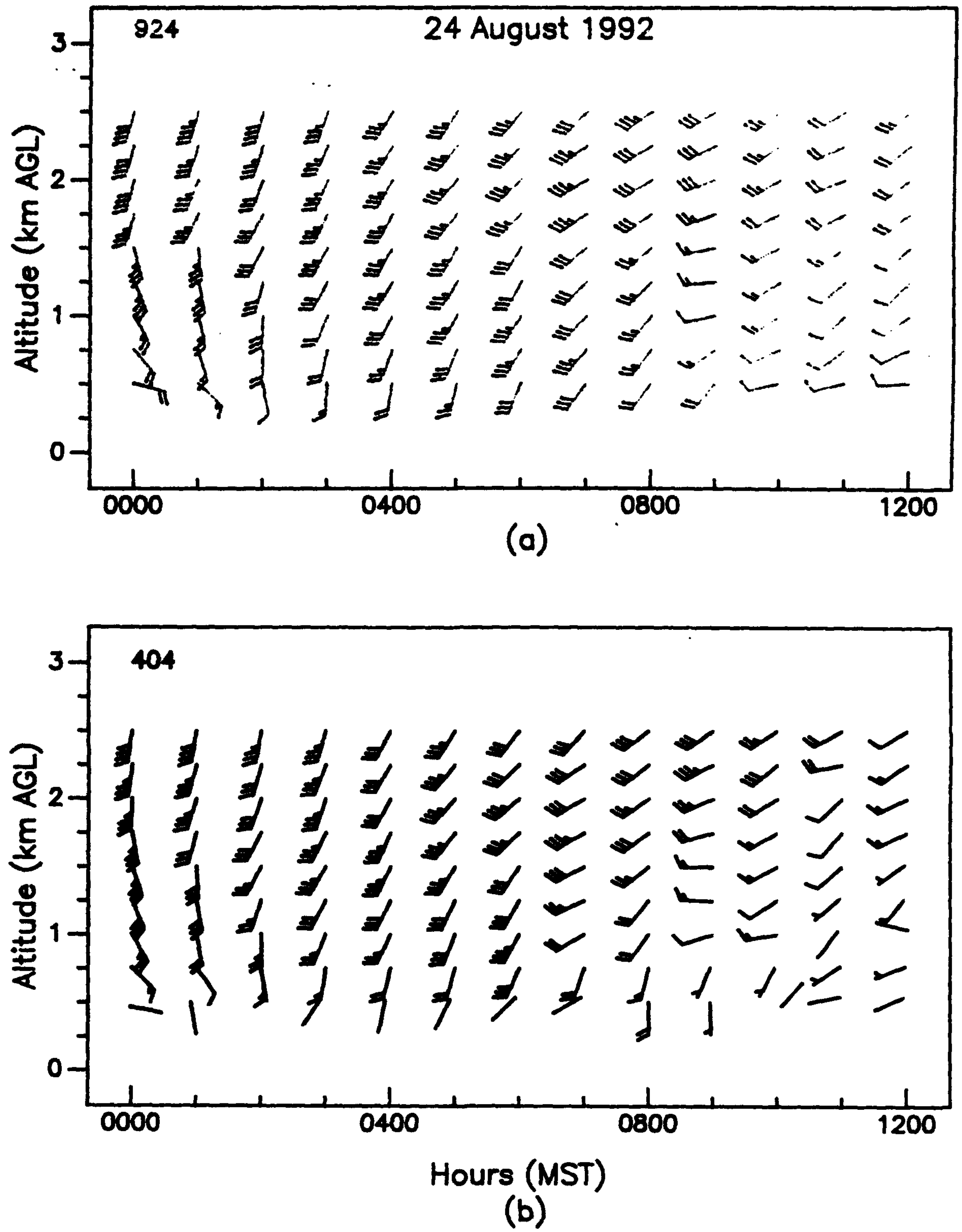
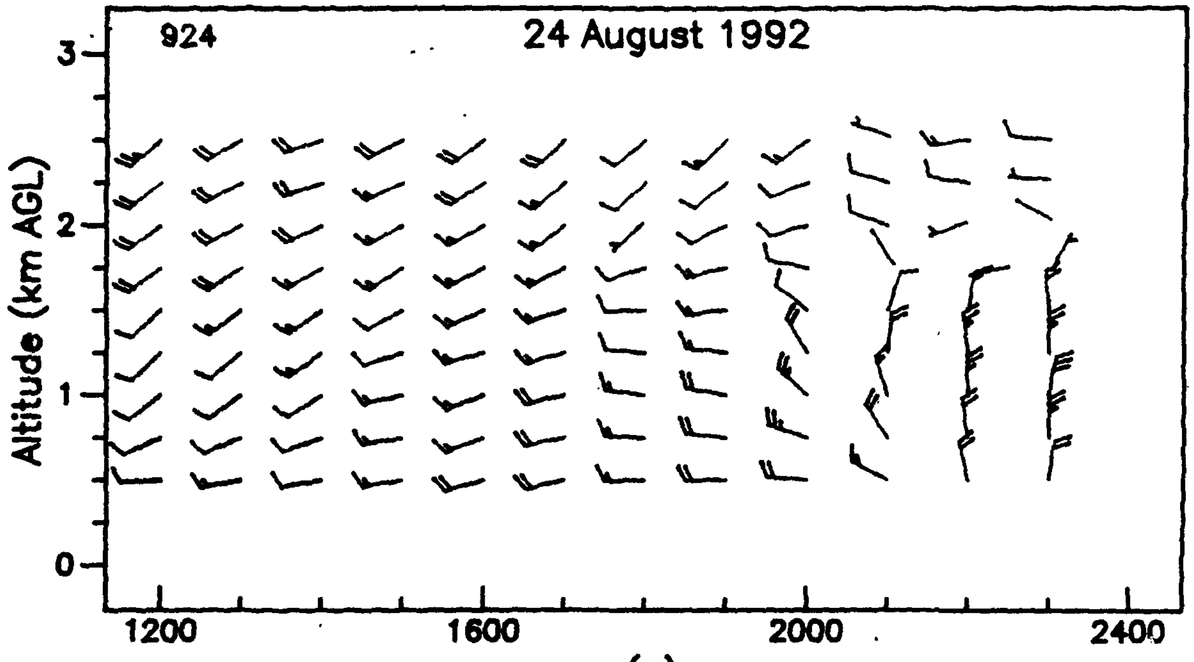
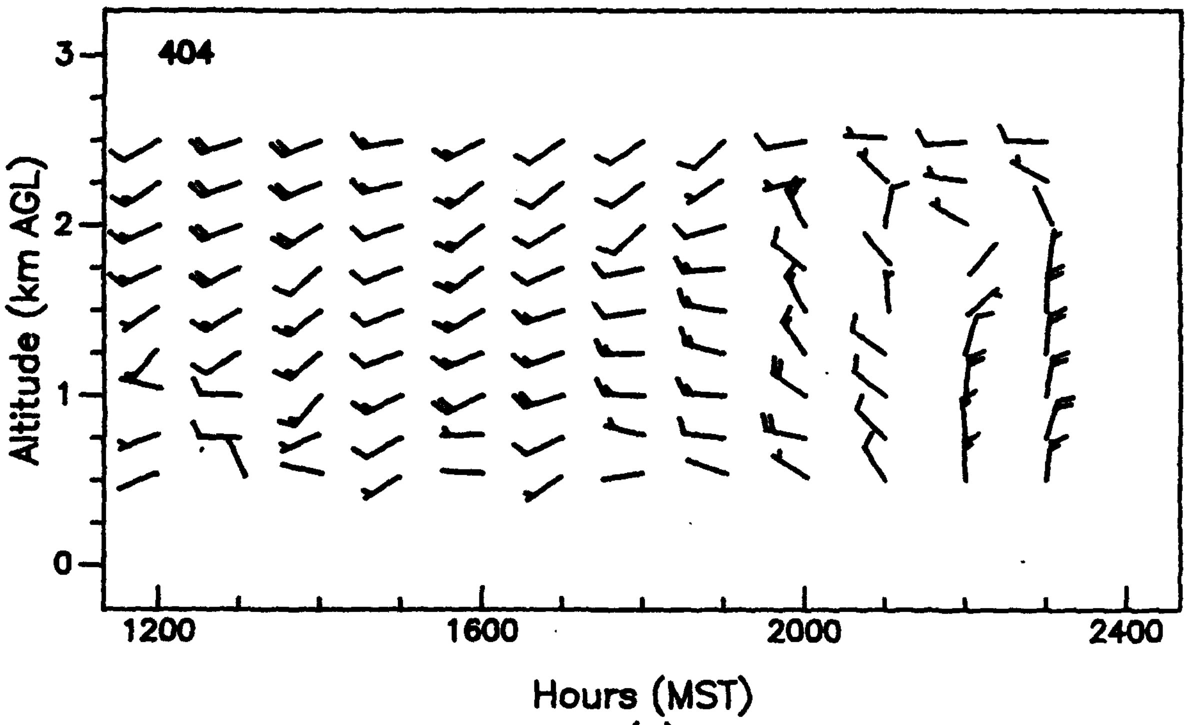


Figure 76. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 24 August 1992 (1-h averages).



(a)



(b)

Figure 77. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 24 August 1992 (1-h averages).

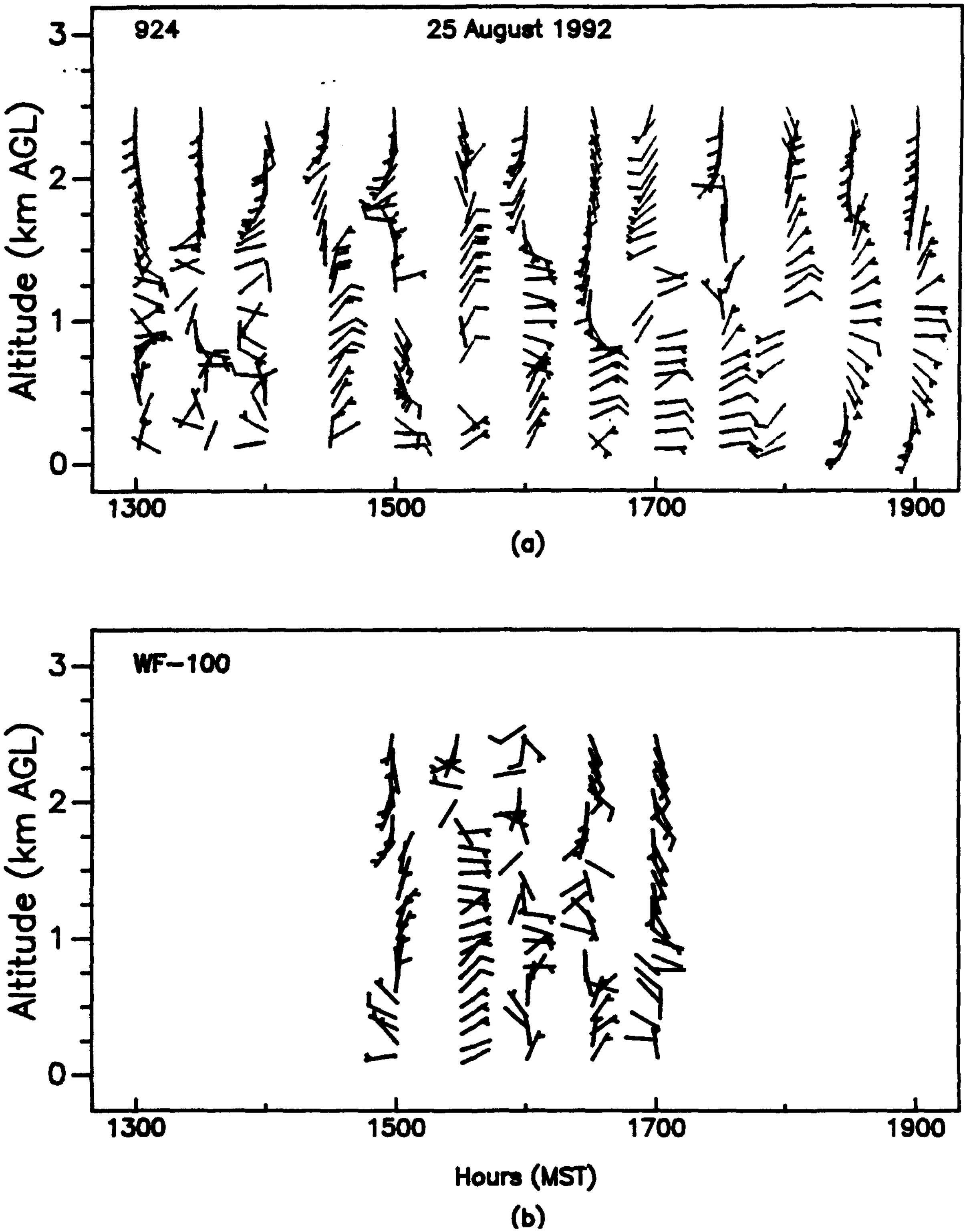


Figure 78. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler at APRF site and (b) a WF-100 radar at Oasis site, WSMR, 1300 to 1900 MST, 25 August 1992 (15-min averages for the 924 data).

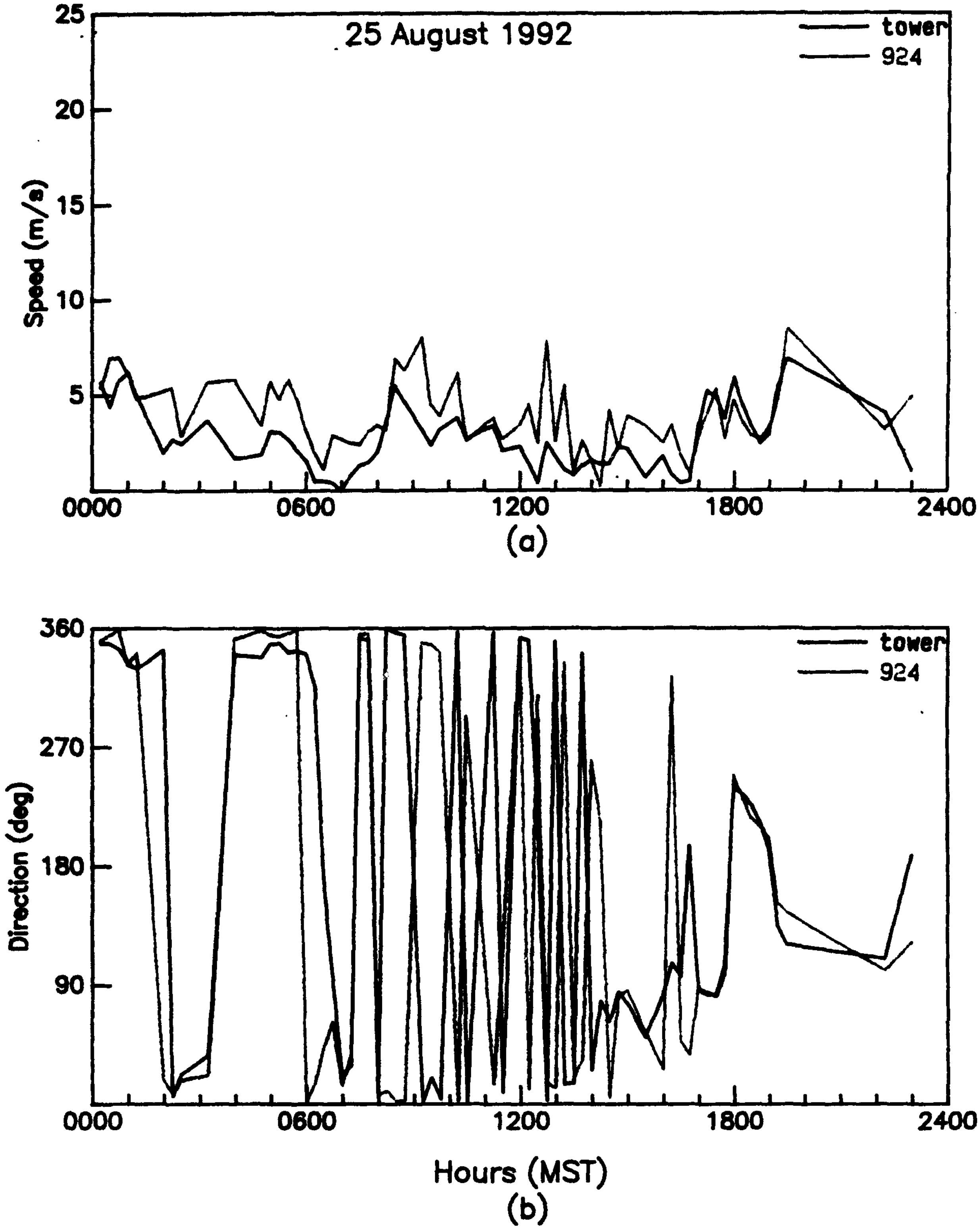


Figure 79. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 25 August 1992 (15-min averages).

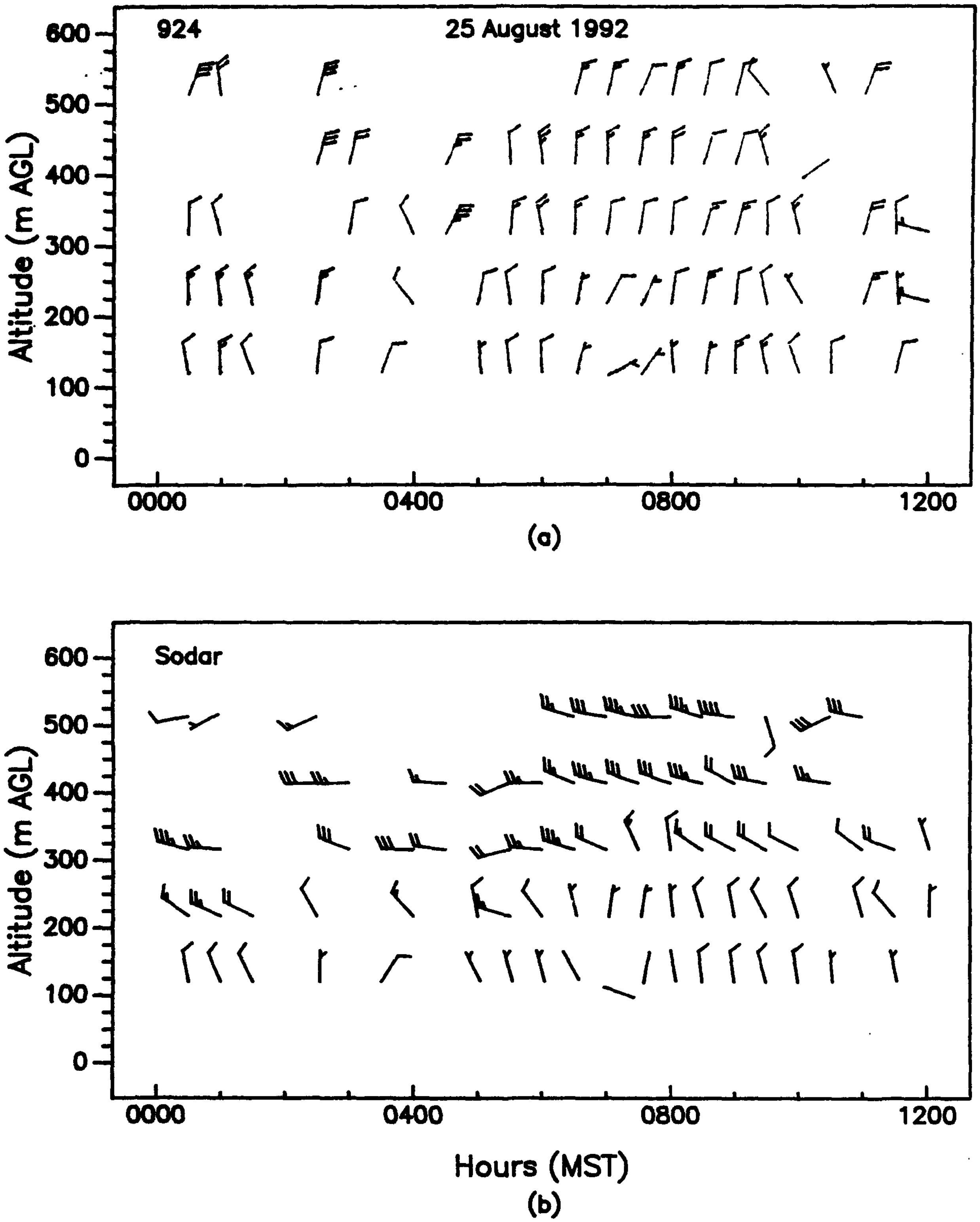
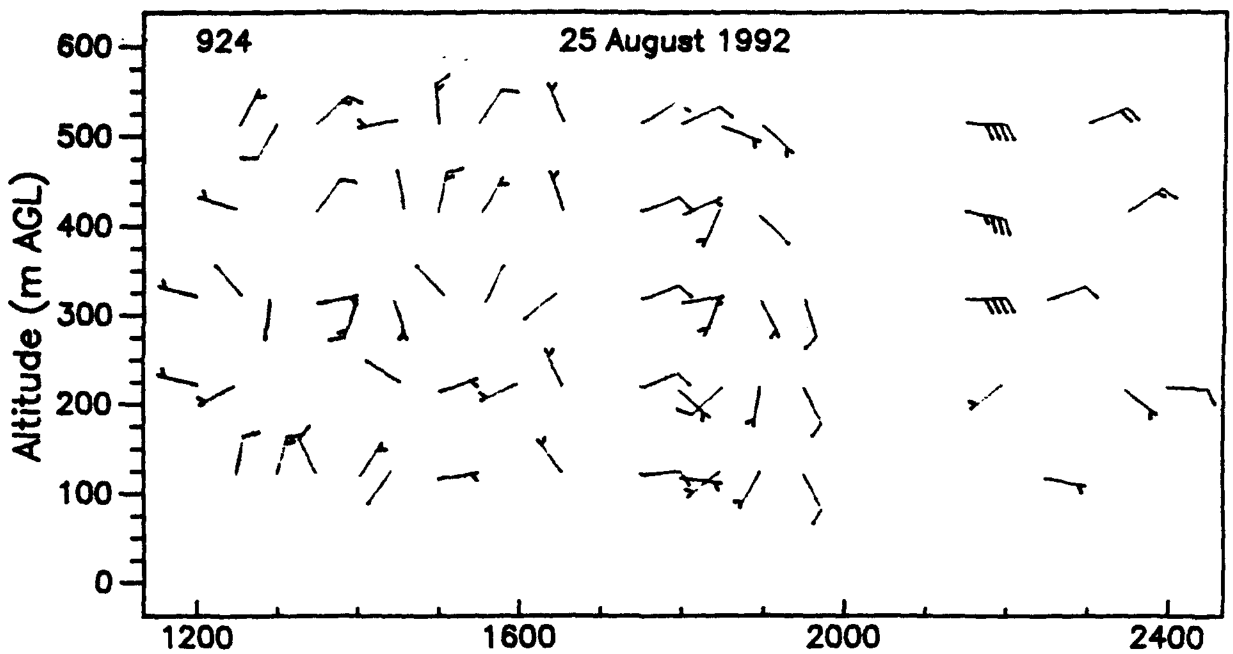
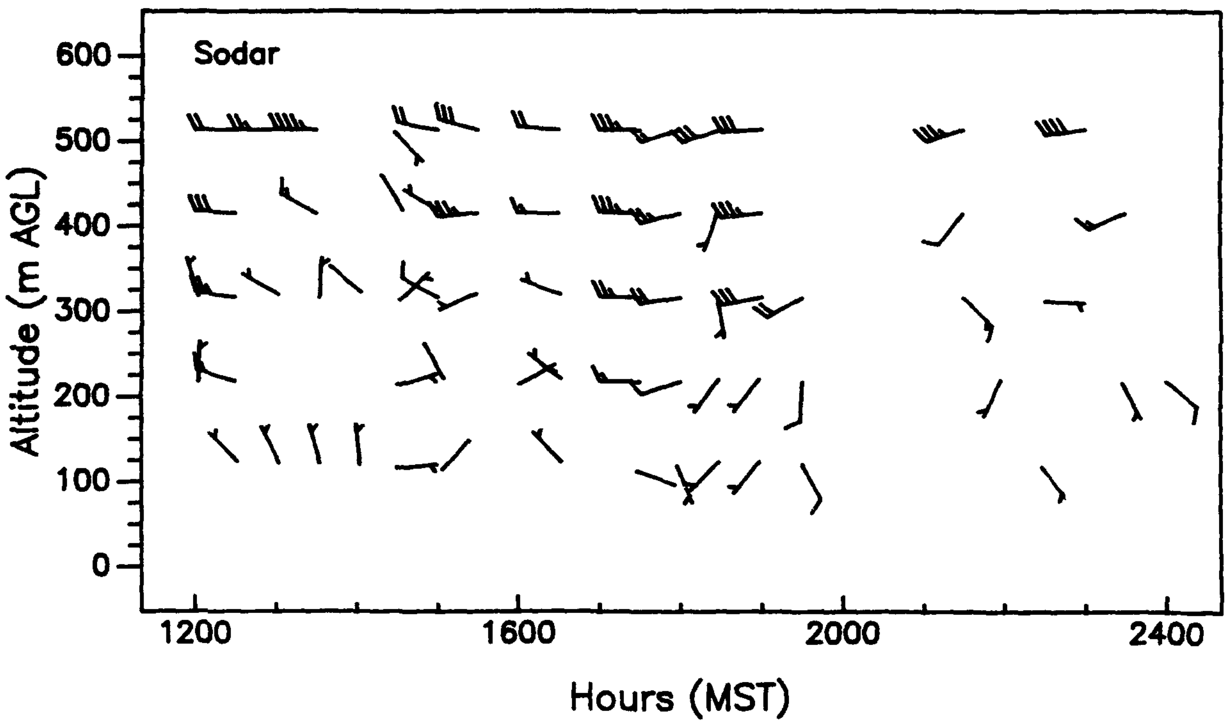


Figure 80. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 0000 to 1200 MST, 25 August 1992 (15-min averages).



(a)



(b)

Figure 81. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a sodar, APRF site, WSMR, 1200 to 2400 MST, 25 August 1992 (15-min averages).

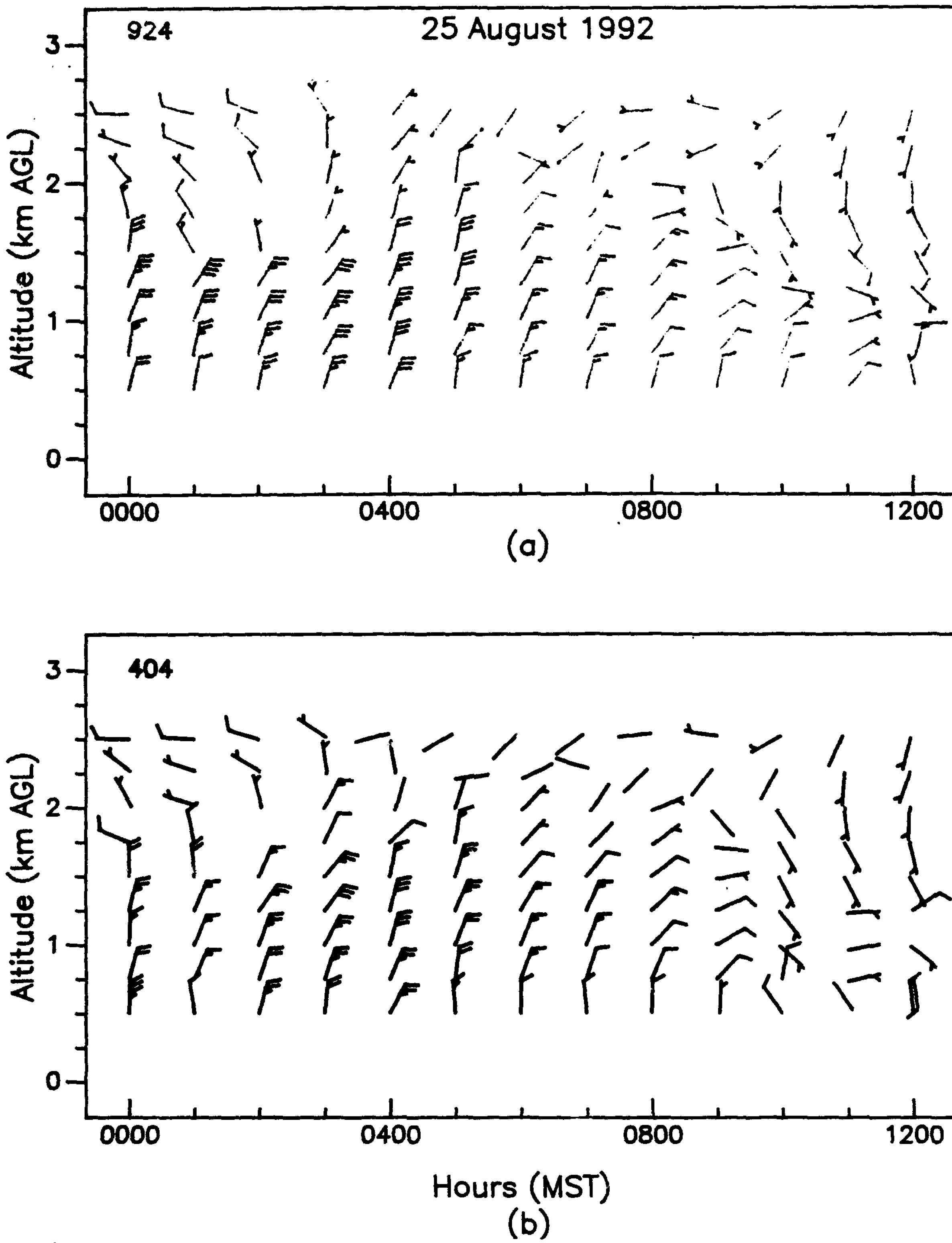


Figure 82. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 0000 to 1200 MST, 25 August 1992 (1-h averages).

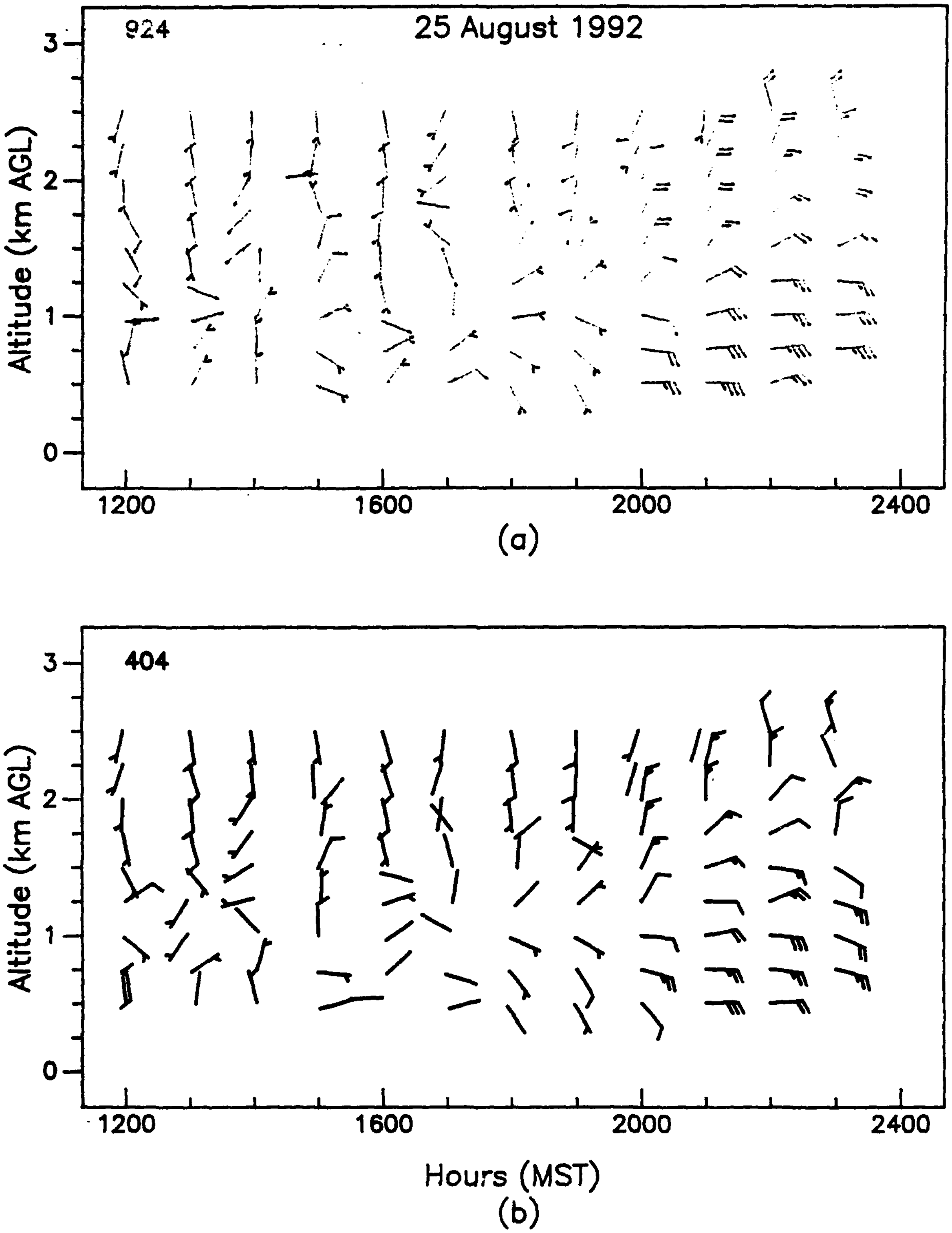


Figure 83. Vertical profiles of wind speed and wind direction, as measured with (a) a 924-MHz profiler and (b) a 404-MHz profiler, APRF site, WSMR, 1200 to 2400 MST, 25 August 1992 (1-h averages).

Table 8. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 17-18 and 24-25 June 1992

Statistic	17 June	18 June	24 June	25 June
		924 vs. WF-100		
Prob > $\lvert t \rvert$: U	0.0008	0.0001	0.0001	0.0066
Prob > $\lvert t \rvert$: V	0.0136	0.0001	0.0001	0.9992
Prob > $\lvert t \rvert$: S	0.0001	0.0003	0.0001	0.0001
ρ: U	0.796	0.529	0.746	0.488
ρ: V	0.642	0.552	0.802	0.317
ρ: S	0.450	0.438	0.784	0.609
root MSE	2.92	2.20	2.67	2.19
$E[x_{924} - x_{WP}]$	3.42	0.97	3.78	1.60
		924 vs. Tower		
Prob > $\lvert t \rvert$: U	0.0118	0.0008	0.8218	0.8194
Prob > $\lvert t \rvert$: V	0.0052	0.5822	0.3748	0.1526
Prob > $\lvert t \rvert$: S	0.0001	0.0079	0.0008	0.0001
ρ: U	0.321	0.911	0.892	0.578
ρ: V	0.683	0.669	0.915	0.973
ρ: S	0.473	0.774	0.784	0.931
root MSE	1.47	1.76	0.87	1.26
$E[x_{924} - x_{TO}]$	2.83	1.14	0.99	1.96
		924 vs. Sodar		
Prob > $\lvert t \rvert$: U	0.0001	0.0002	0.1107	0.0201
Prob > $\lvert t \rvert$: V	0.0001	0.0019	0.9790	0.0066
Prob > $\lvert t \rvert$: S	0.0001	0.0001	0.7850	0.0001
ρ: U	0.228	0.655	0.786	0.543
ρ: V	0.885	0.674	-0.074	-0.941
ρ: S	0.656	0.570	0.386	0.901
root MSE	0.97	2.33	1.67	1.24
$E[x_{924} - x_{SO}]$	1.64	1.98	0.16	1.95

Table 8. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 17-18 and 24-25 June 1992 (continued)

Statistic	17 June	18 June	24 June	25 June
		924 vs. 404		
Prob > $\lvert t \rvert$: U	0.0005	0.2383	0.0001	0.0001
Prob > $\lvert t \rvert$: V	0.0004	0.0001	0.0001	0.5191
Prob > $\lvert t \rvert$: S	0.0001	0.0017	0.0001	0.0001
ρ: U	0.948	0.226	0.934	0.777
ρ: V	0.925	0.238	0.898	0.282
ρ: S	0.930	0.026	0.935	0.621
root MSE	1.18	1.89	1.09	2.33
$E[x_{924} - x_{404}]$	1.49	1.90	1.75	1.74

Table 9. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 1-2 and 8-9 July 1992

Statistic	1 Jul	2 Jul	8 Jul	9 Jul
		924 vs. WF-100		
Prob > $\lvert t \rvert$: U	0.0061	0.0001	0.0013	0.0161
Prob > $\lvert t \rvert$: V	0.0001	0.0009	0.6061	0.0234
Prob > $\lvert t \rvert$: S	0.5967	0.0001	0.0001	0.0028
ρ: U	0.407	0.563	0.182	0.248
ρ: V	0.831	0.601	0.243	0.069
ρ: S	0.665	0.557	0.348	-0.15
root MSE	2.15	3.91	2.29	5.64
$E[x_{924} - x_{WF}]$	0.16	5.26	2.24	3.03

Table 9. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 1-2 and 8-9 July 1992 (continued)

Statistic	1 Jul	2 Jul	8 Jul	9 Jul
		924 vs. Tower		
Prob > $\|t\|$: U	NA	NA	NA	NA
Prob > $\|t\|$: V	NA	NA	NA	NA
Prob > $\|t\|$: S	NA	NA	NA	NA
ρ: U	NA	NA	NA	NA
ρ: V	NA	NA	NA	NA
ρ: S	NA	NA	NA	NA
root MSE	NA	NA	NA	NA
$E[x_{924} - x_{TO}]$	NA	NA	NA	NA
		924 vs. Sodar		
Prob > $\|t\|$: U	0.0004	0.0001	0.0110	0.6769
Prob > $\|t\|$: V	0.0050	0.0001	0.9755	0.4415
Prob > $\|t\|$: S	0.0002	0.0001	0.0005	0.0004
ρ: U	-0.668	0.638	0.031	0.949
ρ: V	0.363	0.613	0.784	0.899
ρ: S	0.677	0.638	0.461	0.731
root MSE	1.20	0.71	2.31	1.57
$E[x_{924} - x_{SO}]$	1.30	1.72	1.94	2.01
		924 vs. 404		
Prob > $\|t\|$: U	NA	NA	NA	NA
Prob > $\|t\|$: V	NA	NA	NA	NA
Prob > $\|t\|$: S	NA	NA	NA	NA
ρ: U	NA	NA	NA	NA
ρ: V	NA	NA	NA	NA
ρ: S	NA	NA	NA	NA
root MSE	NA	NA	NA	NA
$E[x_{924} - x_{404}]$	NA	NA	NA	NA

Table 10. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 18-21 August 1992

Statistic	18 Aug	19 Aug	20 Aug	21 Aug
		924 vs. WF-100		
Prob > $\lvert t \rvert$: U	0.2983	0.0001	0.0001	0.0001
Prob > $\lvert t \rvert$: V	0.2790	0.0001	0.0001	0.0001
Prob > $\lvert t \rvert$: S	0.0015	0.0001	0.0001	0.0001
ρ: U	0.836	0.269	-0.602	0.239
ρ: V	0.758	0.605	0.481	0.513
ρ: S	0.784	0.269	-0.038	0.163
root MSE	2.12	2.27	1.59	1.39
$E[x_{924} - x_{MF}]$	0.62	-2.44	-2.97	-2.37
		924 vs. Tower		
Prob > $\lvert t \rvert$: U	NA	0.5344	0.0338	0.8636
Prob > $\lvert t \rvert$: V	NA	0.7019	0.0067	0.2567
Prob > $\lvert t \rvert$: S	NA	0.2874	0.0199	0.0224
ρ: U	NA	0.975	0.244	0.782
ρ: V	NA	0.790	0.150	0.927
ρ: S	NA	0.970	-0.055	0.947
root MSE	NA	1.19	0.61	0.66
$E[x_{924} - x_{TO}]$	NA	0.60	-0.75	0.54
		924 vs. Sodar		
Prob > $\lvert t \rvert$: U	NA	0.7591	0.1425	0.0103
Prob > $\lvert t \rvert$: V	NA	0.7131	0.0434	0.5313
Prob > $\lvert t \rvert$: S	NA	0.3653	0.0055	0.0896
ρ: U	NA	0.904	-0.062	0.056
ρ: V	NA	0.451	0.160	0.885
ρ: S	NA	0.896	-0.111	0.237
root MSE	NA	1.72	0.50	1.84
$E[x_{924} - x_{SO}]$	NA	0.44	-1.53	-2.05

Table 10. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 18-21 August 1992 (continued)

Statistic	18 Aug	19 Aug	20 Aug	21 Aug
		924 vs. 404		
Prob > $\|t\|$: U	0.3513	0.5267	0.5240	0.0015
Prob > $\|t\|$: V	0.0615	0.5924	0.2492	0.0336
Prob > $\|t\|$: S	0.0170	0.7080	0.0001	0.0259
ρ: U	0.693	0.695	0.885	0.564
ρ: V	0.902	0.844	0.739	0.611
ρ: S	0.769	0.731	0.417	0.588
root MSE	1.87	1.58	0.95	0.92
$E[x_{924} - x_{404}]$	0.90	-0.12	0.99	0.50

Table 11. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 24 and 25 August 1992

Statistic	24 Aug	25 Aug
	924 vs. WF-100	
Prob > $\|t\|$: U	0.0001	0.0001
Prob > $\|t\|$: V	0.0001	0.0001
Prob > $\|t\|$: S	0.0001	0.0001
ρ: U	-0.629	0.425
ρ: V	-0.389	-0.436
ρ: S	0.509	0.330
root MSE	1.80	1.35
$E[x_{924} - x_{WF}]$	2.39	-2.20

Table 11. Statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition on 24 and 25 August 1992 (continued)

Statistic	24 Aug	25 Aug
	924 vs. Tower	
Prob > $\|t\|$: U	0.0010	0.9192
Prob > $\|t\|$: V	0.9310	0.0411
Prob > $\|t\|$: S	0.0006	0.0863
ρ: U	0.539	0.615
ρ: V	0.646	-0.317
ρ: S	0.559	0.558
root MSE	1.14	0.95
$E[x_{924} - x_{TO}]$	1.82	0.99
	924 vs. Sodar	
Prob > $\|t\|$: U	0.1276	0.0061
Prob > $\|t\|$: V	0.0087	0.9542
Prob > $\|t\|$: S	0.0647	0.0220
ρ: U	0.348	-0.167
ρ: V	0.787	0.445
ρ: S	0.371	0.001
root MSE	2.42	1.05
$E[x_{924} - x_{SO}]$	1.16	1.04
	924 vs. 404	
Prob > $\|t\|$: U	0.0002	0.8453
Prob > $\|t\|$: V	0.0111	0.3396
Prob > $\|t\|$: S	0.0001	0.0005
ρ: U	-0.073	0.357
ρ: V	0.315	0.830
ρ: S	-0.056	0.579
root MSE	1.15	1.01
$E[x_{924} - x_{404}]$	2.23	0.81

Table 12. Composite statistical summary of 924-MHz wind profiler wind speed comparisons for the periods of WF-100 data acquisition

Statistic	924 vs. WF-100	924 vs. Tower	924 vs. Sodar	924 vs. 404
Prob > $\lvert t \rvert$: U	0.0001	0.0373	0.2222	0.0001
Prob > $\lvert t \rvert$: V	0.0001	0.2285	0.7385	0.1869
Prob > $\lvert t \rvert$: S	0.0001	0.0001	0.0001	0.0001
ρ: U	0.618	0.934	0.785	0.872
ρ: V	0.502	0.915	0.901	0.827
ρ: S	0.524	0.869	0.643	0.787
root MSE	3.77	1.58	2.29	2.29
$E[x_{924} - x_{comp}]$	0.47	1.25	1.15	1.32
95% C. I.	0.25, 0.69	0.95, 1.55	0.88, 1.43	1.06, 1.58

3.3.2.6 24-25 August 1992.--On 24 and 25 August, south central New Mexico was again under the influence of weak monsoonal flow from the Gulf of Mexico. Dewpoints were generally in the 50's although dewpoints as high as 64 °F were recorded at Oasis before sunrise on 24 August. Convective activity was limited to scattered cumulus clouds on 24 August. The convective activity was a little more intense on 25 August with cumulonimbus clouds and rain showers in the vicinity of Oasis.

3.3.3 Surface to 600 m AGL (924, tower, sodar)

Additional information on the quality of the 924-MHz wind data within the first 600 m AGL was provided by comparison of the 924-MHz data with data from the tower-mounted anemometers and the sodar over more extended periods of time than those represented by the comparisons during the WF-100 periods.

15 April, selected to exemplify additional comparisons, was one of the 23 days involved in the 924-MHz/rawinsonde comparison. Because of the proximity of the two profilers and the tower-mounted anemometers, the criterion of a uniform wind field was not as important in this case. However, the wind field up to 600 m AGL was reasonably uniform, the data sets from all three systems were nearly complete and the atmosphere was convectively quiet throughout the 24-h period.

The diurnal variations are shown in figures 84 through 90.

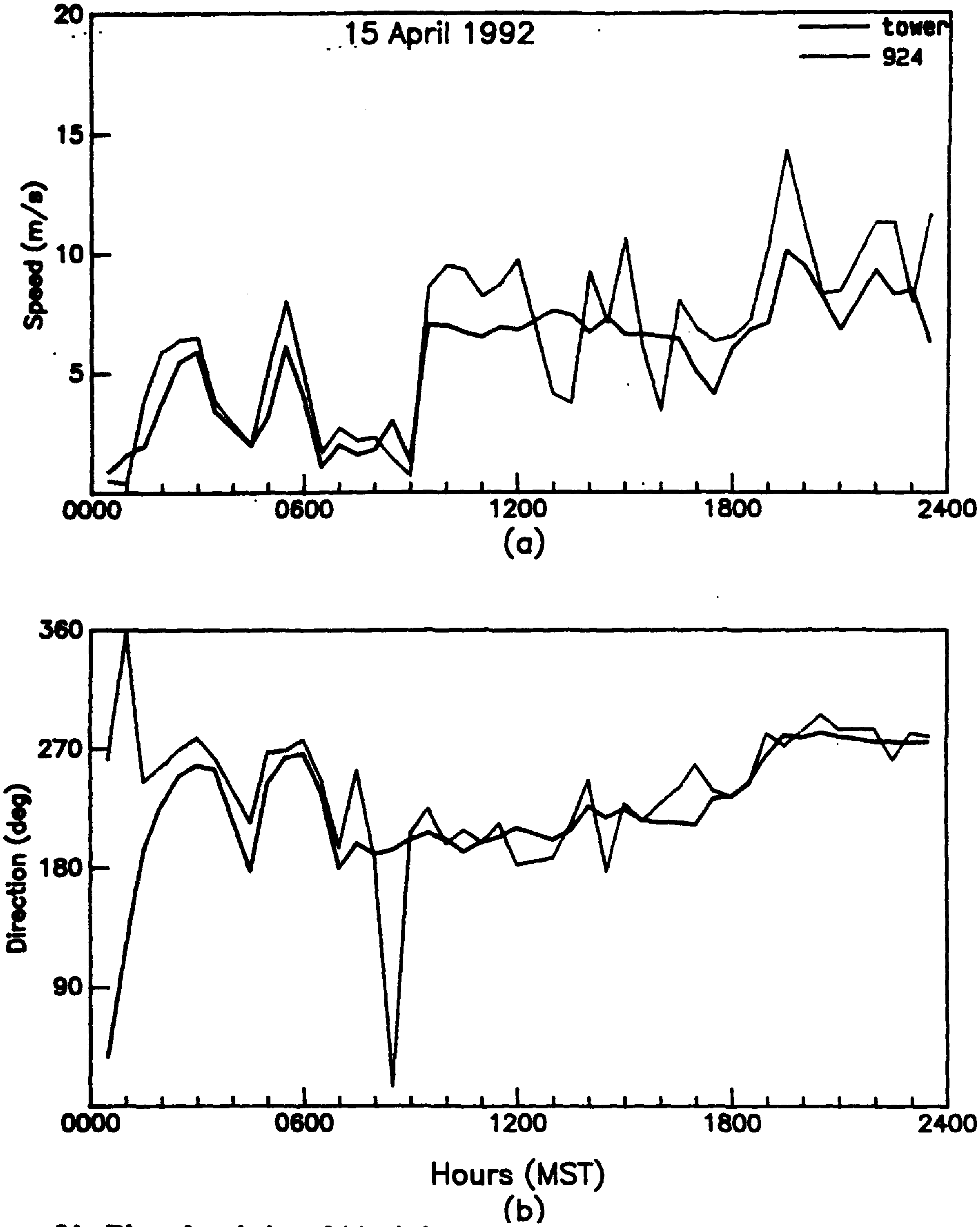


Figure 84. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

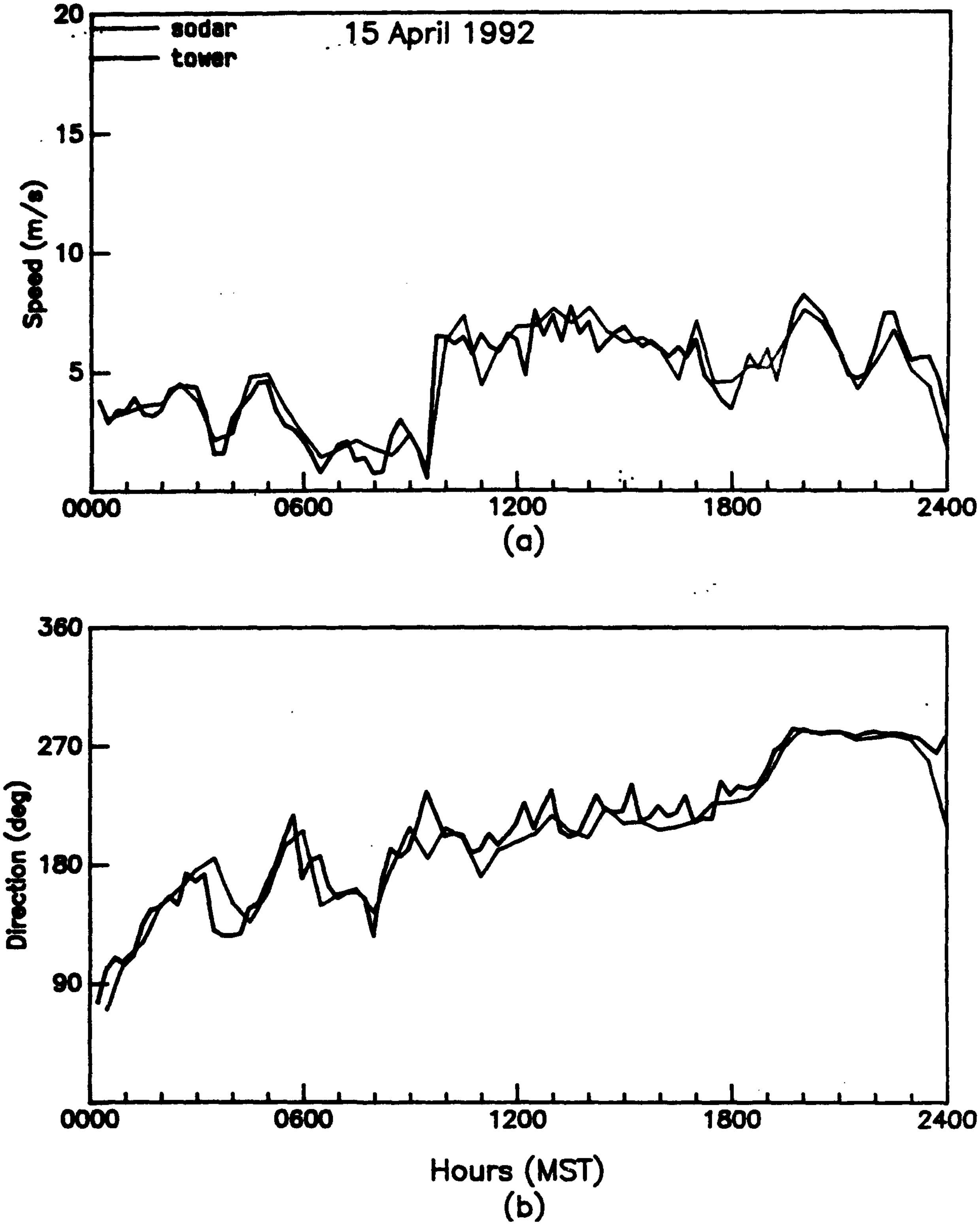


Figure 85. Diurnal variation of (a) wind speed and (b) wind direction as measured with tower-mounted anemometers at 40 and 50 m AGL (LC-35) and a sodar at 50 m AGL (APRF site), WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

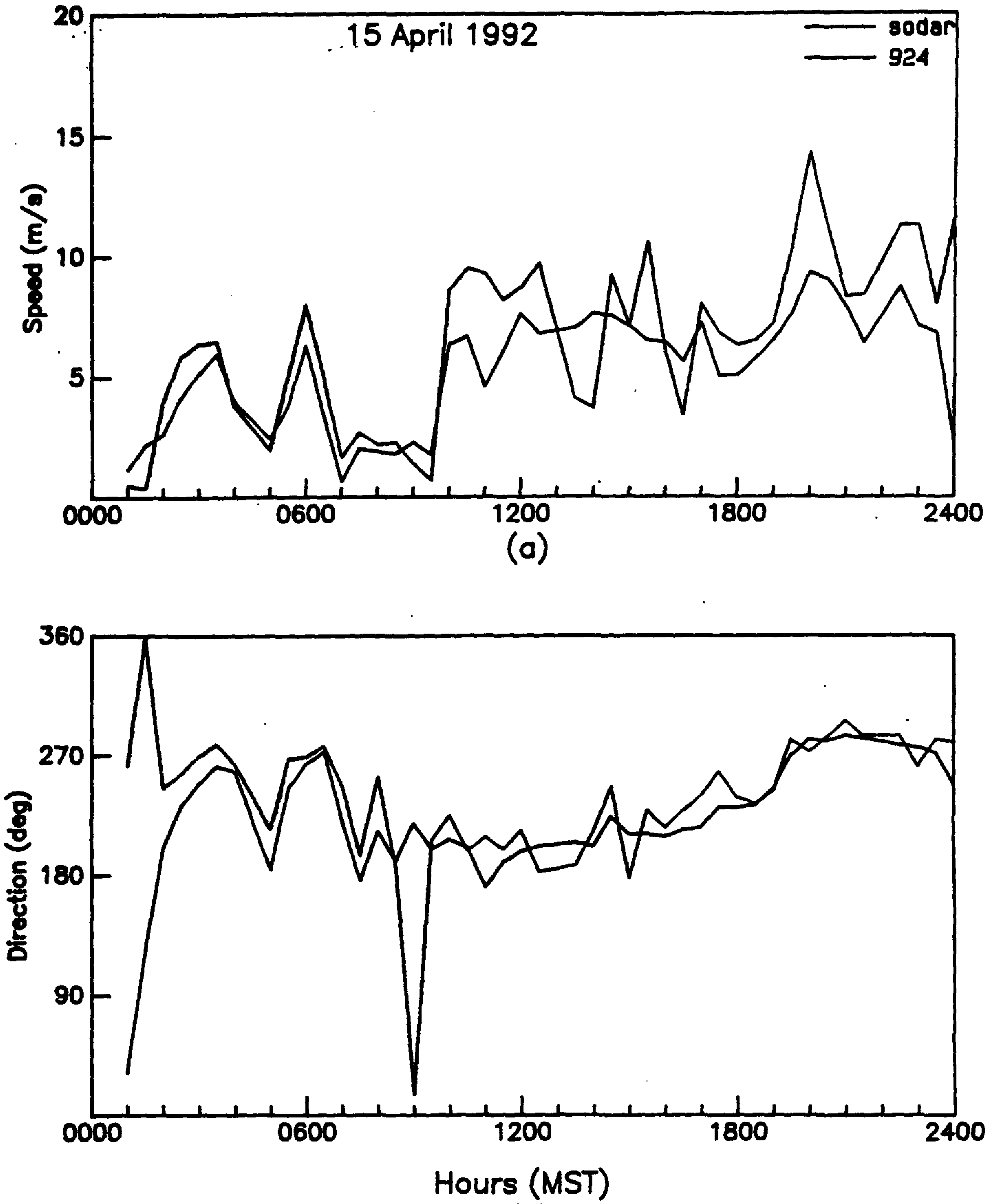


Figure 86. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 120 m AGL and a sodar at 75, 100, 125, and 150 m AGL, APRF site, WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

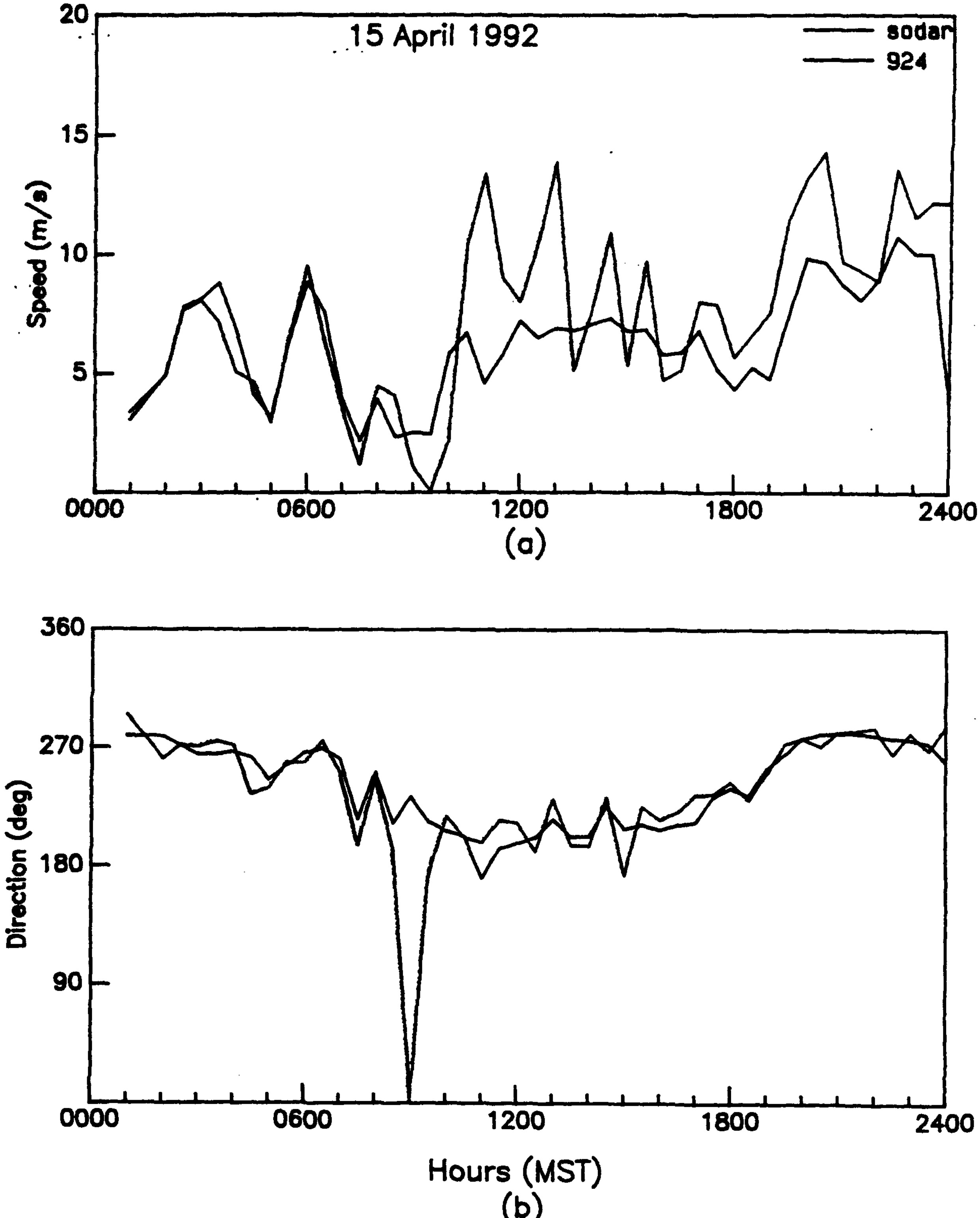


Figure 87. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 218 m AGL and a sodar at 175, 200, 225, and 250 m AGL, APRF site, WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

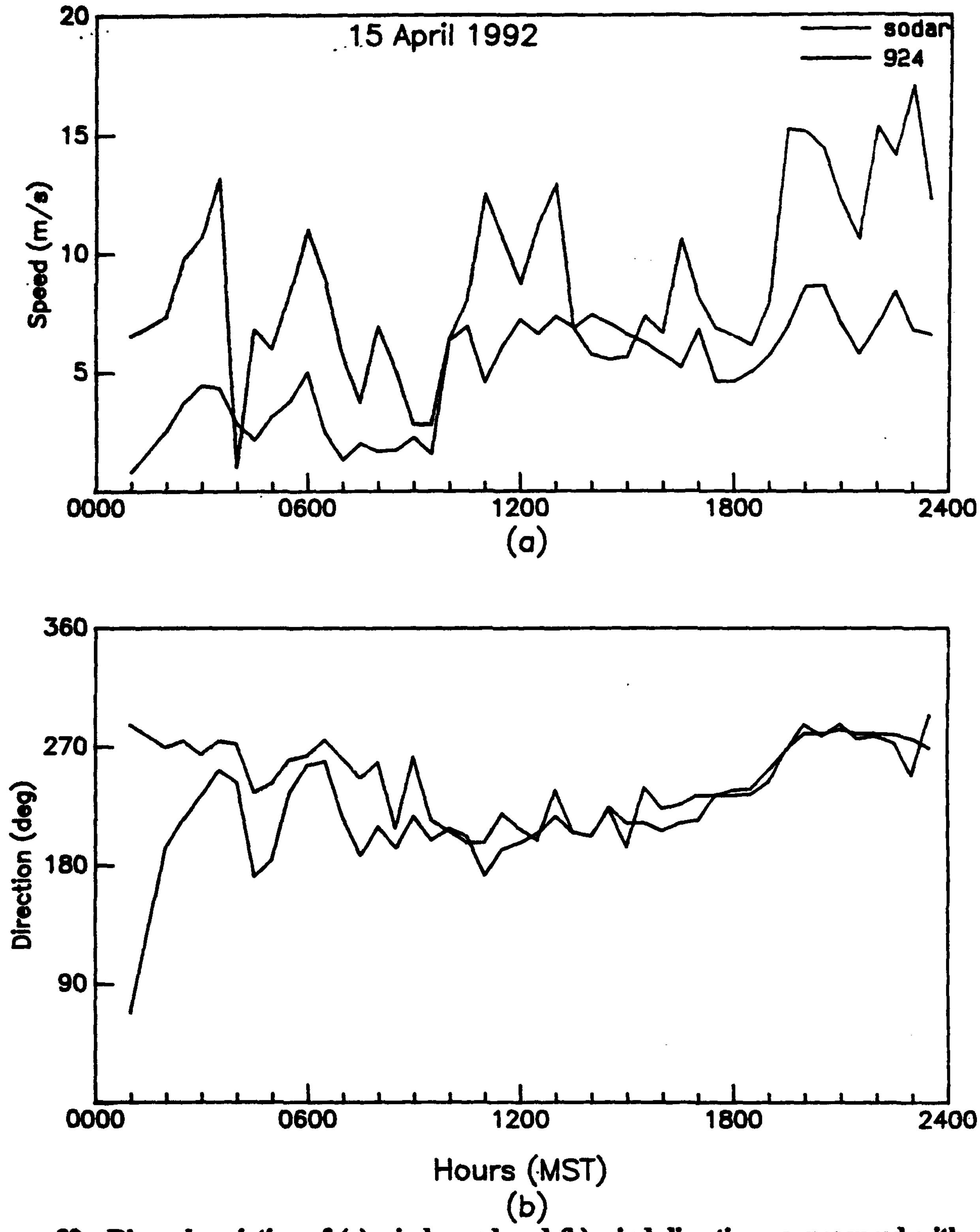


Figure 88. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 317 m AGL and a sodar at 275, 300, 325, and 350 m AGL, APRF site, WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

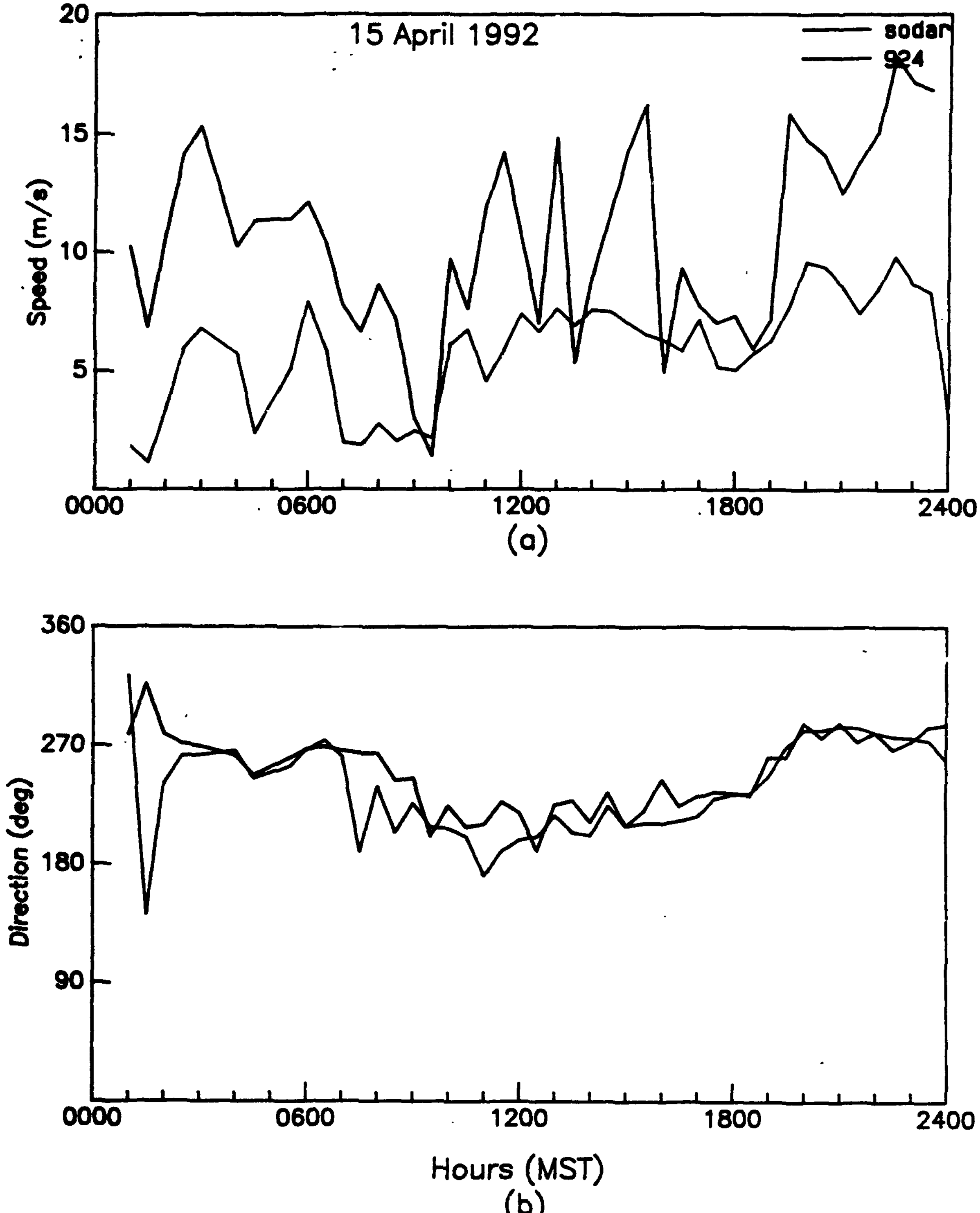


Figure 89. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 416 m AGL and a sodar at 375, 400, 425, and 450 m AGL, APRF site, WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

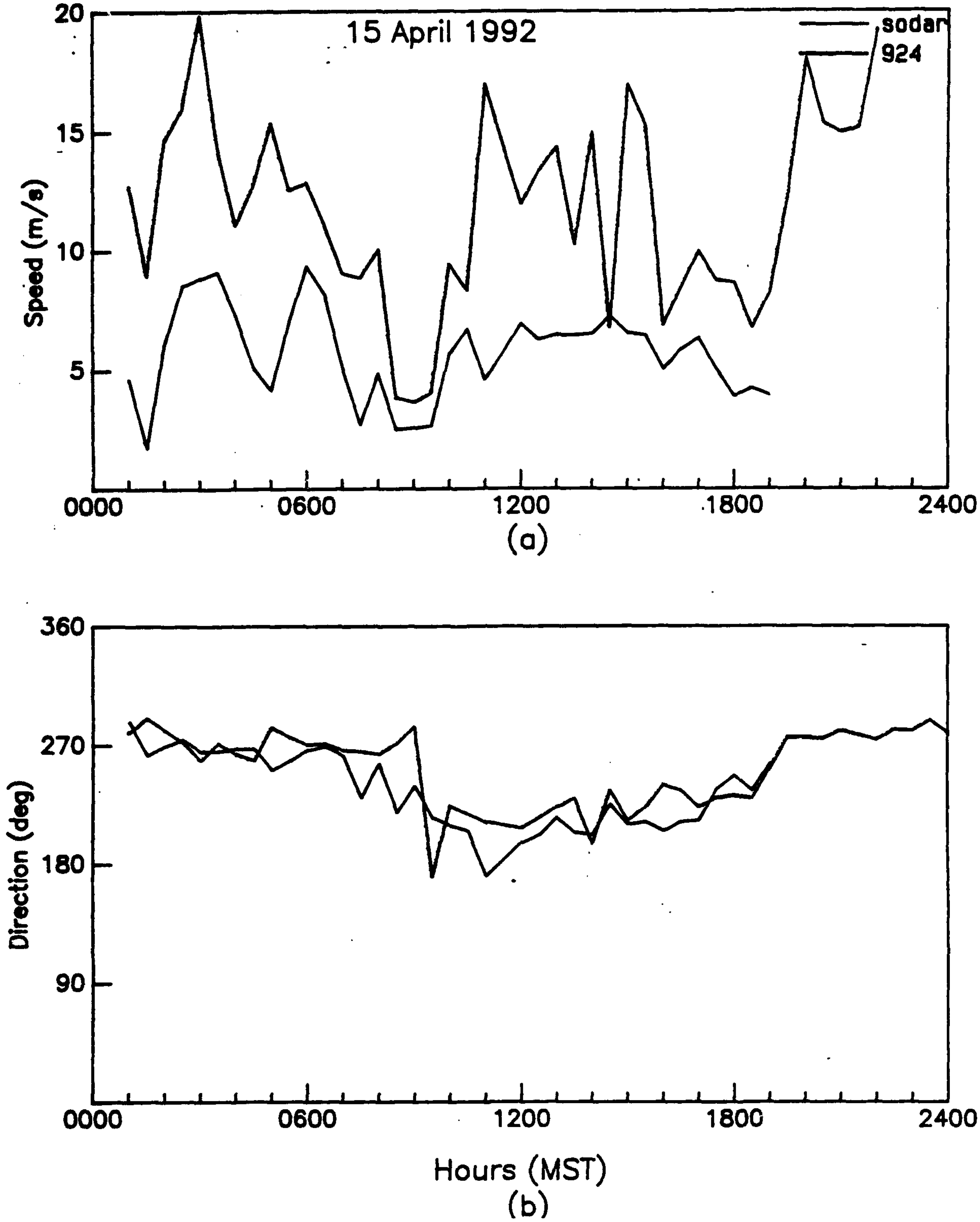


Figure 90. Diurnal variation of (a) wind speed and (b) wind direction as measured with a 924-MHz profiler at 514 m AGL and a sodar at 475 and 500 m AGL, APRF site, WSMR, 0000 to 2400 MST, 15 April 1992 (30-min averages).

3.3.4 924- versus 404-MHz Wind Data

A more extensive statistical comparison of 924- and 404-MHz wind data was provided on a monthly basis for March through June and August. Comparisons for July were not available because the local archive tape of the 404-MHz data for July has a parity error and the NOAA archive tape is in a format not currently compatible with the local data processing software.

The statistics are shown in table 13.

Table 13. Monthly statistical summaries of 924- and 404-MHz wind speed comparisons during the spring and summer of 1992

Statistic	March	April	May	June	August
Prob > $\|t\|$: U	0.0001	0.0001	0.0001	0.0001	0.1755
Prob > $\|t\|$: V	0.0001	0.0001	0.0001	0.0001	0.7325
Prob > $\|t\|$: S	0.0001	0.0001	0.0001	0.0001	0.0001
ρ: U	0.628	0.836	0.680	0.834	0.867
ρ: V	0.175	0.773	0.579	0.853	0.892
ρ: S	0.742	0.735	0.423	0.756	0.812
root MSE	3.18	3.32	3.21	2.37	2.43
$E[x_{924} - x_{404}]$	1.18	1.97	0.82	1.50	1.08
95% C. I.	1.09, 1.28	1.88, 2.07	0.65, 0.98	1.43, 1.58	0.97, 1.18

4. Virtual Temperature (RASS)

May, et al. [3] show that the root mean square difference between radiosonde measurements and RASS observations are about 1.0 °C under a variety of meteorological conditions and 0.2 °C is achievable under ideal conditions. To see if similar results would be observed with the RASS system at APRF, RASS virtual temperature data were compared with virtual temperature data computed from the air temperature and moisture data obtained with radiosondes released from Oasis. The radiosonde runs selected for comparison were limited to those runs used for the rawinsonde versus 924-MHz comparisons. However, because the RASS system did not become operational until 2 April, only the 19 radiosonde runs beginning on 2 April were included in the comparison.

In contrast to the wind data from the radiosondes released from Oasis, the temperature data are continuous from the surface to balloon burst. Moisture data (relative humidity) obtained with the air temperature data were used to convert the radiosonde air temperature data to virtual temperature.

The 924-MHz profiler reports RASS data to a maximum height of 1284 m AGL. Data from the higher range gates are often missing or discontinuous because of lower signal return.

For statistical comparisons of the data, the samples were temporally and spatially paired as close as possible. The RASS data are reported as 3- or 5-min averages for each gate, while radiosonde air temperature and moisture data are reported every 10 s as the balloon rises. This makes pairing the data for statistical analysis challenging and imperfect. RASS data are paired temporally with the radiosonde data by selecting the averaging period that most overlaps the radiosonde flight during the first 1300 m of the flight. RASS data are reported as 6-min averages before 5 June 1992 and as 3-min averages after that date.

Radiosonde data were matched to RASS data with respect to gate height. Radiosonde temperature readings reported within the upper and lower boundaries of a RASS gate were averaged and paired with the RASS temperatures from the same gate.

Paired temperature readings where the corresponding difference in wind speed exceeded 10 m/s were eliminated before the data were subjected to statistical evaluation. Few data points were eliminated with this quality control, and those that were eliminated were the highest reported RASS temperature values. Vertical profiles of the virtual temperature, virtual temperature differences, and regression line from the 19 radiosonde runs and the corresponding 924-MHz RASS data are shown in figures 91 to 108.

The root MSE, the Pearson product-moment (correlation) coefficient, the regression slope and y intercept, and the paired Student's t-test probability were determined for each of the 19 periods using paired values from each gate as repeated samples.

A summary of the comparison statistics is shown in table 14.

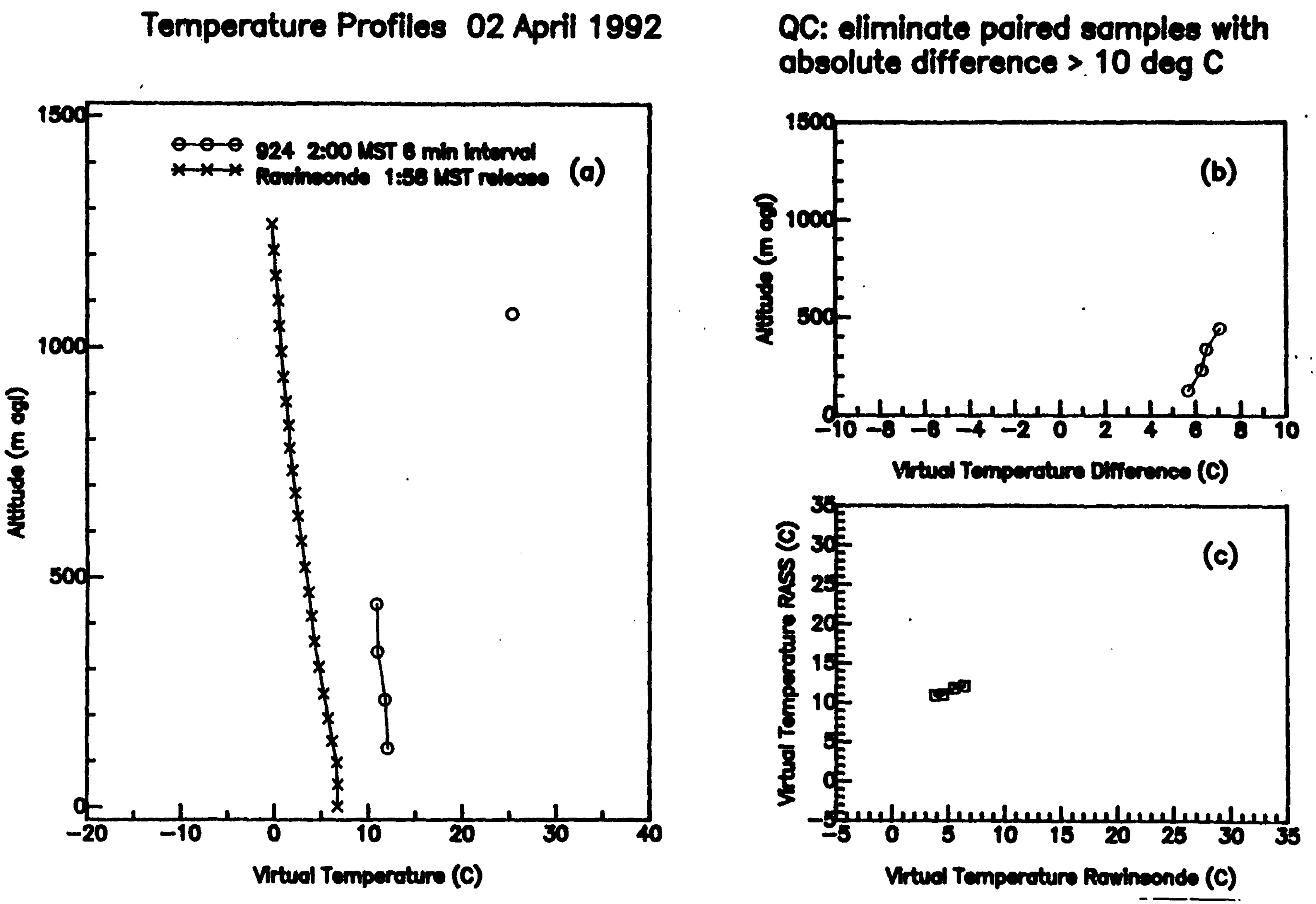


Figure 91. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 2 April 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 0200 to 0206 MST, and the radiosonde was released at 0158 MST.

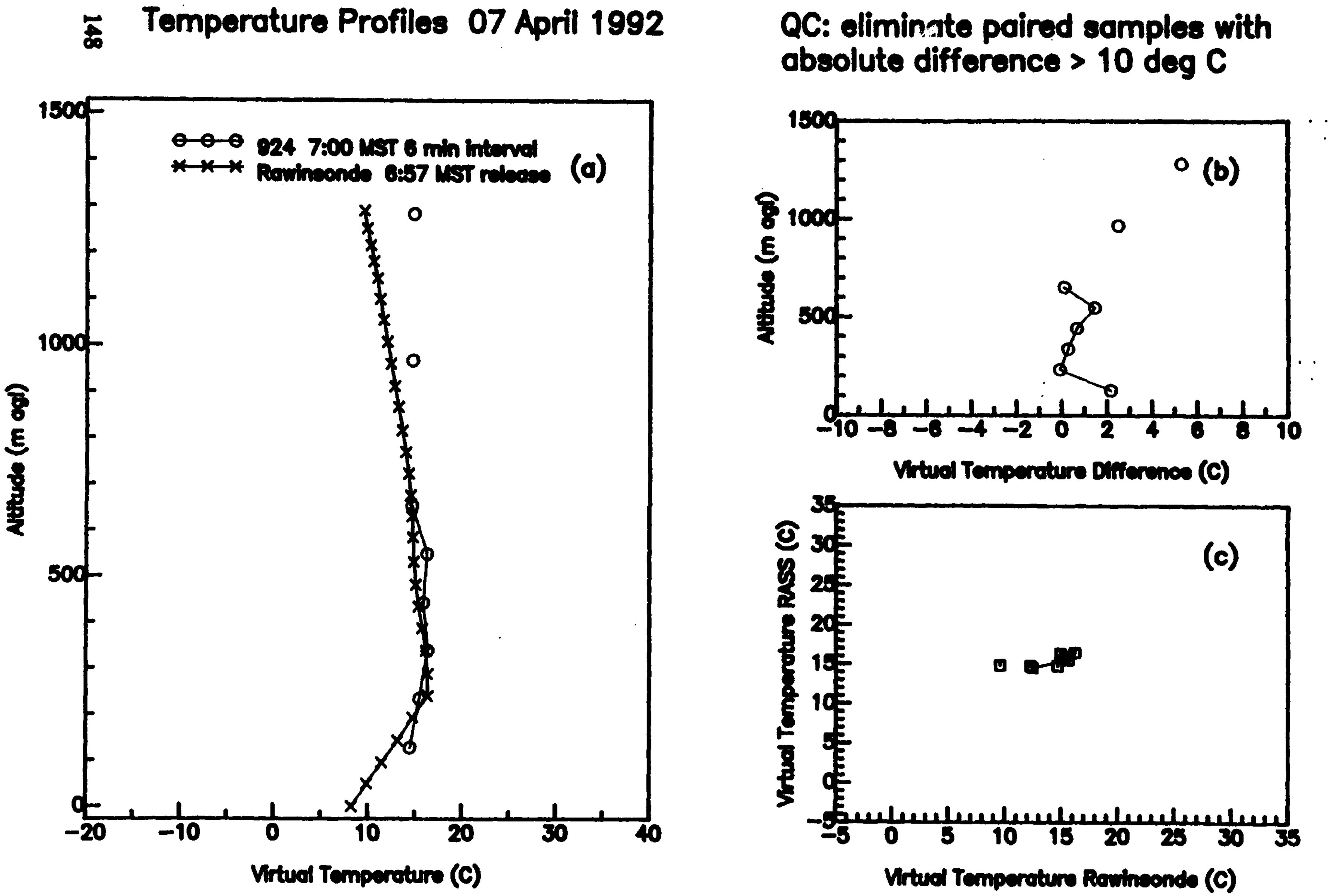


Figure 92. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 7 April 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 0700 to 0706 MST, and the radiosonde was released at 0657 MST.

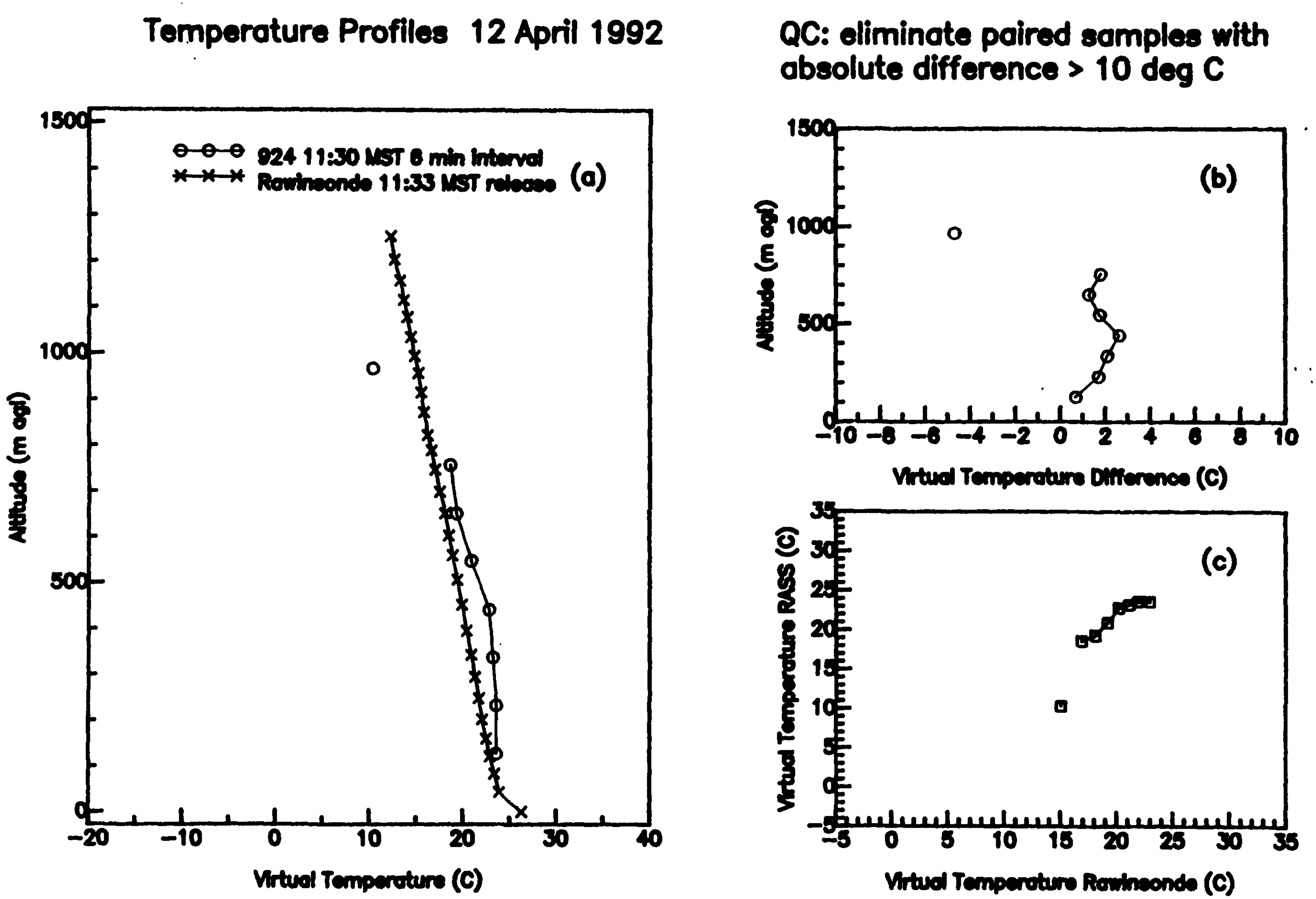


Figure 93. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 12 April 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 1130 to 1136 MST, and the radiosonde was released at 1133 MST.

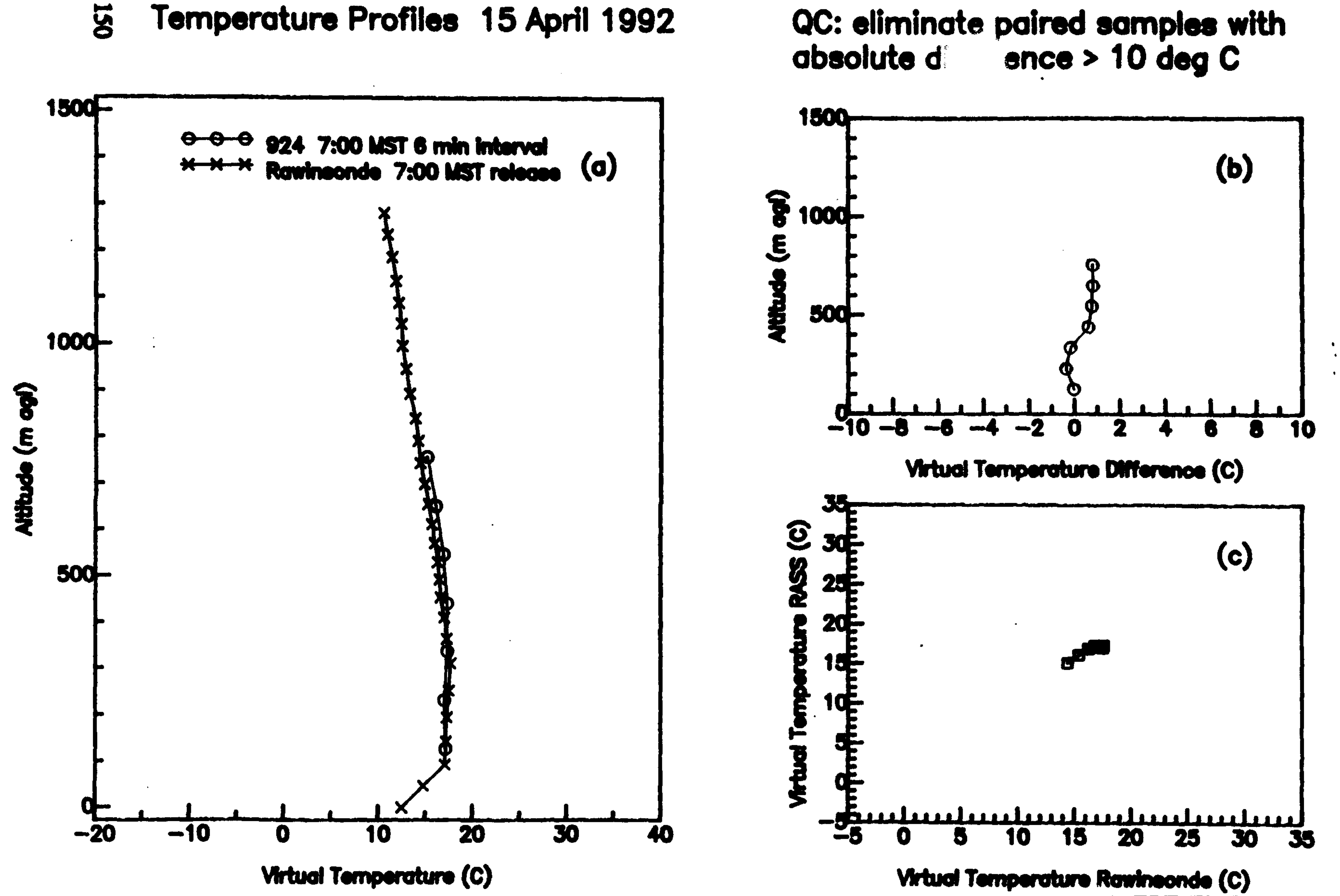


Figure 94. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 15 April 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 0700 to 0706 MST, and the radiosonde was released at 0700 MST.

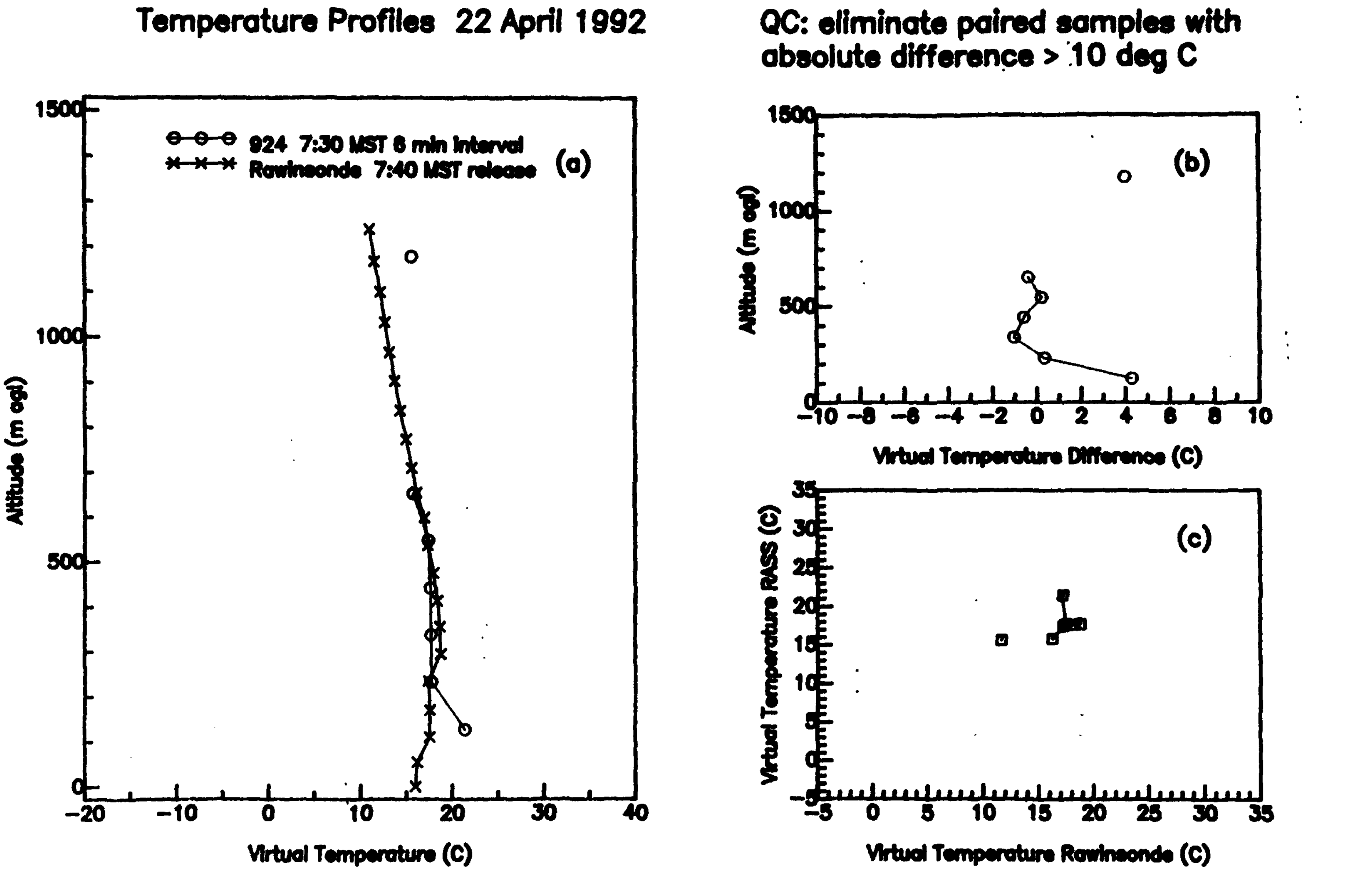


Figure 95. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 22 April 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 0730 to 0736 MST, and the radiosonde was released at 0740 MST.

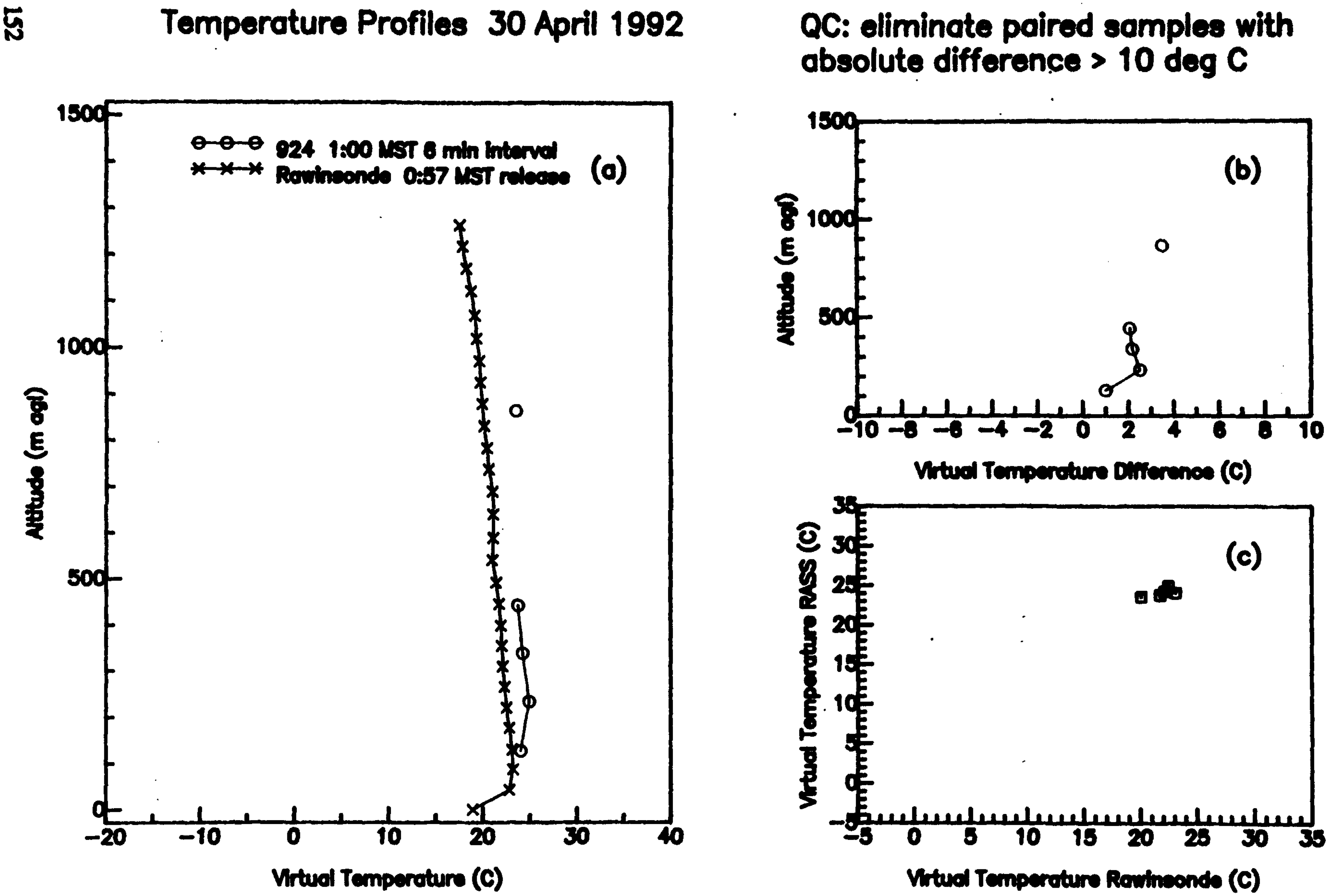


Figure 96. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 30 April 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 0100 to 0106 MST, and the radiosonde was released at 0057 MST.

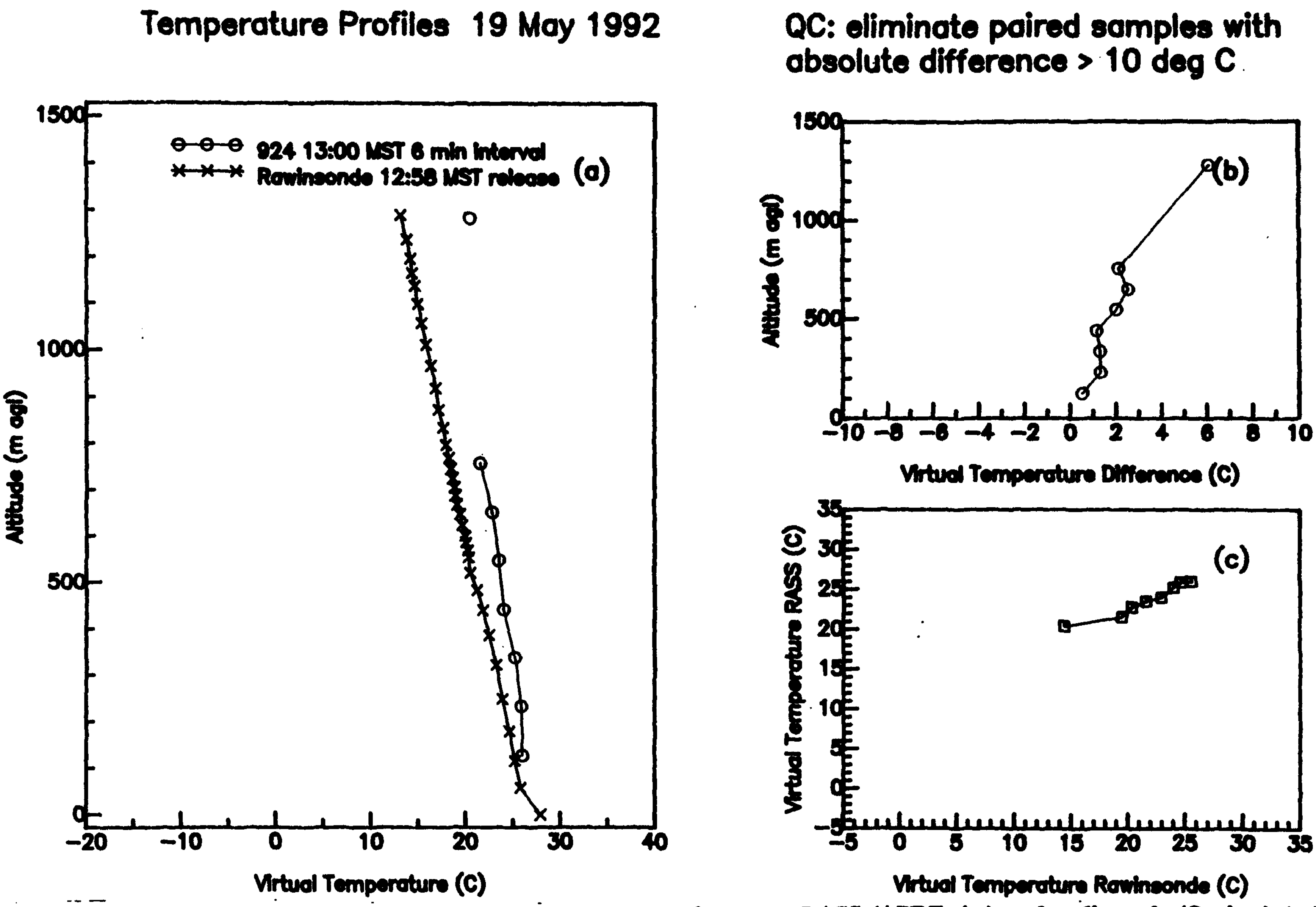


Figure 97. *Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 19 May 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 1300 to 1306 MST, and the radiosonde was released at 1258 MST.*

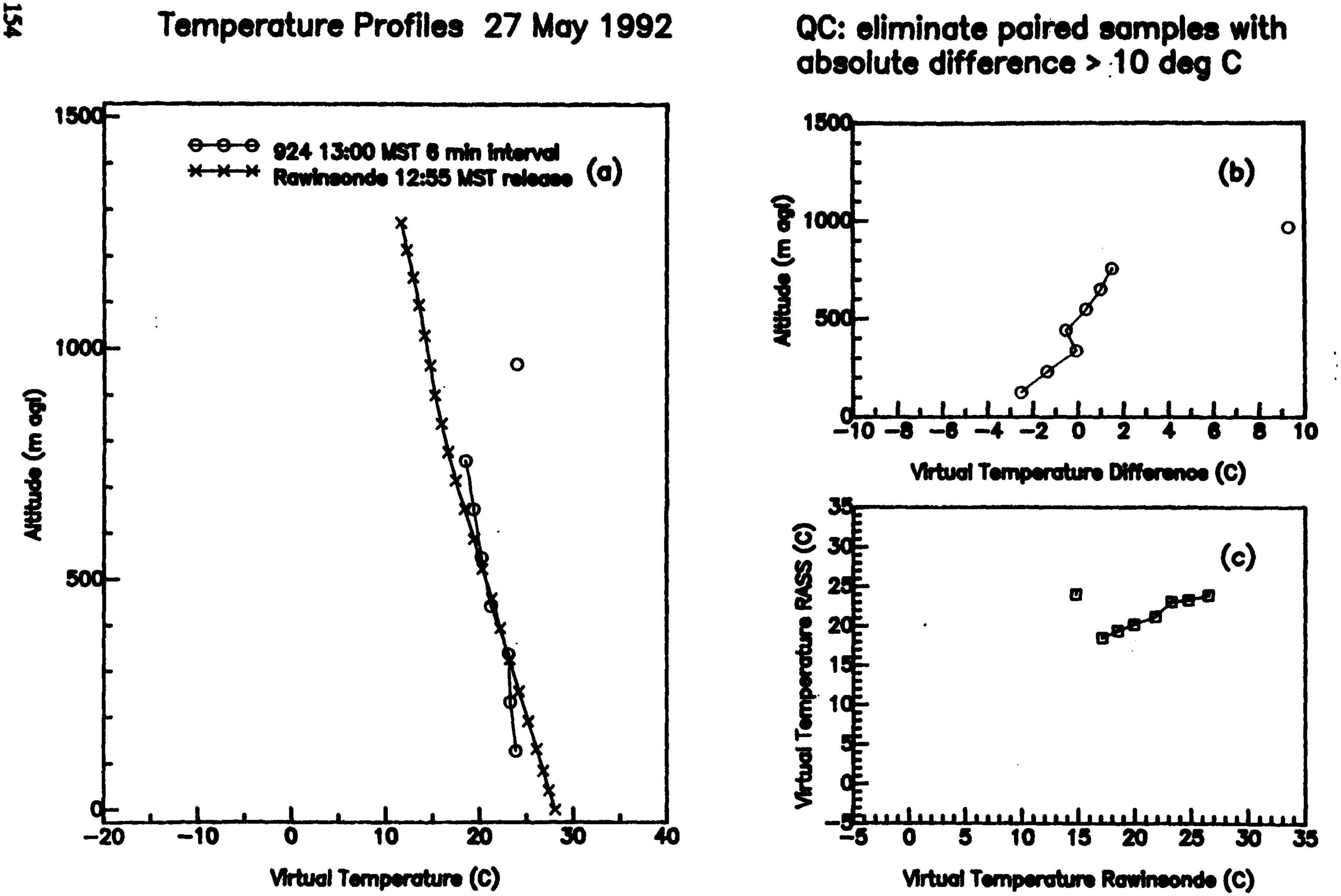


Figure 98. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 27 May 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 1300 to 1306 MST, and the radiosonde was released at 1255 MST.

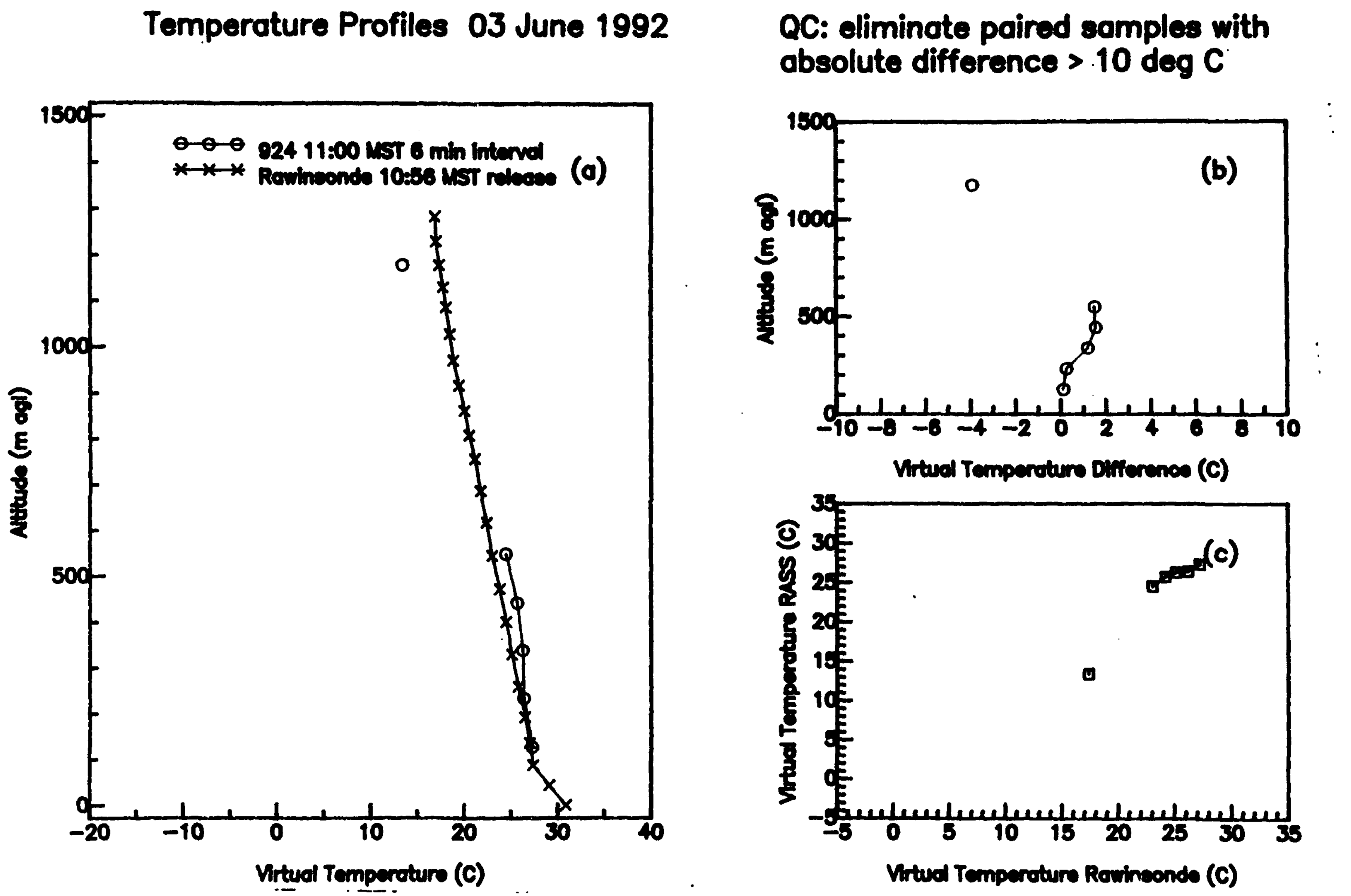


Figure 99. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 3 June 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 6-min average from 1100 to 1106 MST, and the radiosonde was released at 1056 MST.

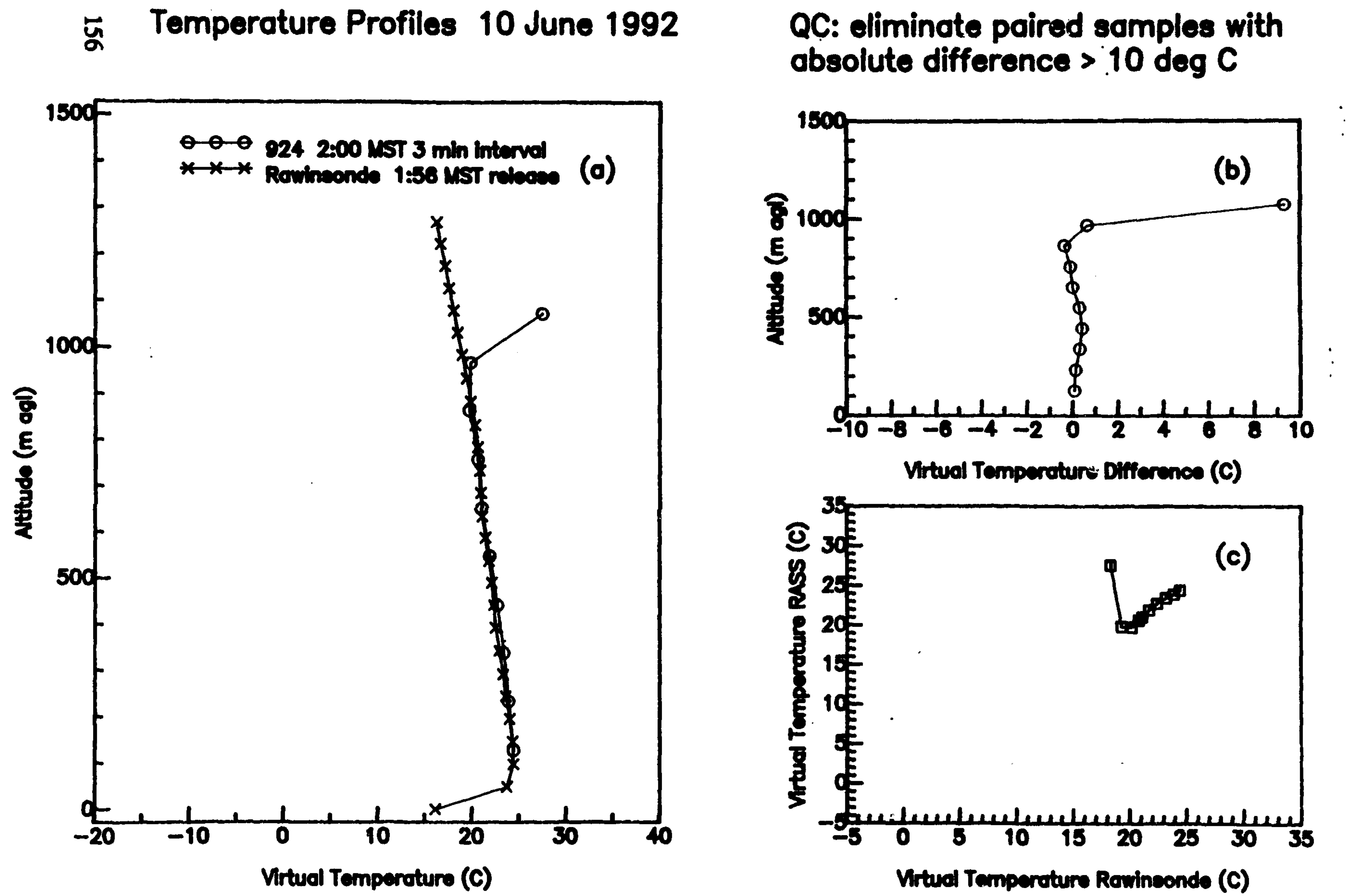


Figure 100. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 10 June 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0200 to 0203 MST, and the radiosonde was released at 0156 MST.

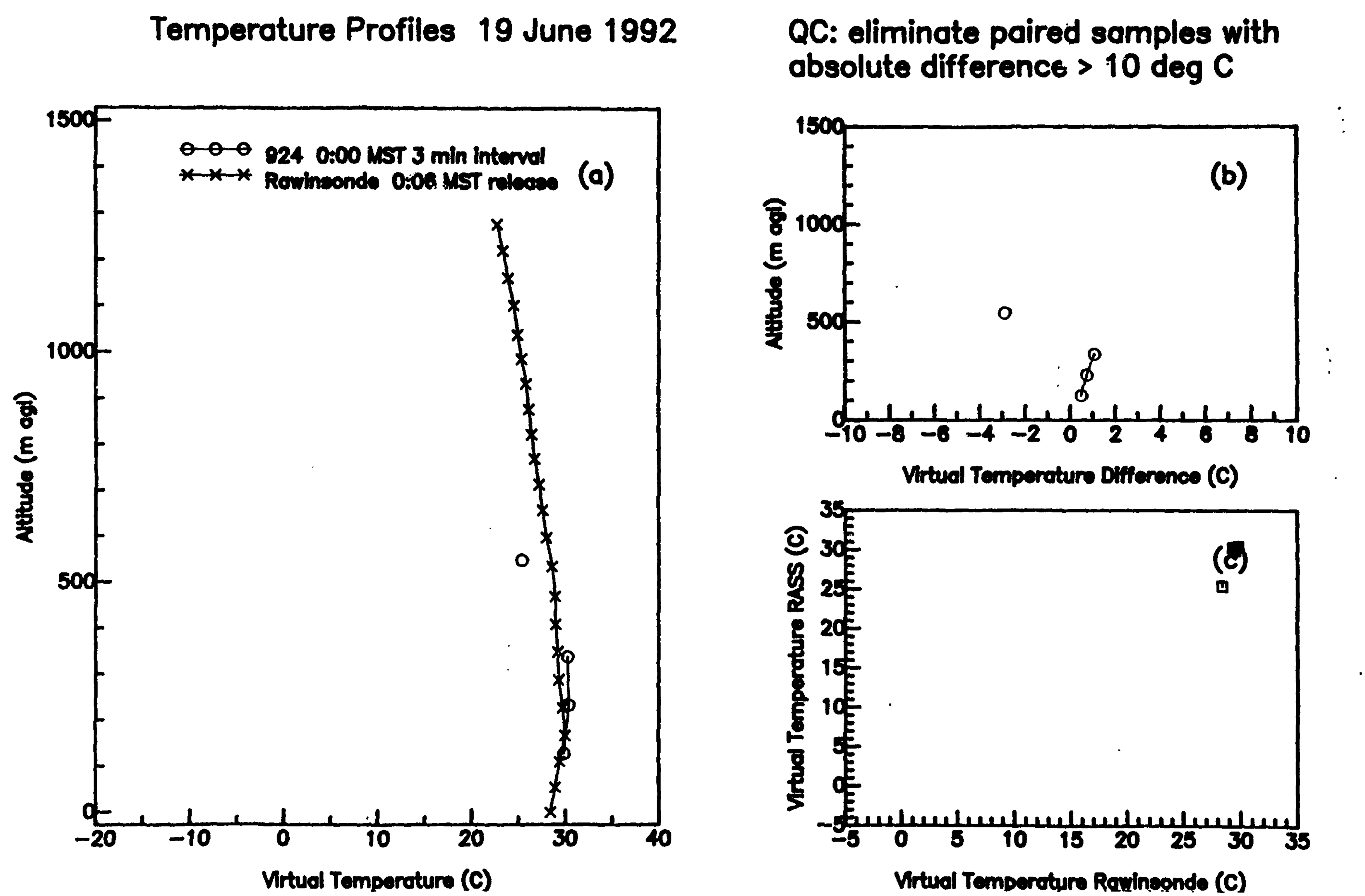


Figure 101. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 19 June 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0000 to 0003 MST, and the radiosonde was released at 0006 MST.

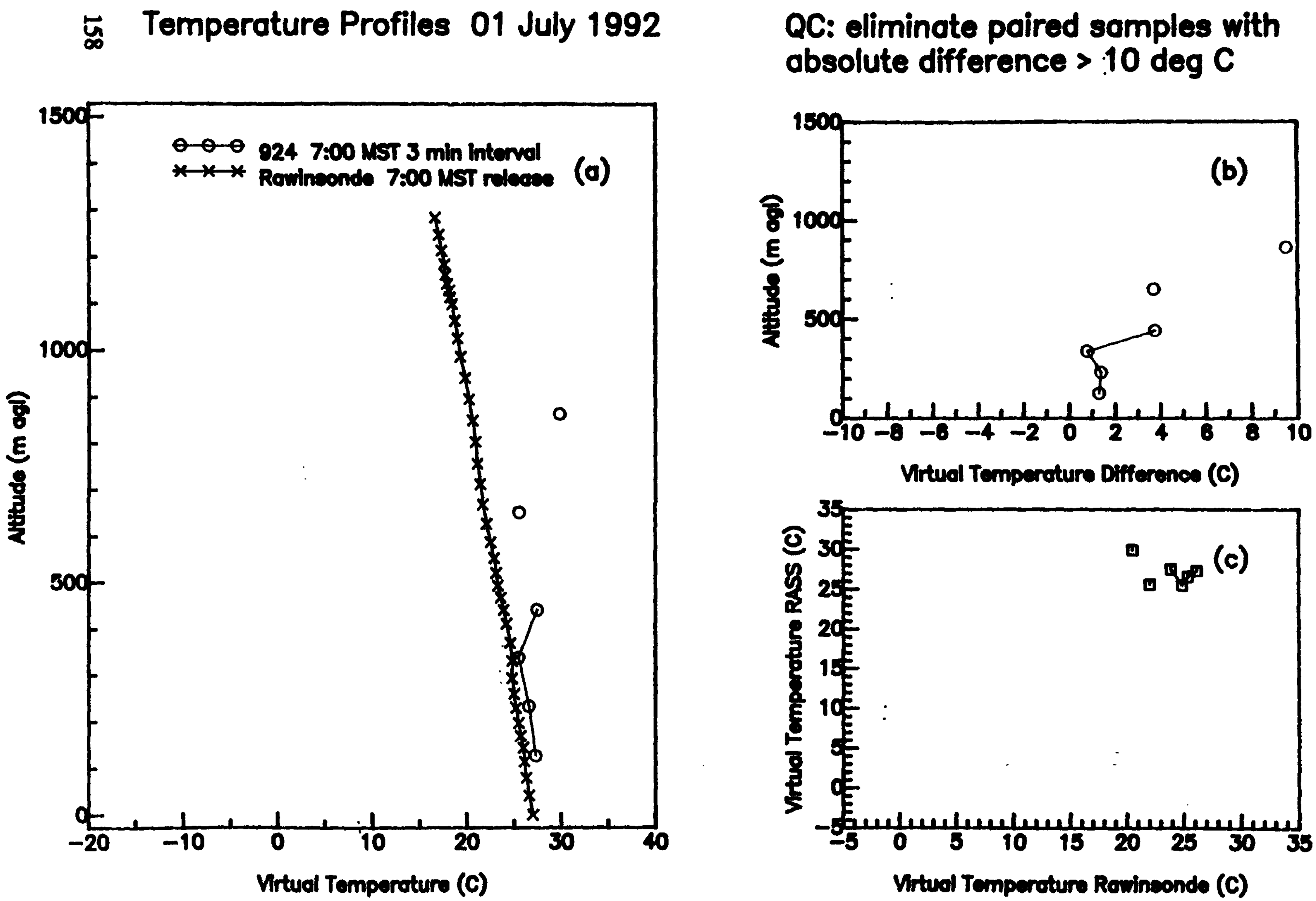


Figure 102. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 1 July 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0700 to 0703 MST, and the radiosonde was released at 0700 MST.

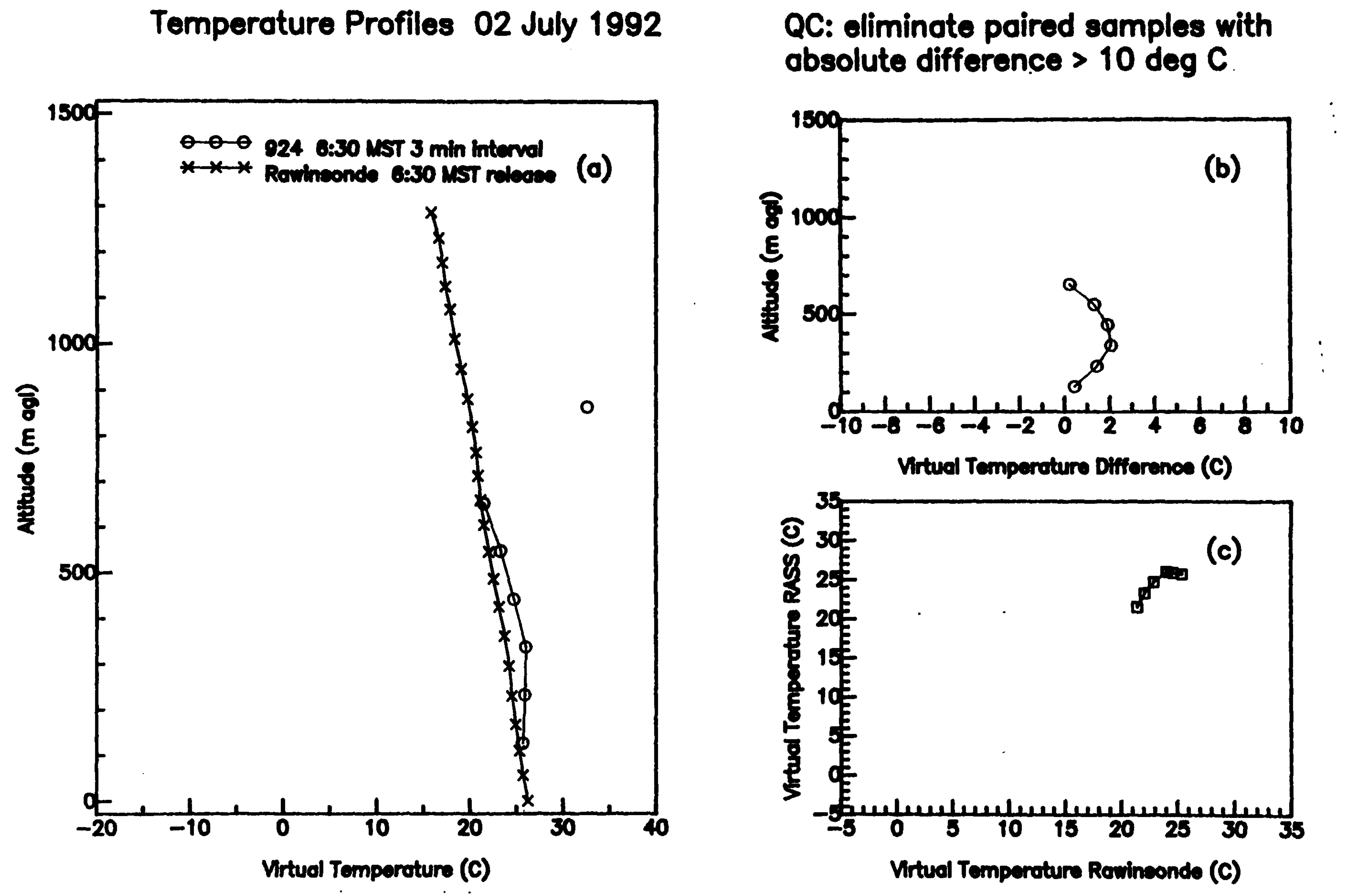


Figure 103. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 2 July 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0630 to 0633 MST, and the radiosonde was released at 0630 MST.

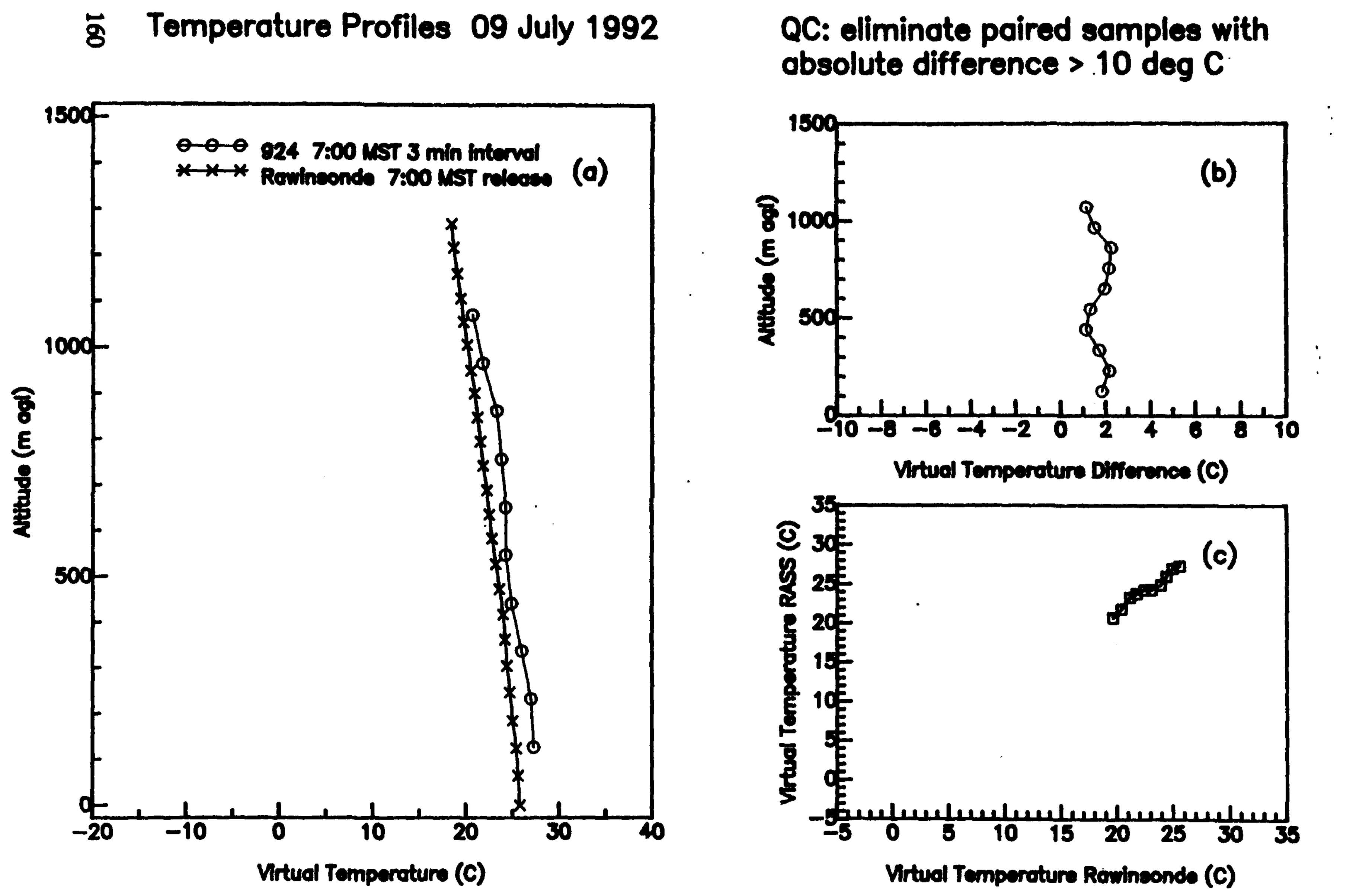


Figure 104. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 9 July 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0700 to 0703 MST, and the radiosonde was released at 0700 MST.

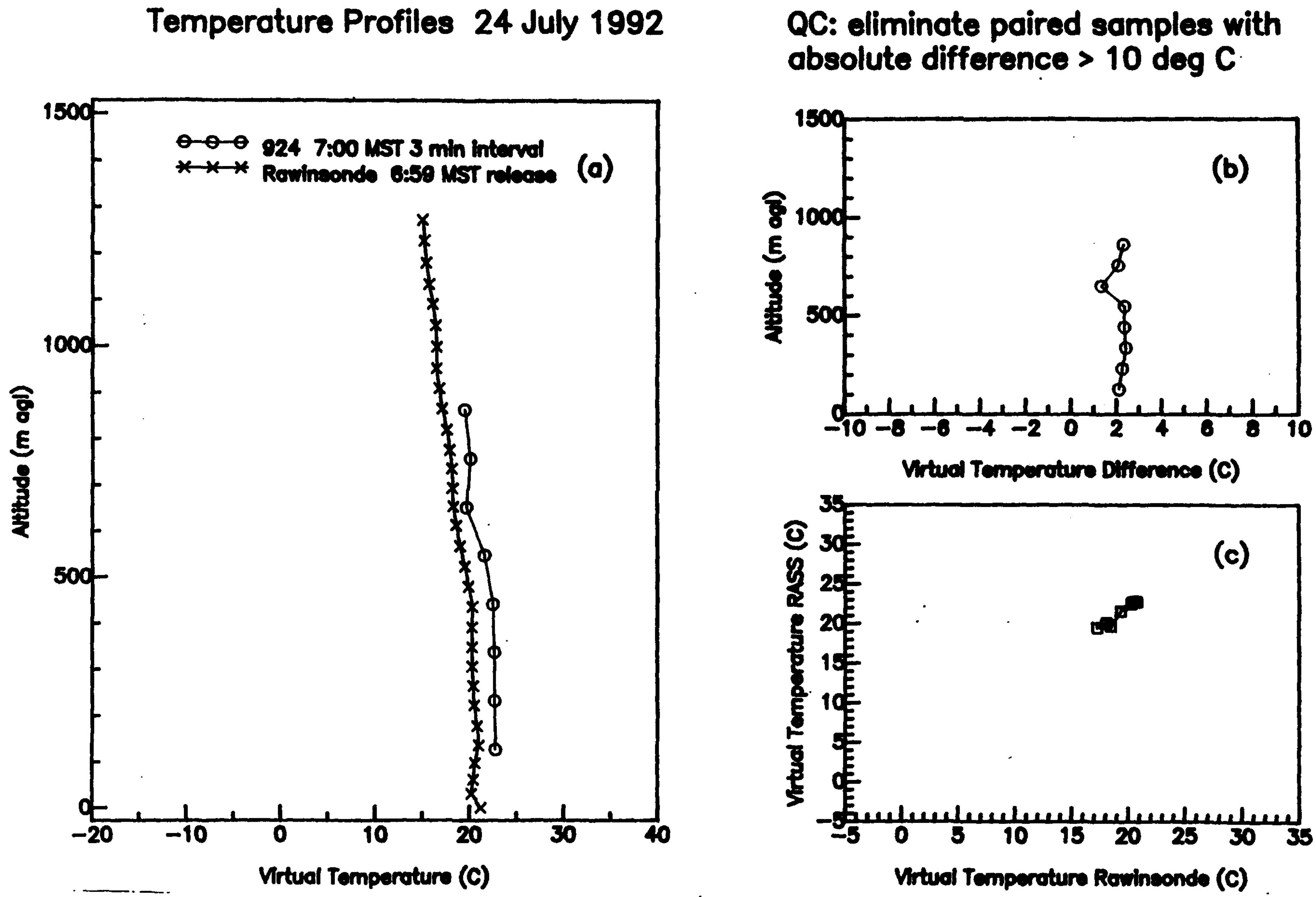


Figure 105. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 24 July 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0700 to 0703 MST, and the radiosonde was released at 0659 MST.

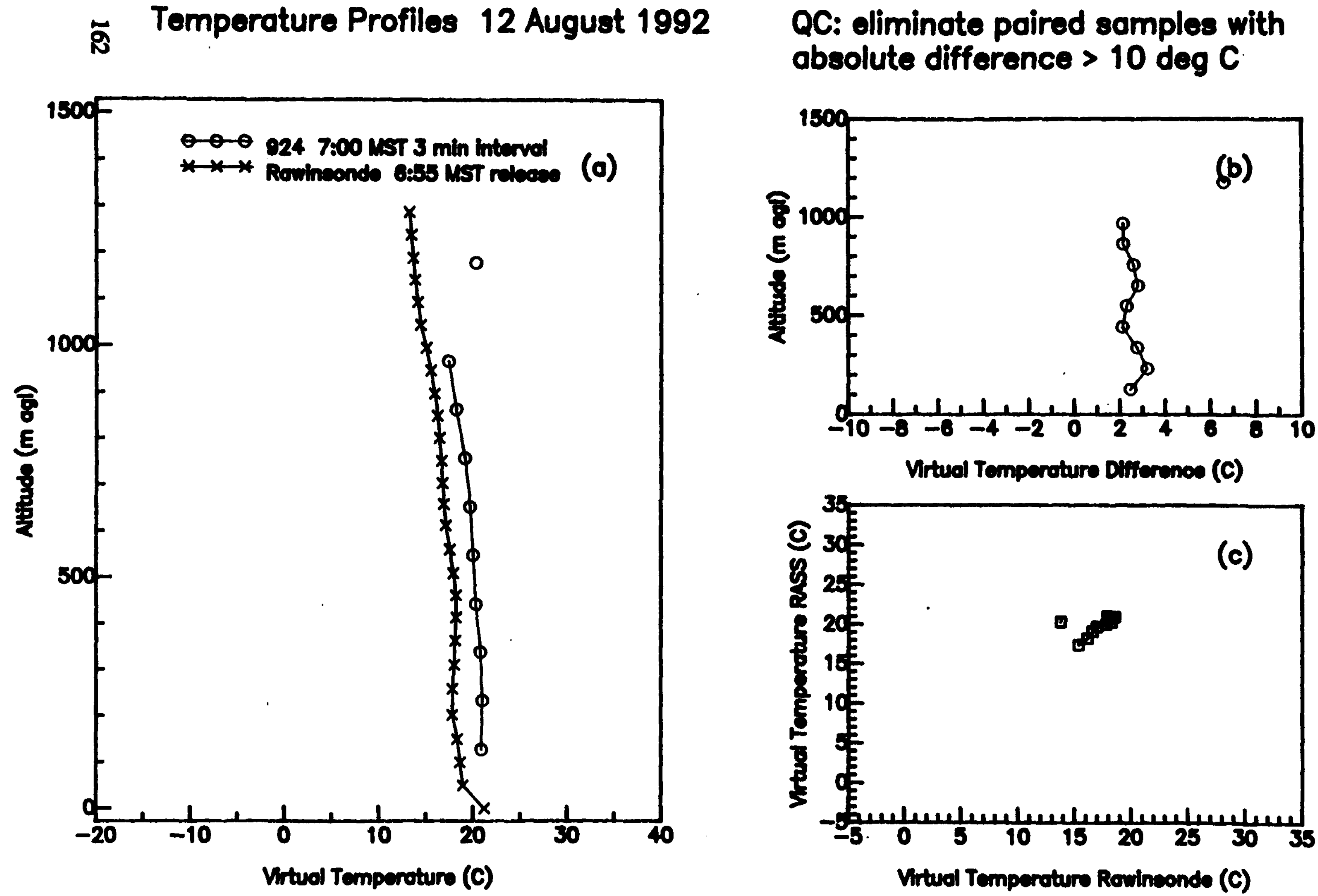


Figure 106. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 12 August 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0700 to 0703 MST, and the radiosonde was released at 0655 MST.

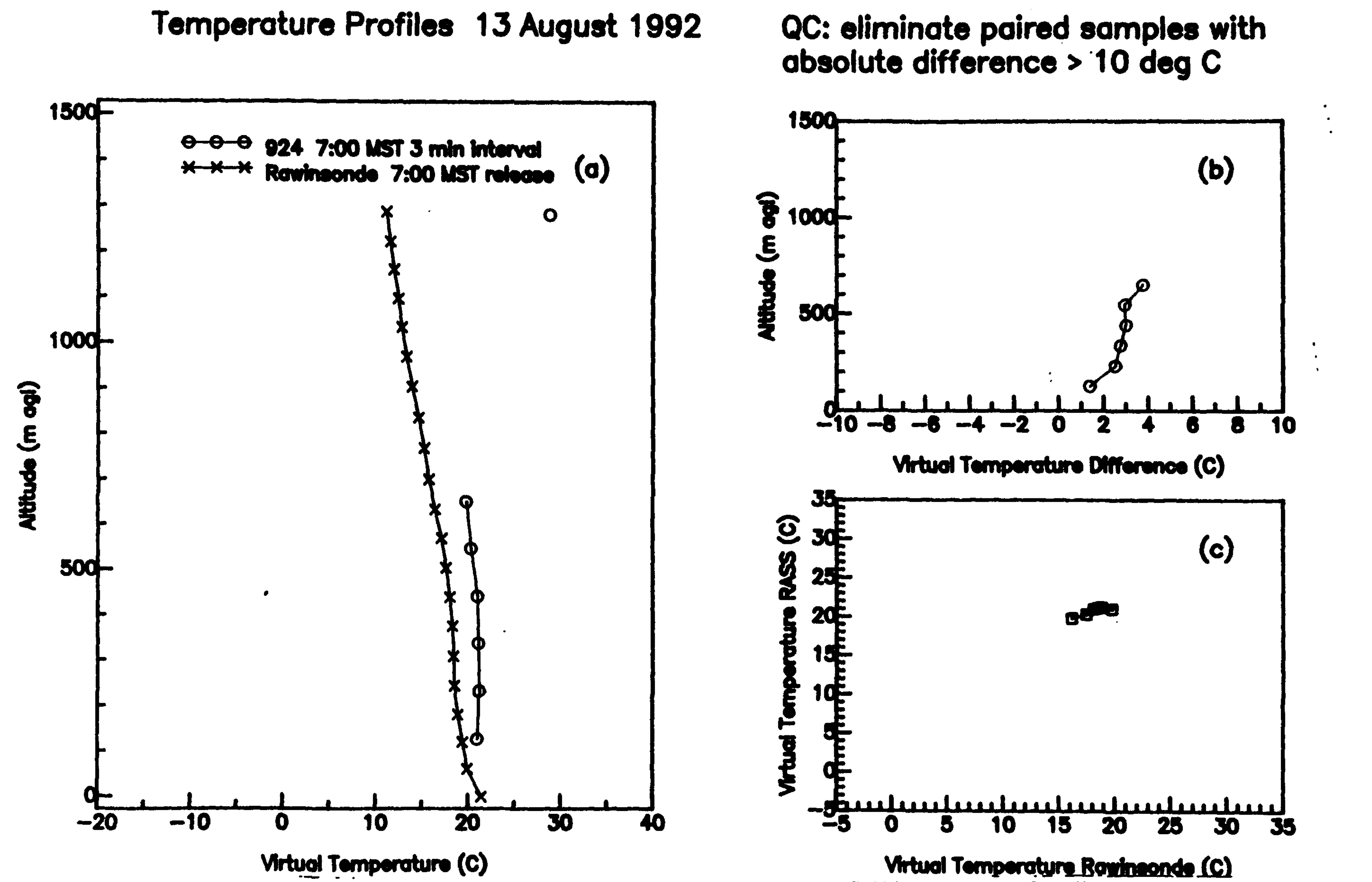


Figure 107. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 13 August 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0700 to 0703 MST, and the radiosonde was released at 0700 MST.

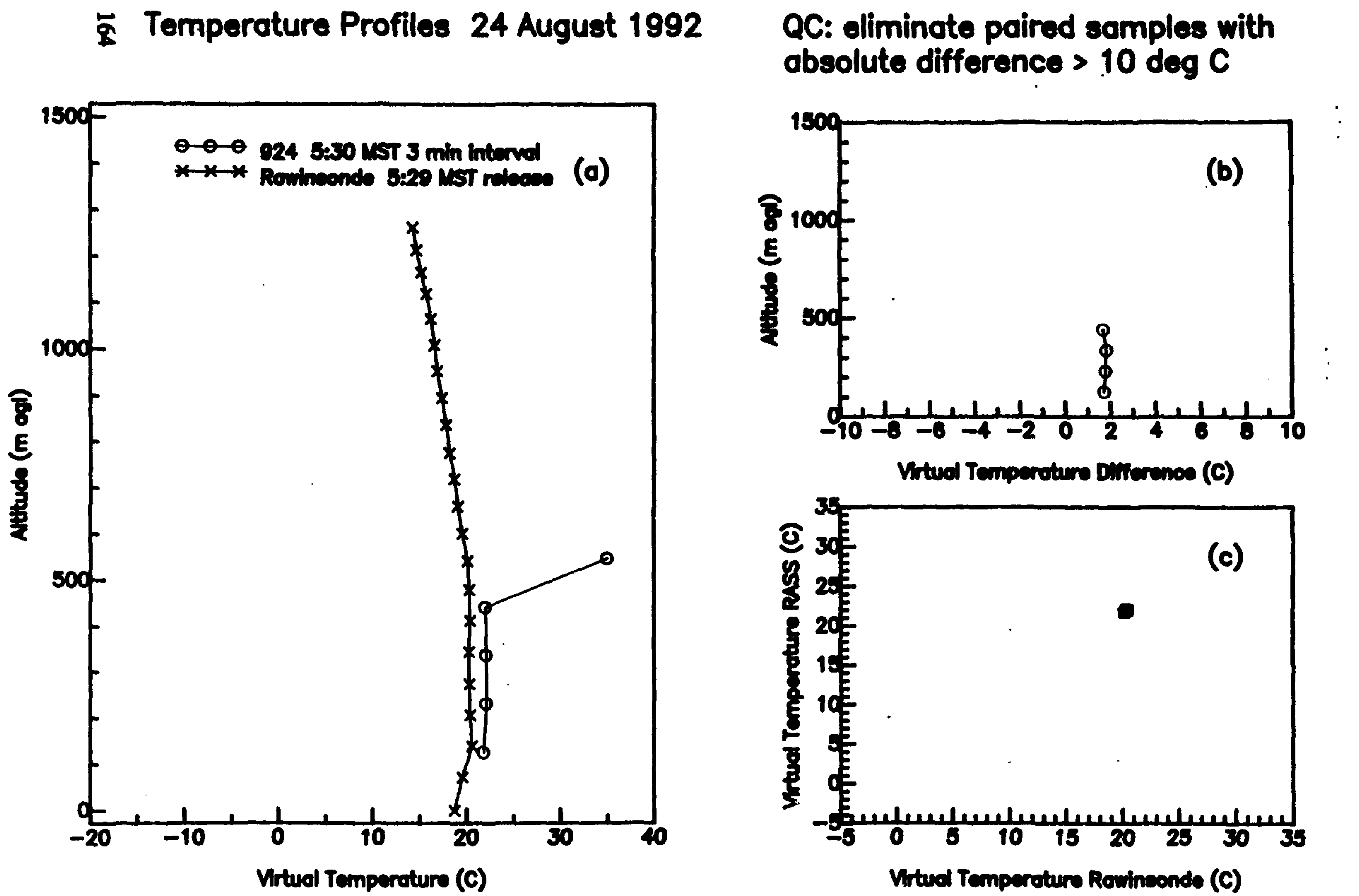


Figure 108. Comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during apparently uniform wind field conditions, WSMR, 24 August 1992: (a) vertical virtual temperature profiles, (b) vertical temperature difference profiles, and (c) regression line. RASS data represent a 3-min average from 0530 to 0533 MST, and the radiosonde was released at 0529 MST.

Table 14. Statistical summary of 924-MHz profiler RASS and radiosonde temperature data comparisons for uniform wind field days

Date (1992)	Time (MST)	Root MSE	ρ^a	m^b	b^c	Prob > |t|
2 Apr	0158	0.16	0.97	0.51	8.82	0.0002
7 Apr	0657	0.59	0.71	0.25	11.91	0.0438
12 Apr	1133	2.03	0.91	1.52	-9.17	0.3100
15 Apr	0700	0.32	0.93	0.63	6.32	0.1484
22 Apr	0730	1.83	0.48	0.38	11.20	0.2959
30 Apr	0057	0.49	0.62	0.29	17.67	0.0054
19 May	1258	0.58	0.96	0.55	11.90	0.0101
27 May	1255	0.41	0.98	0.61	8.26	0.6526
3 June	1056	1.53	0.97	1.41	-10.40	0.8953
10 June	0156	0.32	0.96	1.00	0.26	0.1680
19 June	0006	0.86	0.96	3.78	-81.40	0.8654
30 June	1257	0.14	0.99	0.25	24.27	0.4552
1 July	0706	0.96	0.45	0.26	20.11	0.0278
2 July	0630	0.85	0.91	1.06	-0.20	0.0116
9 July	0655	0.45	0.98	1.03	0.94	0.0001
24 July	0659	0.36	0.97	1.07	0.75	0.0001
12 Aug	0655	1.08	0.53	0.42	12.65	0.0001
13 Aug	0700	0.30	0.87	0.40	13.54	0.0004
24 Aug	0529	0.07	0.89	1.06	0.53	0.0001
Composite		1.62	0.93	0.83	4.89	0.0001

[a] Correlation coefficient
[b] Slope of regression line
[c] y intercept of regression line

5. Discussion

These data sets are not intended to be randomly representative of the data sets for the 24 March to 26 August 1992 period. Therefore, generalizations based on this data set should not be presented without adequate caveats as to how the data were selected with regard to meteorological and instrumental considerations. The data sets studied were checked for normality of the distribution and met the criterion.

Direction statistics are, for the most part, not specifically tabulated because of the 0/360° problem; rather speed data are presented as the resultant speed (S), and the east-west (U) and north-south (V) components. High, positive correlations in U and V imply a high correlation in direction.

5.1 Paired t-test

The results of the paired t-test for the different wind comparison categories are summarized in tables 5, 7, 12, and 13. A major result is that for many of the data sets the significance level is below the 0.05 significance level. In some cases the U components correlate much better than the V components or vice versa with a resultant overall poor correlation in the wind speed. These results are an artifact of having chosen the paired t-test that is sensitive to small standard deviations and sample size. The results of the t-test imply the possibility of a constant (or dc) offset between instruments. An examination of the tables indicates that, although there may be individual data sets in which, for reasons yet unknown, the mean difference between the 924-MHz and another system may be as high as 6-8 m/s for all the data selected, the mean of the 924-MHz measurements is within 2 m/s of the mean of the other systems.

5.2 Rawinsonde Comparisons

The results of the 924-MHz/rawinsonde comparison are tabulated in tables 4 through 7.

Although the wind fields were uniform based on the 924-MHz profiler data, low and negative correlation coefficients (the latter identified by underlined values in table 4) appeared on some days. The surface weather data were examined for evidence of convective activity, a factor that might disturb an apparently uniform wind field.

The data in table 4 indicate that on days when there is a uniform wind field and no convective activity even the coefficient of determination, ρ^2, is above 0.9 for speed or direction or both. From table 5 we see that the difference in means for all data sets was 1.8 m/s, about equivalent to the root MSE for regression of 2.2 m/s.

5.3 WF-100 Comparisons

During the periods WF-100 data were available, an overall offset in wind speed of about 2 m/s is observed, with many individual data sets showing regression offsets of upwards of 5 m/s or higher. As can be seen in table 12, the mean speed measured by the 924-MHz is within our ad hoc criteria of 2 m/s of the mean speed measured by the other systems.

5.4 Anemometer and Sodar Comparisons

Figure 84 shows a comparison between the wind speed and direction in the lowest low-mode gate (120 m that spans 70 through 169 m AGL) of the 924-MHz profiler and concurrent, vectorially averaged wind data from the top three levels (90, 120, and 150 m AGL) of the tower. The speed and the direction agree reasonably well, an agreement consistent throughout the other data sets examined. The anomalous 924-MHz direction data at 0830 MST is probably an artifact caused by a profiler difficulty in resolving wind speeds near zero.

Figure 85 shows the comparison of the speed and direction for the lowest gate of the sodar (37.5 through 62.5 m AGL) with the concurrent, vectorially averaged wind data from the 40 and 50 m AGL levels of the tower over the same 24-h period. The speed and direction agree quite well, also typical of the other data sets examined.

Figures 86 through 90 show the comparison of the wind speed and direction as determined from 924-MHz and sodar profiler systems over the lowest five range gates of the 924-MHz system. The direction comparisons are favorable throughout the vertical extent of the comparison, but the speed comparisons degrade as a function of altitude, and the 924-MHz shows the higher wind speeds. The degradation with height appears to be typical, and present indications are that the problem is with the sodar data.

5.5 404-MHz Profiler Comparisons

Comparison statistics for the 924- and 404-MHz profiler (the standard unit of the NOAA profiler network) data are presented in tables 6 through 8 and 10 through 13. Comparisons are for the uniform wind field days at the rawinsonde release times, for the WF-100 release times, and for the entire months of April, May, June, and August 1992.

The results for the uniform wind field days agree with the results of the comparison of the 924-MHz profiler with the rawinsonde; the overall agreement is within 2 m/s and for most days when the 924-MHz versus rawinsonde correlation coefficients are very high, the 924- versus 404-MHz correlation coefficients are very high. The 924- and 404-MHz data show anomalies during the uniform wind field days when the correlations are very low, usually attributable to convective activity. Additional research should be undertaken to understand the anomalous situations.

The monthly statistics are not as good as anticipated considering the two profilers were essentially collocated. Although the mean difference in measured speeds over all days and heights was within 2 m/s, the best correlation coefficient was only about 0.8 for August. An analysis of variance with respect to gate height and time of day might provide a reason for the poor correlation coefficients.

5.6 Virtual Temperature Comparisons

Although the number of samples from each day was low, correlation coefficients between RASS and radiosonde data were greater than 0.90 on 12 of the 19 days and as high as 0.98 on three days. The few days that show low correlation between RASS and radiosonde temperature data have one or two values in the upper gates that differ by as much as 6 to 8 °C. Root MSE between the paired measurements ranged from 0.07 to 2.03 °C.

Paired data from all the days were combined and analyzed. A composite comparison of virtual temperatures for the 19 periods is shown in figure 109. The overall correlation coefficient between RASS and radiosonde data was 0.93, and the root MSE was 1.62 °C. Considering that the RASS and radiosonde sites are separated by about 6 km and that both the spatial and temporal resolutions differ, these statistics are encouraging.

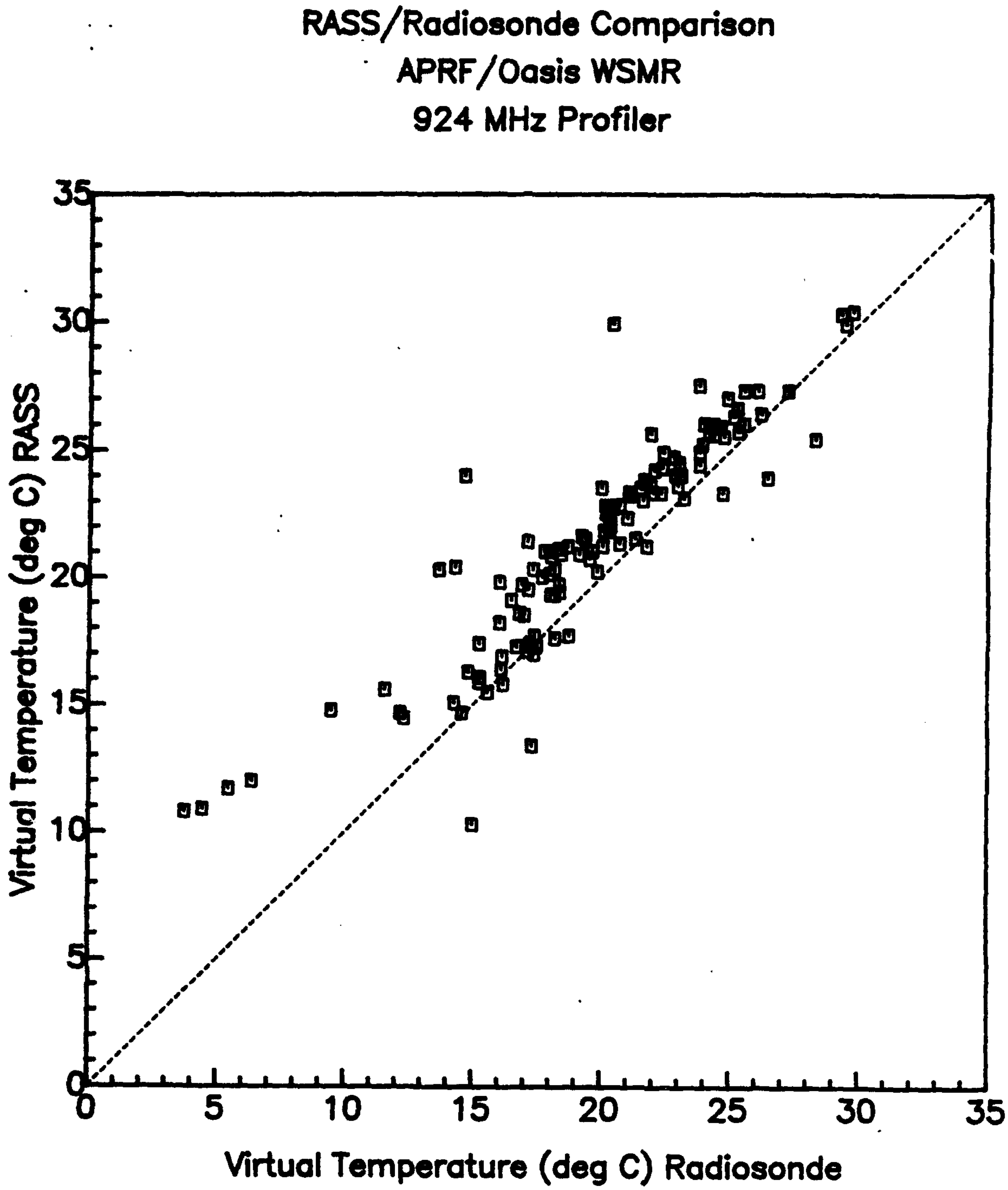


Figure 109. Composite comparison of virtual temperatures based on RASS (APRF site) and radiosonde (Oasis site) data during 19 days of apparently uniform wind field conditions, WSMR, 2 April to 24 August 1992. RASS data represent both 3- and 6-min averages.

6. Conclusions

These data show encouraging and discouraging tendencies. Two encouraging tendencies are the overall good comparison between the wind data obtained by the 924-MHz system and the five other systems on days of uniform wind fields within the WSMR air shed, and the good comparison at low altitudes between the 924-MHz and the WF-100, although, the latter comparison days were not necessarily distinguished by uniform wind fields.

In all the uniform wind field days and WF-100 days studied, the overall statistics indicate that the mean 924-MHz profiler measurements of wind speed are within 2 m/s of the means from the other systems.

Discouraging tendencies are the sharp differences in wind between the 924-MHz system and the other systems -- if individual days are singled out, the mean differences can approach 8 m/s; the differences between the 924-MHz profiler and the sodar at the upper range gates of the sodar; and the lack of good data from the high mode of the 924-MHz profiler.

Judicious use of data editing procedures and quality control measures currently under development would significantly improve the statistics for the periods of significant disagreement amongst profilers at a site. In most cases of disagreement between the 924-MHz profiler and the rawinsonde data, there appear to be reasonable meteorological reasons for the discrepancies.

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Acronyms

AGL	above ground level
APRF	Atmospheric Profiler Research Facility
ARL	Army Research Laboratory
BED	Battlefield Environment Directorate
HELSTF	High Energy Laser Systems Test Facility
HIDL	High Energy Laser Instrumentation Development Laboratory
MET	meteorological
MHUB/MASS	Microhub/Meteorological Atmospheric Sensing System
MPS	Mobile Profiler System
MSE	mean square error
MSL	above mean sea level
NAVAID	navigation aid
NOAA	National Oceanic and Atmospheric Administration
RASS	Radio Acoustic Sounding System
SAS	Statistical Analysis Software
WSMR	White Sands Missile Range

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Appendix A

Range Gate Data for the Vertical Wind Profilers

Vertical profiles of wind speed and direction were obtained with the 924-MHz profiler, the sodar, and the 404-MHz profiler. The gate numbers, corresponding gate heights, and height ranges for each of these three systems are listed in tables A-1 to A-3.

Table A-1. Low-mode gates for the 924-MHz wind profiler

Gate Number	Gate Height (m AGL)	Height Range (m AGL)
1	120	70-169
2	218	169-268
3	317	268-367
4	416	367-465
5	514	465-564
6	613	564-663
7	712	663-761
8	810	761-860
9	909	860-959
10	1008	959-1057
11	1106	1057-1156
12	1205	1156-1255
13	1304	1255-1353
14	1402	1353-1452
15	1501	1452-1551
16	1600	1551-1649
17	1698	1649-1748
18	1797	1748-1847
19	1896	1847-1945
20	1994	1945-2044
21	2093	2044-2143
22	2192	2143-2241
23	2290	2241-2340
24	2389	2340-2439
25	2488	2439-2538

Table A-2. Sodar gates

Gate Number	Gate Height (m AGL)	Height Range (m AGL)
1	50	37.5-62.5
2	75	62.5-87.5
3	100	87.5-112.5
4	125	112.5-137.5
5	150	137.5-162.5
6	175	162.5-187.5
7	200	187.5-212.5
8	225	212.5-237.5
9	250	237.5-262.5
10	275	262.5-287.5
11	300	287.5-312.5
12	325	312.5-337.5
13	350	337.5-362.5
14	375	362.5-387.5
15	400	387.5-412.5
16	425	412.5-437.5
17	450	437.5-462.5
18	475	462.5-487.5
19	500	487.5-512.5
20	525	512.5-537.5

Table A-3. Low-mode gates for the 404-MHz wind profiler

Gate Number	Gate Height (m AGL)	Height Range (m AGL)	Gate Number	Gate Height (m AGL)	Height Range (m AGL)
1	500	332.5-667.5	19	5000	4832.5-5167.5
2	750	582.5-917.5	20	5250	5082.5-5417.5
3	1000	832.5-1167.5	21	5500	5332.5-5667.5
4	1250	1082.5-1417.5	22	5750	5582.5-5917.5
5	1500	1332.5-1667.5	23	6000	5832.5-6167.5
6	1750	1582.5-1917.5	24	6250	6082.5-6417.5
7	2000	1832.5-2167.5	25	6500	6332.5-6667.5
8	2250	2082.5-2417.5	26	6750	6582.5-6917.5
9	2500	2332.5-2667.5	27	7000	6832.5-7167.5
10	2750	2582.5-2917.5	28	7250	7082.5-7417.5
11	3000	2832.5-3167.5	29	7500	7332.5-7667.5
12	3250	3082.5-3417.5	30	7750	7582.5-7917.5
13	3500	3332.5-3667.5	31	8000	7832.5-8167.5
14	3750	3582.5-3917.5	32	8250	8082.5-8417.5
15	4000	3832.5-4167.5	33	8500	8332.5-8667.5
16	4250	4082.5-4417.5	34	8750	8582.5-8917.5
17	4500	4332.5-4667.5	35	9000	8832.5-9167.5
18	4750	4582.5-4917.5	36	9250	9082.5-9417.5

Appendix B
Range Gate Data for the Temperature Profiler

Vertical profiles of the virtual temperature were obtained with the RASS system associated with the 924-MHz profiler. The gate numbers and corresponding gate heights and height ranges are listed in table B-1.

Table B-1. Low-mode gates for the 924-MHz RASS system

Gate Number	Gate Height (m AGL)	Height Range (m AGL)
1	127	74-180
2	233	180-285
3	338	285-390
4	442	390-494
5	548	494-600
6	652	600-704
7	757	704-810
8	863	810-915
9	967	915-1019
10	1072	1019-1125
11	1178	1125-1231
12	1283	1231-1336

Appendix C

Vaisala Rawinsonde and WF-100 Systems at WSMR

Vaisala Rawinsonde

The Vaisala stand-alone rawinsonde system consists of a DigiCORA ground station and RS-80-15N (Omega) radiosonde packages to provide Omega-based navigation aid (NAVAID) winds.

Worldwide there are 12 Omega NAVAID stations, each broadcasting in the 11-14 kHz range. At White Sands Missile Range (WSMR) a maximum of nine stations are used because the three Russian stations have been blocked out. A minimum of three stations are required to compute the wind vector from the rate of change of the signal phase that depends on the movement of the radiosonde flight package. According to Passi and Morel,[1] the Omega navigation system has an inherent noise of 200 m in differential position measurements so at least 3-min averages are required for wind measurement. Data are acquired at 10-s intervals.

For the first 12 10-s data points (2 min or about 600 m depending on the rise rate of the balloon) the wind data are estimated theoretically from an Ekman spiral that depends on the wind measured at the surface and on the 25-point average wind at the 2-min point.

The derivation of the Ekman spiral (a hodograph of the wind velocity vector) assumes that the atmosphere is:

- steady state
- horizontally homogeneous
- statically neutral
- barotropic (geostrophic wind constant with height)

and that there is no subsidence. Because the combination of these conditions rarely occurs in the atmosphere, there may be a marked difference between the Ekman wind and the actual wind.

Two types of Vaisala systems are currently in use at WSMR. This causes a problem because the low-level (surface to about 600 m AGL = first 2 min of the flight) winds are derived differently with the two systems. Also, the system used for a rawinsonde flight is not identified with the wind data provided to a user. Only a technician would be able to differentiate between the two systems and even then it would require opening up the system. For the Vaisala data acquired at Oasis during the summer of 1992, the site logbook indicated that only the Ekman system was used.

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[1] Passi, R. M. and C. Morel, "Wind Errors using the Worldwide Loran Network." *J. Atmos. Ocean. Technol.*, *4*, pp. 670-700, 1987.

The older of the two systems, hereinafter referred to as the Ekman system, derives the winds in the first 2 min of the flight using the Ekman spiral. The newer system, referred to as the SYSGEN system, uses a cubic spline technique as the basis for deriving winds during the first 2 min of the flight.

Problems with the first generation Ekman system were originally discovered by a Canadian group. Apparently unknown to the users, Vaisala changed the software and in 1982 came out with the DigiCORA 11 system (also Ekman based). WSMR purchased 12 of these newer Ekman systems in 1982. This led to the development of the Integrated Upper Air System (IUAS), whereby the problems encountered in the low levels would be circumvented by using an Enterprise WF-100 radar system up to about 20,000 ft AGL.

Of the 12 newer Ekman systems purchased by WSMR, nine are still in use. When used in the STANDALONE mode, these systems are still Ekman based (i.e., they were never modified to the SYSGEN configuration). Moreover, the vertical averaging interval is fixed at 4 min.

In 1984 or during the 1987-1988 time frame, Vaisala introduced the SYSGEN system to alleviate the problems with the Ekman spiral. Although the SYSGEN system has an operator-selectable averaging interval that ranges from 13 to 25 10-s data points (2 to 4 min), only 4 min is used at WSMR.

Currently there are 13 Vaisala systems in use at WSMR--9 Ekman and 4 SYSGEN.

WF-100

IUAS

The IUAS system was developed to alleviate problems with the Ekman spiral data in the lowest 600 m and to provide improved data at higher levels. This system uses an Enterprise WF-100 Wind-Finding Radar system and can provide elevation angle, azimuth angle and range data at 1-s intervals from the ground up to an altitude where the WF-100 switches over to the Vaisala system.

To obtain an optimum data set, several hours should be allowed for alignment. Personnel at Oasis claim there has never been a problem with the data at low elevation angles.

The sampling rate of the WF-100 is 250 samples per second of each of the range, azimuth, and elevation angle. However, only the last 196 of the 250 samples (0.784 s) are used to obtain a 1-s arithmetic mean. The average position data for the first two 1-s data points are used to determine the 1-s wind.

A .WND file containing the following data is created:

- altitude--m above sea level (m MSL)
- wind speed (knots)
- wind direction (°)
- eastern horizontal displacement (m)
- northern horizontal displacement (m)

A smoothing technique is used to ease a possible discontinuity in the data at the level the WF-100 switches over to the Vaisala. In this technique, the transition begins about 4 min before the switch point when 24 of the 25 10-s points represent WF-100 data and 1 10-s data point represents Omega data. The WF-100/Omega weighting systematically decreases with altitude until the switch over point when the 4 min average wind consists of 2 min of WF-100 data and 2 min of Vaisala data. The weighting continues to decrease with altitude until the data are entirely Omega data.

Obviously bad data, usually caused by tracking problems, are manually purged. Replacement data may be manually interpolated and entered or the computer may be tasked to do the interpolation and entering.

The averaging interval for the 1-s data is operator selectable. Data are usually provided at 10-s intervals to correspond with the Vaisala data. The 10-s data represent 30-s means (15 s before and 15 s after the 10-s height). The 30-s averaging interval was selected to reduce the noise inherent in the 1-s data. At the first 10-s data point (10 s after balloon release) the 30-s averaging interval is an average of the first 10 1-s points.

The mean and standard deviation of the 1-s samples constituting an averaging interval are computed. Any data exceeding 2 standard deviations are rejected. However, the actual number of samples constituting the averaging interval is not archived.

Appendix D

Sample Statistical Output

A sample of the statistical output from the SAS statistics package follows:

```
                         ALL SDR_924 DATA
                       Correlation Analysis

6 'VAR' Variables:  W9_SPD  W9_U  W9_V  SDR_SPD  SDR_U  SDR_V

                         Simple Statistics

Variable    N         Mean      Std Dev          Sum      Minimum      Maximum

W9_SPD    286       5.7056       2.9859         1632       0.1000      13.4000
W9_U      286      -2.2504       4.7599    -643.6154     -12.7612      11.3638
W9_V      286      -0.1446       3.7181     -41.3550      -9.2565      12.2700
SDR_SPD   286       4.5516       2.6055         1302       0.2700      16.0700
SDR_U     286      -2.4636       3.6949    -704.5886     -15.8259       8.0622
SDR_V     286      -0.1109       2.7969     -31.7263      -5.9455      10.0349

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 286

             W9_SPD        W9_U        W9_V     SDR_SPD       SDR_U       SDR_V

W9_SPD      1.00000    -0.45010     0.13487     0.64273    -0.32007     0.17278
             0.0         0.0001      0.0225      0.0001      0.0001      0.0034

W9_U       -0.45010     1.00000     0.03273    -0.43236     0.78528     0.04097
             0.0001      0.0         0.5815      0.0001      0.0001      0.4902

W9_V        0.13487     0.03273     1.00000     0.10705    -0.00030     0.90117
             0.0225      0.5815      0.0         0.0707      0.9960      0.0001

SDR_SPD     0.64273    -0.43236     0.10705     1.00000    -0.64040     0.09651
             0.0001      0.0001      0.0707      0.0         0.0001      0.1034

SDR_U      -0.32007     0.78528    -0.00030    -0.64040     1.00000     0.00982
             0.0001      0.0001      0.9960      0.0001      0.0         0.8687

SDR_V       0.17278     0.04097     0.90117     0.09651     0.00982     1.00000
             0.0034      0.4902      0.0001      0.1034      0.8687      0.0
```

Dependent Variable: W9_SPD

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1049.64452	1049.64452	199.899	0.0001
Error	284	1491.24653	5.25087		
C Total	285	2540.89105			

Root MSE	2.29148	R-square	0.4131
Dep Mean	5.70559	Adj R-sq	0.4110
C.V.	40.16194		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	2.353086	0.27310176	8.616	0.0001
SDR_SPD	1	0.736560	0.05209581	14.139	0.0001

Dependent Variable: W9_U

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	3981.87985	3981.87985	456.877	0.0001
Error	284	2475.18167	8.71543		
C Total	285	6457.06152			

Root MSE	2.95219	R-square	0.6167
Dep Mean	-2.25040	Adj R-sq	0.6153
C.V.	-131.18493		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.241817	0.20992462	1.152	0.2503
SDR_U	1	1.011619	0.04732789	21.375	0.0001

Dependent Variable: W9_V

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	3199.58836	3199.58836	1227.526	0.0001
Error	284	740.25581	2.60653		
C Total	285	3939.84417			

Root MSE	1.61448	R-square	0.8121
Dep Mean	-0.14460	Adj R-sq	0.8114
C.V.	-1116.52838		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-0.011706	0.09554132	-0.123	0.9026
SDR_V	1	1.197967	0.03419241	35.036	0.0001

U COMPONENT

Univariate Procedure

Variable=U

Moments

N	286	Sum Wgts	286
Mean	0.213193	Sum	60.97321
Std Dev	2.947319	Variance	8.686691
Skewness	1.252448	Kurtosis	3.953438
USS	2488.706	CSS	2475.707
CV	1382.465	Std Mean	0.174279
T:Mean=0	1.223288	Prob>|T|	0.2222
Num ^= 0	286	Num > 0	140
M(Sign)	-3	Prob>|M|	0.7676
Sgn Rank	253.5	Prob>|S|	0.8567

99% Confidence Interval

N	ALPHA	MEAN	UPPER	LOWER
286	0.01	0.21319	0.66213	-0.23575

95% Confidence Interval

N	ALPHA	MEAN	UPPER	LOWER
286	0.05	0.21319	0.55478	-0.12839

Appendix E

Sample Regression Line Plots

Selected regression line plots involving the 924-MHz, tower, sodar, and 404-MHz systems during the WF-100 and rawinsonde systems are shown in figures E-1 through E-5.

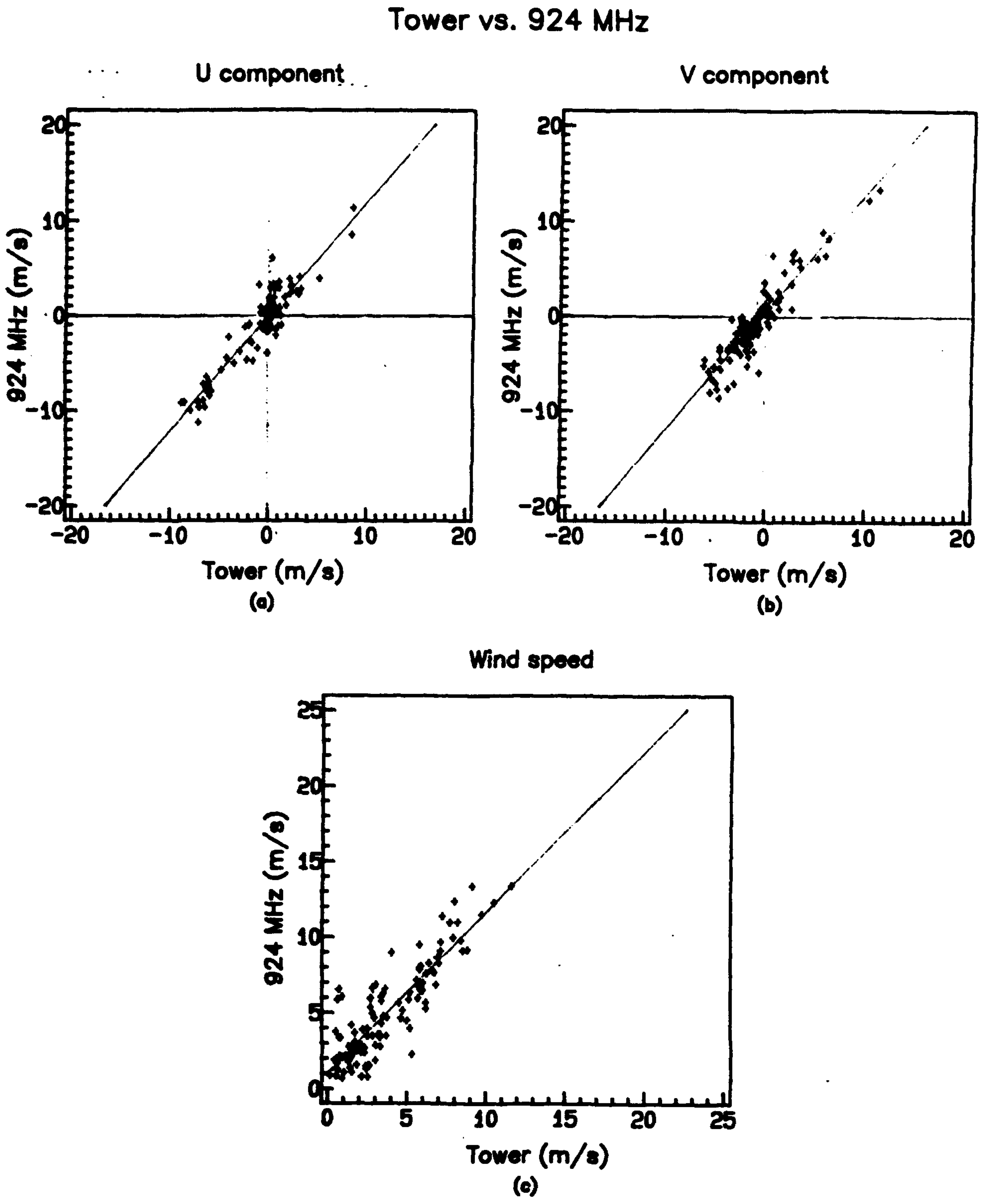

Figure E-1. Regression lines for (a) U component, (b) V component, and (c) resultant wind speed based on measurements with a 924-MHz wind profiler at 120 m AGL (APRF site) and tower-mounted anemometers at 90, 120, and 150 m AGL (LC-35), WSMR, during 9 of 14 WF-100 measurement periods listed in table 3 (15-min averages).

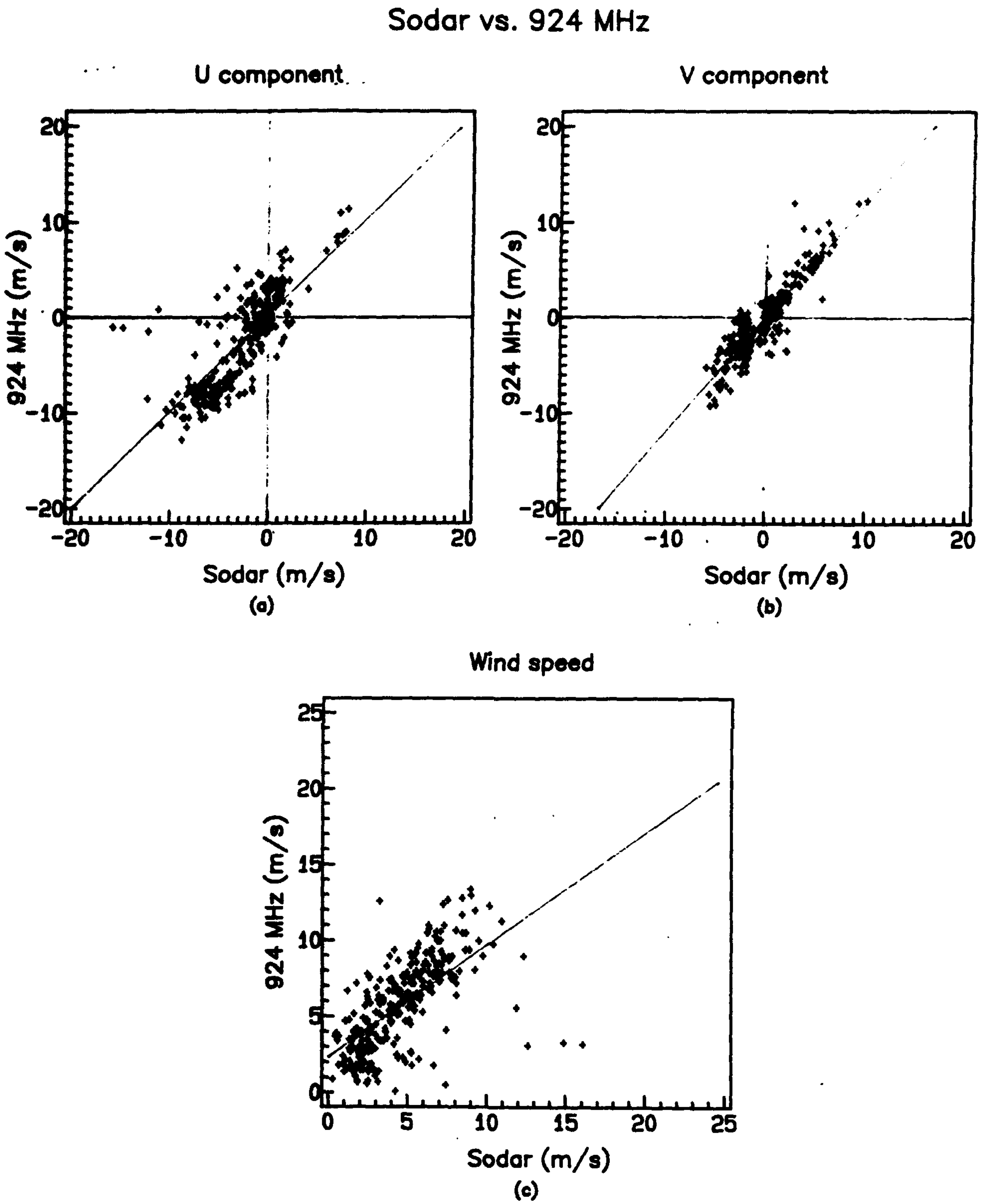

Figure E-2. Regression lines for (a) U component, (b) V component, and (c) resultant wind speed based on measurements with a 924-MHz wind profiler and a sodar, APRF site, WSMR, during 13 of 14 WF-100 measurement periods listed in table 3 (15-min averages).

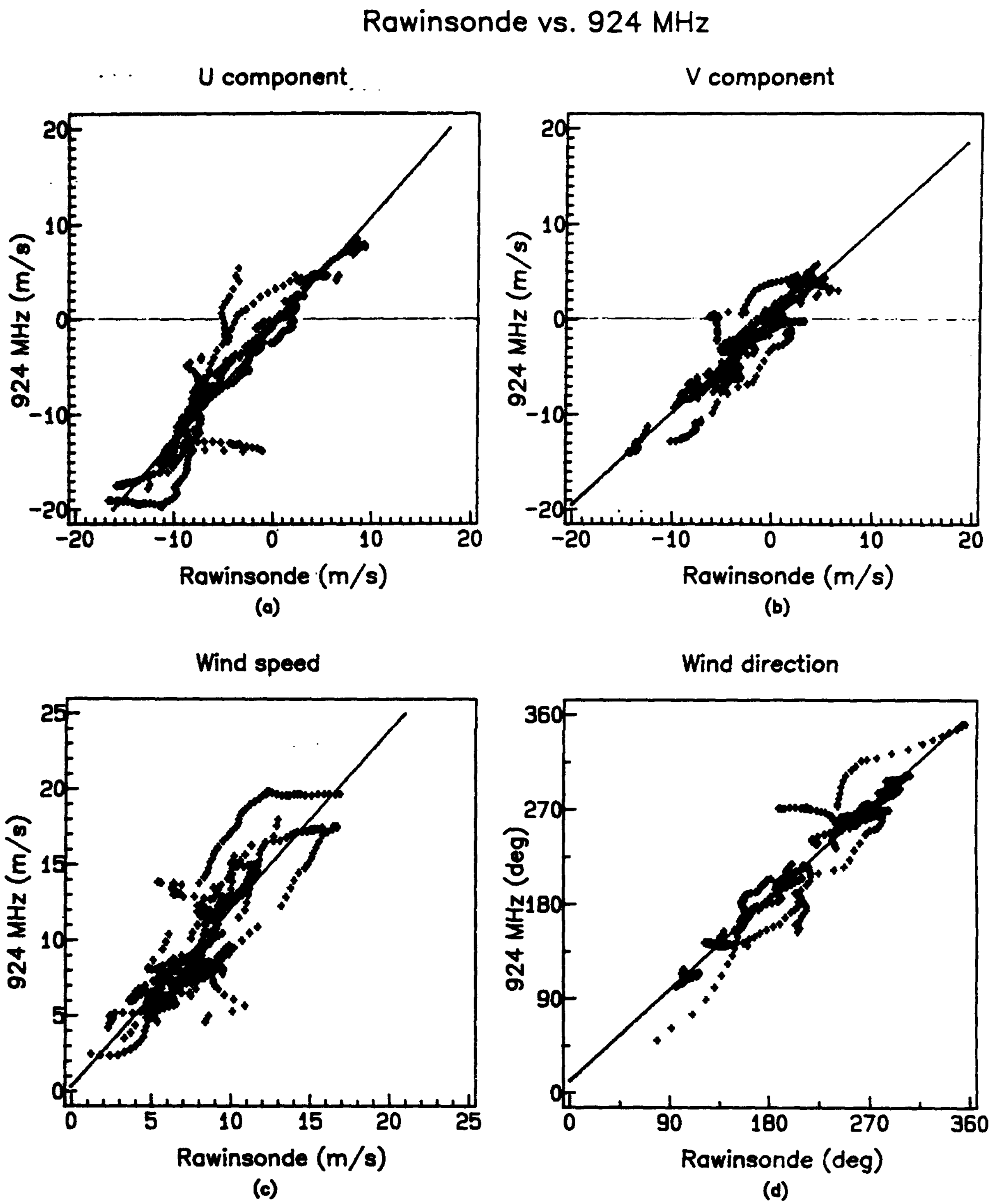

Figure E-3. Regression lines for (a) U component, (b) V component, (c) resultant wind speed, and (d) wind direction based on measurements with a 924-MHz wind profiler (APRF site) and rawinsondes (Oasis site), WSMR, during the 23 days of expected uniform wind fields listed in table 4 (30-min 924 averages before 5 June and 15-min averages after 5 June).

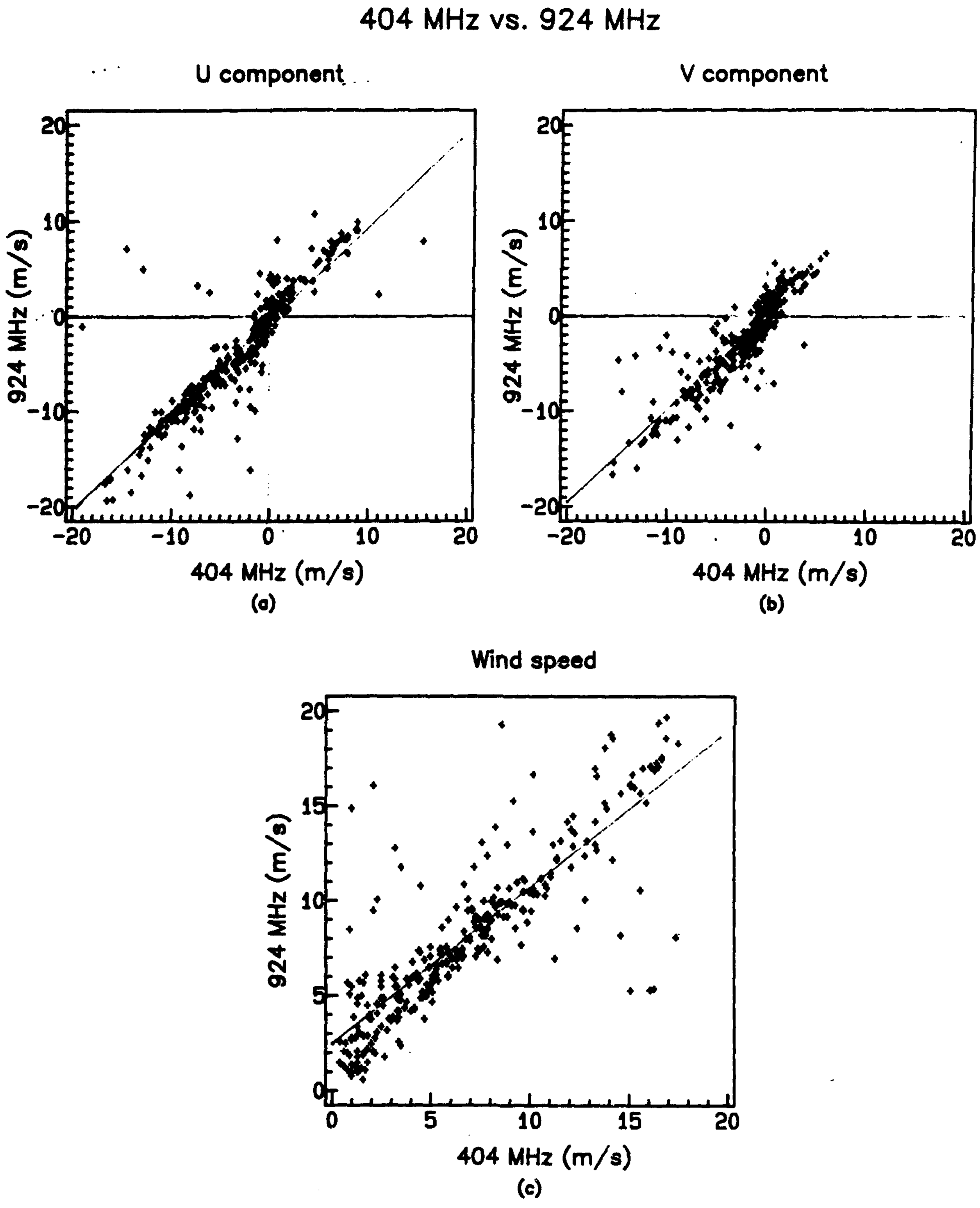

Figure E-4. Regression lines for (a) U component, (b) V component, and (c) resultant wind speed based on measurements with a 924-MHz wind profiler and a 404-MHz wind profiler, APRF site, WSMR, during 19 of 23 days of expected uniform wind fields listed in table 4 (60-min averages).

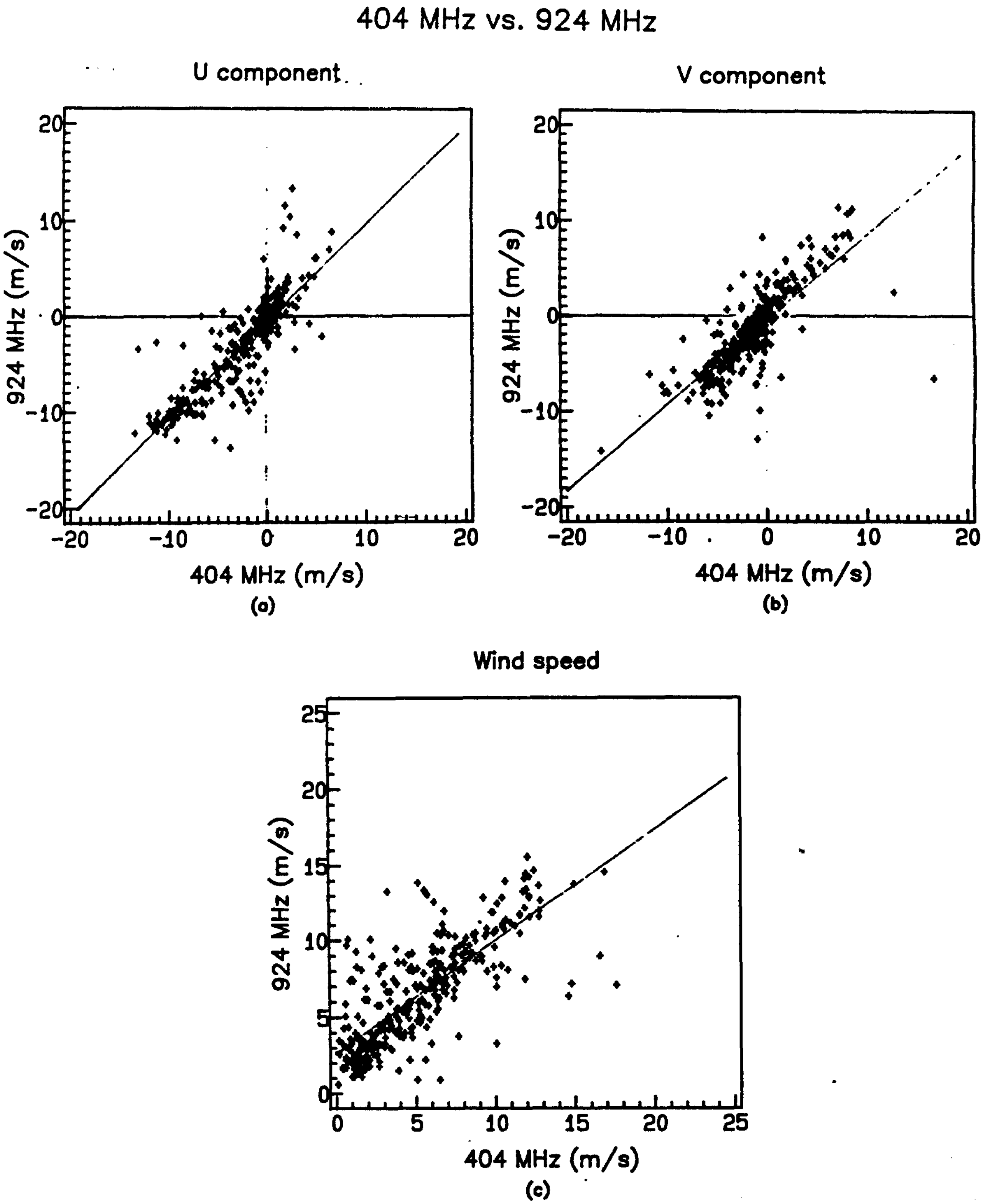

Figure E-5. Regression lines for (a) U component, (b) V component, and (c) resultant wind speed based on measurements with a 924-MHz wind profiler and a 404-MHz wind profiler, APRF site, during 10 of 14 WF-100 measurement periods listed in table 3 (60-min averages).