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Abstract. Profiles are presented of virtual temperature, potential temperature, specific humidity, and windspeed, based on data gathered with the Boundary Layer Instrument Package (BLIP) during the Barbados Oceanographic and Meteorological Experiment (BOMEX) in 1969. Included are mean profiles of these parameters for undisturbed conditions and several sets of profiles for disturbed conditions.

1. INTRODUCTION

Data used in forming the profiles presented in this document were gathered during the Barbados Oceanographic and Meteorological Experiment (BOMEX) in 1969 with a specially designed Boundary Layer Instrument Package (BLIP), which was launched from four of the five BOMEX ships by means of tethered balloons (Almazan 1971). Only data from the *Oceanographer* and *Mt. Mitchell* were used for this study.

The BLIPs were instrumented to measure dry- and wet-bulb temperatures, windspeed, and wind direction. They operated in two modes: a fixed level mode and a profile mode. In the fixed-level mode, the BLIPs were raised from the surface to a nominal height of 300 m, where they remained for several hours before descent. In the profile mode, they were allowed to rise well above 300 m before descending, but because far fewer runs were made in this mode, only the lowest 300 m of the atmosphere were considered in the analysis presented here. The recorded height could not be used because no correction was made for the error caused by the catenary formed on the tether line.

2. DERIVED QUANTITIES

Continuous pressure readings were not taken on most BLIP flights. A modified version of the standard radiosonde aneroid baroswitch was used to indicate pressure. The height of the BLIP was calculated from the surface pressure and the baroswitch readings. The ascent and descent rates between pressure contacts were assumed constant. The instrument's height before the first pressure contact was flagged cannot be determined with certainty, however, and data from below 50 m were therefore not included in this analysis.

Pressures from the five to seven contact changes up to 300 m were interpolated to 10-m increments, and averages of dry- and wet-bulb temperatures were computed for each increment. These 10-m values were used in computing the 10-m mean vapor pressure by use of the Goff-Gratch and Ferrel formulas (Smithsonian 1951, pp. 350 and 365).

The specific humidity was calculated from the expression (Haltiner and Martin 1957)

$$q = 0.622e/(P-0.378e), \quad (1)$$

where P is the pressure, and e is the vapor pressure.

Poisson's relationship was used in computing potential temperature, and the virtual temperature, T_v, was calculated by use of the equation

$$T_v = T/(1-0.379e/P),$$

where T is temperature in ^{o}K.

3. PROFILES

The profiles presented here include average profiles for undisturbed conditions and typical profiles for disturbed conditions. The atmosphere was considered undisturbed when no precipitation was recorded on the ship's surface observations form within 2 hr before BLIP release time. A total of 29 such soundings were identified. Conditions were considered disturbed when precipitation was reported at or in the vicinity of the ship within 2 hr of the sounding.

3.1 Undisturbed Conditions

A total of 29 BLIP soundings taken during undisturbed conditions were identified, and classified in terms of ship, day, night, ascent, and descent. Profiles of virtual temperature, specific humidity, and windspeed were drawn for each of these categories. Since no systematic differences were found, mean profiles of all 29 soundings are presented.

Lapse rates of virtual temperature for the individual cases varied from $0.9^{o}C/100$ m to $1.2^{o}C/100$ m, yielding a mean lapse rate of approximately $1.1^{o}C/100$ m (fig. 1). This indicates the atmosphere is near-neutral to slightly unstable under undisturbed conditions.

There is no significant change in potential temperature with height, as shown in the mean sounding (fig. 2). This implies a neutral or near-neutral atmosphere for the undisturbed case.

The mean specific humidity is essentially constant with height from 50 to 300 m (fig. 3), and amounts in this layer to 16.59 ± 0.23 g/kg. It should be noted, however, that several BLIP soundings taken during undisturbed conditions but not included in this analysis showed very strong lapse rates of specific humidity. In the lower part of these anomalous soundings, the specific humidity was greater than 22 g/kg and decreased to less than 20 g/kg at 300 m. These values correspond to relative humidities greater than 98 percent over the entire layer. Since no physical explanation could be found for these extreme values, it seems likely that the dewpoint sensor had been malfunctioning during these runs.

By far the greatest variability of any parameter was found in the individual windspeed soundings, and this variability is reflected in the mean profile (fig. 4). A slight increase in windspeed with height is clearly discernible, however, with mean windspeeds averaging 8.7 m/s in the 50- to 100-m layer and 9.7 m/s in the layer from 250 to 300 m. This finding is qualitatively consistent with data on the northeast trades in the lowest part of the planetary boundary layer presented by Roll (1965). The windspeeds are slightly greater than the 5-day mean, four-ship average windspeeds based on rawinsonde data (E.M. Rasmusson 1974, private communication). This difference is ascribed to differences in instrumentation.

3.2 Disturbed Conditions

Profiles of virtual temperature, potential temperature, specific humidity, and windspeed based on data from eight BLIP runs are presented as typical for disturbed conditions (figs. 5 through 37). Ship, date, time, and weather conditions for the eight cases are given below.

Case A (figs. 5, 13, 21, and 29)

Mt. Mitchell, July 14, 1969, 0008 to 0026 GMT. Surface observations indicate a shower beginning at 2324 GMT on July 13 and ending at 0012 GMT on July 14. Total cloud amount for several hours before the shower was 6/8 to 7/8 of cumulonimbus, dropping to 2/8 of moderate cumulus by 0300 GMT, with overcast during the shower. The low cloud amount remained between 1/8 and 2/8 throughout the run, except during the shower. Surface wind direction was from the northeast for several hours before and after the shower. Windspeeds varied from 3 to 8 kn.

Case B (figs. 6, 14, 22, and 30)

Mt. Mitchell, July 17, 1969, 1935 to 1958 GMT. Intermittent showers were reported in the area, but not at the ship, from 1200 to 1800 GMT. Total cloud cover in the early morning, 1200 GMT, was 6/8, dropping to 3/8 by 1500 GMT. The low cloud amount remained constant at 2/8, and well-developed cumulonimbus were observed at 1200 and 1800 GMT. Wind direction was from the northeast, except for east-southeasterly winds reported at 1800 GMT. Windspeeds varied from 6 to 8 kn.

Case C (figs. 7, 15, and 31)

Mt. Mitchell, June 29, 1969, 0745 to 0758 GMT. Surface observations indicate intermittent light showers from 0816 to 1016 GMT. Total cloud cover was 7/8 and 8/8 from 0600 GMT to several hours after the sounding. Low cloud amount ranged from 3/8 to cumulonimbus at 0730 GMT to between 5/8 and 6/8 after 0900 GMT. Winds were from the east-northeast at 16 to 17 kn.

Case D (figs. 8, 16, 23, and 32)

Mt. Mitchell, July 1, 1969, 0424 to 0435 GMT. A brief shower was reported from 0412 to 0416 GMT. The sky was overcast with between 4/8 and 5/8 of cumulonimbus and well-developed cumulus. Surface winds varied between 14 and 15 kn from the east-northeast.

Case E (figs. 9, 17, 24, and 33)

Mt. Mitchell, July 1, 1969, 0754 to 0804 GMT. Conditions were generally the same as in Case D. A shower began at 0729 and ended at 0733 GMT. Overcast skies with 5/8 of cumulonimbus during the shower and 3/8 after the shower were reported. Surface winds were from the east-northeast, with speeds of 22 kn at 0730 GMT decreasing to 14 kn at 0900 GMT.

Case F (figs. 10, 18, 25, and 34)

Oceanographer, June 28, 1969, 2145 to 2154 GMT. At the time of the sounding, 5/8 to 7/8 of cumulonimbus with showers were reported in the vicinity. A light shower at the ship was reported at 2316 GMT, ending at 2336 GMT. Winds were from the east-southeast at 13 to 15 kn.

Case G (figs. 11, 19, 26, and 35)

Oceanographer, July 13, 1969, 1022 to 1039 GMT. A light shower occurred from 1015 to 1100 GMT. The sky was overcast with 7/8 of moderate cumulus. Windspeed was 14 kn. Wind direction was not reported.

Case H (figs. 12, 20, 27, and 36)

Oceanographer, July 13, 1969, 1054 to 1104 GMT. Weather conditions were the same as in Case G.

The lapse rate of virtual temperature is taken as a measure of stability since moisture and its variation with height is important in a tropical environment. As seen in figures 5 and 6, the lapse rate of virtual temperature is approximately 0.7°C/100 m for Case A and 0.5°C/100 m for Case B. These two soundings, as well as four others (figs. 7, 10, 11, and 12) indicate that the atmosphere is slightly stable in the lowest 300 m during disturbed conditions, a finding that agrees with results reported by Seguin (1972). Note, however, that this stable lapse rate is not found in Cases D and E (figs. 8 and 9).

The existence of a stable layer in the lowest 300 m is also clearly evident in the potential temperature profiles. In Case A (fig. 13), the potential temperature rises approximately 0.7°C from the bottom to the top of the layer. In Case B (fig. 14), the rise is approximately 1.2°C. Two of the other soundings show a similar pattern (figs. 17 and 20), but the four remaining cases (figs. 15, 16, 18, and 19) show more neutral behavior.

The values of specific humidity for Case A (fig. 21) are greater than those shown by the mean sounding under undisturbed conditions discussed in the preceding section (fig. 3), and are much more variable with height. The same does not apply, however, to the other specific humidity profiles for disturbed conditions (figs. 22 through 27). The profile for Case B was not plotted, because several dewpoint values were reported as being larger than the corresponding temperature values and thus obviously incorrect.

The range of specific humidity values for disturbed conditions is shown in figure 28.

No increase in windspeed with height comparable to that shown by the mean sounding for undisturbed conditions (fig. 4) was found in either Case A or B (figs. 29 and 30). In Case A the windspeed decreases with height in the lower 300 m; in Case B it increases slightly, but drops above 250 m. A slight increase with height was found in Case E (fig. 33), but the wind profiles for the remaining disturbed cases show no significant slopes (figs. 31, 32, 35, and 36).

The range of windspeed values is shown in figure 37.

ACKNOWLEDGMENT

The computer programs used in this analysis were written by Jordan Matejceck.

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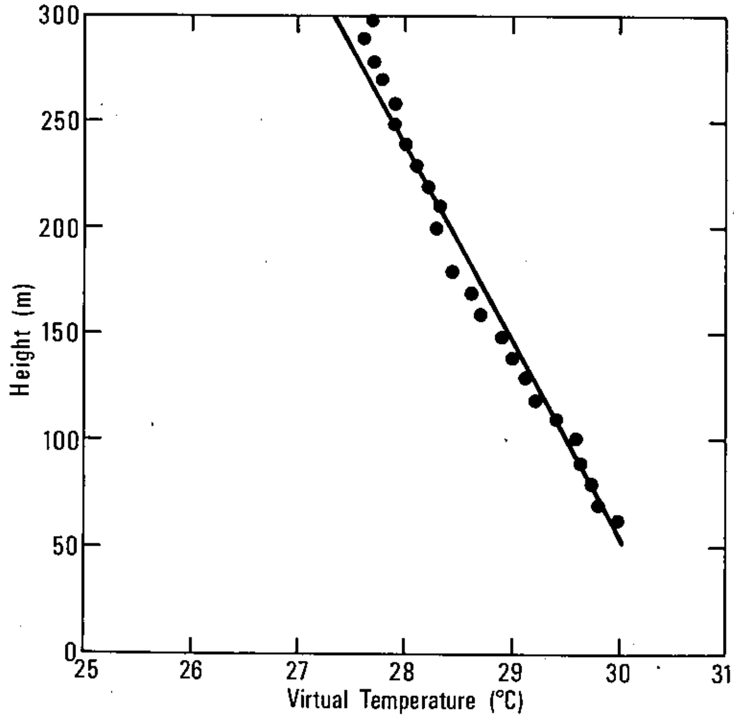

Figure 1.--Average profile of virtual temperature, undisturbed conditions.

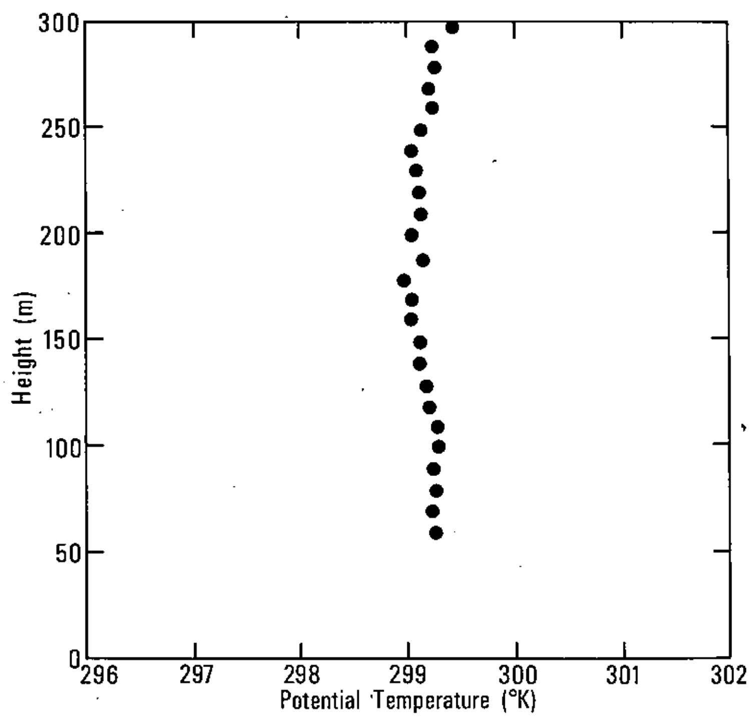

Figure 2.--Average profile of potential temperature, undisturbed conditions.

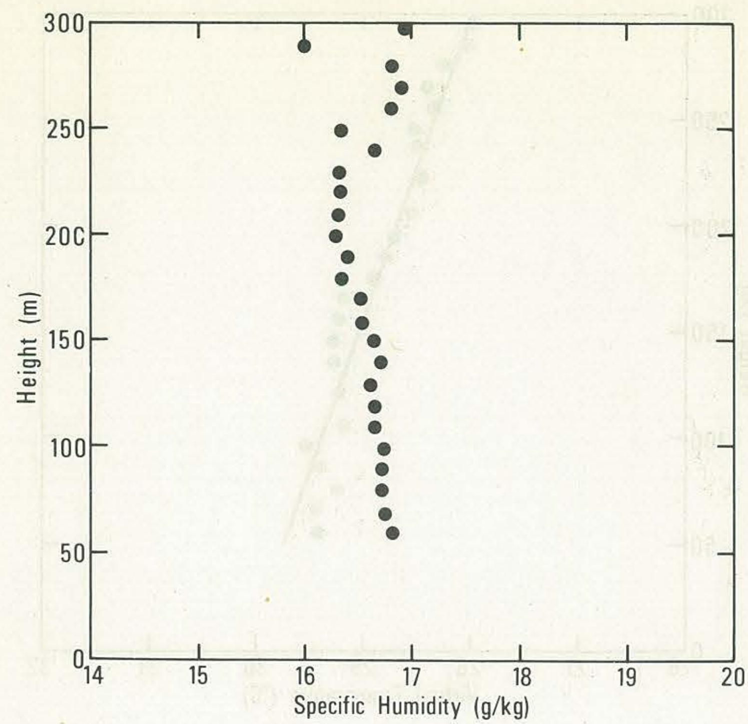

Figure 3.--Average profile of specific humidity, undisturbed conditions.

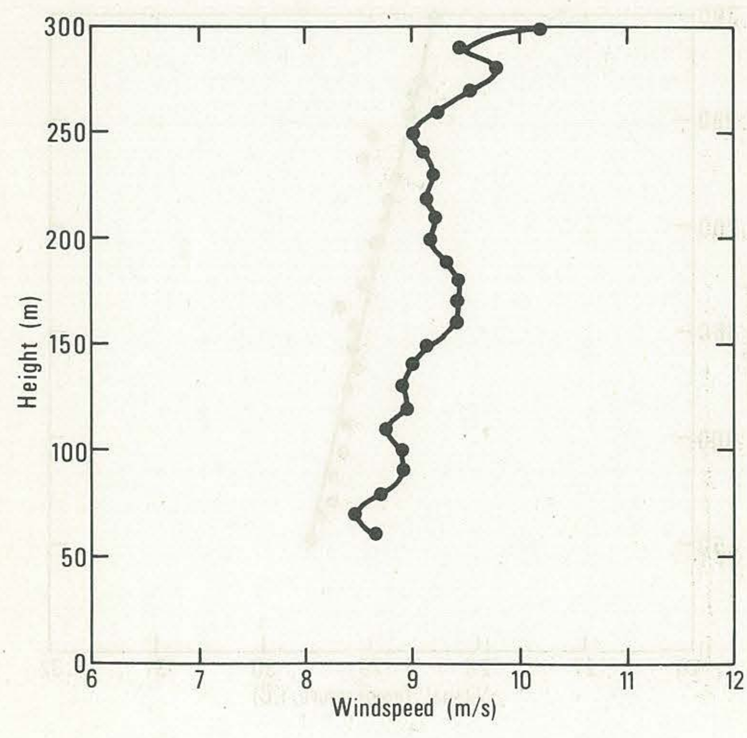

Figure 4.--Average profile of windspeed, undisturbed conditions.

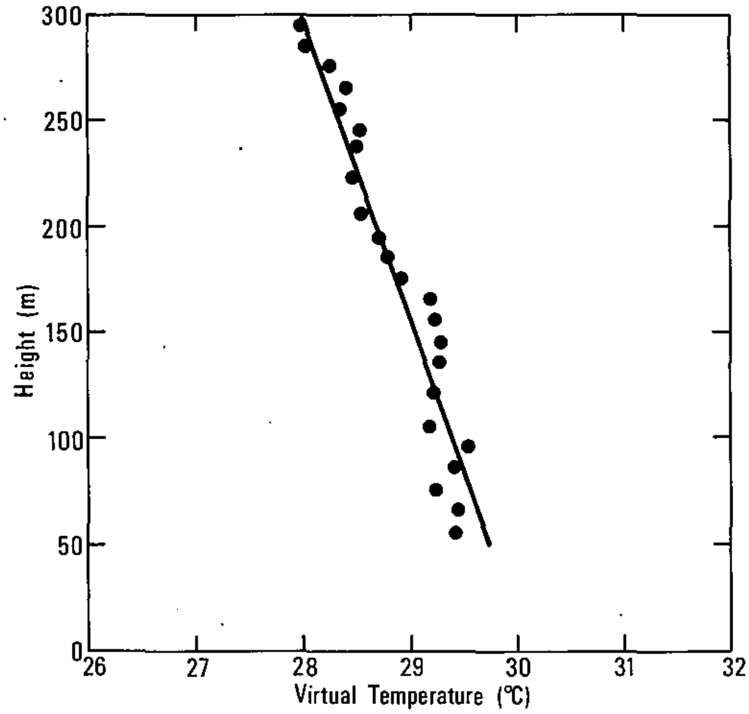

Figure 5.--Case A. Virtual temperature profile, disturbed conditions.

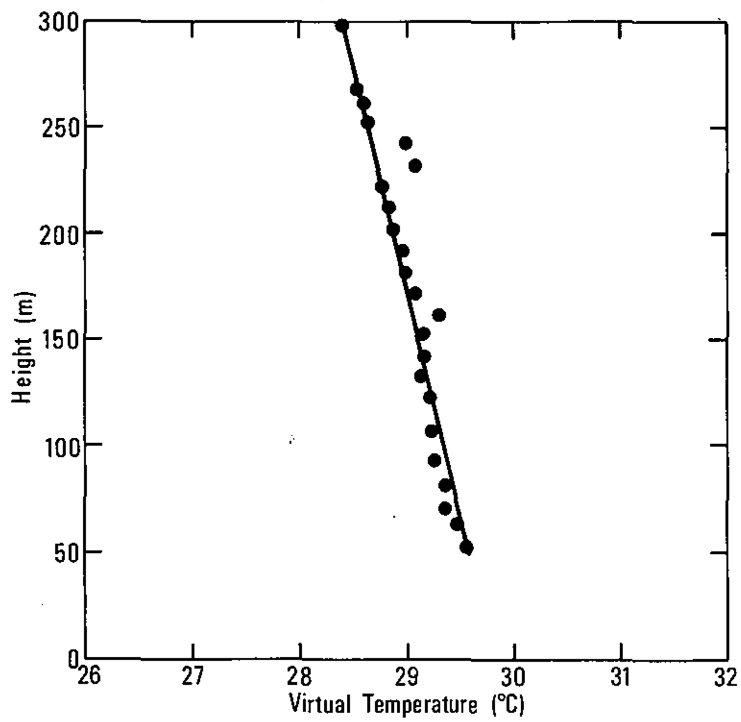

Figure 6.--Case B. Virtual temperature profile, disturbed conditions.

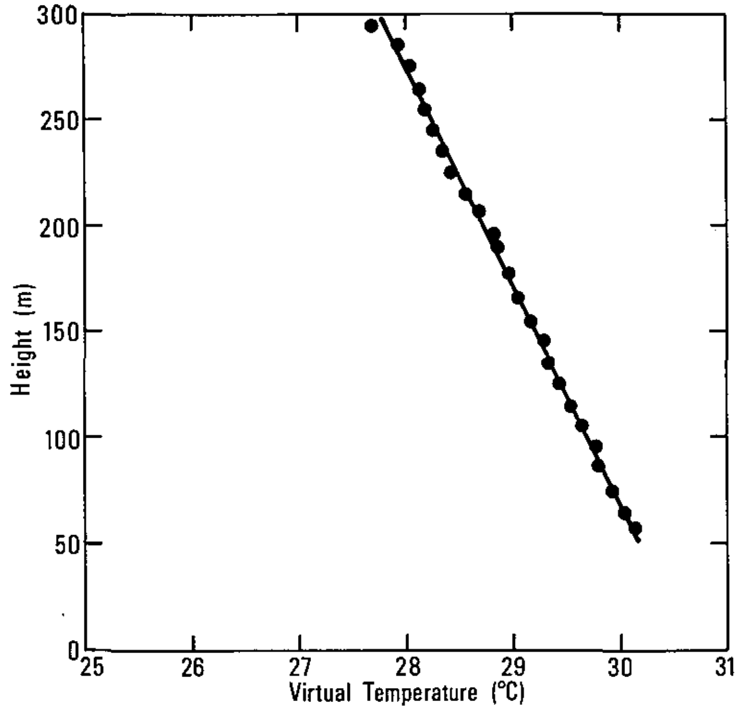

Figure 7.--Case C. Virtual temperature profile, disturbed conditions.

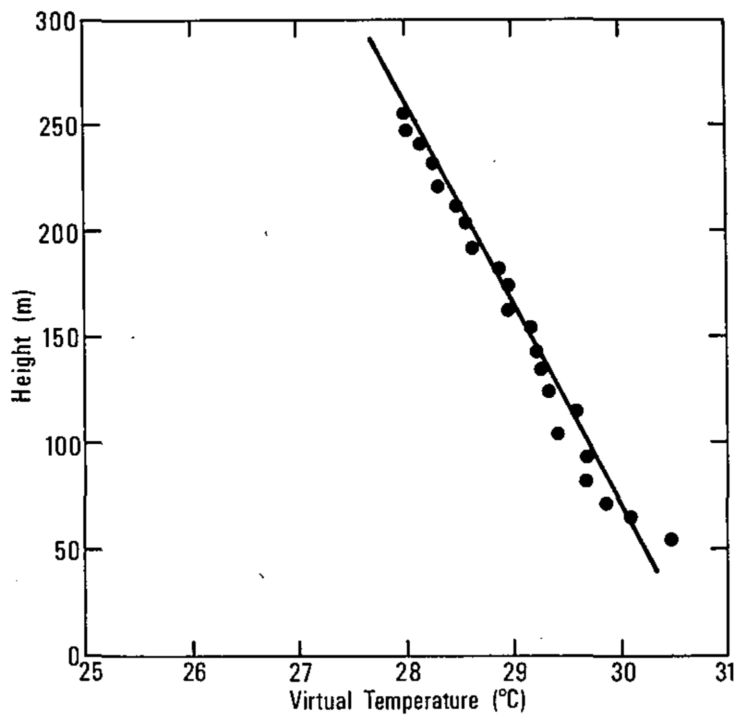

Figure 8.--Case D. Virtual temperature profile, disturbed conditions.

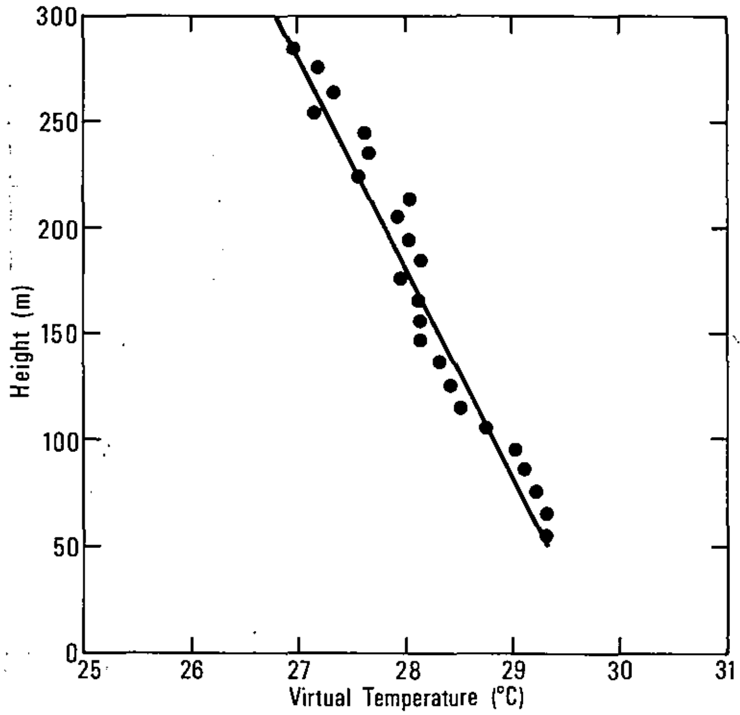

Figure 9.--Case E. Virtual temperature profile, disturbed conditions.

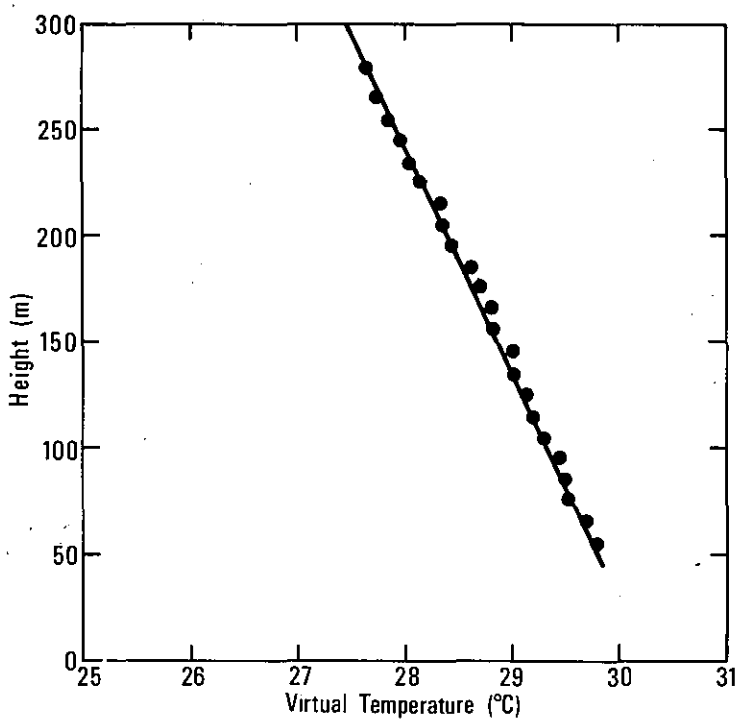

Figure 10.--Case F. Virtual temperature profile, disturbed conditions.

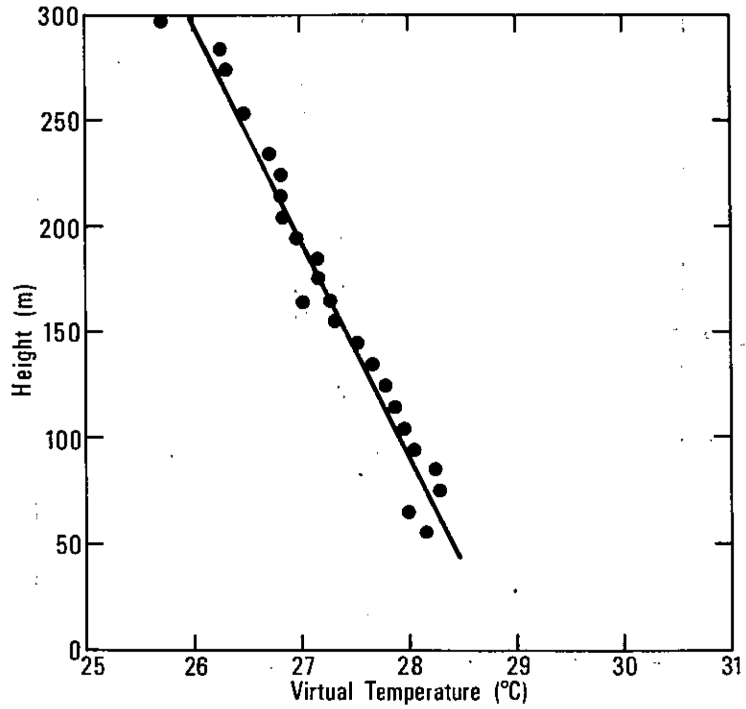

Figure 11.--Case G. Virtual temperature profile, disturbed conditions.

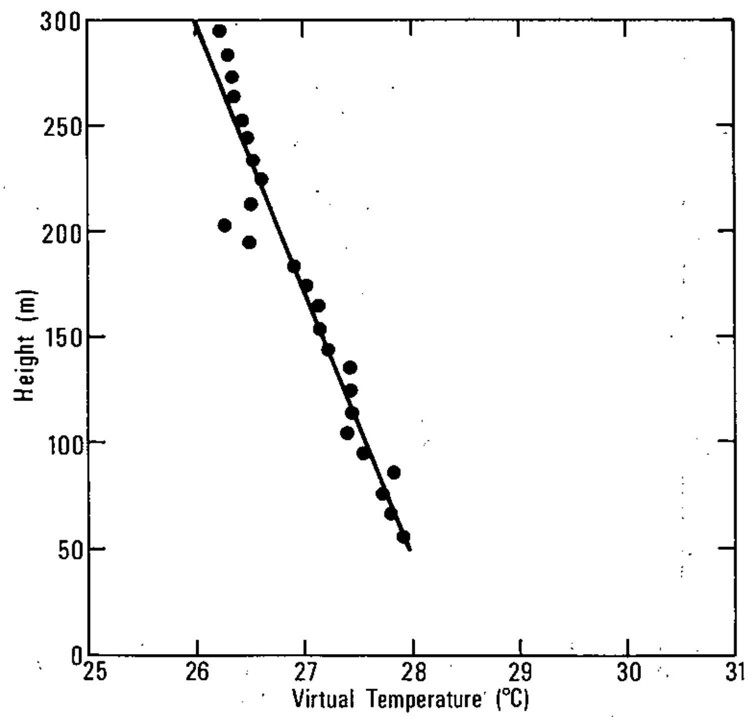

Figure 12.--Case H. Virtual temperature profile, disturbed conditions.

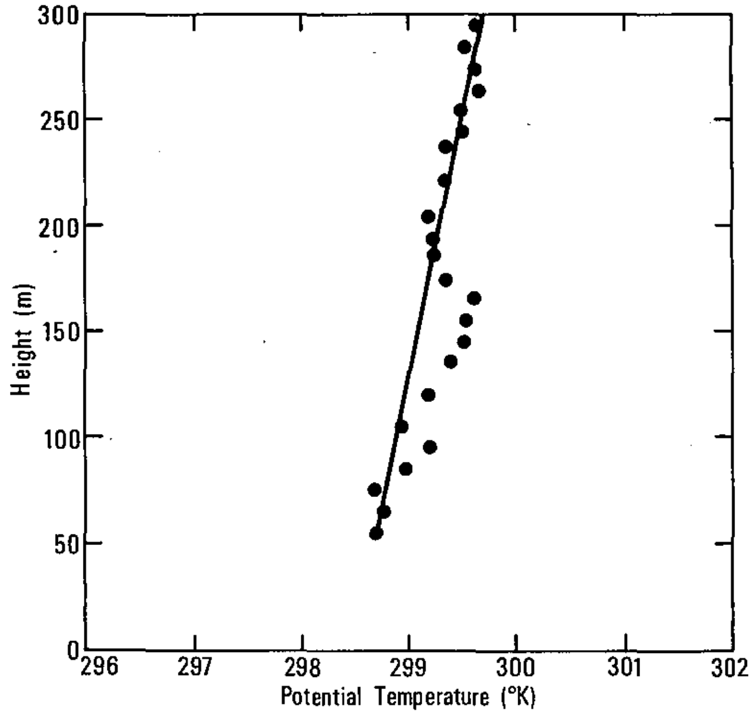

Figure 13.--Case A. Potential temperature profile, disturbed conditions.

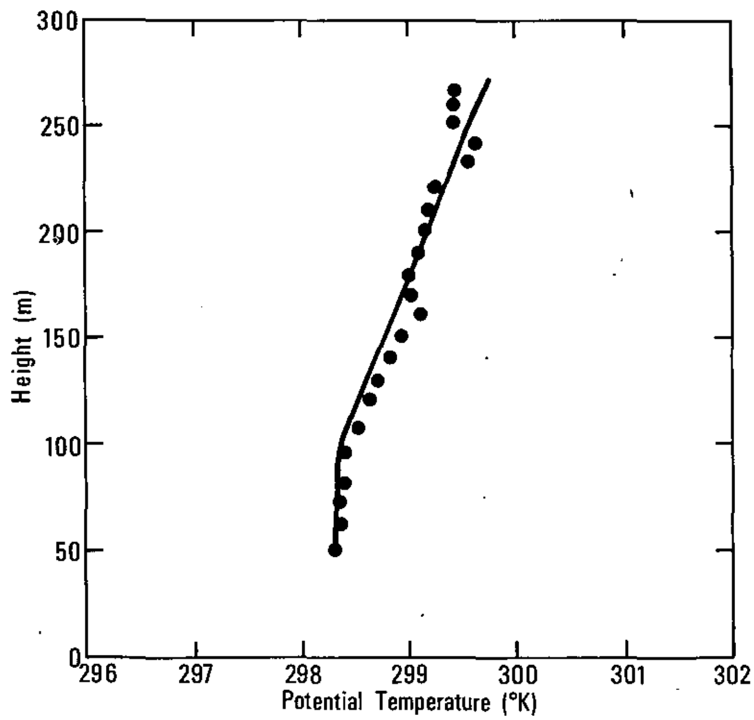

Figure 14.--Case B. Potential temperature profile, disturbed conditions.

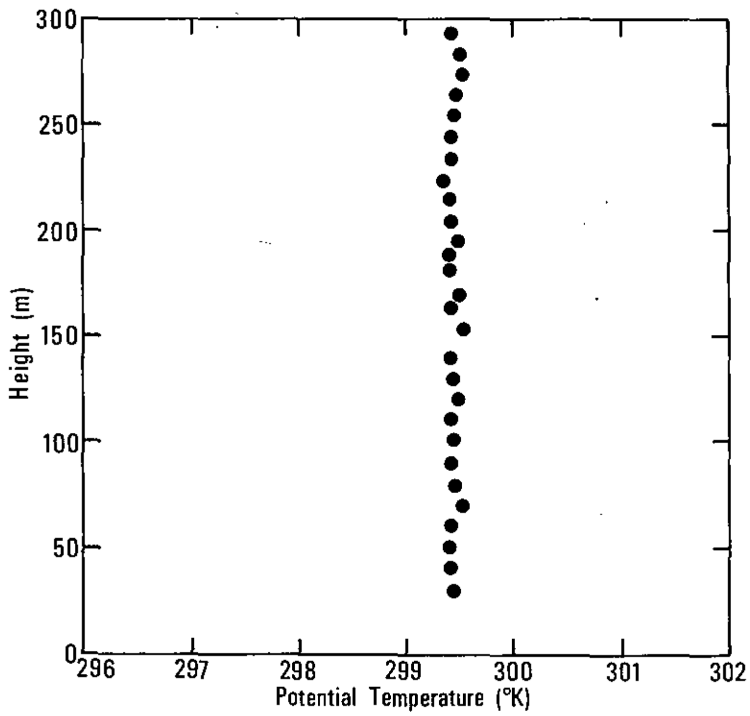

Figure 15.--Case C. Potential temperature profile, disturbed conditions.

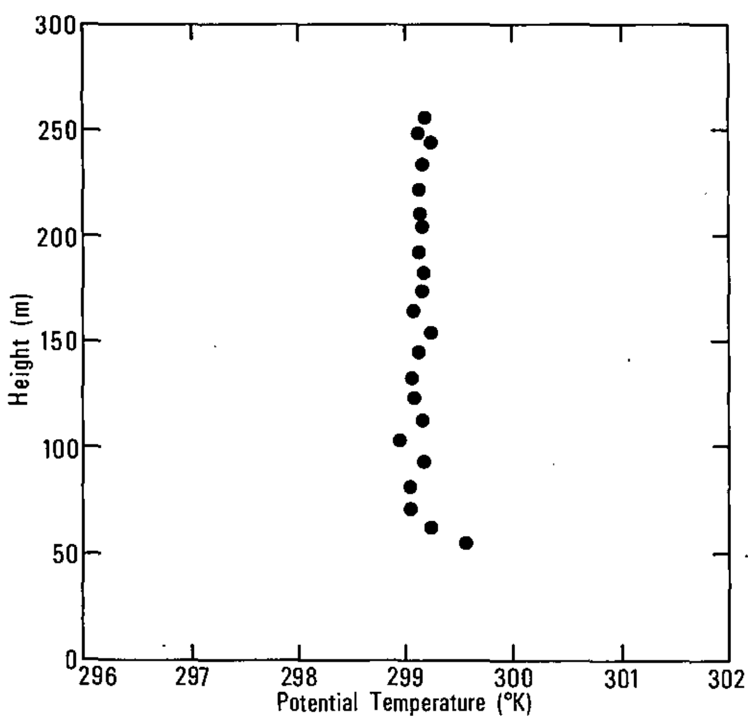

Figure 16.--Case D. Potential temperature profile, disturbed conditions.

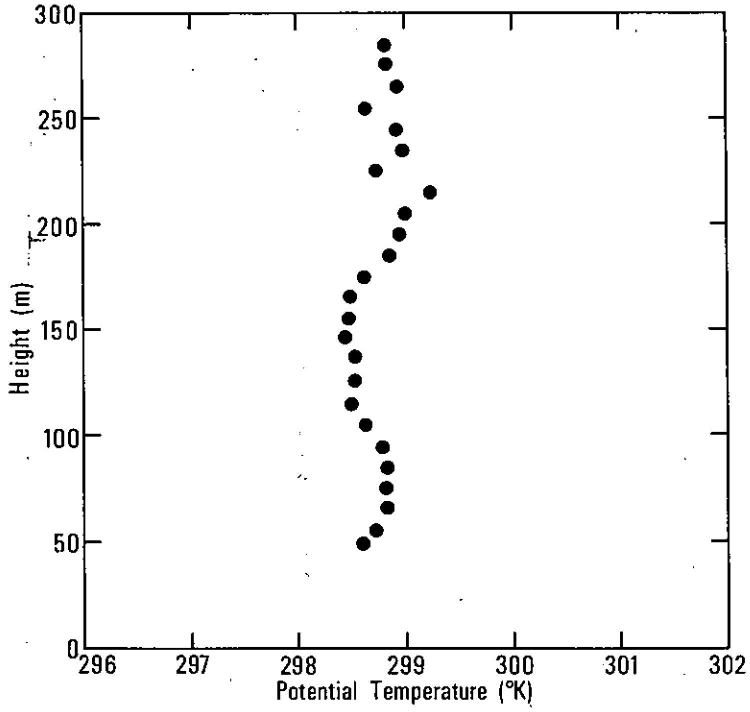

Figure 17.--Case E. Potential temperature profile, disturbed conditions.

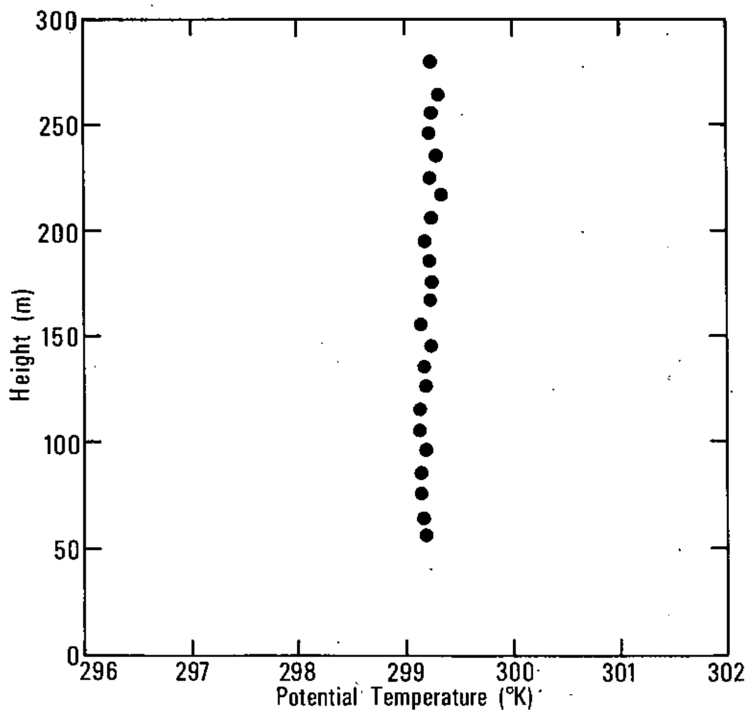

Figure 18.--Case F. Potential temperature profile, disturbed conditions.

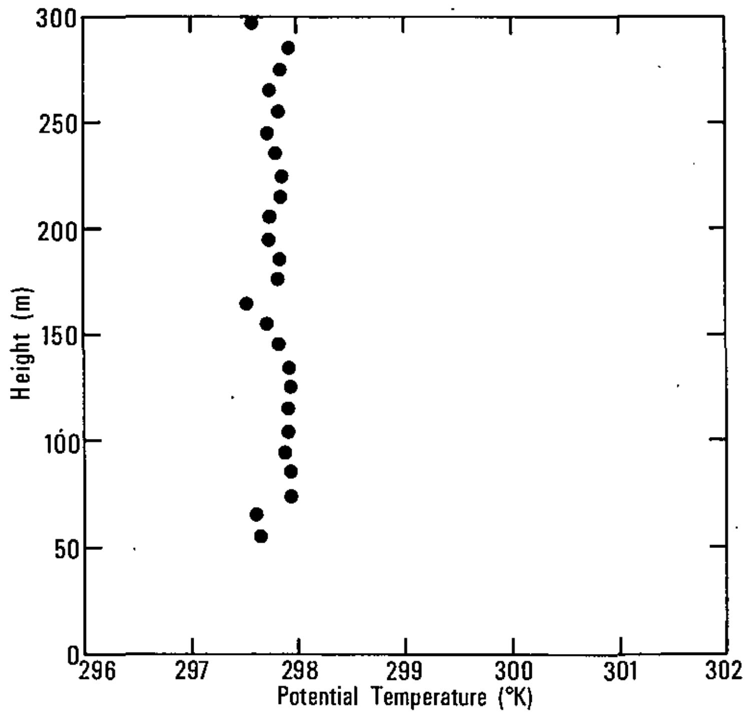

Figure 19.--Case G. Potential temperature profile, disturbed conditions.

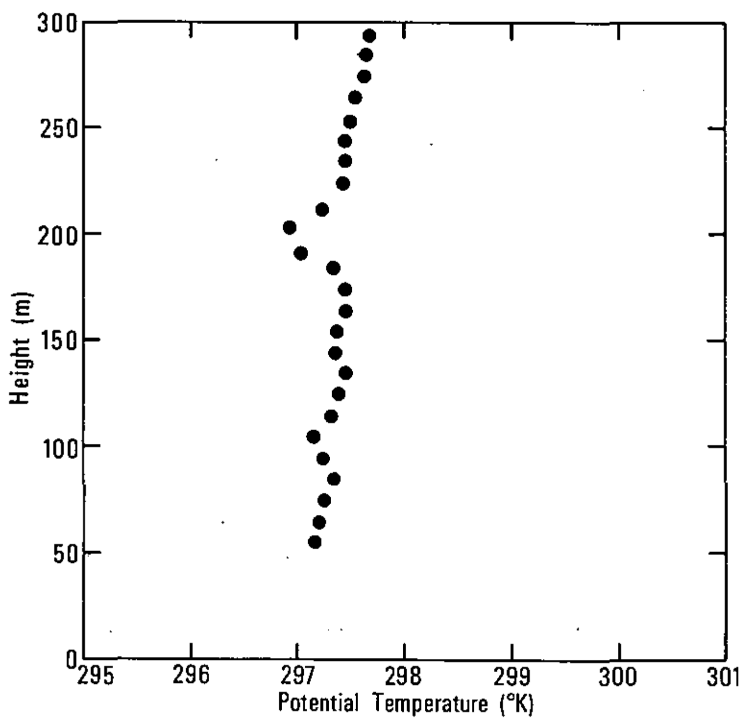

Figure 20.--Case H. Potential temperature profile, disturbed conditions.

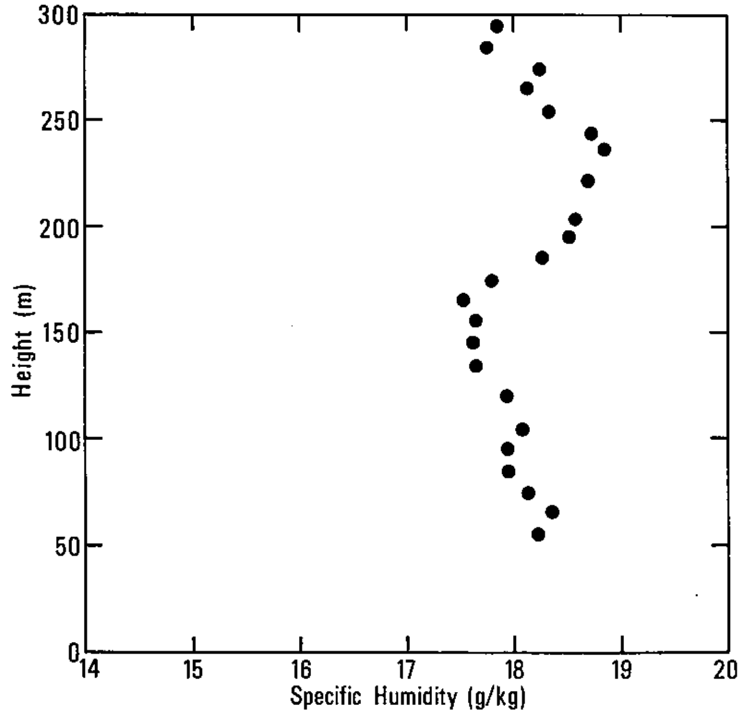

Figure 21.--Case A. Specific humidity profile, disturbed conditions.

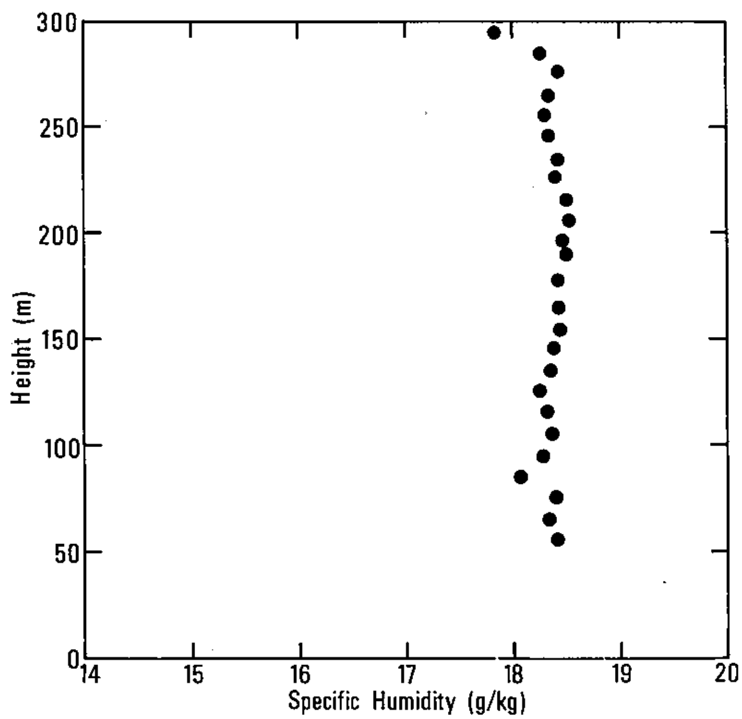

Figure 22.--Case C. Specific humidity profile, disturbed conditions.

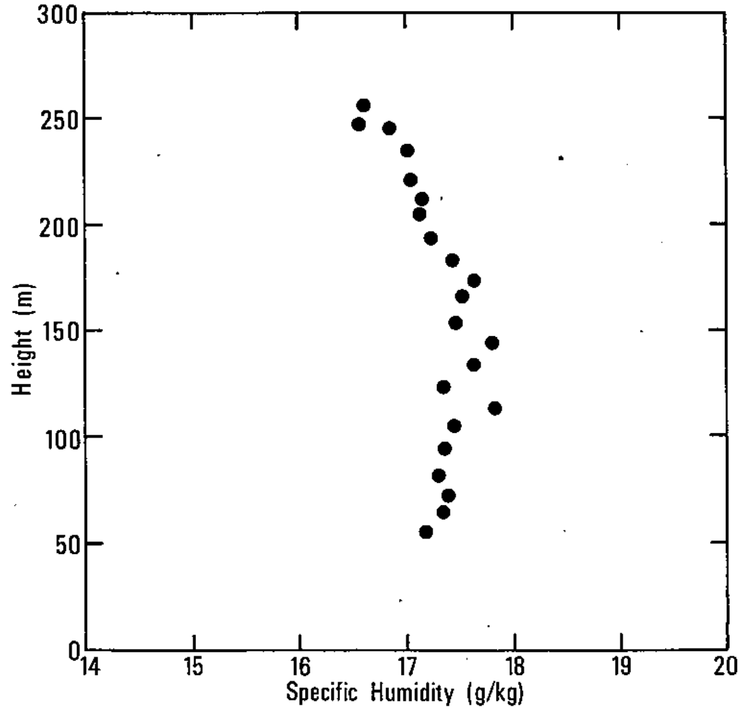

Figure 23.--Case D. Specific humidity profile, disturbed conditions.

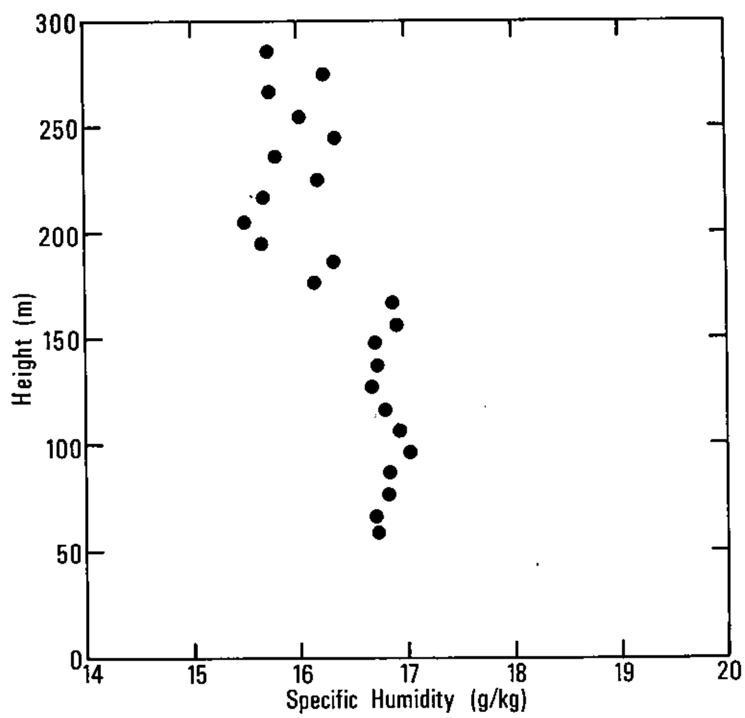

Figure 24.--Case E. Specific humidity profile, disturbed conditions.

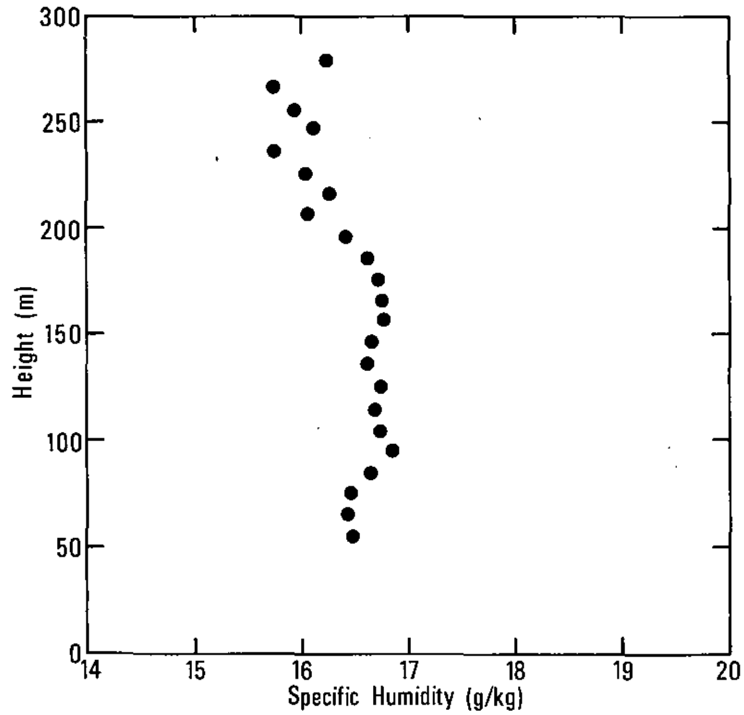

Figure 25.--Case F. Specific humidity profile, disturbed conditions.

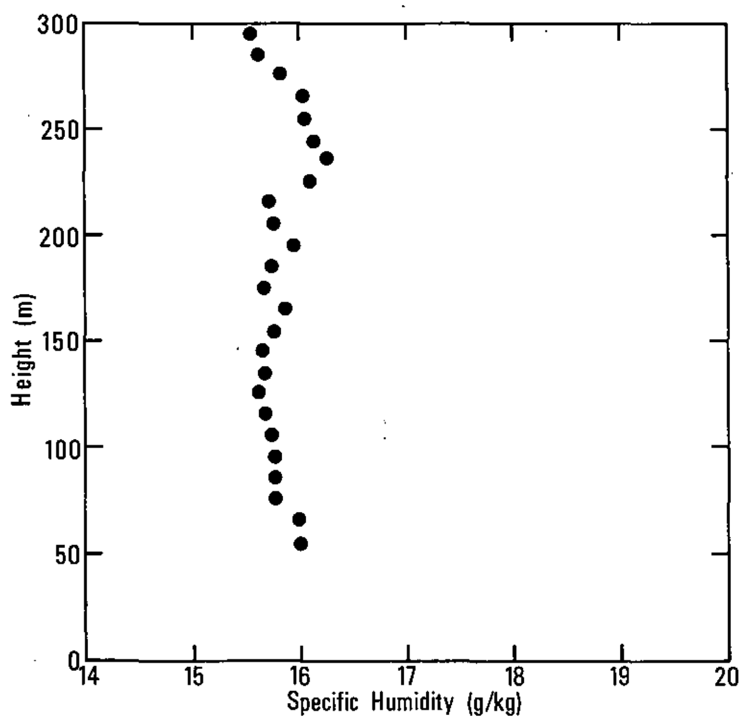

Figure 26.--Case G. Specific humidity profile, disturbed conditions.

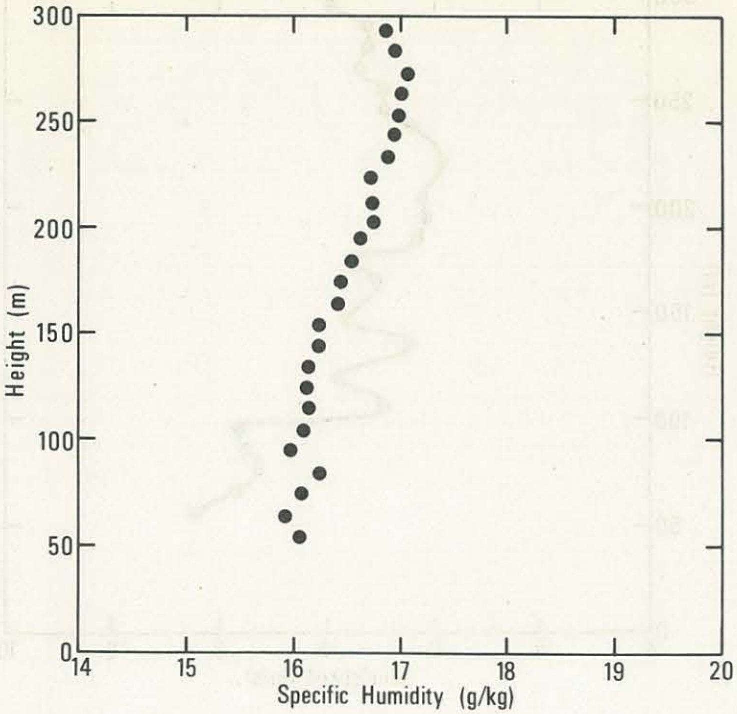

Figure 27.-- Case H. Specific humidity profile, disturbed conditions.

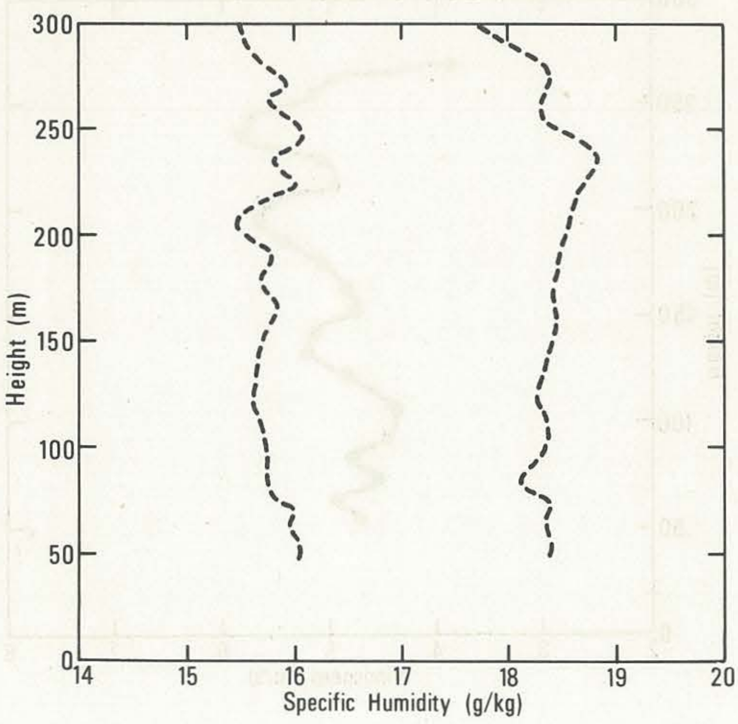

Figure 28.--Range of specific humidity values, disturbed conditions.

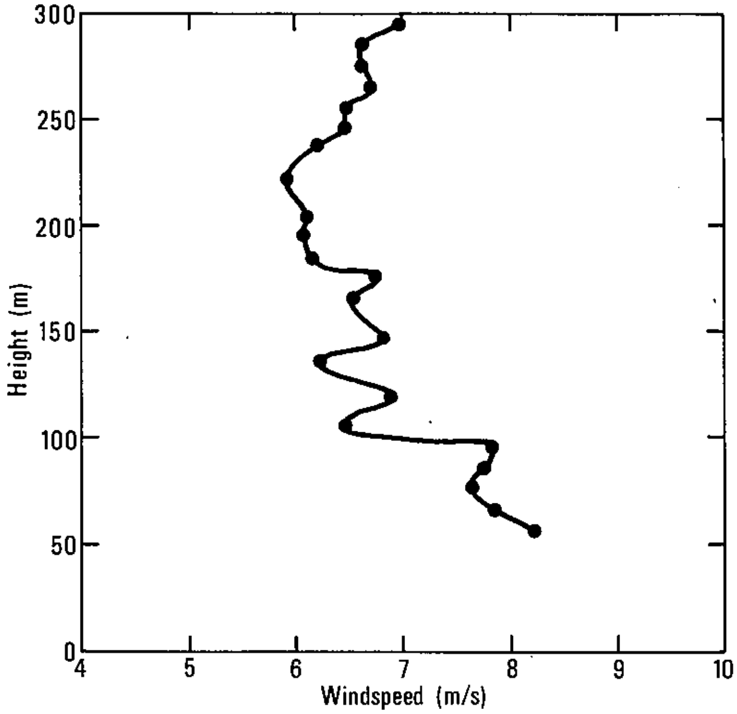

Figure 29.--Case A. Windspeed profile, disturbed conditions.

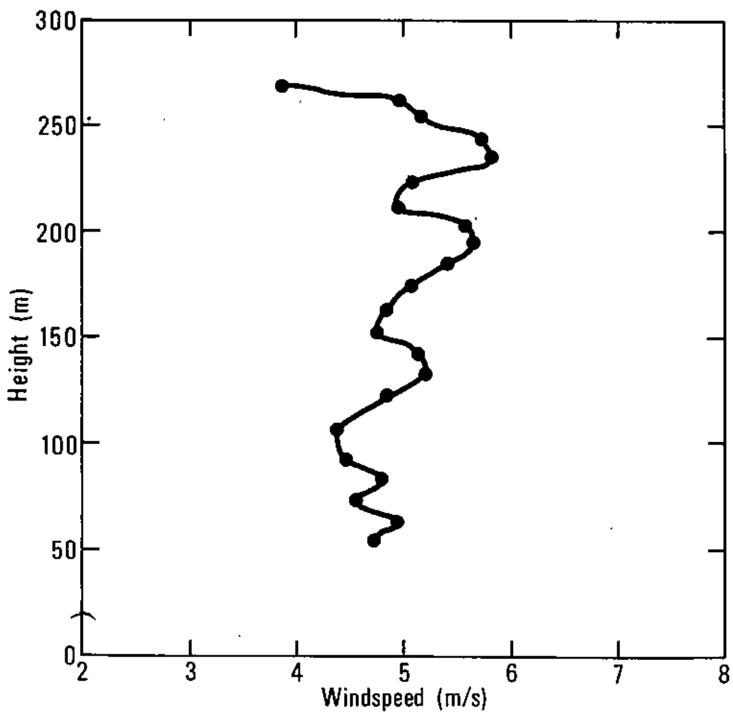

Figure 30.--Case B. Windspeed profile, disturbed conditions.

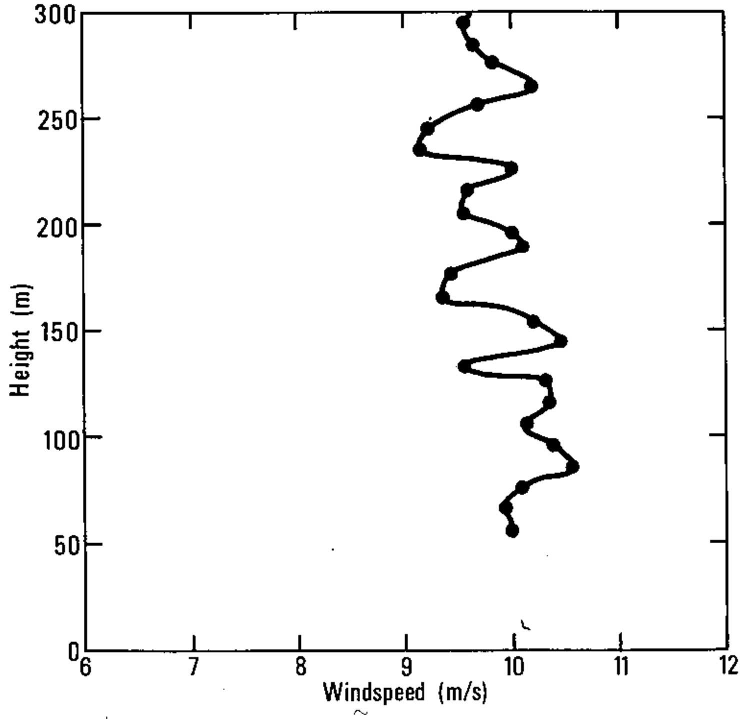

Figure 31.--Case C. Windspeed profile, disturbed conditions.

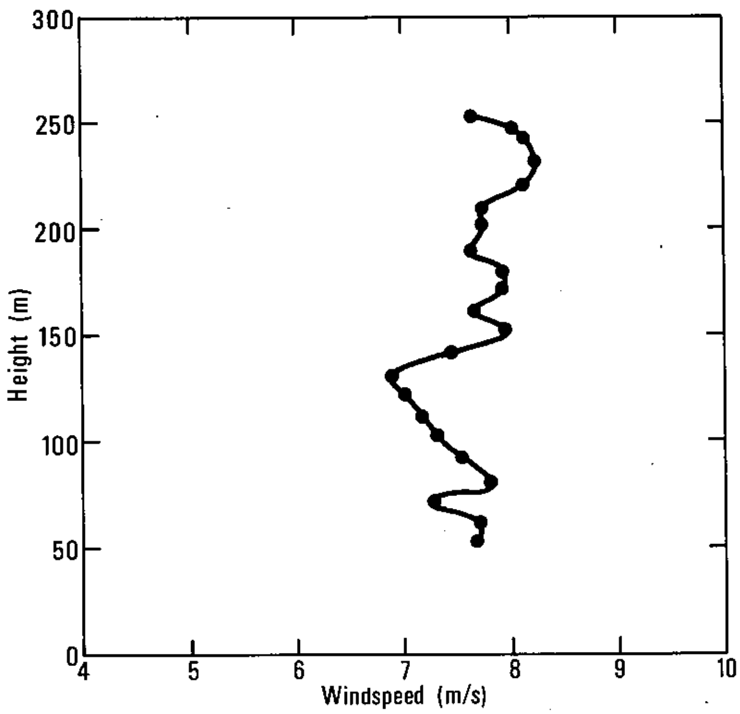

Figure 32.--Case D. Windspeed profile, disturbed conditions.

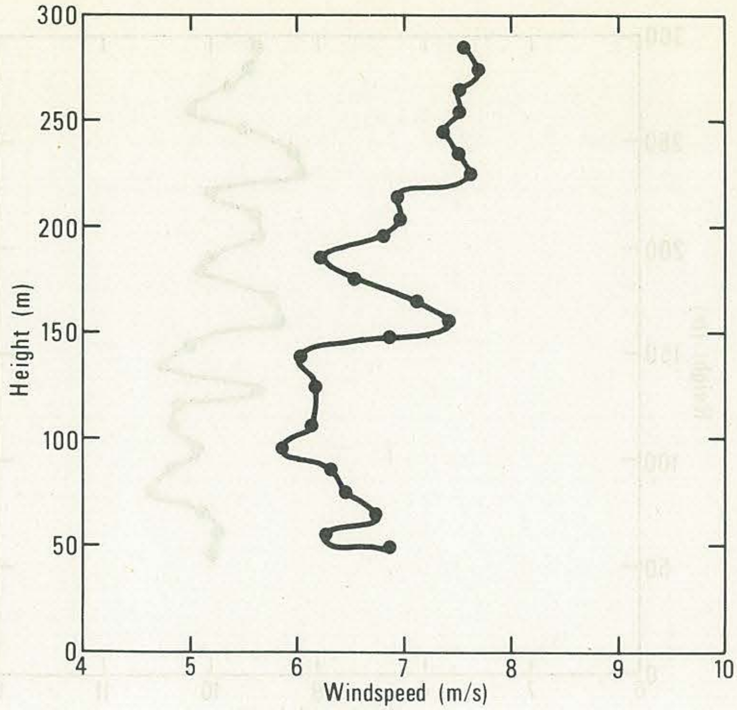

Figure 33.--Case E. Windspeed profile, disturbed conditions.

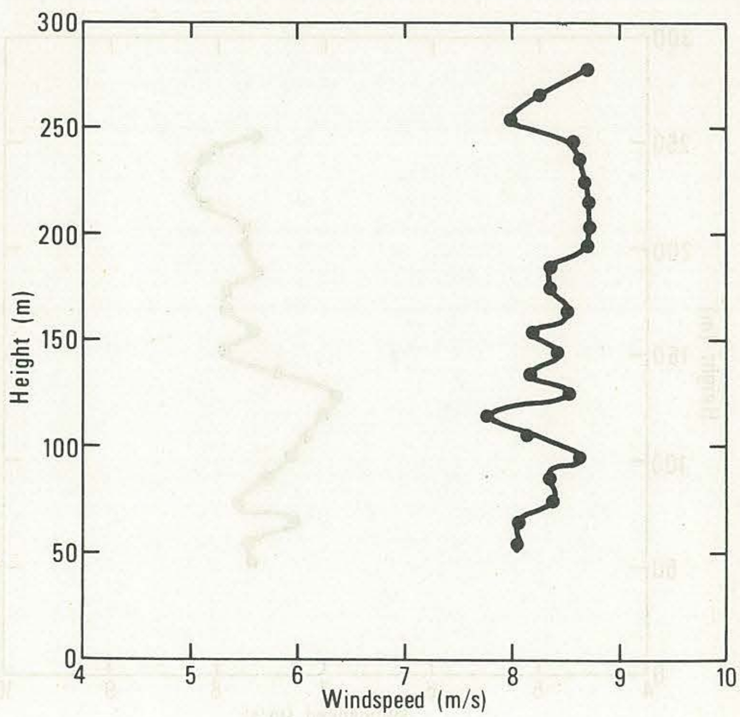

Figure 34.--Case F. Windspeed profile, disturbed conditions.

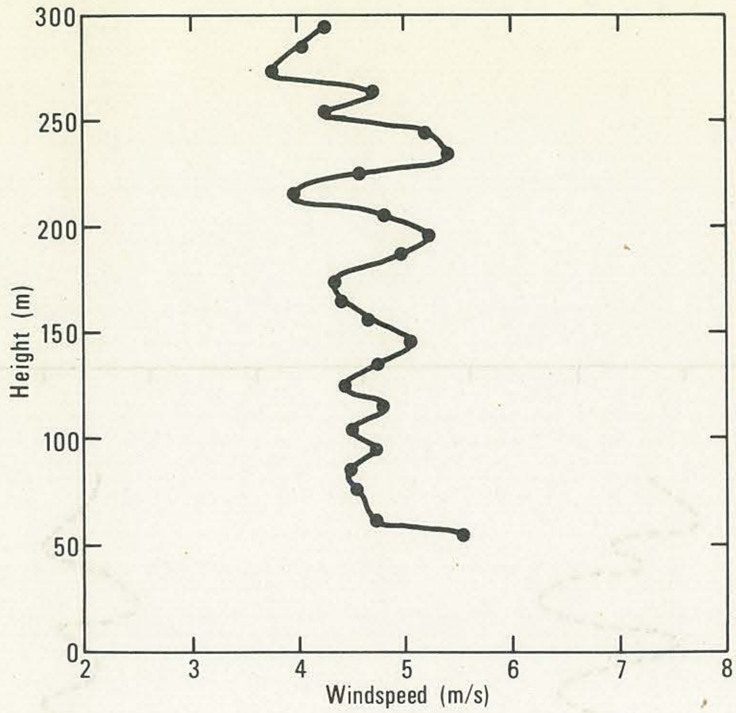

Figure 35.--Case G. Windspeed profile, disturbed conditions.

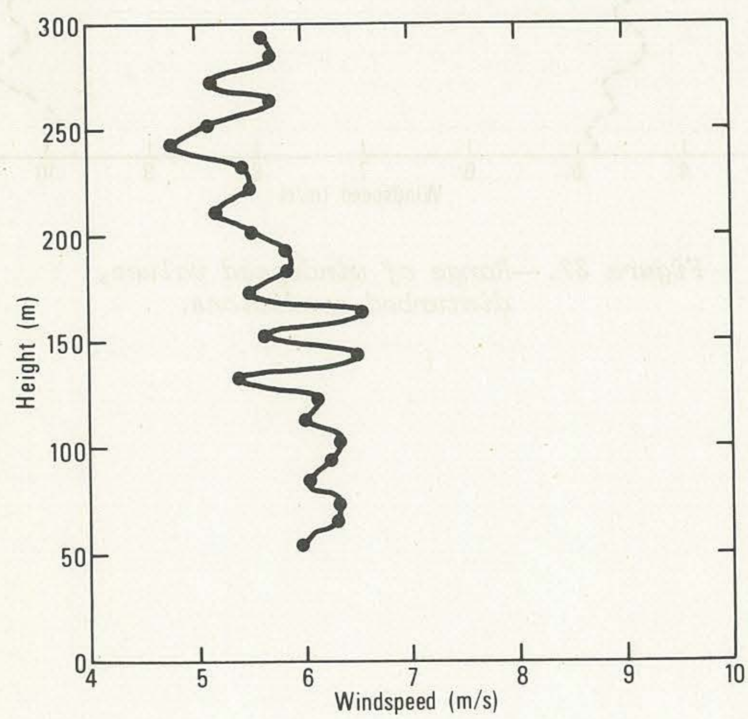

Figure 36.--Case H. Windspeed profile, disturbed conditions.

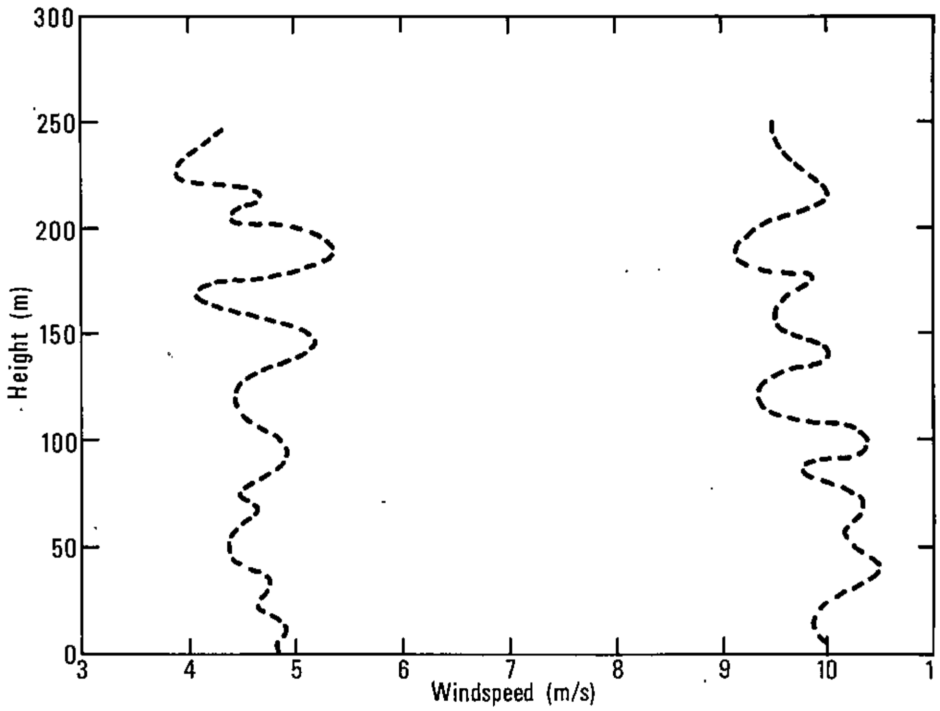

Figure 37.--Range of windspeed values, disturbed conditions.