STRUCTURE OF THE TROPOSPHERE OVER SOUTHEAST ASIA DURING THE SUMMER MONSOON MONTH OF JULY

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George P. Woollard
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ABSTRACT

Mean aerological data for Saigon during July 1966 and 1967 and for Udorn in 1967 are presented and compared with similar data for tropical maritime regions. The comparison indicates that level for level the atmosphere over Southeast Asia has greater humidity and higher static energy. Comparison of dew-point profiles taken during periods of suppressed and increased convection over Southeast Asia reveals that the atmosphere is more moist during increased convection and that the diurnal variation of humidity is largest during suppressed conditions. Comparisons of vertical profiles of virtual equivalent potential temperature (θ_{ve}) taken during periods of suppressed and increased convection show that the daily convective instability is strong during suppressed days and weak during days of increased convection. The characteristic differences in structure as shown by θ_{ve} suggest convection is controlled by the synoptic scale.

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1. Introduction

Mean aerological soundings for various tropical maritime regions have been published for some time, c.f. Colon (1953), Shimada (1962), Hebert and Jordan (1959), and Jordan (1957). Without exception these data show the tropical atmosphere to be conditionally and convectively unstable during the summer-fall period. A similar study, Garstang, et al. (1967), revealed that significant day-to-day variations of observed thermodynamic properties, under both disturbed and undisturbed conditions, were confined to the humidity element. Although significant differences in humidity were observed between disturbed and undisturbed weather conditions, larger interdiurnal variations occurred during undisturbed periods. The study implied that the observed thermodynamic properties did not adequately portray the differences in atmospheric structure between disturbed and undisturbed weather conditions. The authors suggested that some derived variable, such as equivalent potential temperature, which combines both moisture and temperature, might be a more meaningful parameter for portraying differences in the thermodynamic structure under varying weather conditions than temperature or moisture alone. In contrast, day-to-day variations in both temperature and moisture are observed in temperate latitudes where data show the atmosphere to be convectively stable in winter and neutrally or weakly convectively unstable in summer (Hebert, 1966).

Study of stability concepts used in forecasting convective activity in temperate latitudes, c.f. Miller (1967), reveals that two basic requirements are paramount. Horizontal advection of moisture and heat must be such that the convective instability increases beyond some critical limit. Once the atmosphere has become critically unstable a triggering mechanism is needed to initiate convection.

Many fruitless attempts have been made to use these stability concepts in forecasting convective activity over Southeast Asia. Most often such efforts have failed because they consisted of attempts to modify stability indices developed for use in more temperate latitudes. Such approaches have failed to take into account the degree of convective instability inherent in the structure of the tropical atmosphere.

The purpose of this report is to present the mean aerological data, to compare them with data from other tropical regions, and to examine the suggestion that equivalent potential temperature more reliably portrays day-to-day variations in the structure of the tropical atmosphere over Southeast Asia. Finally, suggestions as to why earlier approaches to forecasting convective activity over Southeast Asia were unsuccessful will be offered.

2. The Mean Aerological Data

In an effort to determine the basic structure of the atmosphere over Southeast Asia, data for Saigon (10°49'N - 106°39'E) during July 1966 and 1967 and for Udorn (17°22'N - 102°48'E) during July 1967 were collected and processed. Although mean aerological data for one or two years may not be representative of long term means, due to sample size, it is felt that the lack of published data for tropical continental stations makes the publication of such a short record desirable.

a. Processing of the Data

Data used to prepare the mean thermodynamic soundings were taken from several sources; however, thermodynamic charts prepared at operating locations and teletype transmissions formed the principal data base. When not otherwise available, complete thermodynamic diagrams were plotted for each Saigon sounding. These soundings were visually checked for thermal consistency. Dry-bulb temperature values which appeared abnormal were compared with transmitted data and synoptic maps and were checked for consistency in time. Most inconsistencies were due either to transmission or plotting errors and were corrected. Although occasional dewpoint temperature values were suspect, corrections were made in only those values which were found to be reported or plotted erroneously.

Values of dry-bulb and dewpoint temperatures were then extracted at 50 mb intervals between 1000 and 100 mb. Values for geopotential height were extracted from standard reporting levels.

Udorn data for the period 1 to 15 July 1967 were taken primarily from teletype reports and Environmental Technical Applications Center (ETAC) printouts, whereas data for the period 16 to 31 July 1967 were taken from locally prepared thermodynamic charts. Where such diagrams were not available, data for the layer between 700 and 500 mb were plotted on thermodynamic charts so that values at the 650, 600, and 550 mb levels could be obtained. Values for dry-bulb and dewpoint temperatures were then extracted for these and mandatory levels, whereas values for geopotential height were taken only from mandatory reporting levels.

These data were card-punched and programmed to obtain mean values for thermodynamic parameters at each level.

b. Computation of Derived Parameters

In addition to mean values for geopotential height and dry-bulb and dewpoint temperatures, mean values for potential temperature (θ), specific humidity (q), virtual potential temperature (θ_v) and virtual equivalent potential temperature (θ_{ve}) were computed.

(1) Computational equations

(a) $$\theta = T\left(\frac{1000}{P}\right)^K$$

(b) $$q = \frac{.622e}{p-.378e}$$

(c) $$e_s = 6.1078\left(\frac{273.16}{T_d}\right)^{5.34} \exp\left[25.21\left(1-\frac{273.16}{T_d}\right)\right] \text{ for water}$$

$$e_s = 6.1071\left(\frac{273.16}{T_d}\right)^{5.27} \exp\left[17.49\left(1-\frac{273.16}{T_d}\right)\right] \text{ for ice}$$

(d) $$T_v = T(1+0.61q)$$

(e) $$\theta_v = T_v\left(\frac{1000}{P}\right)^K$$

(f) $$\theta_{ve} = \theta_v \exp\left(\frac{Qs.L}{C_p T_c}\right),$$ where

P is pressure (mb), e_s is saturation vapor pressure, T_d is dewpoint temperature, K is Poisson's constant $\left(\frac{R}{C_p}\right)$, C_p is the specific heat at constant pressure (.24 cal/gm deg), L is the latent heat of condensation $[596.5 - 0.5T(\dot{C})]$ cal/gm, and Q_s and T_c are the specific humidity and temperature, respectively, at the lifting condensation level.

Unless otherwise noted herein, only values for vapor pressure with respect to water were utilized because the Clausius-Clapeyron approximation for the ice phase yielded a weak, first order discontinuity in the shape of the derived profiles where the change from water to ice phase might take place.

(2) Computational Procedure

In order to compute values of the virtual equivalent potential temperature, Q_s and T_c were determined through an iterative process as follows:

(a) Given the pressure, dry-bulb and dewpoint temperatures at a level (P_i); the specific humidity (q_i), the virtual temperature (T_{vi}), and the virtual potential temperature (Θ_v) were computed from equations (b), (c), (d), and (e).

(b) Holding Θ_v constant, the virtual temperature (T_v) and saturation specific humidity (q_s) were computed for pressure decrements of 100 mb (i-100n) until at some level (P_j) $qs < q$ using

$$T_v(i-100n) = \Theta_v \left[\frac{P_{(i-100n)}}{1000}\right]^K \quad \text{and}$$

$$q_s(i-100n) = \frac{0.622e_s}{P_{(i-100n)}-0.378e_s}, \quad n = 1,2,3, \ldots, \text{ where } e_s$$

was computed by substituting T_v(i-100n) for the dewpoint temperature in eqn. (1) (c) from page 3.

(c) With Θ_v remaining constant, T_v and q_s were computed for pressure increments of 10 mb (j+10n) until at some level (P_k) $qs > q$ using

$$T_v(j+10n) = \Theta_v \left[\frac{P_{(j+10n)}}{1000}\right]^K \quad \text{and}$$

$$qs(j+10n) = \frac{0.622e_s}{P_{(j+10n)}-0.378e_s}$$

(d) With Θ_v still constant, T_v and q_s were computed as above for pressure decrements of 1 mb (k-ln) until at some level (P_c) $qs < q$. The level, P_c, is the lifting condensation level within the accuracy of 1 mb. The virtual temperature (T_v) at this level is taken as the condensation temperature (T_c) and the specific humidity (q) is taken as the specific humidity at the condensation level (Q_s).

(e) Insertion of values of T_c and Q_s, taken at level P_c, into equation (1) (f), page 3, yields the virtual equivalent potential temperature for the initial level (P_1).

c. Discussion of the Data

The mean thermodynamic soundings for Saigon and Udorn (Figs. 1 and 2, respectively) portray a moist, conditionally and convectively unstable atmosphere. The Udorn sounding (Fig. 2) exhibits a nearly moist adiabatic temperature lapse rate between 700 and 450 mb. The Saigon sounding (Fig. 1) shows a larger diurnal variation in the dewpoint temperature than in the dry-bulb temperature at all levels. Comparison of the two soundings reveals the diurnal variation of the dewpoint temperature is larger at Saigon. The larger variation in moisture at Saigon is probably a result of the larger diurnal variation of convective activity in that area. Atkinson (1967) has shown that Udorn has a much higher frequency of thunderstorms during July than Saigon, whereas Conover (1968) showed that the diurnal variation in convection at Saigon was larger than at Udorn. Differences in geographical location and diurnal variation and frequency of convective activity help to explain both the large diurnal variation in moisture at Saigon and the differences in diurnal variation of moisture between the two stations. The data for Saigon is summarized in Tables 1a and 1b for 0000Z and 1200Z, respectively.

The vertical profiles of dry-bulb temperature for Saigon depict Figures 3a (1966), 3b (1967), and 3c (1966 and 1967). These figures reveal that with the exception of the lower convective layer and the upper troposphere only minor diurnal variations occurred. The afternoon warming of the upper troposphere is probably a result of the release of latent heat of condensation caused by convection. On the other hand, the profiles of dewpoint temperature (Figs. 4a, 4b, and 4c) reveal significant diurnal variations in moisture, particularly during 1967. As mentioned above these large diurnal variations in moisture are probably a result of the large diurnal variation in convection over the Saigon area.

Vertical profiles of specific humidity (Figs. 5a through c) show the atmosphere to be moist to a considerable height above the surface. The profiles show there is a diurnal increase in moisture, again probably reflecting increased convective activity during the afternoon and early evening.

The vertical distribution of virtual equivalent potential temperature (Figs. 6a through c) agrees well in principle with the findings of Garstang, et al. (1967). The profiles show the atmosphere over Saigon to be convectively unstable, with values of θ_{ve} decreasing from the surface to a minimum near 600 mb and increasing above that level. As found by Garstang, et al. (1967), the early evening soundings show higher values of θ_{ve} probably as a consequence of diurnal heating in the lower troposphere and the vertical transport of moisture into the middle troposphere due to convection. The higher values of θ_{ve} shown for the early evening soundings might be viewed as evidence that energy is routinely transported vertically upward by convective activity. In contrast with the θ_{ve} profile for Saigon in July 1967 (Fig. 6b), the Udorn profile (Fig. 7) portrays more convectively stable conditions between 700 and 450 mb. In Figure 2, this layer was shown to have a nearly moist adiabatic temperature lapse rate. Schacht (1946) found a similar lapse rate for the Caribbean area.

Although not shown in the mean sounding for Udorn, dewpoint temperatures were often obtained at levels above 250 mb. To be precise, at 0000Z, 9 of 26 soundings and at 1200Z, 13 of 24 soundings depicted moisture at 100 mb during July 1967. Available information indicates that the humidity element used consisted of a lithium chloride device--which compounds suspicion of any moisture measurements at these levels. However, from a meteorological viewpoint the accuracy of these observations is of secondary importance. More significantly, if the humidity elements were in fact operating, most of the measurements may be viewed as evidence of energy being vertically transported into the upper troposphere. On those days when moisture readings were obtained, the satellite photographs showed large amounts of cirrus anvils caught up in the strong easterlies found at and above the 200 mb level over that area.

d. Comparison of the Data

Colon (1953) and Shimada (1962), Hebert and Jordan (1959), and Jordan (1957) have published mean aerological data for the western Pacific, Gulf of Mexico, and West Indies regions, respectively. Additionally, unpublished data for Port Blair during July 1963 and 1964 were taken from IIOE sources. This station was selected because it represents a maritime sounding in the same current which dominates Saigon. Although the referenced studies are for maritime tropical regions, a comparison of their data with the Saigon and Udorn data reveals some interesting similarities and differences. Each of these authors utilized only nighttime data owing to radiational problems. The Southeast Asia and Port Blair data were obtained for the most part during daylight; both observational times will therefore be used in the comparison.

In Table 2 dry-bulb temperature data for Saigon and Udorn are compared with the data for other tropical regions. The data show that Udorn is warmer at all levels below 100 mb. At both Saigon and Udorn 100 mb temperatures are lower than at the other tropical locations probably indicating a higher tropopause over Southeast Asia.

The specific humidity data shown in Table 3 reveal that the atmosphere over Southeast Asia is more moist above the subcloud layer than over the other tropical maritime regions. Further, the data show that moisture penetrates to a greater height over Southeast Asia. Equivalent potential temperature data, Table 4, show that Udorn and Saigon, in that order, have higher values at every level than have the tropical maritime regions. This is believed to be a result of the higher frequency and intensity of convective activity over Southeast Asia. For example, during July Udorn and Saigon observe 17 and 9 thunderstorm days, respectively (Atkinson, 1967), while Barbados, Guam, and Port Blair experience 5 or less thunderstorm days (WMO, 1956).

3. Virtual Equivalent Potential Temperature as a Measure of the Structure of the Atmosphere over SEA

Garstang, et al. (1967), have fully discussed the use of Θ_E to describe the structure of the tropical atmosphere. From a study of data taken in the Caribbean they concluded that the equivalent potential temperature (Θ_e) portrayed differences in the thermodynamic structure during periods of suppressed and increased convection better than did observed variables. Further, the observed variations in the vertical distribution of Θ_E were not due simply to synoptic scale disturbances but were also due to increased convective scale activity forming within synoptic scale disturbances. These convective scale disturbances provided increased upward transport of energy. Others have found that disturbed conditions are accompanied by an increase in the amount and depth of the moisture.

In order to test these previous findings the data for Saigon during July 1966 were analyzed. Unlike the Caribbean, separation of disturbed from undisturbed periods over the Saigon area is difficult because convective activity occurs almost daily over most of Southeast Asia. The problem is not one of separating occurrence and non-occurrence of convective activity, rather it becomes one of isolating periods of increased or suppressed convective activity. To make this separation, use was made of the Radar Index data prepared by Conover (1968).

The Radar Index as defined by Conover applies to a circle of 50 nautical miles radius, centered on Tan Son Nhut, located at the Saigon airport. Hourly values of the Radar Index were obtained from radar reports by weighting echoes reported within the circular area according to whether the echoes were scattered, broken, overcast, or cellular. The daily averaged Radar Index for July 1966 (Fig. 8) indicates that 12, 13, 19, and 20 July 1966 were days of increased convective activity while 3, 8, 23, and 25 July 1966 were days of diminished or suppressed convective activity. These days were selected as "bad" and "good" days and mean profiles of thermodynamic properties were prepared for comparisons.

Although the value of statistical tests of significance on very small data samples is at best debatable, such tests do provide a reference base for evaluating differences between data taken from good and bad days. Accordingly as a threshold of significance the requirement was made that differences between values for good and bad days must be larger than the standard deviations for either the good or bad days. The results of this test indicate that the dry-bulb, dewpoint, and θ_{ve} temperature data were statistically significant at 1200Z; whereas, only the dewpoint and θ_{ve} temperature for the 700-550 mb layer were statistically significant at 0000Z.

Dry-bulb temperature profiles (Figs. 9a and 9b) taken at 0000Z and 1200Z, respectively, compare good and bad days. The curves show that bad days are warmer in the upper troposphere than good days during the afternoon. Further comparison of these curves with the monthly mean profiles (Fig. 3a) reveals that at 1200Z good days are cooler than the mean while bad days are warmer than the mean in the layer between 400 and 150 mb. The cooling or warming in the upper troposphere is probably a result of the absence or presence of warming due to condensation. The differences in the lowest layer at 1200Z were probably due to a variation in the amount of incoming radiation with increased or decreased cloud cover.

Vertical profiles of dewpoint temperature (Figs. 10a and 10b) taken at 0000Z and 1200Z, respectively, show significant variation in the moisture between good and bad days. Bad days were more moist than good days, particularly at 0000Z, which again probably indicated that increased convection acted to transport moisture upward. Comparison of the morning and early evening soundings shows the diurnal variation of moisture was largest during good days. This implies the presence of convection daily with the diurnal cycle, though suppressed, being dominant on good days while the synoptic scale dominates on bad days with convection spread thoughout the day.

Vertical profiles of virtual equivalent potential temperature (Figs. 11a and 11b) taken at 0000Z and 1200Z, respectively, show results similar to those obtained by Garstang, et al. (1967). These profiles show that good days were more convectively unstable than bad days. During good days synoptic scale subsidence probably dominated the area. A comparison of the 0000Z and 1200Z profiles for good days reveals that radiant energy received at the surface heated the lower convective layer thereby increasing Θ_{ve} values there. In the absence of significant convection the moist layer remained shallow. Values in the layer of Θ_{ve} minimum showed little variation. The result was an increase in the Θ_{ve} minimum near 650 mb. The synoptic scale descent served to prevent the release of the convective instability by damping vertical motions on the convective scale.

During bad days, the synoptic scale disturbances formed a basic framework within which the convective scale could then become active. As shown by the 0000Z and 1200Z profiles for bad days, the resulting convection transported energy upward, partially eliminating the layer of Θ_{ve} minimum as energy was added to that layer. With increased convective activity the diurnal variation in the amount of radiant energy received in the lower layers was diminished. Resultantly, the gradient of Θ_{ve} or the convective instability was decreased between the surface and the layer of Θ_{ve} minimum.

4. Conclusion

The mean data reveal that during July--and probably within the summer monsoon season--a basic thermodynamic state of convective instability is routine over Southeast Asia. That this instability is great enough to generate convection is easily verified by the daily satellite photographs which most often show considerable convective activity, by the Radar Index which indicates the presence of significant convective activity almost daily, and by climatology which reflects a relatively high frequency of thunderstorms over Southeast Asia.

The data indicate little difference between the vertical distribution of dry-bulb temperature under various synoptic conditions; however, both the amount and depth of moisture varies between conditions of suppressed and increased convection with days of increased convection being more moist. Days of suppressed convection show a larger diurnal variation of moisture probably due to a diurnal convective cycle.

Vertical profiles of θ_{ve} permit a better visual assessment of convective instability than observed thermodynamic properties. Both θ_{ve} and dewpoint temperature profiles show characteristic differences between conditions of increased and suppressed convection. However, θ_{ve} profiles permit an insight into the physical processes, acting within the synoptic and convective scales, which cause increased or suppressed convection.

The lack of success in forecasting convective activity using stability indices, the apparently negligible role of quasi horizontal advective processes, and the routine convectively unstable structure of the atmosphere over Southeast Asia during July indicate that a thermodynamic approach to forecasting convective activity is invalid. Vertical profiles of θ_{ve} suggest that the role of vertical advective processes is paramount and that conditions of increased or decreased convection are synoptically controlled. The fact that on good days the atmosphere has a strong convectively unstable structure implies absence of a triggering mechanism and suppression of convection through synoptic scale subsidence. The weak convective instability characteristic of bad days implies that the convective scale, acting within a synoptic scale framework, is dominant. The evidence indicates that convection will be increased over Southeast Asia when a synoptic trigger is acting. Convection will be suppressed when synoptic scale subsidence acts to damp convection.

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Tables 1 through 4

Figures 1 through 11

Pressure (mb)	Ht. (gp ft)	T (^{o}C)	Td (^{o}C)	θ (^{o}C)	q (g/kg)	θ_v (^{o}K)	θ_{ve} (^{o}K)
100	54290	-77.9		377.3			
150	46629	-67.4		354.1			
200	40726	-53.4		348.3			
250	35883	-41.3	-48.3	344.7	0.2	346.6	347.5
300	31711	-31.3	-41.2	341.3	0.4	341.6	343.0
350		-22.9	-32.3	337.9	0.8	338.0	340.8
400	24876	-16.2	-24.2	333.9	1.5	334.2	339.2
450		-10.8	-17.9	329.7	2.2	330.1	337.4
500	19120	- 6.0	-12.2	325.7	3.1	326.3	336.2
550		- 2.1	- 7.2	321.6	4.2	322.4	335.2
600		1.6	- 3.4	317.9	5.1	318.9	334.3
650		5.4	0.2	315.1	6.1	316.3	334.3
700	10210	8.8	3.5	312.2	7.2	313.6	334.3
750		11.8	6.7	309.4	8.3	311.0	334.8
800		14.6	9.7	306.7	9.6	308.5	335.5
850	4834	17.3	13.2	304.3	11.2	306.3	337.5
900		20.0	16.1	302.1	12.9	304.5	339.7
950		22.4	19.2	299.9	14.9	302.6	342.9
1000	164	24.5	23.1	297.6	17.8	300.9	348.6

Table 1a. Mean aerological data for Saigon (48900) at 0000Z during July 1966-1967.

Pressure (mb)	Ht. (gp ft)	T (°C)	Td (°C)	Θ (°K)	q (g/kg)	$Θ_v$ (°K)	$Θ_{ve}$ (°K)
100	54256	-79.4		374.3			
150	46563	-67.6		353.7			
200	40668	-53.1		348.8			
250	35625	-40.6	-45.0	345.7	0.3	346.7	347.8
300	31656	-30.5	-37.6	342.4	0.5	342.4	344.4
350		-22.2	-28.9	338.9	1.1	339.2	343.0
400	24767	-15.8	-21.7	334.4	1.8	334.9	341.0
450		-10.6	-15.0	330.0	2.7	330.5	339.3
500	19109	- 5.8	- 9.7	325.9	3.8	326.7	338.5
550		- 1.8	- 5.5	322.0	4.7	322.9	337.4
600		1.9	- 1.8	318.4	5.7	319.5	336.6
650		5.8	1.9	315.5	6.8	316.8	337.0
700	10211	9.1	5.3	312.6	8.0	314.1	337.3
750		12.1	8.6	309.7	9.4	311.5	338.2
800		15.2	11.7	307.3	10.8	309.3	339.7
850	4840	18.0	14.7	305.0	12.3	307.3	341.5
900		20.9	17.5	303.1	14.0	305.6	344.1
950		24.1	20.7	301.6	16.1	304.6	348.5
1000	200	27.1	23.6	300.2	18.3	303.6	353.2

Table 1b. Mean aerological data for Saigon (48900) at 1200Z during July 1966-1967.

Pressure (mb)	Saigon 48900	Udorn 48354	West Pacific Colon	West Pacific Shimada	Gulf of Mexico Hebert/Jordan	W.Indies Jordan	Pt. Blair IIOE
100	-79.4 (77.9)	-79.2 (-77.0)	-76.5	-77.3	-70.2	-73.5	-72.5 (-72.3)
150	-67.6 (-67.4)	-66.1 (-66.0)	-68.9	-67.6	-66.7	-67.6	-64.6 (-64.9)
200	-53.1 (-53.4)	-51.2 (-53.4)	-55.8	-53.2	-55.1	-55.2	-52.2 (-52.2)
250	-40.6 (-41.3)	-38.9 (-39.2)	043.7	-40.5	-43.2	-43.3	-40.1 (-40.8)
300	-30.5 (-31.3)	28.8 (-29.4)	-33.2	-30.6	-33.2	-33.2	-29.8 (-31.1)
350	-22.2 (-22.9)		-24.6		-24.8	-24.8	-22.1 (-22.9)
400	-15.8 (-16.2)	-14.0 (-14.9)	-17.7	-15.6	-17.7	-17.7	-15.6 (-15.9)
450	-10.6 (-10.8)		-12.0		-11.8	-11.9	-10.0 (-10.3)
500	- 5.8 (- 6.0)	- 3.8 (- 4.6)	- 7.0	- 5.6	- 6.8	- 6.9	- 5.2 (- 5.4)
550	- 1.8 (- 2.1)	- 0.6 (- 0.6)	- 2.7		- 2.4	- 2.5	- 1.0 (- 1.0)
600	- 1.9 (1.6)	4.1 (3.5)	1.2		1.5	1.4	2.7 (2.7)
650	5.8 (5.4)	7.5 (6.9)	5.0		5.4	5.1	6.5 (6.4)
700	9.1 (8.8)	10.9 (9.9)	8.5	9.7	9.0	8.6	9.9 (9.9)
750	12.1 (11.8)		11.7		12.4	11.8	13.0 (12.7)
800	15.2 (14.6)		14.5		15.6	14.6	15.8 (15.4)
850	18.0 (17.3)	20.7 (18.9)	17.0	18.2	18.6	17.3	18.3 (18.3)
900	20.9 (20.0)		19.6		21.4	19.8	
950	24.1 (22.4)		22.6		23.8	23.0	
1000	27.1 (24.5)		26.0	25.9	26.2	26.0	26.5 (25.3)

Table 2. Comparison of mean dry-bulb temperatures ($^{\circ}C$) for different tropical localities (data in parentheses taken at 00Z)

Pressure (mb)	Saigon 48900	Udorn 48354	W. Pacific Shimada	Gulf of Mexico Hebert/Jordan	W. Indies Jordan	Pt. Blair IIOE
100						
150						
200						
250	0.3 (0.2)	0.2 (0.2)				
300	0.5 (0.4)	0.5 (0.4)	0.4			
350	1.1 (0.8)					
400	1.8 (1.5)	1.5 (1.1)	1.4	1.0		
450	2.7 (2.2)			1.5	1.4	
500	3.8 (3.1)	3.1 (2.8)	3.5	2.1	2.1	
550	4.7 (4.2)	4.3 (4.0)		2.8	3.2	4.1 (3.4)
600	5.7 (5.1)	5.4 (5.0)		3.7	3.6	5.4 (5.1)
650	6.8 (6.1)	6.7 (6.3)		4.6	4.6	6.[illegible] (6.1)
700	8.0 (7.2)	8.4 (7.8)	7.1	5.7	5.8	7.2 (7.4)
750	9.4 (8.3)			7.0	7.1	8.4 (8.4)
800	10.8 (9.6)			8.5	8.4	9.7 (9.9)
850	12.3 (11.2)	13.4 (12.1)	12.2	10.3	11.0	11.6 (11.5)
900	14.0 (12.9)			12.6	13.0	
950	16.1 (14.9)			15.2	15.3	
1000	18.3 (17.8)		19.4	17.7	17.6	

Table 3. Comparison of mean specific humidity (g/kg) for different tropical localities (data in parentheses taken at 00Z)

Pressure (mb)	Saigon 48900	Udorn 48354	W. Pacific Shimada	Gulf of Mexico Hebert/Jordan	W. Indies Jordan	Pt. Blair IICE
100						
150						
200						
250						
300	345 (343)	347 (345)	343			
350	343 (343)	344 (342)				
400	341 (341)	342 (339)	338	330		
450	340 (337)	340 (337)		334	333	
500	339 (336)	339 (336)	345	332	332	
550	338 (336)	339 (337)		331	332	
600	337 (335)	338 (337)		330	329	337 (334)
650	337 (335)	339 (337)		329	329	334 (336)
700	338 (334)	341 (339)	330	330	330	336 (336)
750	339 (335)	343 (340)		331	331	335 (337)
800	341 (336)	346 (341)		333	333	337 (337)
850	343 (338)	349 (342)	334	336	337	338 (338)
900	345 (340)			340	340	340 (340)
950	351 (343)			345	344	
1000	354 (350		346	349	349	

Table 4. Comparison of mean equivalent potential temperatures (°K) for different tropical localities (data in parentheses taken at OCZ)

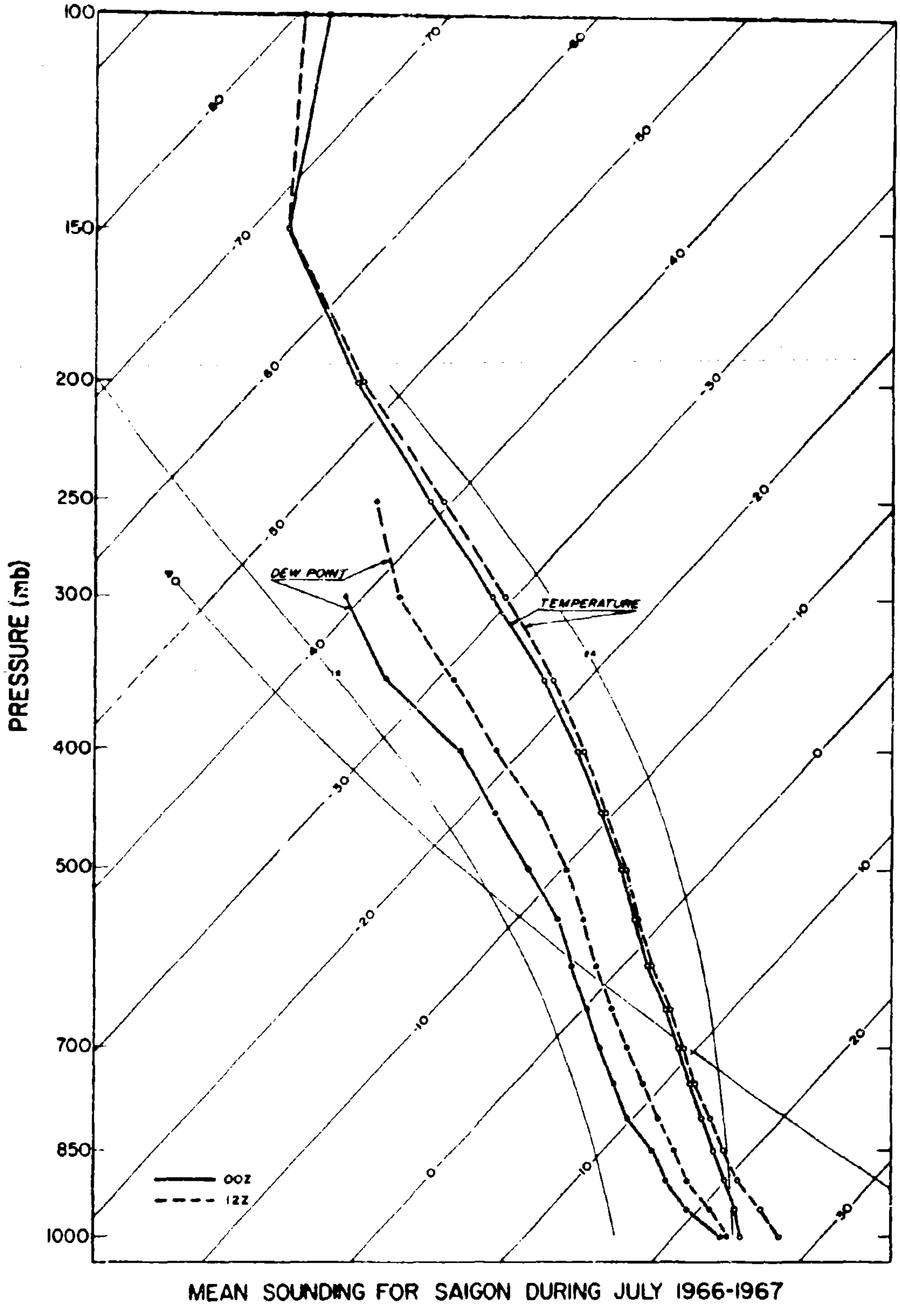

FIGURE 1. Mean aerological sounding for Saigon during July 1966-1967.

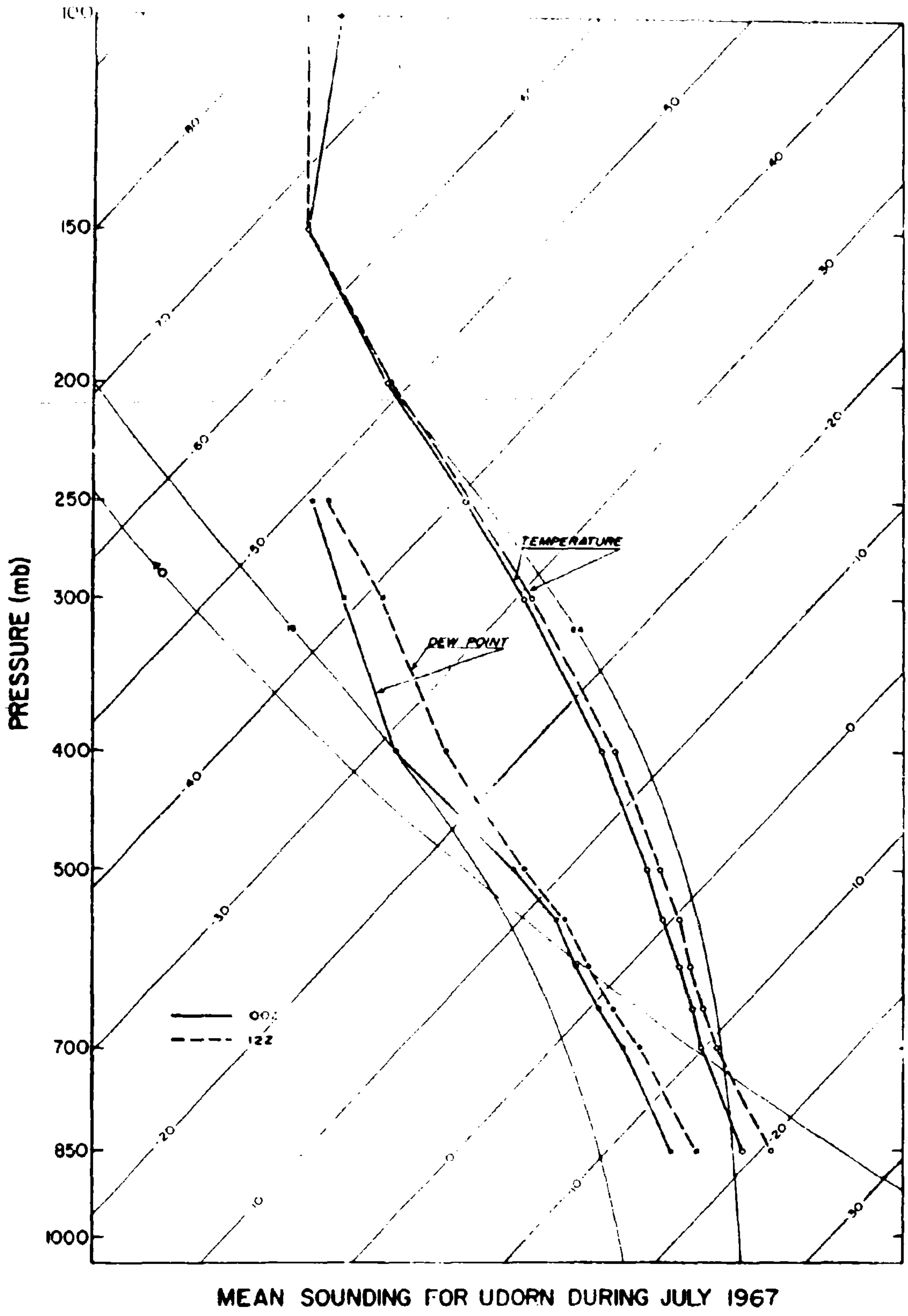

FIGURE 2. Mean aerological sounding for Udorn during July 1967.

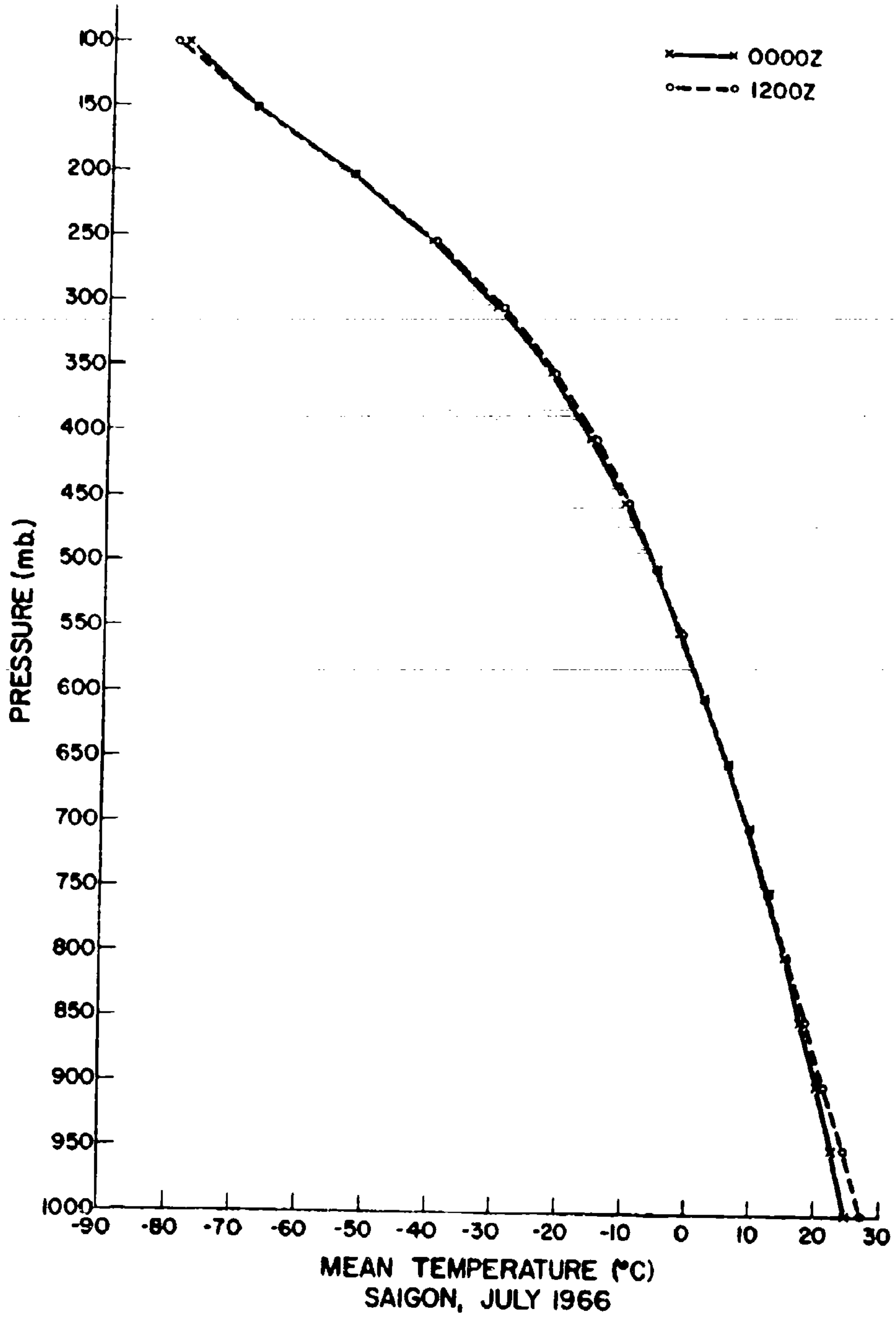

FIGURE 3a. Mean vertical profiles of dry-bulb temperature for Saigon during July 1966.

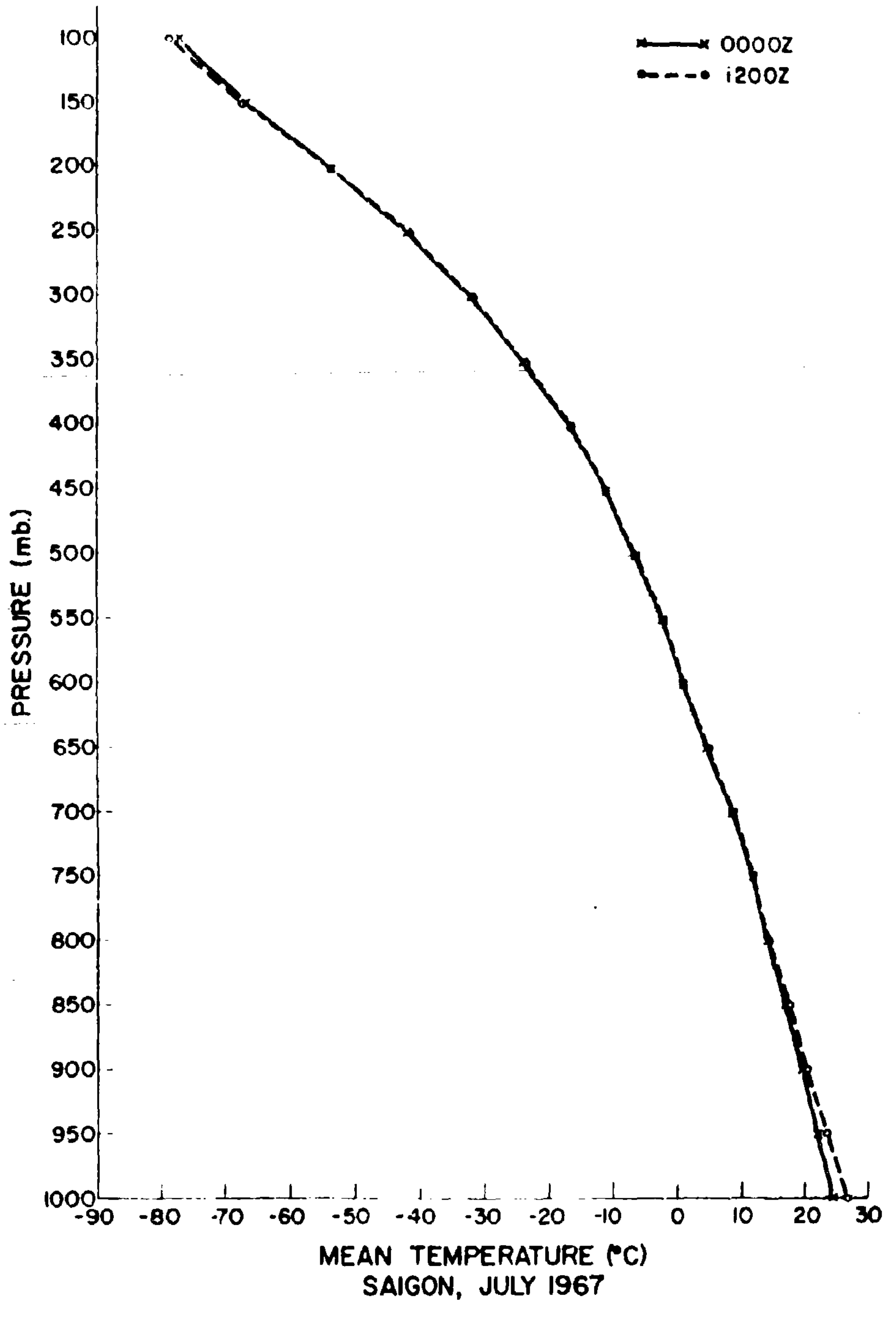

FIGURE 3b. Mean vertical profiles of dry-bulb temperature for Saigon during July 1967.

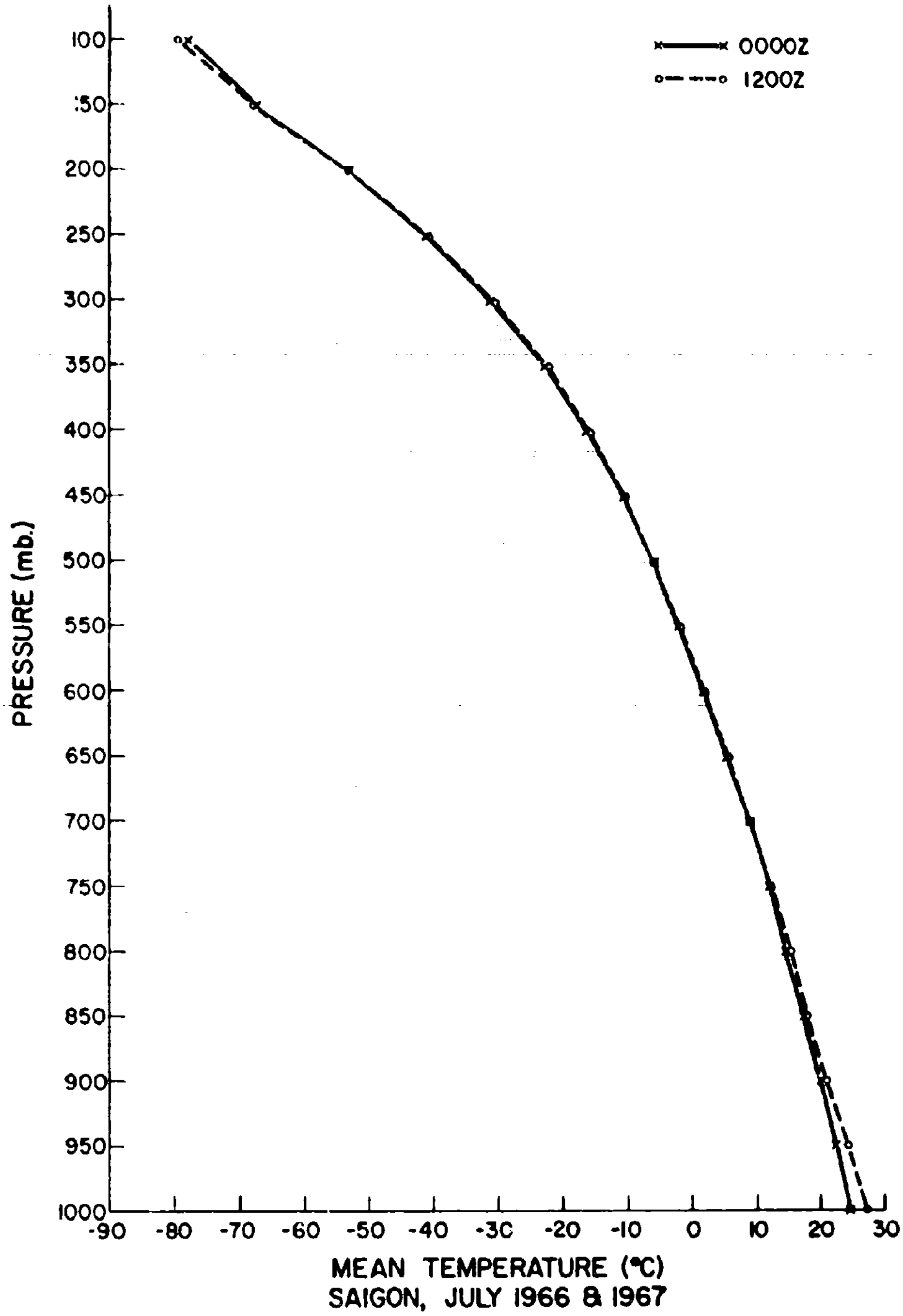

FIGURE 3c. Mean vertical profiles of dry-bulb temperature for Saigon during July 1966-1967.

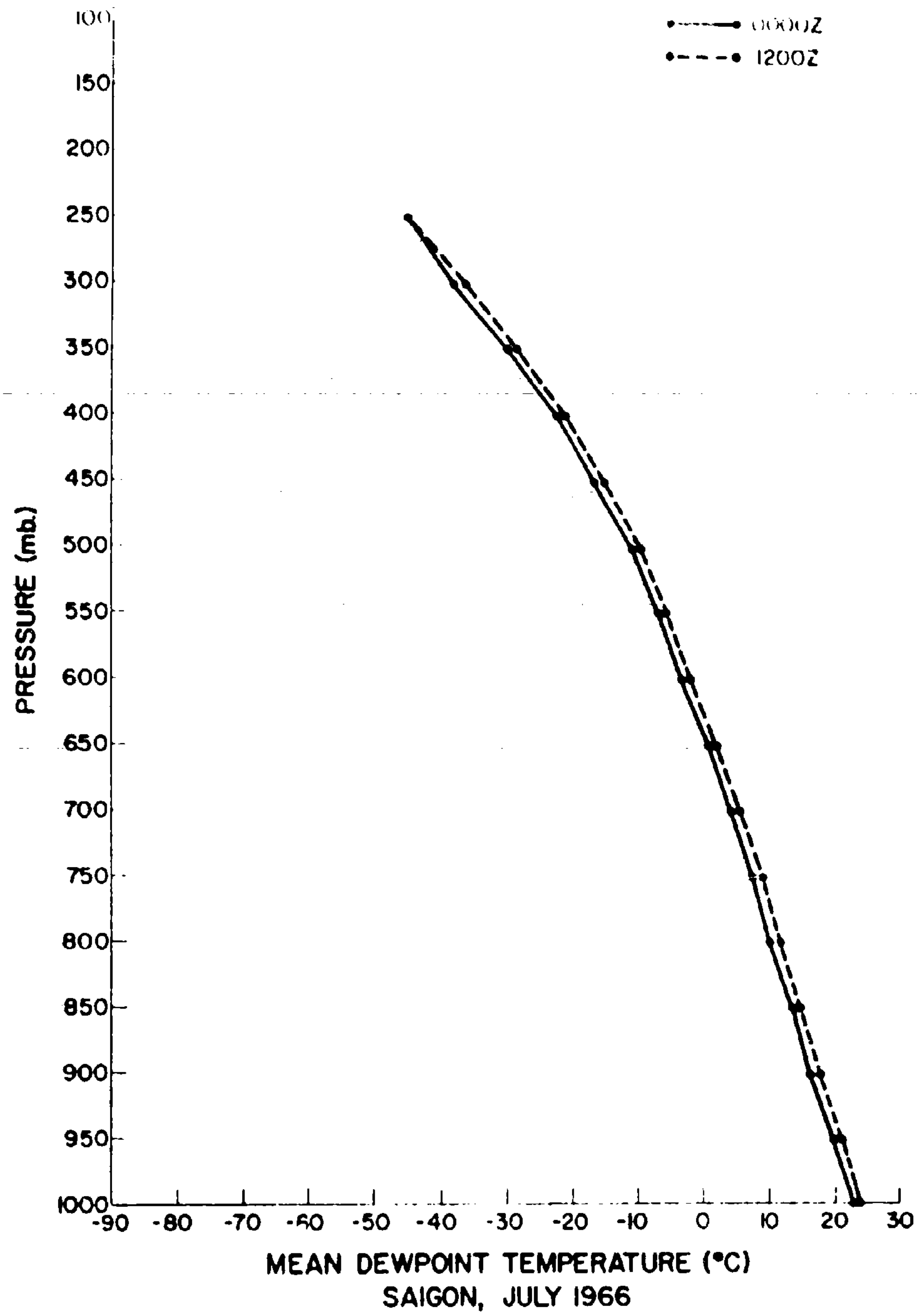

FIGURE 4a. Mean vertical profiles of dewpoint temperature for Saigon during July 1966.

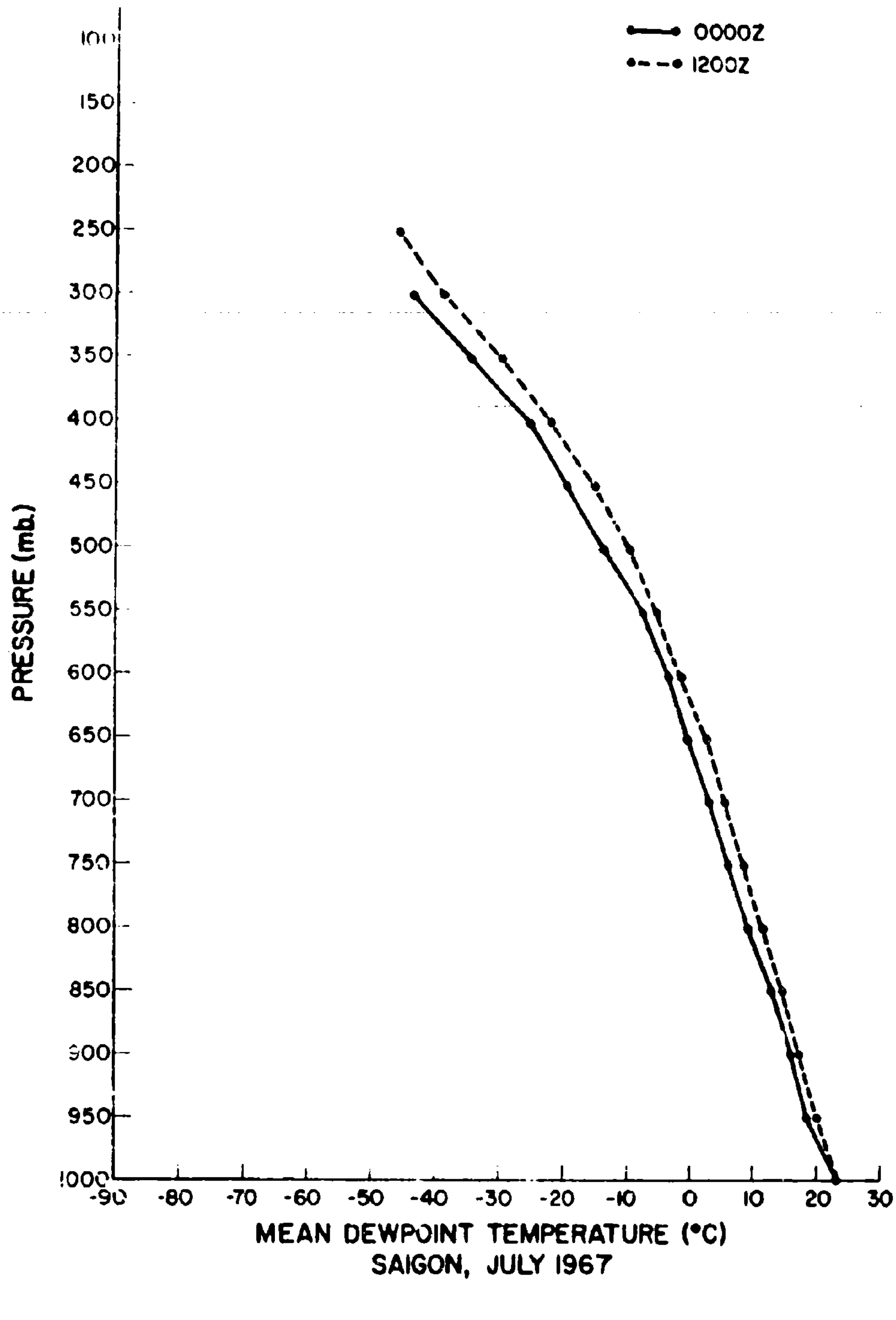

FIGURE 4b. Mean vertical profiles of dewpoint temperature for Saigon during July 1967.

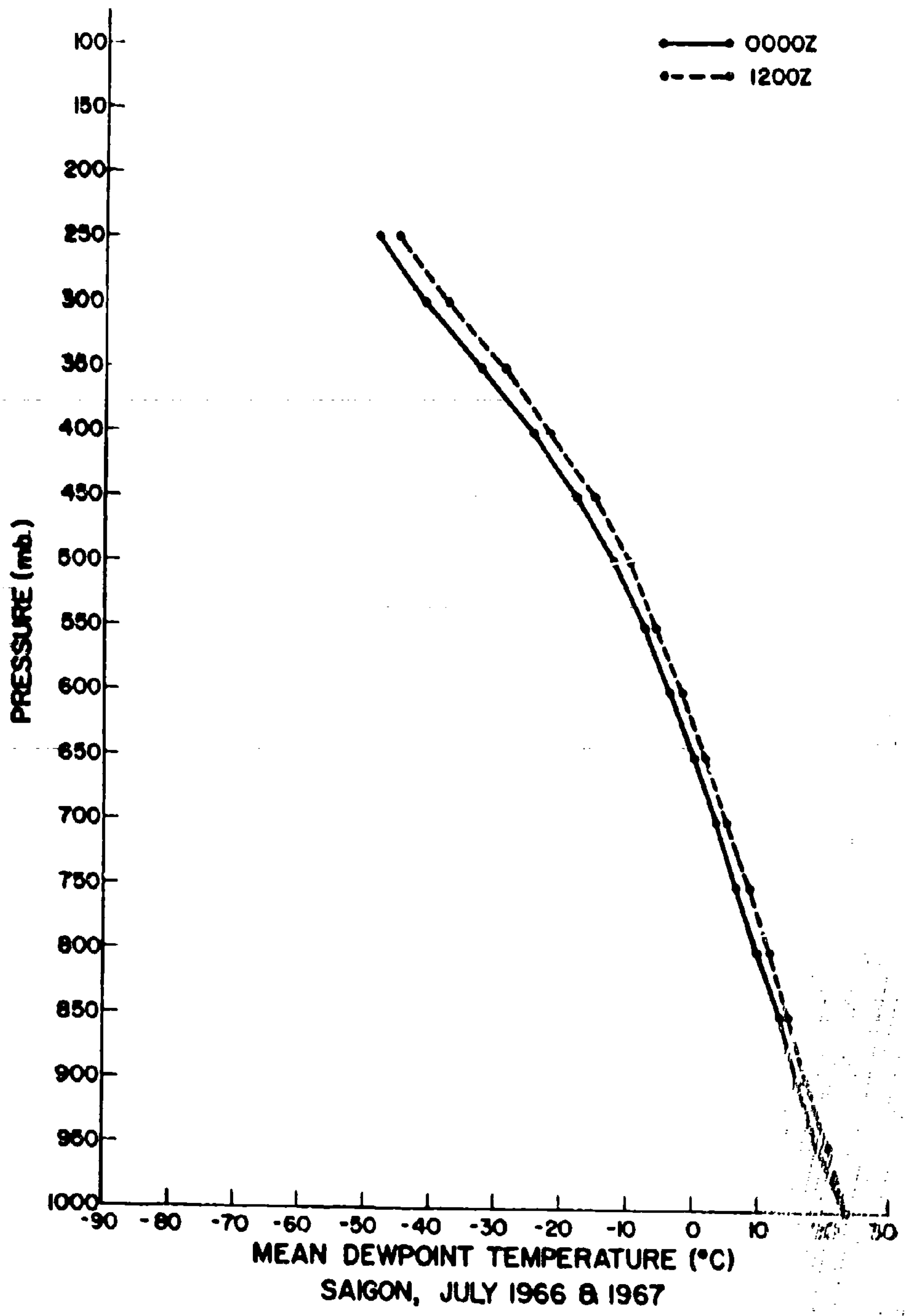

FIGURE 4c. Mean vertical profiles of dewpoint temperature for Saigon during July 1966-1967.

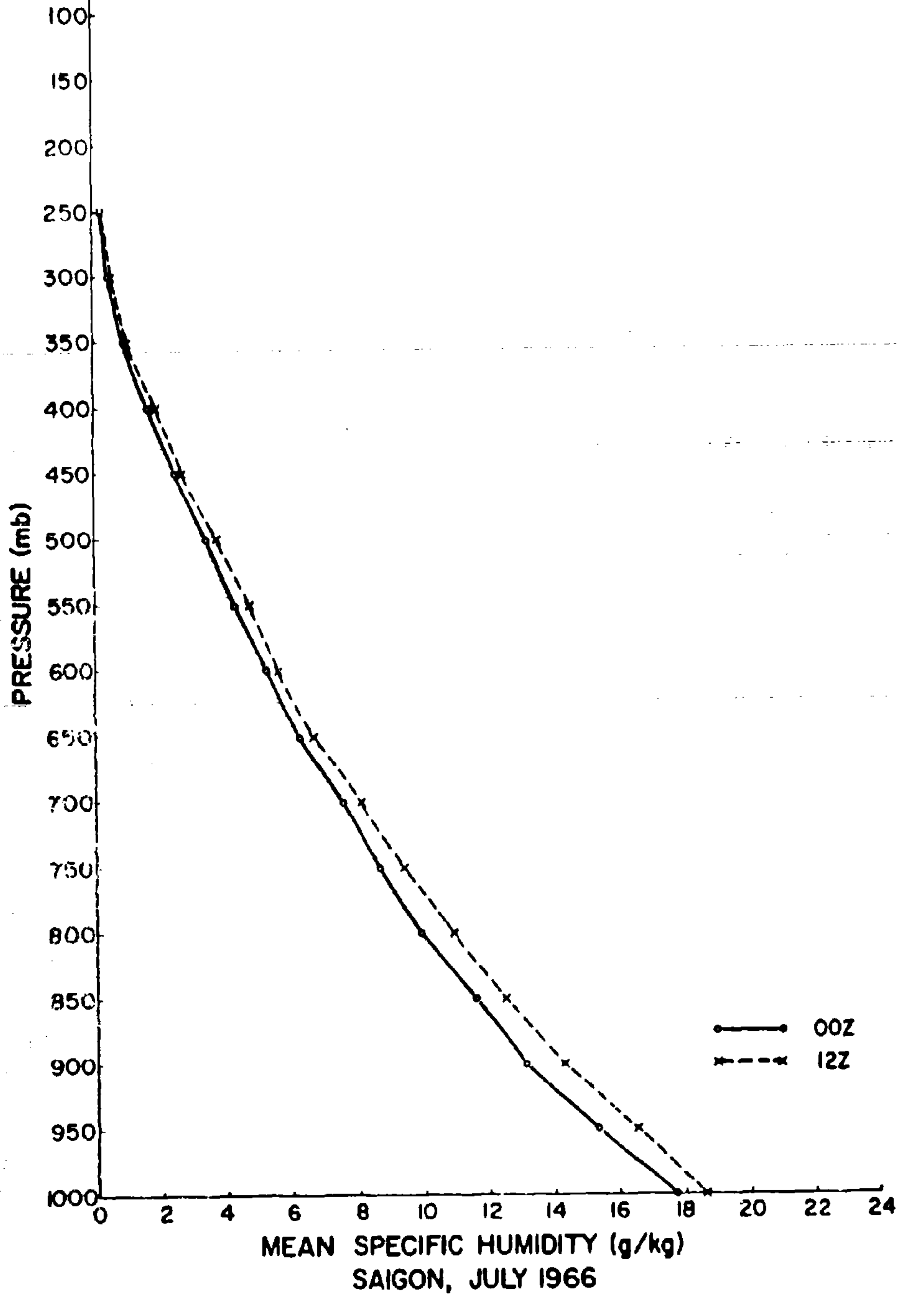

FIGURE 5a. Mean vertical profiles of specific humidity for Saigon during July 1966.

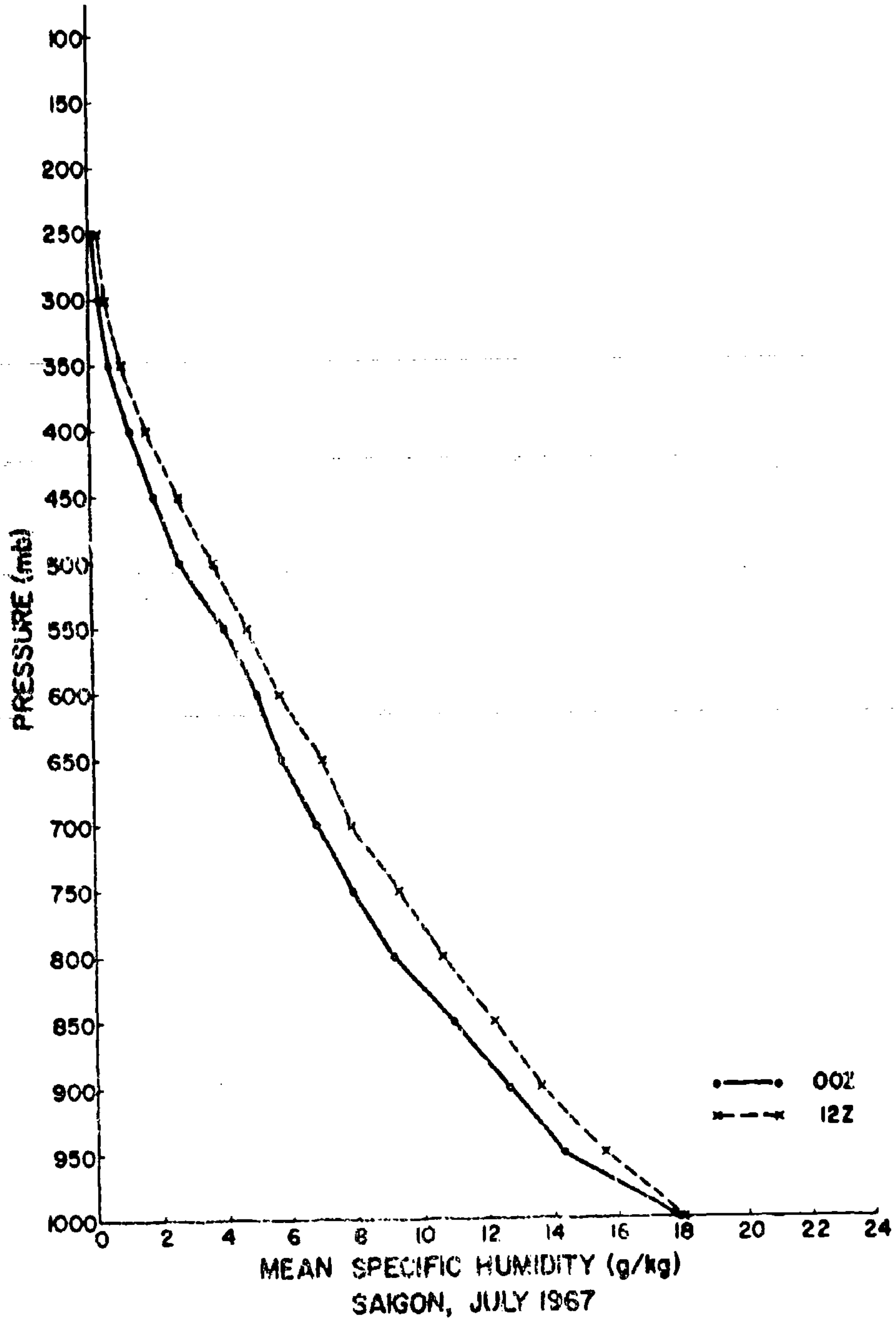

FIGURE 5b. Mean vertical profiles of specific humidity for Saigon during July 1967.

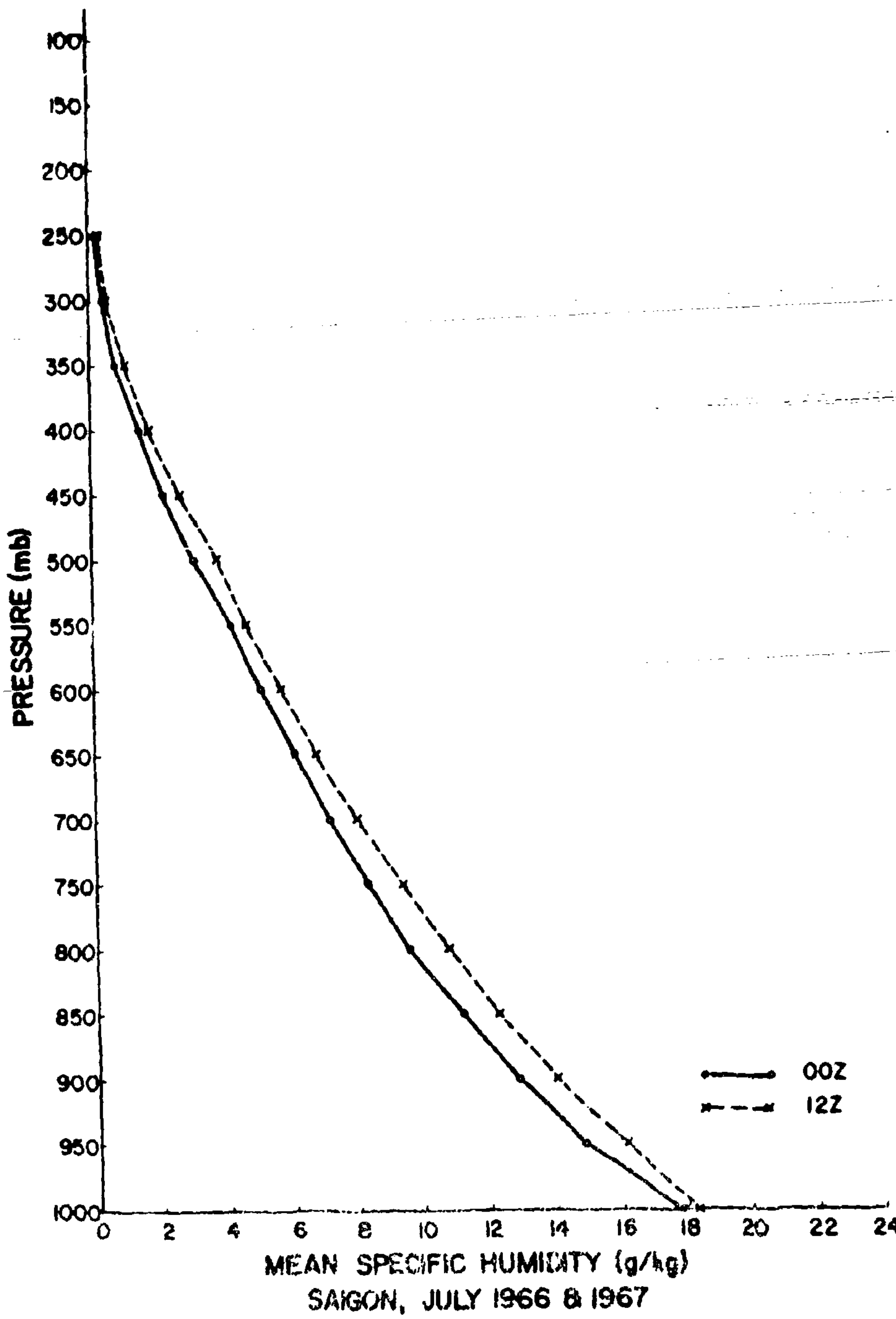

FIGURE 5c. Mean vertical profiles of specific humidity for Saigon during July 1966-1967.

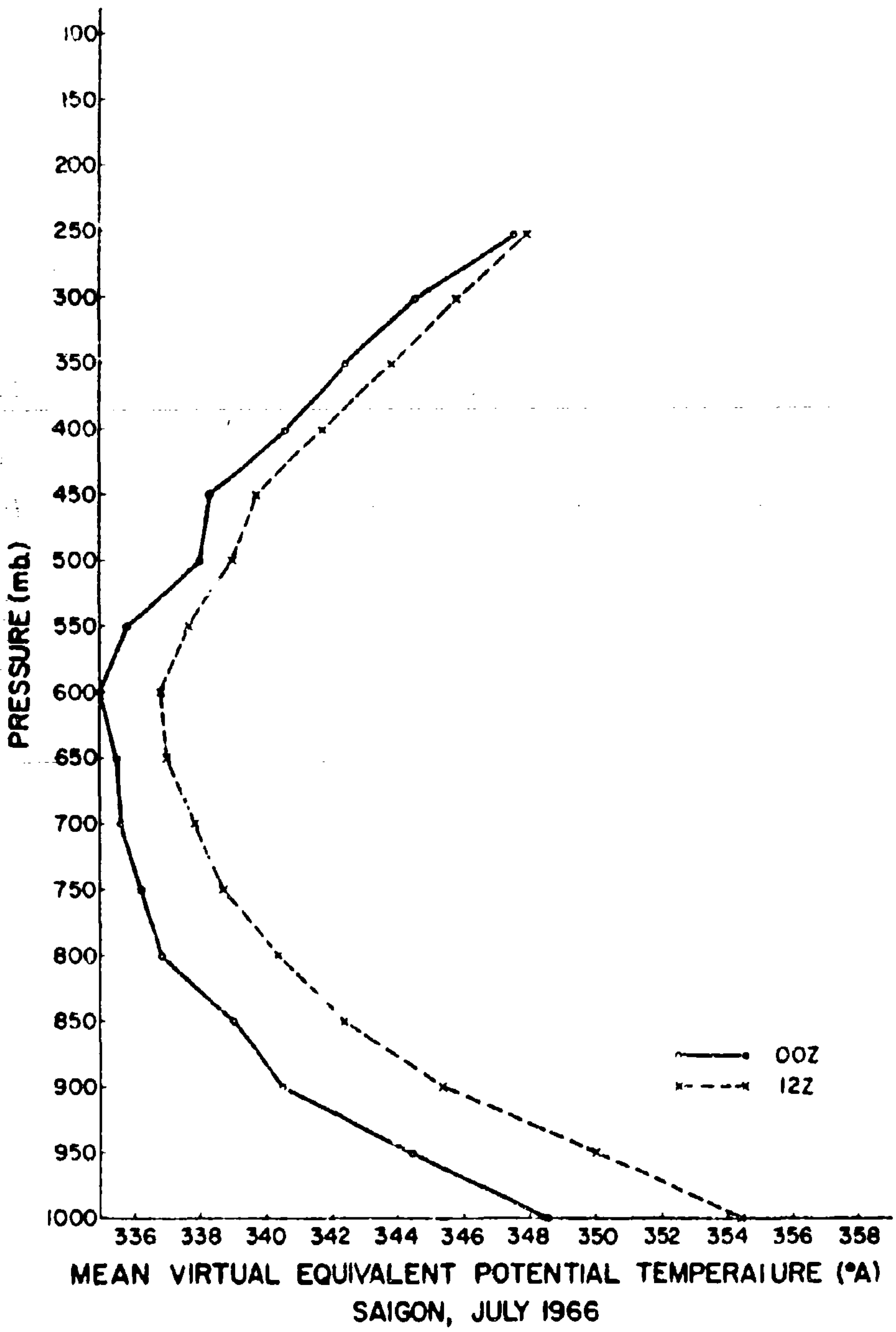

FIGURE 6a. Mean vertical profiles of virtual equivalent potential temperature for Saigon during July 1966.

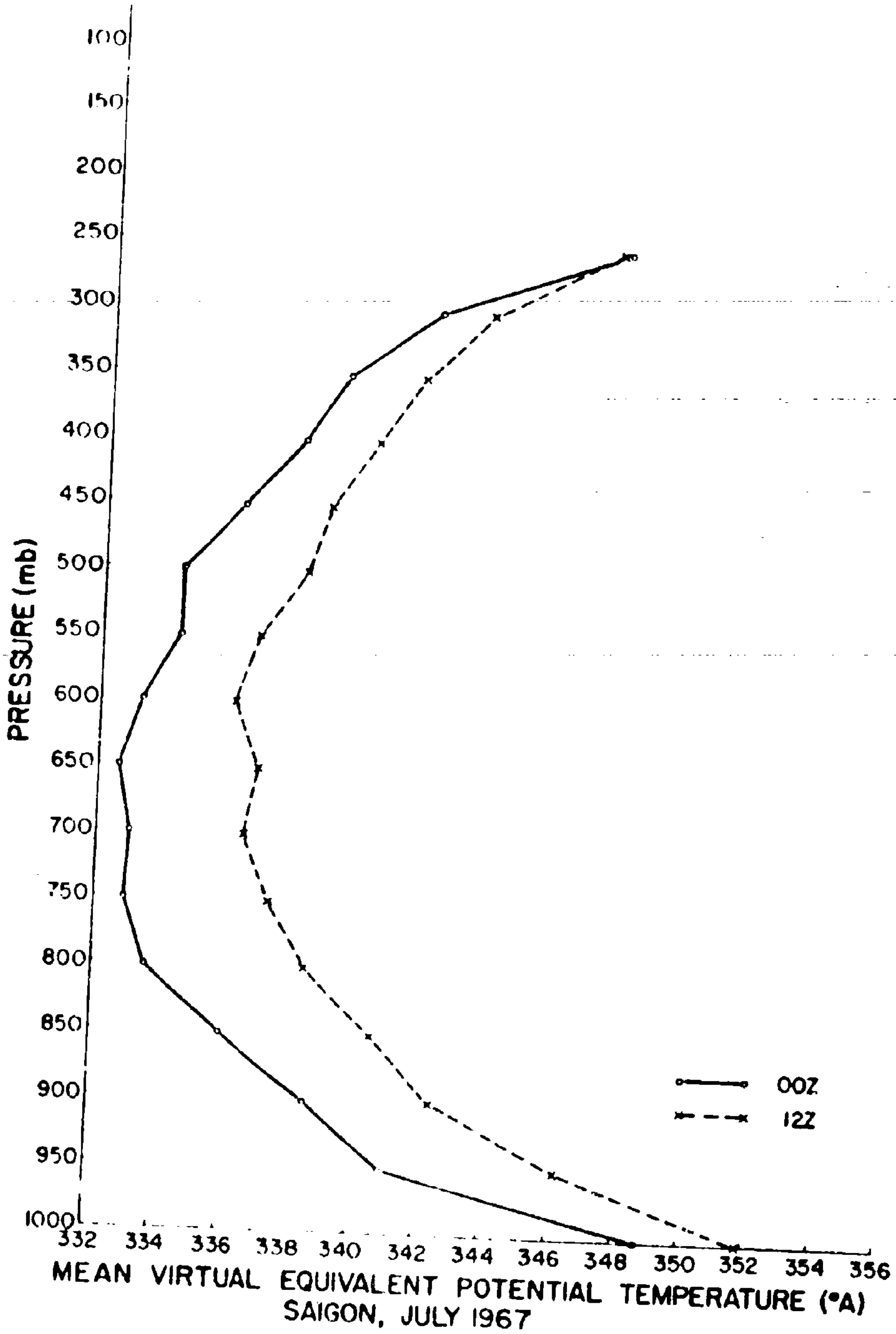

FIGURE 6b. Mean vertical profiles of virtual equivalent potential temperature for Saigon during July 1967.

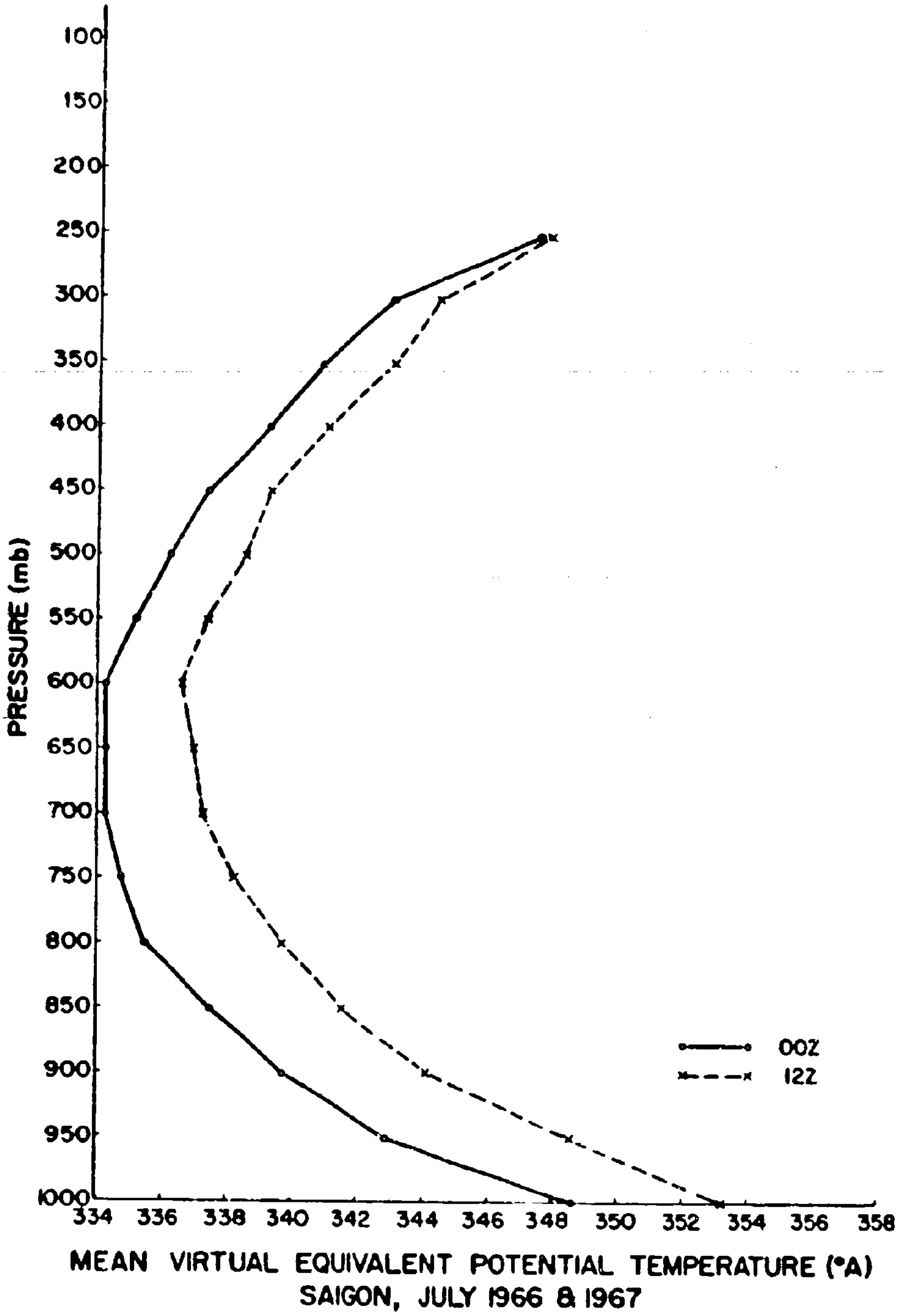

FIGURE 6c. Mean vertical profiles of virtual equivalent potential temperature for Saigon during July 1966-1967.

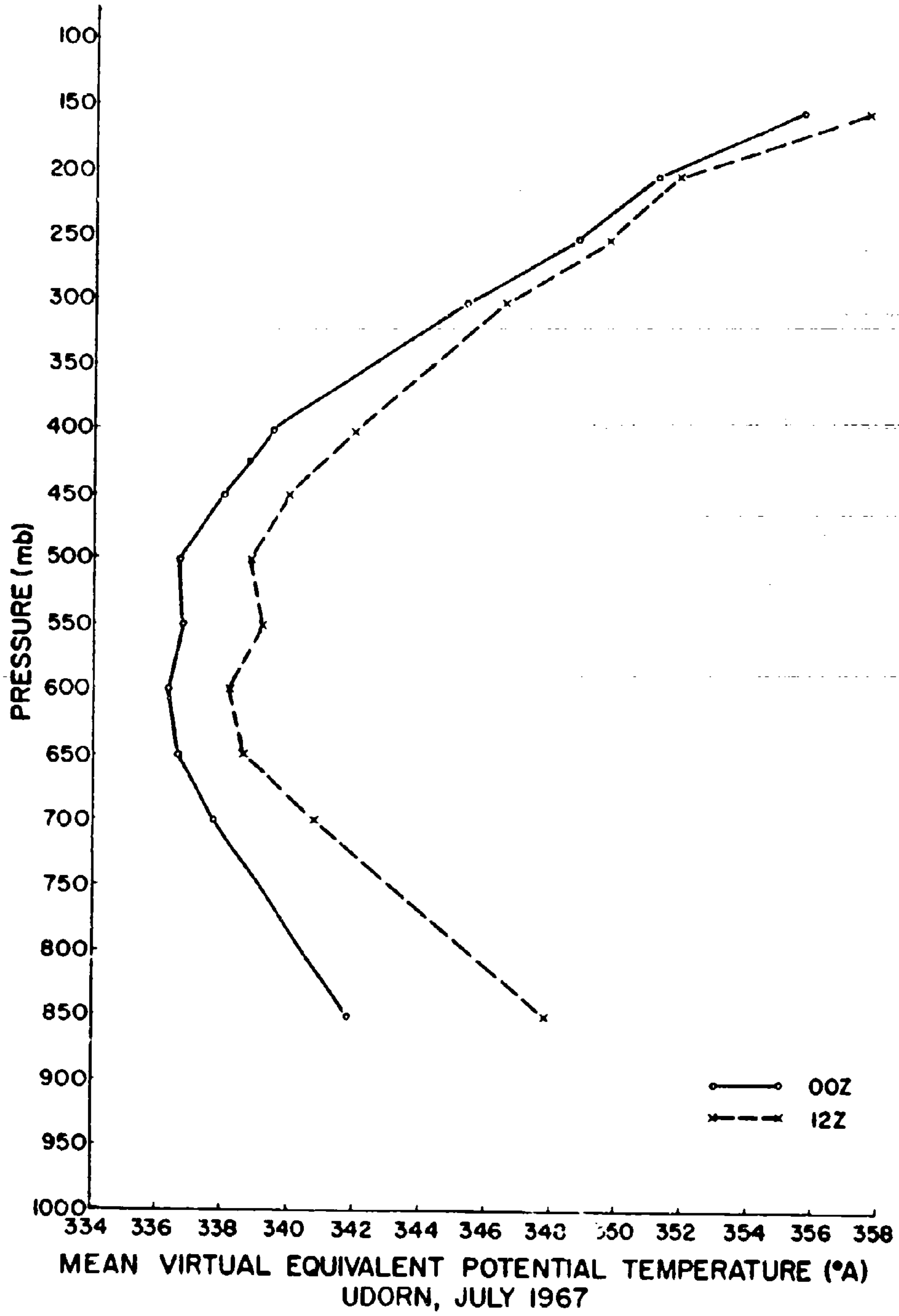

FIGURE 7. Mean vertical profiles of virtual equivalent potential temperature for Udorn during July 1967.

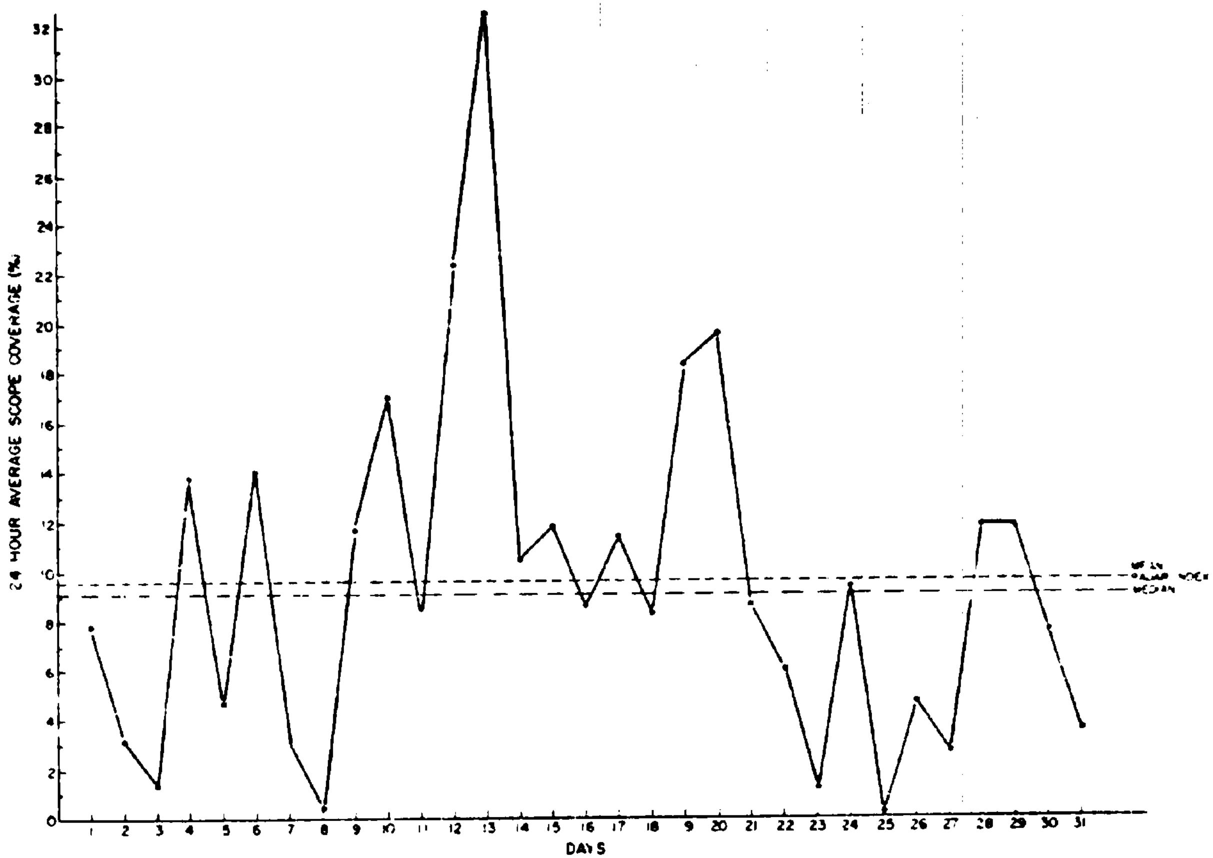

FIGURE 8. Profile of daily averaged Radar Index values for July 1966.

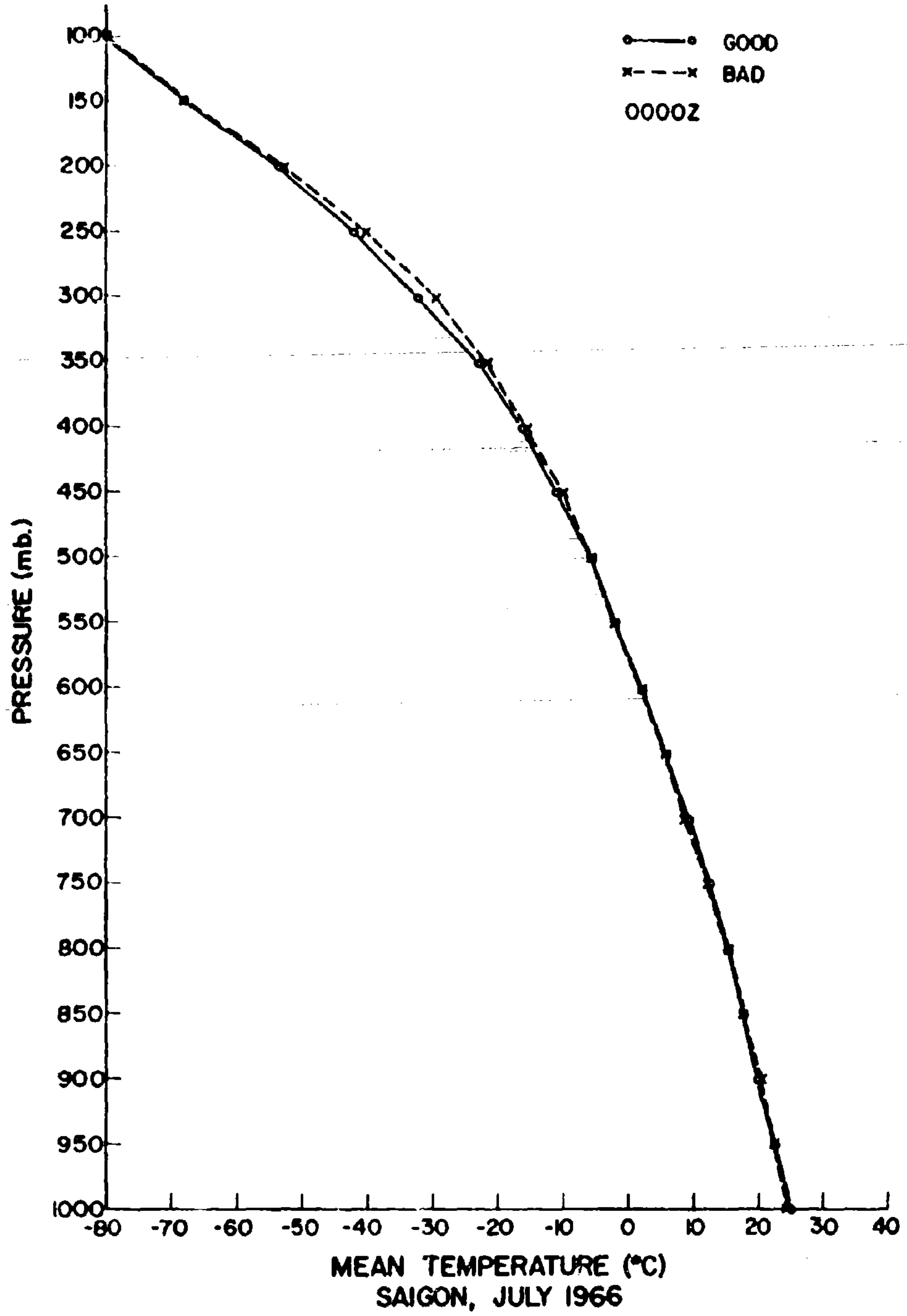

FIGURE 9a. Mean vertical profiles of dry-bulb temperature for Saigon during good and bad days for 0000Z, July 1966.

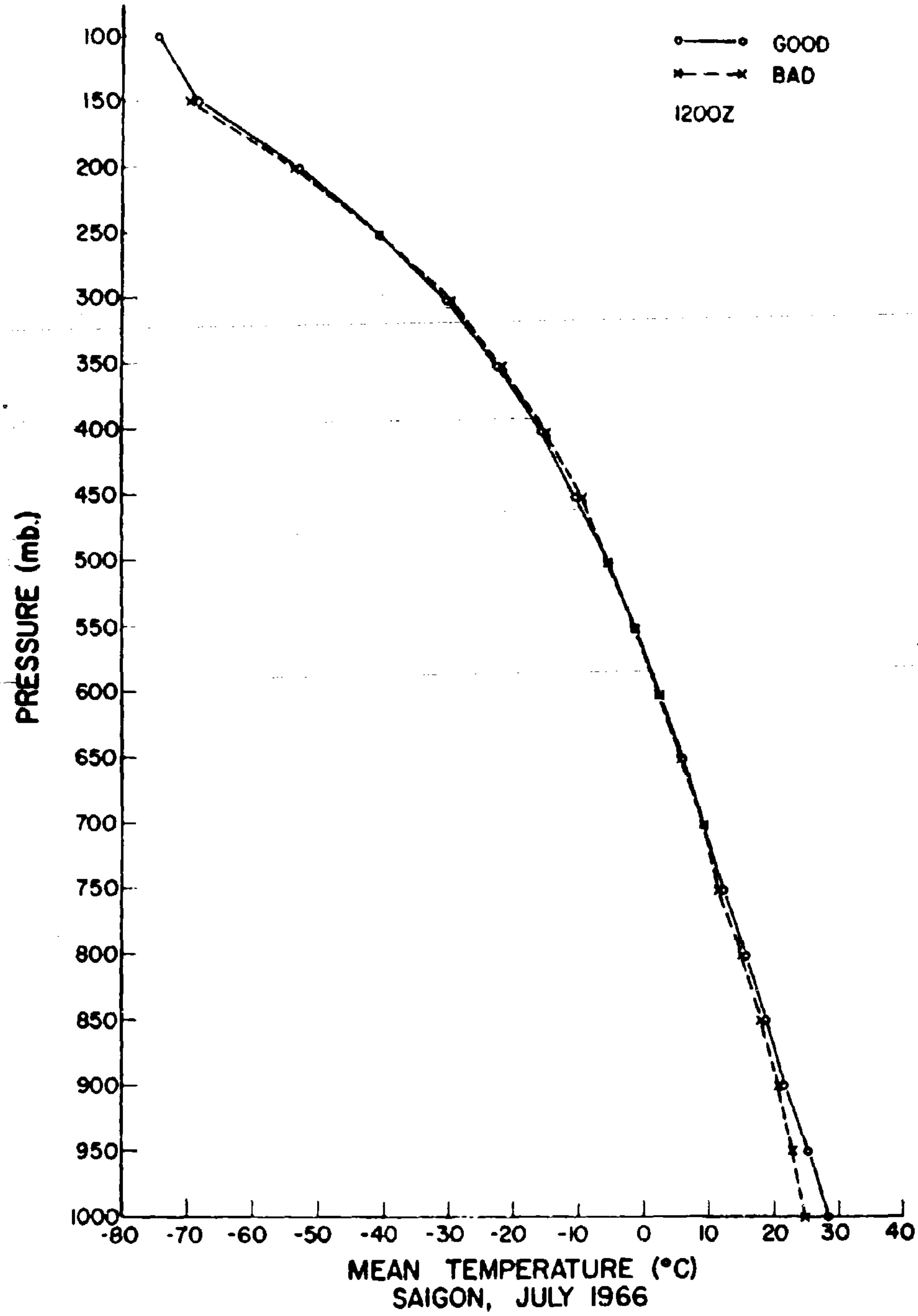

FIGURE 9b. Mean vertical profiles of dry-bulb temperature for Saigon during good and bad days for 1200Z, July 1966.

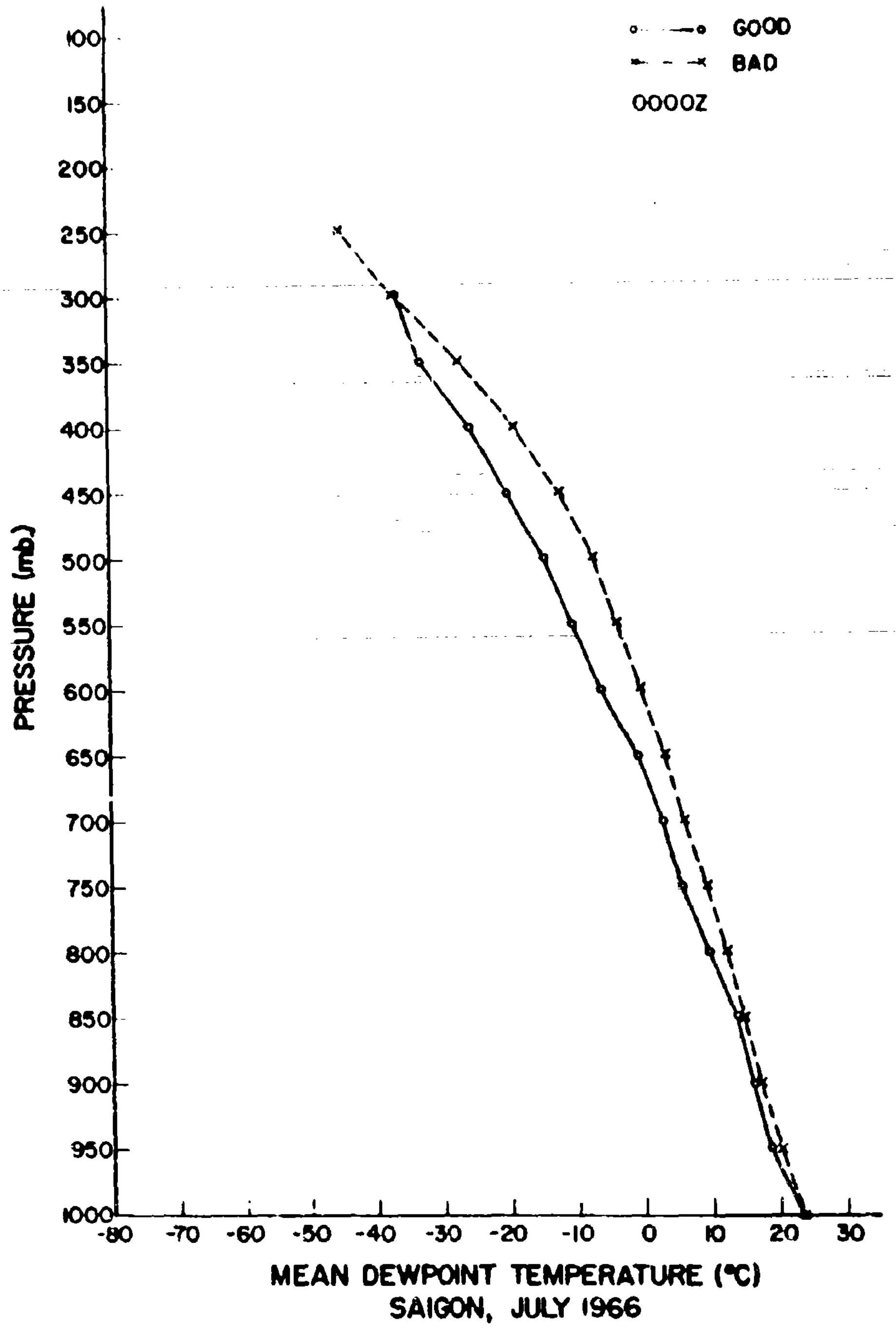

FIGURE 10a. Mean vertical profiles of dewpoint temperature for Saigon during good and bad days for 0000Z, July 1966.

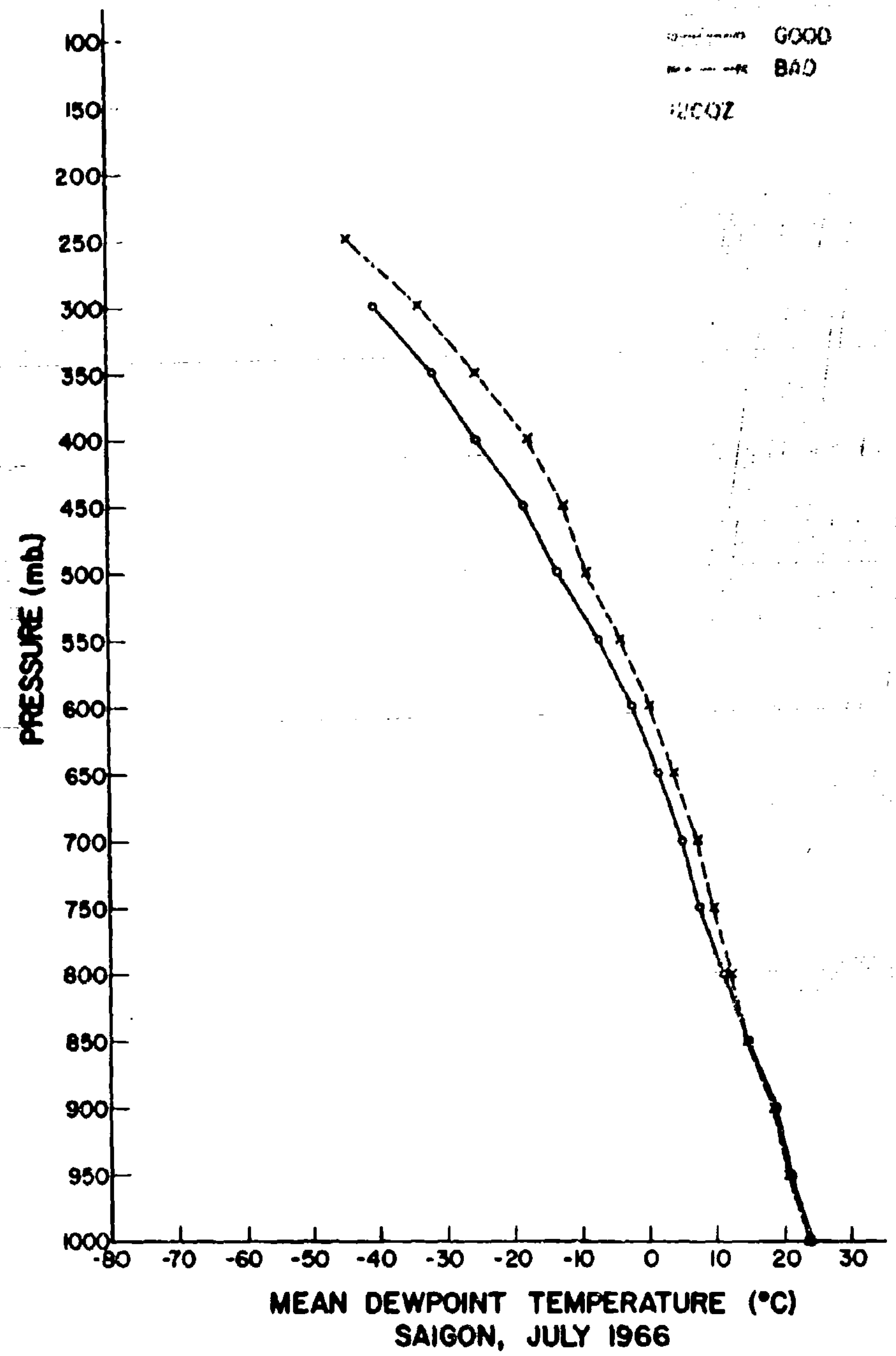

FIGURE 10b. Mean vertical profiles of dewpoint temperature for Saigon during good and bad days for 1200Z, July 1966.

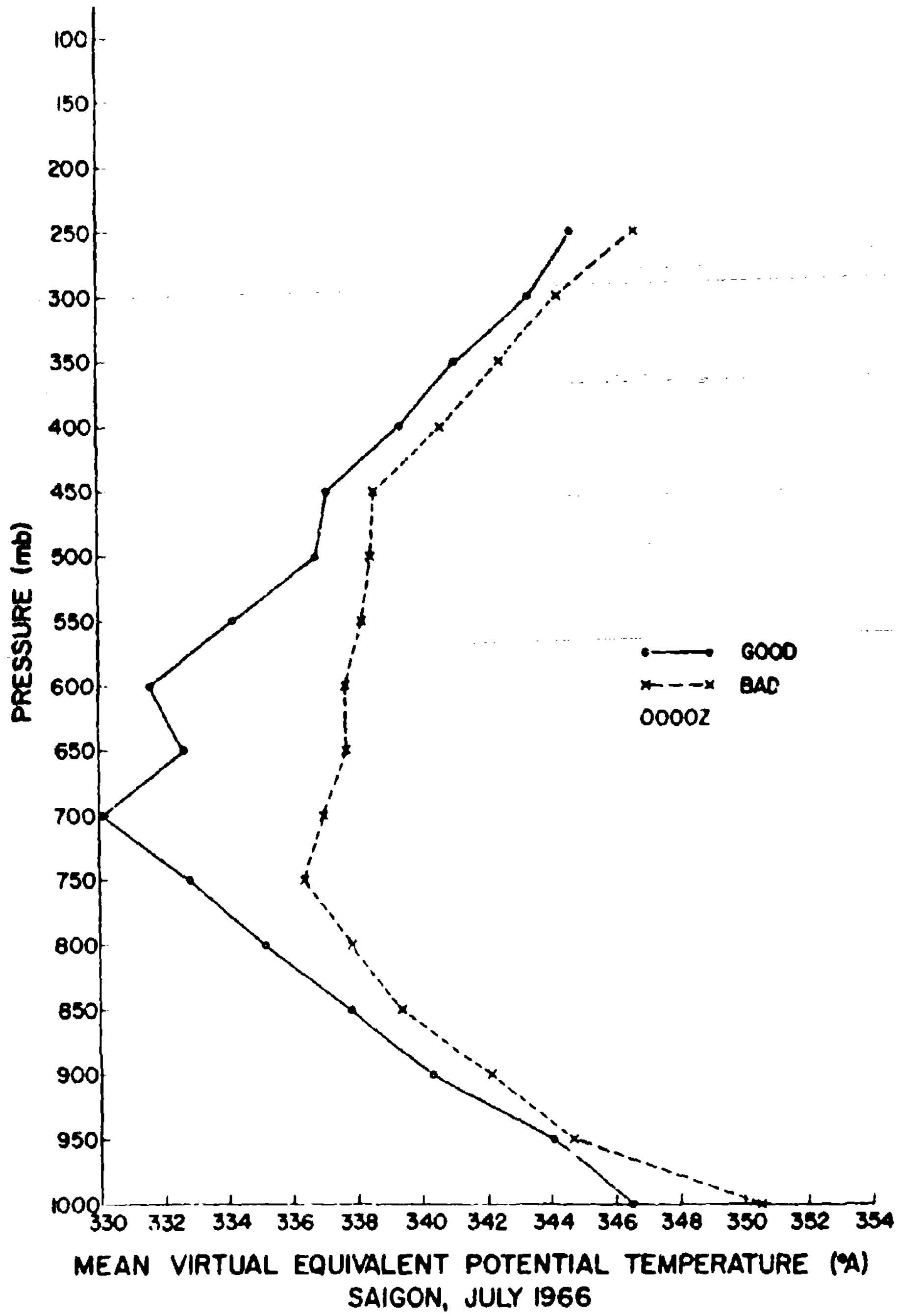

FIGURE 11a. Mean vertical profiles of virtual equivalent potential temperature for Saigon during good and bad days for 0000Z, July 1966.

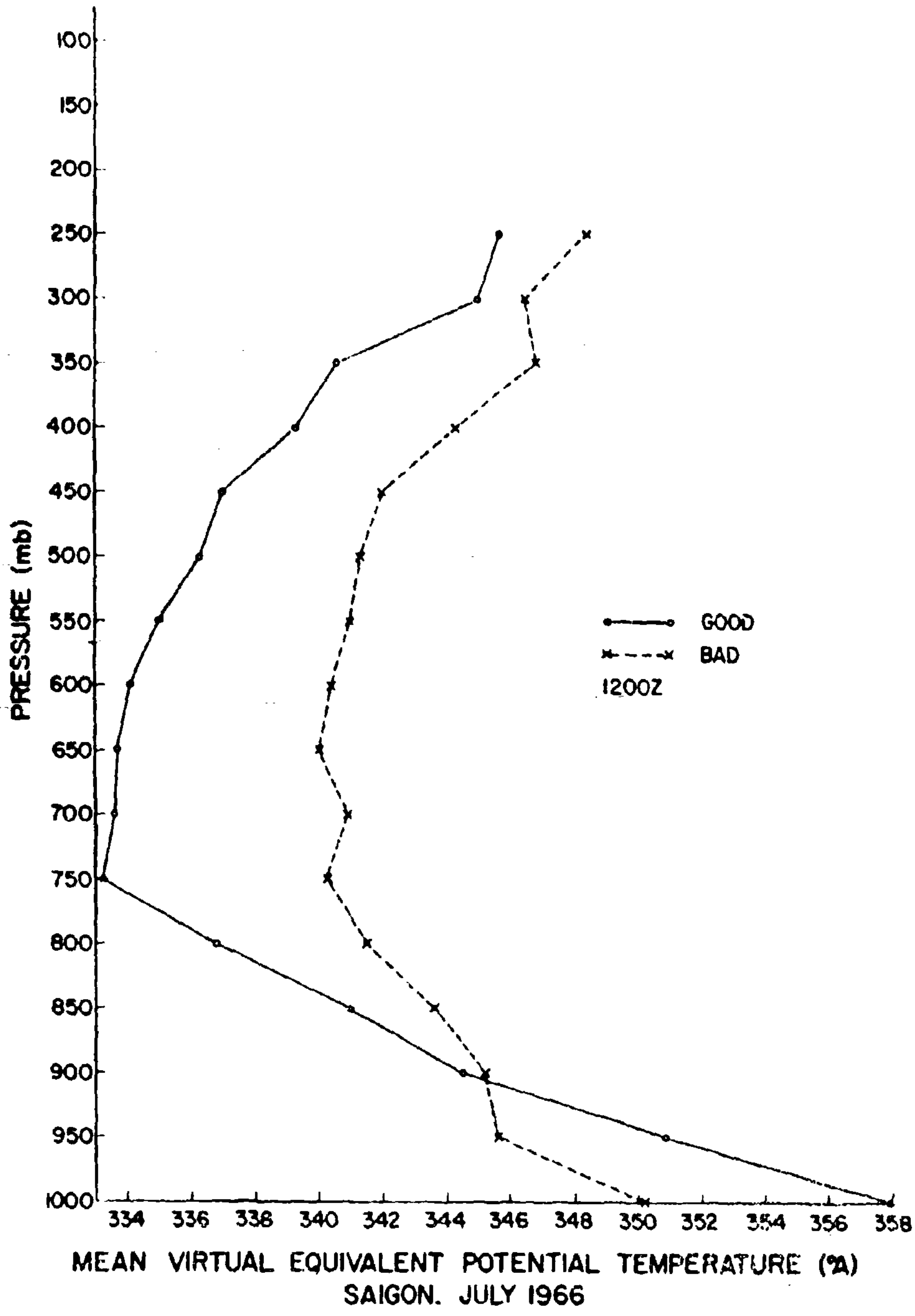

FIGURE 11b. Mean vertical profiles of virtual equivalent potential temperature for Saigon during good and bad days for 1200Z, July 1966.

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ABSTRACT

Mean aerological data for Saigon during July 1966 and 1967 and for Udorn in 1967 are presented and compared with similar data for tropical maritime regions. The comparison indicates that level for level the atmosphere over Southeast Asia has greater humidity and higher static energy. Comparison of dewpoint profiles taken during periods of suppressed and increased convection over Southeast Asia reveals that the atmosphere is more moist during increased convection and that the diurnal variation of humidity is largest during suppressed conditions. Comparisons of vertical profiles of virtual equivalent potential temperature (θ_{ve}) taken during periods of suppressed and increased convection show that the daily convective instability is strong during suppressed days and weak during days of increased convection. The characteristic differences in structure as shown by θ_{ve} suggest convection is controlled by the synoptic scale.

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