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Wetenschappelijk Rapport W.R. 56-007 (II-009)

A. Delver

SYSTEMATIC DEVIATIONS, RANDOM DEVIATIONS AND RADIATION INFLUENCE OF DIFFERENT TYPES OF RADIOSONDE

Computed from the comparisons held at Payerne, May/June 1956.

De Bilt, 1956.

Summary

The present report is the Netherlands contribution to the Final Report on the second World Comparison of Radiosondes.

To ascertain the systematic differences between the types of sonde, during the experiment many ascents, each with several sondes of different type, had to be carried out. The original experimental program, based on strictly symmetrical "balanced incomplete block designs", each of 26 ascents with 4 sondes, had been abandoned in the later course of the experiment for various reasons. Thus, a new statistical method had to be developed in order to make the best possible estimates of the systematic differences, based on the total rather chaotic sample of observations made.

To arrive at this aim for each of the 48 analyses a system of n + l + 1 linear equations with n + l + 1 unknowns had to be solved, where n = the number of types and l = the number of ascents. For most of the analyses n + l + 1 was about 40. To solve the sets of equations an iteration method was devised avoiding the immense task of calculation, inherent to the direct solution.

The unbiassed estimates of the systematic effects are shown in tables and graphs for each type, for pressure, temperature and humidity, for each standard level and for day and night separately, with an indication of the confidence to be put in them. Measures of the random deviations are also given, but only as an average for all the types.

Finally, as a result of a special study of observations of temperature not corrected for radiation, unbiassed estimates of the relative radiation error of each type for each standard level could be made. They are likewise presented in tabular and graphical form.

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SYSTEMATIC DEVIATIONS, RANDOM DEVIATIONS AND RADIATION INFLUENCE OF DIFFERENT TYPES OF RADIOSONDE.

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1. Introduction

The standard statistical method[1)] can only be applied to those observations, which satisfy the conditions of the balanced incomplete block design originally agreed upon. Unfortunately, the actual experiment has yielded a pattern of observations, which differs considerably from the ideal. Consequently, even when using standard techniques for levels with 1, 2 or 3 missing observations, this method can deal with only about half the total amount of observations.

This is not very satisfactory, and therefore another, very general method of analysis has been devised, much more laborious, but yielding unbiassed estimates of type effects and of random scatter based on all the observations, however haphazard their pattern may be.

2. The statistical model

The statistical model for any combination of meteorological element, standard level and day or night, is assumed to be

$$y_{ij} = \mu + \beta_j + \tau_i + \varepsilon_{ij} \quad ^{*)}$$

where

y_{ij} = the observation value of type i (i = 1, 2 ... 14) at ascent j.

μ = a general average, around which all the observations are fluctuating.

β_j = a deviation inherent to ascent j. This part of the total variation has to be eliminated from the results.

τ_i = a deviation inherent to type i. The chief object of the analyses is to give an unbiassed estimate t_i of τ_i.

ε_{ij} = a residual error, (random error, experimental error) generally arising from all possible variations not connected with ascent or type. In the first instance, ε_{ij} is assumed to stem from one and the same population for all types, with standard deviation σ.

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*) In accordance with general usage, greek symbols pertain to the population, latin symbols to the sample.

It must be stressed that μ has no simple physical meaning. It is always possible (see appendix) to define it in such a way that $\sum_j \beta_j = \sum_i \tau_i = \mathcal{E}(\varepsilon_{ij}) = 0$ where $\mathcal{E}(\varepsilon_{ij})$ = expectation of ε_{ij}.

Consequently, τ_i is only the systematic deviation relative to the mean of all the types. The systematic error of type i (relative to the "true element value") can never be estimated from the experiment, because no true element values have been measured.

3. The method

The method used to find the estimates t_i of τ_i and $m + b_j$ of $\mu + \beta_j$ works by successive approximations. Under the starting approximation that all t_i are zero, for each ascent j a first approximation $(m + b_j)_1$ to $m + b_j$ is made by averaging over the observations of ascent j. Then, each observation is corrected for this ascent average, i.e. the deviation $y_{ij} - (m + b_j)_1$ is computed. This deviation, averaged over each type i, yields the first approximation t_{i1} to t_i. Next, the differences $y_{ij} - t_{i1}$ are computed and averaged over each of the ascents, furnishing second approximations $(m + b_j)_2$ to $m + b_j$, and so on. The approximations t_{i1}, t_{i2}, t_{i3}... as well as $(m + b_j)_1$, $(m + b_j)_2$, $(m + b_j)_3$ ... will very rapidly converge. As will be demonstrated in the appendix, the limiting value t_i of the sequence t_{i1}, t_{i2}, t_{i3} ... is the least squares estimate of τ_i. This implies two important properties. First, that the estimate is unbiassed, second, that the standard error of estimate is at a minimum. From the first analyses it appeared that the approximations remained constant (within the rounding interval) from t_{i3}, often even from t_{i2}. Therefore, t_{i3} was taken for t_i for all analyses.

4. The observations used

During the experiment, after each ascent, one set of five consecutive round minutes had been allotted to each standard level in such a way that the mean pressure at these five minutes was as close as possible to the standard level pressure. Next, for each participating sonde and for each element (P, T, U) the 5 readings at these 5 minutes had been averaged and entered on form 2. Each 5 minute average constitutes an "observation" for the present purpose.

Analyses were made for day and night, for all levels up to 30 mb as far as pressure and temperature and up to 500 mb as far as relative humidity is concerned.

As to radiation corrections for temperature under day conditions, the analyses were performed for all levels with uncorrected values and, moreover, for the levels 300, 200, 100, 70, 50 and 30 mb with corrected values for the types 5, 7 and 9 (the types which apply the correction in their routine services) and uncorrected values of the other types.[x)]

All the ascents were utilised, with the exception of the five day- and the three night-ascents performed by all the 14 sondes together. These were excluded for the following two reasons. First, the sondes in these ascents had been exposed to abnormally violent shocks, such as to render the observations not representative for routine conditions. Second, it was feared that in these long trains the positions of the types, which unfortunately had been kept constant in all these ascents, might have an appreciable and, as far as temperature is concerned, incalculable effect on the results.

All the data to be utilised were systematically subjected to a check, which amounted to considering the following questions:

1. Are the averages assigned the proper level numbers?
2. Has the averaging, per ascent and per standard level, really been done over the same set of 5 minutes for all the sondes participating in that ascent?
3. Do the temperature averages, indicated by level numbers 0 ... 9 really refer to temperatures, not corrected for radiation?
4. Have types, applying any radiation corrections, done this consistently for <u>all</u> their day ascents, and have they indicated the averages of the corrected temperature values on form 2 with the level numbers 15, 16 and so on?
5. Have the averages on form 2 been computed rightly?

As a result, several hundreds of anomalies were found. In many of them, it was quite evident how to correct. In the numerous cases where the 5-minute-average printed on form 2 deviated from the average as computed from the 5 minute-values printed on form 1, it was assumed that the latter were right, except in a very few cases where it was evident that one of the minute-values on form 1 was erroneous.

Moreover, all the corrections contained in the lists of errata issued by several delegations, were applied to the data.

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x) For the meaning of the type numbers see the list in the appendix.

From a few tentative analyses of sets of observations forming balanced incomplete block designs, it became apparent, that, at least in trains with four positions, the position effect was overshadowed by the random deviations. Neither for pressure, nor for temperature did it appear significant in any of these analyses. Nevertheless, with a view to the longer trains, position corrections were applied to all the pressure data before analysing them with the iteration method.

From the same preliminary calculations it appeared that the random scatter standard deviation σ was about 5 mb and 0,7°C. Using the rule, that the rounding interval should be half this standard deviation or smaller, the pressure data were rounded to the nearest millibar before analysis, but the decimals of the temperature data were retained. The humidity data were analysed in whole percents, as recorded on forms 2.

5. The results

5.1 The main body of each of the tables, 1, 2 and 3 shows the estimates t of the type effects τ . The subscript denotes the number of observations with which the type concerned participated in the analysis. In figures 1a, 1b, 2a, 2b and 3 the t-values are represented graphically.

For each observation y_{ij}, addition of m + b_j and t_i offers the theoretical value of that observation, and the difference $y_{ij} - m - b_j - t_i = e_{ij}$ presents an estimate of the residual error.

The expression

$$\frac{\sum e_{ij}^2}{N - 1 - (n-1) - (l-1)}$$

where the summation is over all the observations, while N = number of observations, n = number of types and l = number of ascents, is the unbiassed estimate s^2 of σ^2. s is given in a separate column, with the number of degrees of freedom (the denominator of the fraction) attached. The number of degrees of freedom indicates the accuracy of the estimate of s. Except for the very high levels, the number of degrees of freedom for error is such that s may be said to represent σ with satisfactory accuracy.

Assuming that ε follows a normal probability distribution, the interpretation of σ is as follows. If, in one and the same ascent j, each of a very large number of sondes of type i would make an observation, the mean value of these observations would be $\mu + \beta_j + \tau_i$, but the individual observations would scatter around this mean to this extent that 95% of them would be comprised in the interval $\mu + \beta_j + \tau_i \pm 2\sigma$. Reversely, if a sonde produces an observation y, the 95% confidence interval for the mean value, which would be yielded by a large number of sondes of the same type under the same conditions, is $y \pm 2\sigma$. So, for an individual pressure observation, the confidence interval has a width of roughly 4 x 5 mb = 20 mb for all levels; or, possibly, a very little more during the day and a very little less during the night. As to the individual temperature observation, the width of the confidence interval gradually increases from about 2,2°C at 850 mb to about 7°C at 30 mb during the day, and from about 2,2°C at 850 mb to about 5°C at 30 mb during the night. The interval is shown in graphical form in the right parts of figures 1a, 1b, 2a and 2b. It should be born in mind, that in our case what is called an individual observation is actually an average of 5 round-minute-values. Of course for a single momentary value the accuracy will be worse.

Presumably, in reality the random scatter will not be equal for all types. In this case, s estimates a kind of average of the σ values of the different types.

Intentionally, no attempt has been made to compute values s_i for each type separately. In the present case, owing to the irregularity of the observational pattern, for such computations only the direct comparisons between at least 3 types could have been utilised. As such direct comparisons are very small in number, the computed s_i value would be only a very poor estimate of σ_i. For accurate s_i values, the appropriate simple and effective approach is in the launching of a series of twin soundings.

Of course, the inaccuracy of the individual observation also effects the estimates t of τ. However, because of the irregularity of the pattern of observations used, it is absolutely unfeasible to compute the accuracy of the t's, which identically differs from type to type. Nevertheless, some impression can be given as to the mean accuracy of the t's for pressure and temperature. If 104 observations were performed following a double balanced incomplete block scheme, the 95% confidence interval of each t value may be shown to be 1,5 x s wide. This means, that we may have a 95% confidence in the claim, that τ_i is in the interval $t_i \pm 0{,}75$ s. The actual, deviating pattern however is less efficient, so that, for that matter, the mean accuracy will be worse. On the other hand, for the analyses for day - 850 mb up to about 100 mb, the number of observations is somewhat larger than 104.

Therefore, for these analyses we may guess that the mean width of the confidence interval of the t's is only slightly larger, say 1,6 x s. Following a similar reasoning, the mean width of the interval for the t's of the night ascents might roughly be estimated at about 1,7 x s up to 100 mb. Also these intervals are presented graphically, only once in figures 1a and 1b (because for pressure the interval is almost constant for the levels 850 ... 100 mb) and for each level up to 100 mb in figures 2a and 2b. Of course, in the higher layers the accuracy will be worse.

With this in mind, it is clear that, as far as pressure is concerned, only a few types deviate significantly from the mean. As to the significance of the t's for humidity, nothing can be said, because type and ascent effect are not additive and because the random errors will not follow the normal probability distribution. These t's are given just for completeness.

In addition to the 48 analyses performed by iteration, a balanced incomplete block design was analysed whenever it was contained in the total pattern of observations. The resulting τ-estimates were only used as a check, but as an interesting item such an analysis further offers an unbiassed estimate $s^2(\tau)$ of $\sigma^2(\tau)$, the latter quantity being defined as $\sum_i \tau_i^2 : n$. Consequently, $\sigma(\tau)$ is the measure of the variation between types and may be termed inter-type standard deviation. It comprises all the τ-values except the one of sonde 14, (the observations of which were not included in any balanced incomplete block design), and its estimate $s(\tau)$ is given in the next column of the tables.

The interest of $s(\tau)$ is in its comparison with s. The fact is, that the standard deviation σ(total) of the total variation in the observations, caused by both random errors and systematic differences, is

$$\sigma^2 \text{ (total)} = \sqrt{\sigma^2 + \sigma^2(\tau)}$$

which implies that σ(total) is largely determined by the greater of the two components, towards which consequently efforts to reduce σ(total) should be concentrated.

As may be seen from the tables, for temperature under day conditions the two components are about of the same magnitude. For most of the remaining cases however, where a balanced incomplete block design could be analysed, the scatter between types appears to be less important than the scatter within types.

The last column indicates whether or not the differences between types, as evaluated from the balanced incomplete block patterns, proved significant. "No" means that the observations do not contradict the null-hypothesis that all τ's are zero. Of course, in our particular case such a hypothesis would be somewhat unrealistic. We might rather say, that "no" means that the systematic deviations are too small relative to the random errors to show up in a sample of 13 x 4 observations.

5.2 The radiation influence

After some correspondence, the observations of temperature, not corrected for radiation, could be completed for all the types and subsequently be analysed. The results are presented in the upper part of table 4.

When subtracting the t values of the night ascents[x)] (lower part of table 2) from the corresponding uncorrected t values of the day ascents, each of the differences Δ_i is an unbiassed estimate of the radiation influence of type i minus the mean radiation influence of all the types. The radiation influence of type i is defined as the systematic difference between the day and the night temperature observations of type i. The proof is given in the appendix.

The values of Δ are shown in the lower part of table 4, and in the left part of figure 4. Those for 50 mb must be considered as inaccurate owing to the small number of observations.

To permit a better review, at the same time reducing the effect of random errors, the values of Δ were averaged for each type from 850 up to and including 70 mb. The averages are presented graphically in ascending order in the right part of figure 4.

It is again emphasized, that this particular investigation is based on temperatures not corrected for radiation. So the graph just reveals the physical properties of the types in relation with radiation.

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x) The t values of the night ascents for the levels 70 and 50 mb from type no. 14 are missing. In evaluating the differences Δ_i, this type must be left out of consideration. Consequently the average of the remaining 13 values, given in the upper part of table 4, does no longer equal 0. To eliminate this effect corrections are applied to an amount of $\frac{0.6}{13}$ and $\frac{1.2}{13}$ respectively.

APPENDIX

1. <u>List of type numbers</u>

1	Belgium
2	German Federal Republic
3	German Democratic Republic
4	U.S.A. (1680 Mc)
5	Finland
6	France
7	Japan
8	India (chronometer)
9	England
10	Netherlands
11	Switzerland
12	U.S.S.R.
13	India (fan)
14	Poland

2. Let, for a particular combination of element, level and day or night, the estimates of the population parameters

$$\mu\ ,\ \beta_j \text{ and } \tau_i$$

be m , b_j and t_i

The latter are least squares estimates, if

$$\sum (y_{ij} - m - b_j - t_i)^2$$

($\sum$ applying to all the observations) is at its minimum. By differentiating with respect to m, to each b_j and to each t_i, it appears, that the condition is satisfied if

$\sum (y_{ij} - m - b_j - t_i) = 0$ (summation over all the observations)

$\sum (y_{ij} - m - b_j - t_i) = 0$ (summation over the observations of each ascent j)

$\sum (y_{ij} - m - b_j - t_i) = 0$ (summation over the observations of each type i)

In words: For each ascent and for each type the residuals must add to zero.

Now let us see if the limiting values $(m + b_j)$ and t_i of the iteration technique satisfy this condition. Consider the procedure at the n-th iteration.

t_{in} is found as the average of $y_{ij} - (m + b_j)_n$ over all observations of type i, or

$$\sum t_{in} = \sum \left\{ y_{ij} - (m + b_j)_n \right\}$$ (summation over the observations of type i)

taking the limit of both members:

$$\lim \sum t_{in} = \lim \sum \left\{ y_{ij} - (m + b_j)_n \right\}$$

$$\sum \lim t_{in} = \sum \left\{ y_{ij} - \lim (m + b_j)_n \right\} \quad \text{or}$$

$$\sum t_i = \sum \left\{ y_{ij} - (m + b_j) \right\}$$

$$\sum y_{ij} - m - b_j - t_i = 0 \qquad \text{q.e.d.}$$

Similarly: $(m + b_j)_{n+1}$ is found by averaging $y_{ij} - t_{in}$ over all the observations of ascent j, or

$$\sum (m + b_j)_{n+1} = \sum (y_{ij} - t_{in})$$ (summation over the observations of ascent j.

taking the limit of both members:

$$\lim \sum (m + b_j)_{n+1} = \lim \sum (y_{ij} - t_{in})$$

$$\sum \lim (m + b_j)_{n+1} = \sum \lim (m + b_j)_n = \sum (y_{ij} - \lim t_{in}) \quad \text{or}$$

$$\sum (m + b_j) = \sum (y_{ij} - t_i)$$

$$\sum (y_{ij} - m - b_j - t_i) = 0 \qquad \text{q.e.d.}$$

3. Let: $S_{i(d)}$ = the systematic error of type i for the day-time.

$S_{i(n)}$ = the systematic error of type i for the night-time.

$S_{(d)}$ = the average systematic error for the day-time over all the types.

$S_{(n)}$ = the average systematic error for the night-time over all the types.

From these definitions it follows that:

$$S_{i(d)} = S_{(d)} + \tau_{i(d)} \qquad \text{(I)}$$

$$S_{i(n)} = S_{(n)} + \tau_{i(n)} \qquad \text{(II)}$$

Subtracting II from I we obtain

$$S_{i(d)} - S_{i(n)} = (S_{(d)} - S_{(n)}) + (\tau_{i(d)} - \tau_{i(n)})$$

or

$$\tau_{i(d)} - \tau_{i(n)} = (S_{i(d)} - S_{i(n)}) - (S_{(d)} - S_{(n)})$$

Defining $S_{i(d)} - S_{i(n)}$ as the radiation effect of type i, the equation may be interpreted as follows: The difference between two corresponding type effects equals the radiation effect of the type considered minus the average radiation effect over all types.
As $t_{i(d)}$ and $t_{i(n)}$ are unbiassed and independent estimates of $\tau_{i(d)}$ and $\tau_{i(n)}$, $\Delta_i = t_{i(d)} - t_{i(n)}$ is an unbiassed estimate of $\tau_{i(d)} - \tau_{i(n)}$.

Reference

1) A. Delver "Design and analysis of the forthcoming radiosonde comparisons at Payerne, May 1956". Working Group on Radiosonde Comparisons, Annex II to recomm. 3, 1955.

PRESSURE (in millibars)

	level in mb	type - number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	s	s(τ)	
DAY	850	2_7	-1_{12}	-2_{10}	0_{10}	1_9	-5_9	-1_8	-4_6	0_7	22_7	-2_{10}	0_7	0_8	-4_6	$4,4_{75}$	5,3	yes
	700	-2_7	-1_{12}	-1_{10}	-1_{10}	0_9	-5_9	-3_8	-5_6	0_7	24_7	-1_{10}	-2_7	-2_8	-3_6	$5,4_{75}$	6,6	yes
	500	-4_7	0_{12}	0_{10}	-2_{10}	2_9	-4_9	-3_8	-2_6	-1_7	15_7	2_{10}	-1_7	0_8	-3_6	$5,9_{75}$	4,4	yes
	300	-11_7	2_{12}	4_{10}	0_{10}	3_9	-4_9	-2_8	1_6	1_7	6_7	2_{10}	-3_7	3_8	-3_6	$5,1_{75}$	3,2	yes
	200	-13_7	2_{12}	5_{10}	0_{10}	3_9	-5_9	-2_8	0_6	2_7	1_7	2_{10}	-4_7	4_8	-2_6	$5,0_{75}$	4,3	yes
	100	-11_7	0_{12}	6_{10}	0_{10}	3_8	-4_9	-1_8	0_6	3_7	-4_6	0_9	-2_7	5_8	0_6	$5,5_{72}$	4,2	yes
	70	-8_7	1_{12}	5_9	0_9	4_7	-3_9	-1_7	1_6	2_7	-6_6	2_7	-1_7	4_6	2_2	$5,0_{63}$		
	50	-8_7	1_{10}	4_7	-1_8	4_5	-4_9	-3_6	0_5	-1_6		1_5	-1_7	2_5	3_1	$5,1_{46}$		
	30	-4_6	0_9	6_4	-3_6	4_4	-7_6	-3_4	0_4	3_3		0_1	-5_4	7_3		$5,8_{24}$		
NIGHT	850	1_5	0_7	-1_7	-1_7	-3_5	-3_7	-4_6	0_8	0_9	16_6	-1_{10}	0_8	-2_7	1_4	$4,7_{60}$	2,5	no
	700	-1_5	0_7	0_7	1_7	-5_5	-2_7	-4_6	0_8	2_9	14_6	-1_{10}	1_8	0_7	-3_4	$5,1_{60}$	1,4	no
	500	-6_5	1_7	1_7	2_7	-6_5	-2_7	-2_6	-3_8	3_9	10_6	1_{10}	1_8	0_7	-3_4	$4,8_{60}$	1,9	no
	300	-8_5	3_7	6_7	3_7	-5_5	-3_7	0_6	-4_8	5_9	-2_6	1_{10}	-3_8	2_7	-1_4	$4,7_{60}$	3,1	yes
	200	-6_5	3_7	5_7	2_7	-4_5	-2_7	1_6	-2_8	6_9	-6_6	0_9	-3_8	-2_7	9_3	$5,8_{59}$	3,1	yes
	100	-2_5	3_7	6_6	2_7	-5_5	-2_7	0_6	-4_7	5_9	-7_6	2_8	-1_8	-1_7	-2_2	$4,9_{56}$	3,6	yes
	70	-1_5	3_7	4_6	1_6	-6_5	-1_7	0_6	-2_5	5_9	-8_6	1_6	-1_8	-1_7		$4,8_{53}$	2,9	no
	50	0_5	3_5	5_4	1_5	-4_5	-4_5	-3_5	-3_2	7_6		-1_5	0_6	0_5		$4,2_{30}$		
	30	1_4	0_3	4_2	3_3	-6_2	-6_3	-2_4	-5_1	6_3		-1_2	-2_3	2_2		$5,8_{10}$		

Table 1

TEMPERATURE (in degrees Celsius)

	level in mb	type - number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	s	s(τ)	
DAY	850	0.1_{7}	-0.2_{12}	-0.2_{10}	-0.4_{10}	-0.2_{9}	0.1_{9}	0.2_{8}	-0.4_{6}	-0.1_{7}	1.4_{7}	-1.1_{10}	0.6_{7}	0.0_{8}	0.9_{6}	0.54_{75}	0.51	yes
	700	-0.5_{7}	-0.4_{12}	-0.3_{10}	-0.7_{10}	0.1_{9}	0.1_{9}	0.1_{8}	-0.3_{6}	-0.3_{7}	1.5_{7}	-1.5_{10}	0.8_{7}	-0.2_{8}	1.1_{6}	0.67_{75}	0.54	yes
	500	-1.3_{7}	-0.6_{12}	-0.1_{10}	-1.0_{10}	0.6_{9}	0.5_{9}	0.0_{8}	-0.1_{6}	-0.4_{7}	0.4_{6}	-1.3_{10}	1.2_{7}	0.2_{8}	1.5_{6}	0.64_{74}	0.48	yes
	300	-2.5_{7}	-0.9_{12}	0.1_{10}	-1.0_{10}	0.9_{8}	0.5_{9}	-0.1_{8}	0.5_{6}	-1.8_{7}	0.5_{6}	-1.3_{10}	1.7_{7}	0.6_{8}	3.1_{6}	0.76_{73}	0.97	yes
	200	-3.0_{7}	-0.8_{12}	0.2_{10}	-0.6_{10}	0.3_{8}	0.4_{9}	-0.4_{8}	0.5_{6}	-1.6_{7}	1.0_{6}	-0.9_{10}	1.3_{7}	1.0_{8}	2.6_{9}	0.99_{73}	0.93	yes
	100	-2.1_{7}	-1.0_{12}	0.6_{10}	-1.0_{10}	-0.6_{8}	1.4_{9}	-0.8_{8}	0.7_{5}	-2.2_{7}	0.5_{5}	-1.2_{9}	1.9_{7}	1.2_{8}	2.1_{6}	1.27_{70}		
	70	-2.0_{7}	-0.9_{12}	0.5_{9}	-1.3_{9}	-1.1_{7}	2.8_{9}	-0.8_{7}	1.1_{5}	-2.2_{7}	0.6_{5}	-1.3_{7}	2.7_{7}	0.6_{7}	1.4_{2}	1.16_{62}		
	50	-2.0_{7}	-1.4_{10}	0.5_{6}	-2.4_{8}	-2.0_{5}	3.6_{8}	-1.9_{6}	2.8_{5}	-3.0_{6}	-0.6_{3}	-1.4_{5}	2.8_{7}	0.0_{6}	5.2_{1}	1.31_{47}		
	30	-1.0_{6}	-1.8_{8}	2.7_{4}	-2.6_{6}	-3.7_{4}	4.0_{5}	-2.4_{4}	5.0_{4}	-2.7_{3}	-1.4_{2}	1.7_{1}	3.3_{4}	-1.1_{3}		1.82_{23}		
NIGHT	850	0.0_{5}	0.0_{7}	-0.2_{7}	0.0_{7}	-0.2_{5}	0.0_{7}	0.2_{6}	0.1_{8}	-0.1_{9}	-0.4_{6}	-0.6_{10}	0.1_{8}	0.3_{7}	1.1_{4}	0.53_{60}	-0.17	no
	700	-0.5_{5}	0.0_{7}	0.1_{7}	0.1_{7}	-0.7_{5}	0.2_{7}	0.2_{6}	0.4_{8}	-0.1_{9}	-0.1_{6}	-1.0_{10}	0.3_{8}	0.4_{7}	1.0_{4}	0.53_{60}	0.30	no
	500	-1.0_{5}	0.1_{7}	0.2_{7}	-0.9_{7}	-0.6_{5}	0.7_{7}	0.1_{6}	0.5_{8}	-0.6_{9}	-0.2_{5}	-0.6_{10}	0.3_{8}	0.5_{7}	1.0_{4}	0.63_{59}		
	300	-2.0_{5}	-0.2_{7}	0.5_{7}	-0.6_{7}	-0.3_{5}	0.3_{7}	0.5_{6}	1.3_{8}	-0.5_{9}	-1.0_{5}	-0.9_{10}	0.3_{8}	0.9_{7}	1.7_{4}	0.70_{59}		
	200	-1.8_{5}	-0.1_{7}	0.9_{7}	-0.3_{7}	-0.3_{5}	0.4_{7}	0.3_{6}	1.1_{8}	-0.1_{9}	-0.9_{4}	-0.6_{9}	-0.4_{8}	1.0_{7}	0.7_{3}	0.73_{57}		
	100	-1.4_{5}	-0.1_{7}	0.9_{6}	-0.1_{7}	-0.1_{4}	0.3_{7}	0.4_{6}	1.6_{7}	0.2_{9}	-1.3_{4}	-0.3_{8}	-0.4_{8}	0.5_{7}	-0.2_{2}	0.80_{53}		
	70	-1.2_{5}	-0.2_{7}	0.9_{5}	-0.4_{6}	0.2_{3}	0.5_{7}	0.3_{6}	1.3_{5}	0.1_{9}	-1.6_{4}	0.0_{6}	-0.6_{8}	0.4_{7}		0.88_{48}		
	50	-1.0_{5}	-0.1_{5}	1.0_{4}	-0.4_{5}	0.5_{2}	-0.2_{5}	0.1_{5}	1.1_{2}	0.3_{6}	0.2_{2}	-0.1_{5}	-1.4_{6}	0.6_{4}		1.07_{28}		
	30	-1.3_{3}	-1.4_{2}	1.4_{2}	-0.6_{3}	0.1_{2}	-0.4_{2}	1.3_{3}	3.1_{1}	1.4_{2}	-2.5_{1}	0.0_{2}	-1.8_{3}	0.6_{1}		1.36_{6}		

Table 2. In accordance with routine conditions, the observations used for the analyses day - 300 mb up to 30 mb of types 5, 7 and 9 are the ones corrected for radiation; all the other observations are uncorrected.

HUMIDITY (in percents)

	level in mb	type - numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY	850	-3_7	5_{12}	-6_{10}	-2_{10}	7_9	-4_8	-2_8	6_6	6_7	-3_7	-3_{10}	1_4	0_7	-7_6
	700	-3_7	6_{11}	-4_{10}	-1_{10}	5_9	-6_9	2_8	11_3	7_7	-7_7	-1_{10}	0_4	3_1	-7_5
	500	-3_7	0_{11}	1_{10}	-5_6	0_9	-6_9	6_8		3_7	-1_6	1_{10}	8_4		5_5
NIGHT	850	-10_5	4_7	1_7	-4_7	2_5	0_7	0_6	4_7	-1_9	1_6	1_{10}	2_7	-4_7	0_4
	700	-9_5	5_7	-3_7	4_6	7_5	-5_7	6_6	6_5	-2_9	-12_6	2_{10}	2_7	0_1	2_4
	500	-7_5	0_7	0_7	2_5	0_5	-6_7	2_6		-1_9	-7_6	-6_9	13_7		11_3

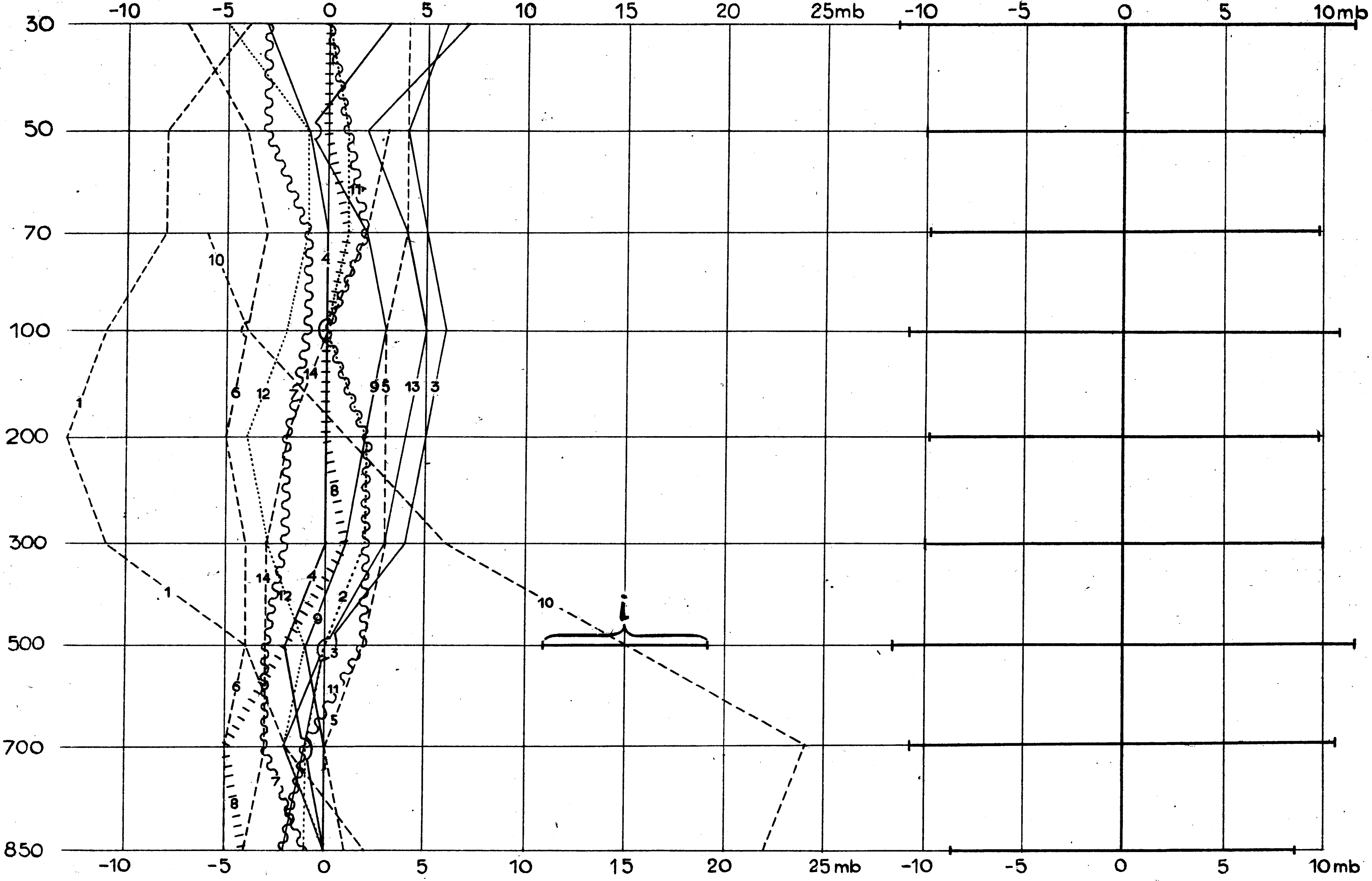
Table 3

TEMPERATURE (in degrees Celsius) not corrected for radiation.

	level in mb	type - number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	s
DAY	850	0.1_{7}	-0.2_{12}	-0.2_{10}	-0.4_{10}	-0.2_{9}	0.1_{9}	0.2_{8}	-0.4_{6}	-0.1_{7}	1.4_{7}	-1.1_{10}	0.6_{7}	0.0_{8}	0.9_{6}	0.54_{75}
	700	-0.5_{7}	-0.4_{12}	-0.3_{10}	-0.7_{10}	0.1_{9}	0.1_{9}	0.1_{8}	-0.3_{6}	-0.3_{7}	1.5_{7}	-1.5_{10}	0.8_{7}	-0.2_{8}	1.1_{6}	0.67_{75}
	500	-1.3_{7}	-0.6_{12}	-0.1_{10}	-1.0_{10}	0.6_{9}	0.5_{9}	0.0_{8}	-0.1_{6}	-0.4_{7}	0.4_{6}	-1.3_{10}	1.2_{7}	0.2_{8}	1.5_{6}	0.64_{74}
	300	-2.7_{7}	-1.1_{12}	-0.1_{10}	-1.2_{10}	1.7_{8}	0.3_{9}	0.1_{8}	0.3_{6}	-0.5_{7}	0.2_{6}	-1.6_{10}	1.5_{7}	0.4_{8}	2.8_{6}	0.77_{73}
	200	-3.3_{7}	-1.1_{12}	-0.1_{10}	-0.9_{10}	1.9_{8}	0.1_{9}	0.0_{8}	0.2_{6}	0.1_{7}	0.7_{6}	-1.2_{10}	1.0_{7}	0.7_{8}	2.2_{6}	0.99_{73}
	100	-2.6_{7}	-1.5_{12}	0.1_{10}	-1.5_{10}	2.7_{8}	0.9_{9}	-0.2_{8}	0.2_{5}	0.3_{7}	0.1_{5}	-1.7_{9}	1.3_{7}	0.7_{8}	1.5_{6}	1.26_{70}
	70	-2.7_{7}	-1.7_{12}	-0.3_{9}	-2.0_{9}	3.4_{7}	2.0_{9}	0.1_{7}	0.3_{5}	0.7_{7}	-0.1_{5}	-2.1_{7}	1.8_{7}	-0.2_{7}	0.6_{2}	1.15_{62}
	50	-3.1_{7}	-2.4_{10}	-0.6_{6}	-3.5_{8}	4.4_{5}	2.6_{8}	-0.3_{6}	1.7_{5}	0.8_{6}	-1.6_{3}	-2.6_{5}	1.6_{7}	-1.0_{6}	4.2_{1}	1.22_{47}
	30	-2.4_{6}	-4.2_{8}	1.2_{4}	-4.2_{6}	5.4_{4}	2.3_{5}	0.0_{4}	3.0_{4}	3.0_{3}	-3.4_{2}	-0.1_{1}	1.5_{4}	-2.4_{3}		1.47_{23}
DAY - NIGHT	850	0.1	-0.2	0.0	-0.4	0.0	0.1	0.0	-0.5	0.0	1.8	-0.5	0.5	-0.3	-0.2	
	700	0.1	-0.3	-0.3	-0.7	0.9	0.0	0.0	-0.6	-0.1	1.7	-0.4	0.6	-0.5	0.2	
	500	-0.3	-0.7	-0.3	-0.1	1.2	-0.2	-0.1	-0.6	0.2	0.6	-0.7	0.9	-0.3	0.5	
	300	-0.7	-0.9	-0.6	-0.6	2.0	0.0	-0.4	-1.0	0.0	1.2	-0.7	1.2	-0.5	1.1	
	200	-1.5	-1.0	-1.0	-0.6	2.2	-0.3	-0.3	-0.9	0.2	1.6	-0.6	1.4	-0.3	1.5	
	100	-1.2	-1.4	-0.8	-1.4	2.8	0.6	-0.6	-1.4	0.1	1.4	-1.4	1.7	0.2	1.7	
	70	-1.5	-1.5	-1.2	-1.6	3.2	1.5	-0.2	-1.0	0.6	1.5	-2.1	2.4	-0.6		
	50	-1.7	-1.9	-1.2	-2.7	4.3	3.2	0.0	1.0	0.9	-1.4	-2.1	3.4	-1.2		

Table 4

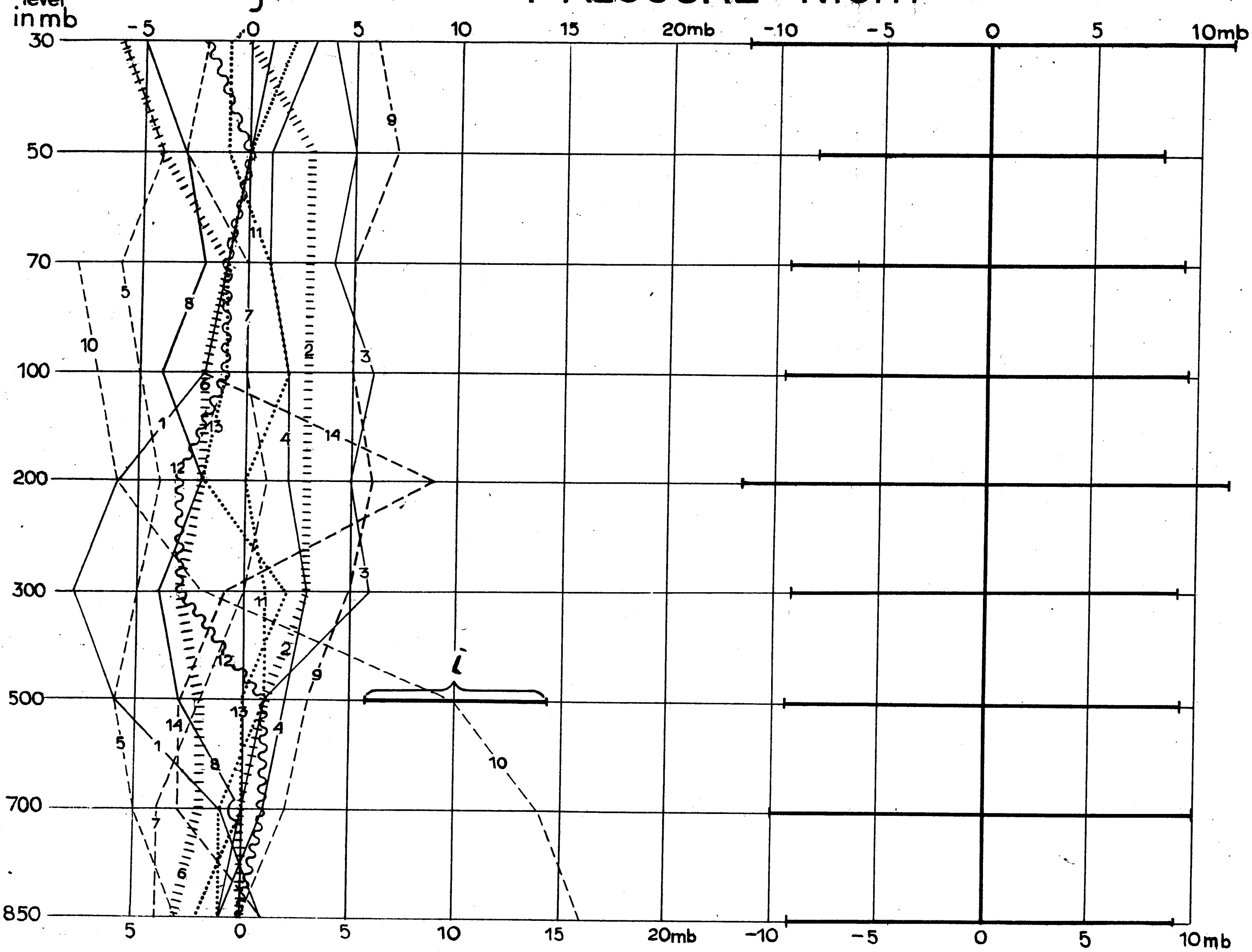
Figure 1a PRESSURE – DAY



t-values for different types and levels. To each t-value a 95% confidence interval of width i should be attached.

95% interval for the random scatter of the "individual observation" around the true type mean $\mu + \beta_j + \tau_i$

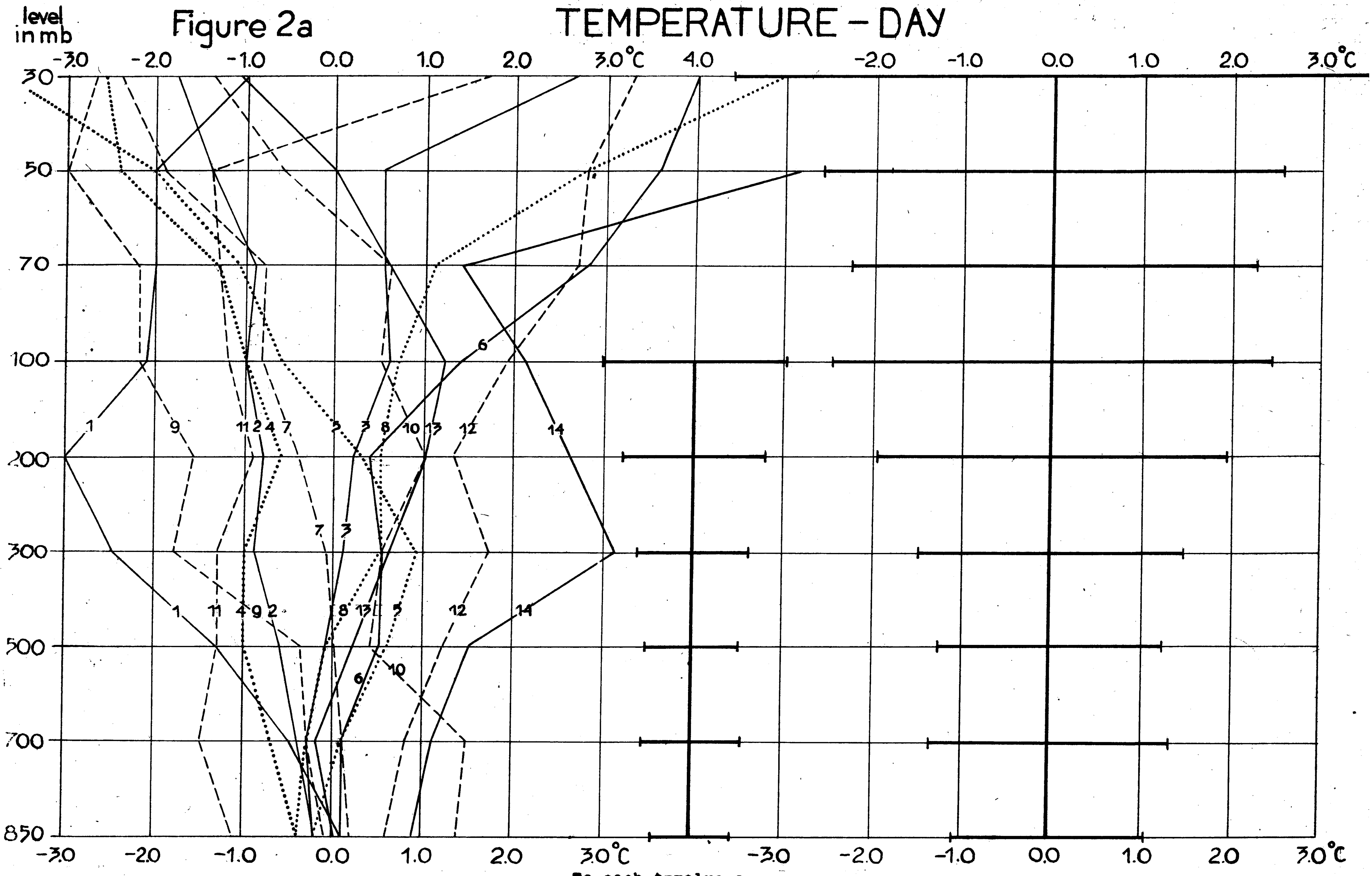
Figure 1b PRESSURE - NIGHT



t-values for different types and levels. To each t-value a 95% confidence interval of width i should be attached.

95% interval for the random scatter of the "individual observation" around the true type mean $\mu + \beta_j + \tau_1$

Figure 2a

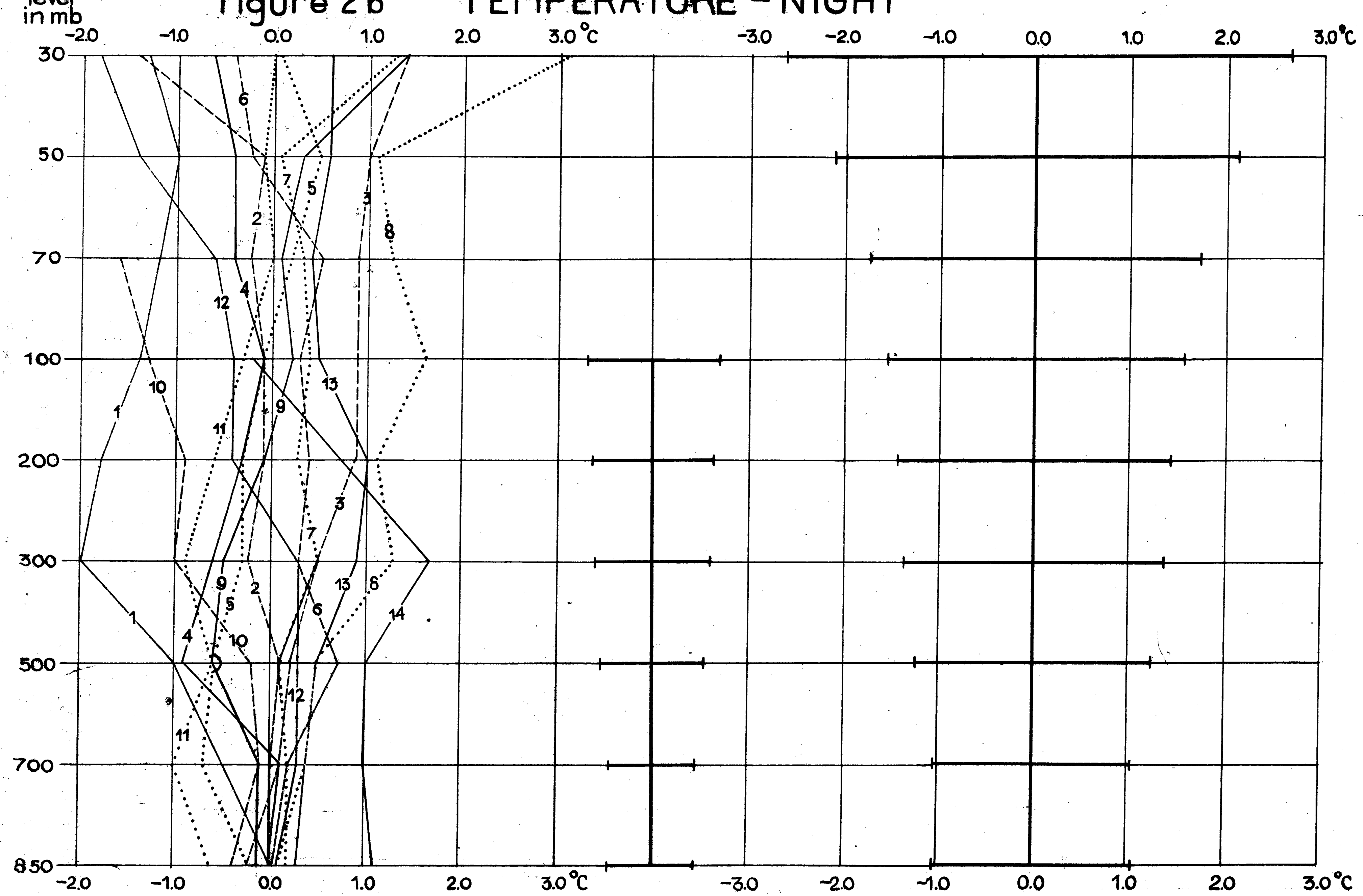


t-values for different types and levels.

To each t-value a 95% confidence interval of this width should be attached.

95% interval for the random scatter of the "individual observation" around the true type mean $\mu + \beta_j + \tau_i$

Figure 2b TEMPERATURE - NIGHT

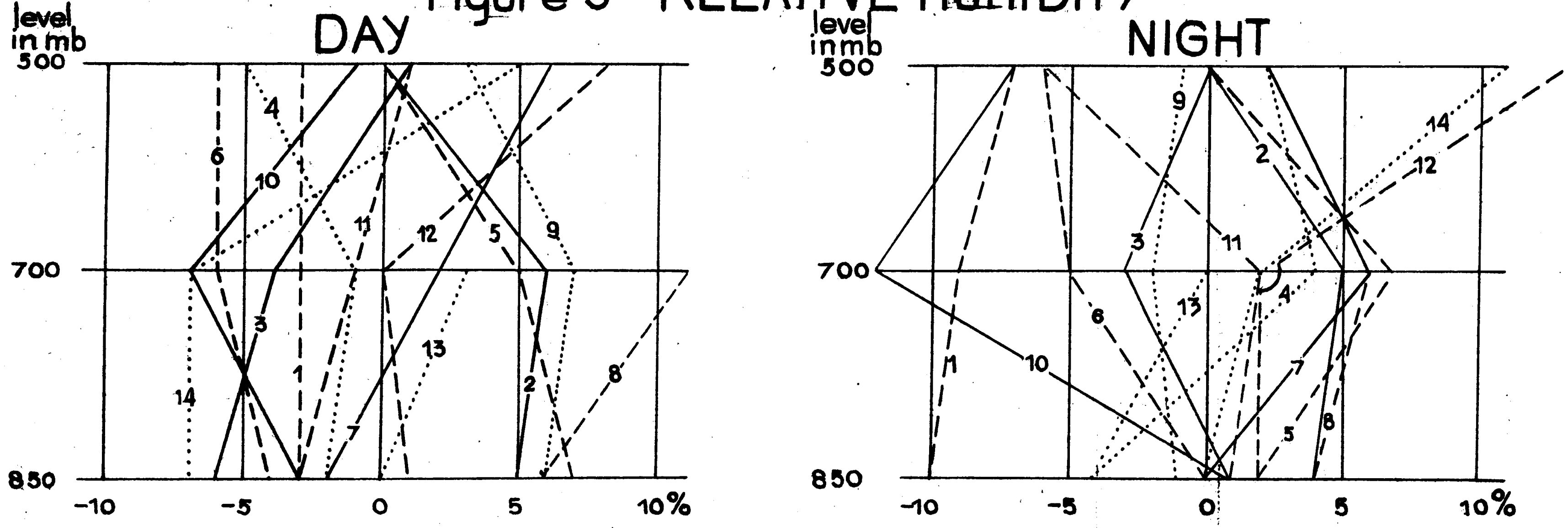


t-values for different types and levels.

To each t-value a 95% confidence interval of this width should be attached.

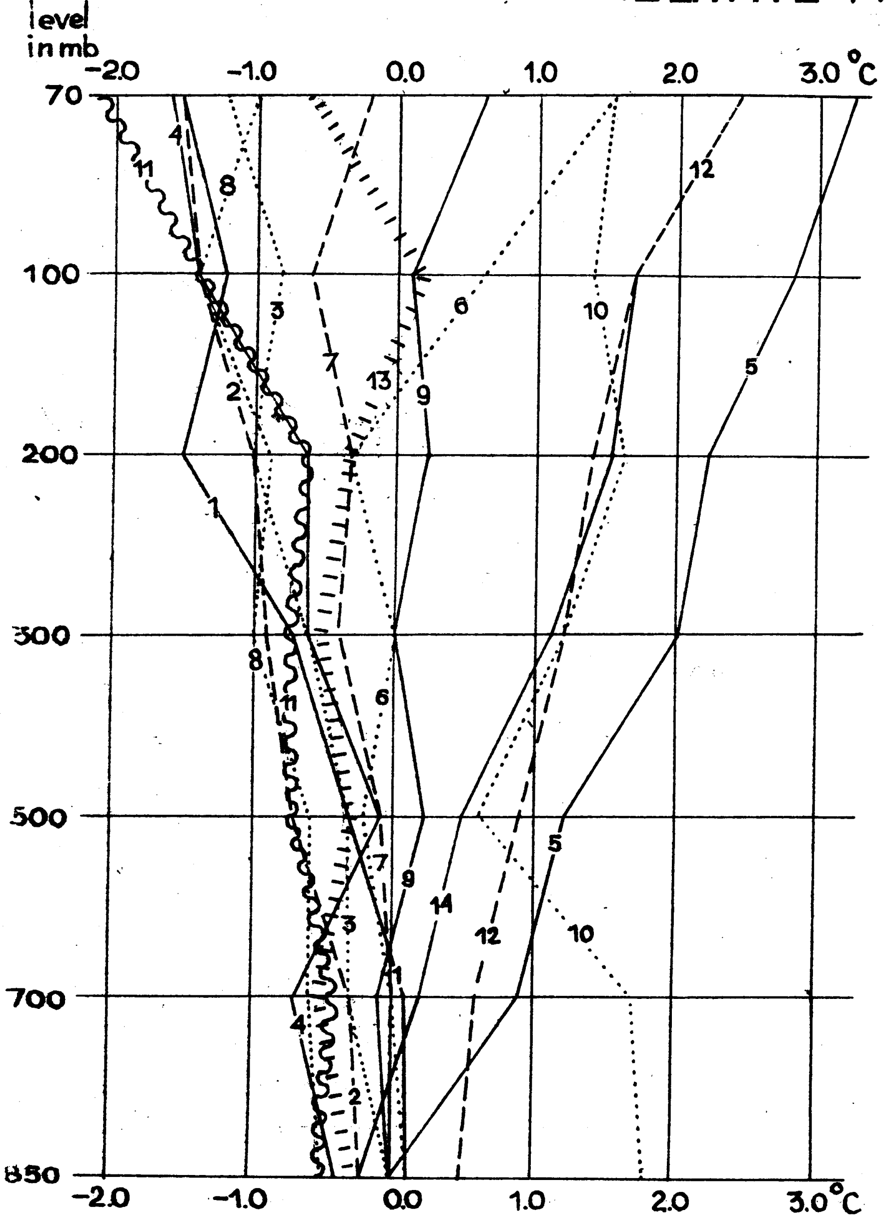
95% interval for the random scatter of the "individual observation" around the true type mean $\mu + \beta_j + \tau_1$

Figure 3 RELATIVE HUMIDITY

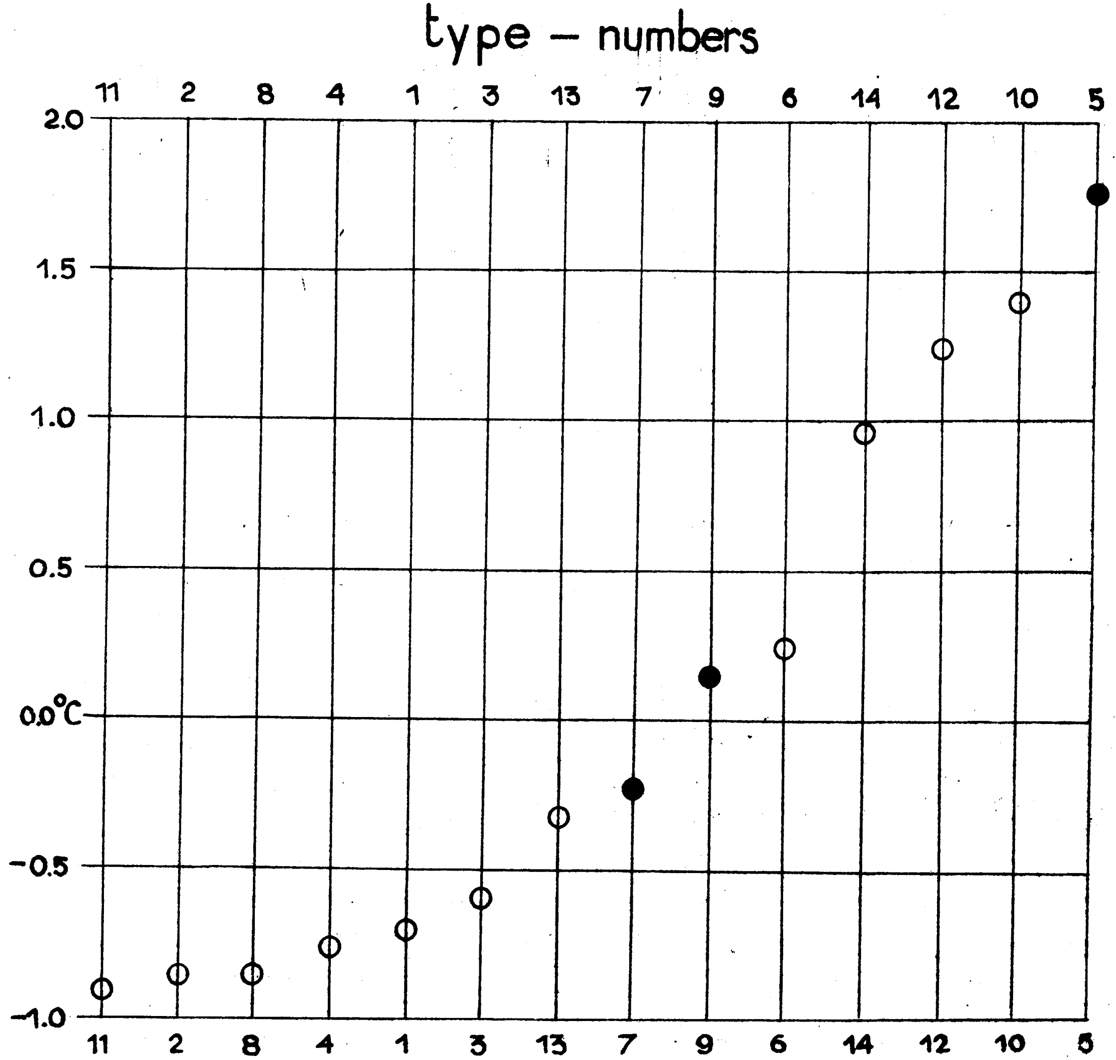


t-values for different types and levels.

Figure 4 TEMPERATURE-DAY (not corrected for radiation) minus TEMPERATURE-NIGHT = RELATIVE RADIATION INFLUENCE



1. for separate levels.



2. as an average over the layers from 850 up to 70 mb. The types are arranged in ascending order of this average. The types applying radiation corrections in routine service are indicated with ●, the others with ○.