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DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

DAY-NIGHT DIFFERENCES IN RADIOSONDE OBSERVATIONS OF THE STRATOSPHERE AND TROPOSPHERE

Washington, D.C.
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ABSTRACT. Day-night differences in temperature and height are used as the basis for a system designed to achieve compatibility between data measured by various radiosonde instruments. The resultant compatibility adjustments in reported data are a prerequisite to the analysis of stratospheric constant-pressure charts above the 100-mb level, and for some instrument types they are significant even at tropospheric levels.

1. INTRODUCTION

In the 1950's, when great numbers of radiosonde balloons were able to ascend for the first time above the 100-mb level and to provide stratospheric data on temperature and geopotential height, large differences became apparent between daytime and nighttime observations. Incompatibility was also observed between temperatures and heights measured during daylight hours by different radiosonde instruments used in adjacent countries. Teweles and Finger (1960) presented evidence that such irregularities at stratospheric levels were largely fictitious. A number of other studies indicated that the problem was most likely due to varying responses of different temperature sensors to solar radiation (Hayashi et al. 1956; Scrase 1956; Badgley 1957). Finally, Finger and McInturff (1968) showed decisively that the true diurnal temperature range of the ambient stratosphere at middle latitudes is much too small to account for the observed discrepancies. Values for this temperature range are approximately 1.0°C at 10 mb, and decrease with decreasing height to 0.5°C at 30 mb; these values are lower, often by an order of magnitude, than the day-night differences that were reported by stations throughout the Northern Hemisphere.

Since the mid-1950's, several national meteorological agencies have developed systems to correct measured temperatures and computed heights at individual stations. Such efforts, however, have generally failed to solve the problem of incompatibility between stratospheric observations. Correction systems based on laboratory tests invariably fail on account of the impossibility of simulating real atmospheric conditions.

McInturff and Finger (1968), following Hawson and Caton (1961), showed that compatibility between instrument types and between daytime and nighttime soundings could be improved through the application of mean day-night differences determined as functions of instrument type and of mean daytime solar elevation angle. A study involving 33 months of twice-daily radiosonde observations from 1964-66 provided the basis for sets of adjustment coefficients dependent on solar elevation angle. (These served to reduce sunlit observations to equivalent nighttime observations for levels from 100 to 10 mb.) This empirical adjustment scheme was used operationally in the Upper Air Branch (UAB) of the National Meteorological Center (NMC) until its recent replacement by the results reported here.

In 1977 it was decided that the problem of day-night differences in radiosonde observations would be reexamined. Reasons for this decision included: (1) developments in radiosonde instrumentation and reduction techniques which have rendered some of the old empirical adjustments obsolete; (2) changes in use of instruments by different national meteorological services, especially in parts of the world where high solar elevation angles might result in large empirical adjustments; (3) requirements within the UAB for extension of the stratospheric (100 to 10 mb) analysis system to the tropics and the Southern Hemisphere (areas of the globe from which little information was used in development of the original empirical adjustment scheme); (4) application of the correction scheme in tuning the regression system used in operational reduction of Vertical Temperature Profile Radiometer (VTPR) observations by the National Environmental Satellite Service (Werbowetzki 1975).

As in the earlier study (McInturff and Finger 1968), it is stressed that attainment of compatibility does not ensure accuracy. For further discussion of this point, as well as more background material on high-level meteorological observations, see Finger et al. (1978), which includes results obtained by Spackman and others in the United Kingdom.

2. TYPES AND NUMBERS OF RADIOSONDES UNDER STUDY

The present study is confined to the following radiosonde instruments: Finnish Vaisala, French Mesural, British Kew, West German Graw, U.S.S.R. A-22, U.S.S.R. RKZ, Japanese "codesending", U.S.A. NOAA, U.S.A. AN/AMT4, Chinese, Swiss, Sangamo (employed by Canada and Portugal), and Australian. Many of these instruments are used outside the country or countries in which they are manufactured, and they are often referred to by different names. For example, the Vaisala instrument is widely used throughout the Scandinavian countries, the Middle East, and South America; the Mesural is used throughout most of the French-speaking world; the Australian instrument is used also in New Zealand; and the U.S.A. AN/AMT4 is still widely used in the countries which at one time contained U.S. military bases. The instrument types listed above account for at least 95% of the soundings that attain levels above 100 mb.

Several instrument types included in the present study were not covered in the 1968 report by McInturff and Finger (example: Australia/New Zealand). In some cases, as in those of the French Mesural and the U.S.S.R. RKZ, the instrument was either still under development or else was not widely enough deployed during the years 1964-66 to provide a sufficiently large statistical sample.

A significant gap in worldwide stratospheric radiosonde coverage has been filled with the acquisition of Chinese data. Unfortunately, the data for levels above 100 mb were not received until after the cut-off date for the sample used here.

Figure 1 and figure 2 show the distribution of upper air stations throughout the Northern Hemisphere and throughout the Southern Hemisphere, respectively. Table 1 provides a summary of current knowledge concerning deployment of instrument types. The remark made in 1968 concerning a similar figure and a similar table is applicable here as well: these representations cannot be definitive, in view of the changes that are continually taking place in the network.

A comparison of figures 3 and 4 shows what areas and on which dates various observation points have daylight and darkness. The sunset and sunrise lines are depicted for 0100 GMT (fig. 3), December 15 and June 15, and the sunset and sunrise lines for the sames dated at 1300 GMT (fig. 4). These times are those at which the radiosonde balloon with nominal 0000 GMT and 1200 GMT observation times will normally reach the 10-mb level. The migration of the sunset and sunrise lines for March 15 and September 15 would lie midway between the lines for June and December. It should be noted that some countries (e.g., the United Kingdom) are always in darkness at 0100 GMT and always in daylight at 1300 GMT. Other countries (e.g., the U.S.A.) have large areas where in summertime daylight occurs at both observation times, and in wintertime darkness occurs at both observation times. Such areas and periods of so-called "double daylight" and "double darkness" cannot be used for computing day-night differences. However, there are sufficient areas and adequately long periods wherein one observation is in daylight and the other, 12 hours later, is in darkness, to permit the calculation of vast numbers of day-night differences in temperature and geopotential height.

Table 2 is a summary of numbers of observed day-night height differences. It is important to keep these numbers in mind, not so much for the information they provide on the decline in quantity of data at levels above 850 mb, but for the interpretation of the scatter-diagrams and the applications of the tables of adjustments, which will be discussed further on. Sample size is crucial in determining confidence-levels, so it can be seen, for example, that one can place less reliance on any adjustment for the Mesural instrument used overseas (with only 356 day-night differences for a 19-month period at 100 mb) than on the Mesural instrument used in Metropolitan France (with 2,157 day-night differences at 100 mb for the same 19-month period).

The question of pretransmission corrections was dealt with in detail by McInturff and Finger (1968). In the perspective of the present work, this question appears to have little importance, since all instruments require post-transmission corrections for solar-induced day-night differences. Thus, even though pretransmission corrections in most cases result in dramatic reductions in day-night differences, adjustments based on studies such as the present one are still necessary. Anyone interested in pursuing the question of pretransmission corrections may refer to the paper by McInturff and Finger (1968). For information on changes made by particular countries, specialized publications by various meteorological agencies and radiosonde manufacturers may be consulted (see, for example, Suzuki and Asahi (1978)).

3. PROCESSING AND ANALYSIS OF TEMPERATURE AND HEIGHT DATA

3.1 Data Processing

The data base for developing the empirical adjustment scheme presented here is the archive of twice-daily rawinsonde reports received operationally at the NMC, together with calculated mean monthly solar elevation angles at various atmospheric levels based upon assumed constant launch times and balloon ascent rates (see the appendix for details of solar elevation angle computations). The calculation scheme (fig. 5) was applied to 19 months of data from the period 1974-76.

The levels for which calculations were made are as follows: 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, and 10 mb. Monthly means of 12-hour day-night temperature changes (ΔT) were computed from every reporting upper-air station in the Northern Hemisphere, also for all such stations in Australia and New Zealand.

We write

$$\Delta T = T_d - T_n$$

where T_d is the temperature obtained in daylight and T_n the temperature obtained at night; the daylight observation occurs at either 00 GMT or at 12 GMT, depending on geographical location. The monthly-mean temperature difference for a particular station is given by

$$\overline{\Delta T} = \sum_{i=1}^{N} (\Delta T)_i, \text{ where } 1 \leq i < N$$

N ?

and N may vary from 1 to 60, depending upon the number of observations. This range of N results from an attempt to obtain the maximum number of observed 12-hour temperature differences, thus aiding in filtering out the effects of moving weather systems and other long-term trends. Accordingly, ΔT was determined for both the 12 hours preceding and the 12 hours following the time of T_d. The same procedure was followed in computing each mean height difference given by

$$\overline{\Delta H} = \sum_{i=1}^{N} (\Delta H)_i, \text{ where } 1 \leq i \leq N$$

N ?

and where $\Delta H = H_d - H_n$ (H_d is the height of a particular isobaric surface corresponding to T_d and H_n is the height corresponding to T_n).

To guard against the effects of gross errors within the data, any individual ΔT or ΔH which differed from $\overline{\Delta T}$ or $\overline{\Delta H}$ by more than twice the standard deviation was rejected and a new monthly mean was calculated.

3.2 Plotting and Analysis Procedure

The output of the computer program is plotted automatically on graphs which show day-night differences in temperature and height (ordinates) versus mean daytime solar elevation angle (abscissas). The graphs (scatter diagrams) were prepared for all the pressure surfaces. All stations using a particular type of sonde were grouped together in a set of scatter diagrams (one for each of $\overline{\Delta T}$, $\overline{\Delta H}$ at each pressure level). The analysis procedure was governed by the following principles: (1) In order for a monthly-mean value to qualify for representation on a scatter diagram, sufficient pairs of successive observations must be available at a particular station to give more than five temperature- or height-differences for the individual month. (2) Each monthly-mean value $\overline{\Delta T}$ or of $\overline{\Delta H}$ based on sample size $n > 10$ is marked by an asterisk in the scatter diagram, while each value based on a sample size $n \leq 10$ is marked by an oval. (3) The abscissa is divided into 10° intervals of solar elevation angle, whereas the ordinate $\overline{\Delta T}$ is divided into 1°C-intervals and the ordinate $\overline{\Delta H}$ into 10-meter intervals. (4) Averages for all the daynight differences are computed within each 10° interval of solar elevation angle, and are indicated in each interval by a plus-sign (+) or a minus-sign (-); the plus-sign is used for means calculated *before* data-rejection, and the minus-sign for means calculated *after* data-rejection. (If no data are rejected, only the plus-signs appear. If some data are rejected, normally both a plus- and a minus-sign appear in the column affected, except when they would be so close together as to interfere with each other.) (5) The standard deviations of all the day-night differences are computed within each 10°-interval of solar elevation angle, and an envelope with half-width equal to twice the standard deviation and whose upper and lower boundaries are marked by 'S' or 'T' is indicated; 'S' is used in case no data are rejected, 'T' is used in case some data are rejected in the column under consideration (in which case the value of the recomputed standard deviation is used). In case data are rejected for a particular column, both 'S' and 'T' will normally appear. Sometimes values of 'S' or 'T' will be so large as not to appear at all on the scatter diagrams, although usually they appear as marking the upper boundaries of the 2σ-envelopes. Most often the space left at the bottom of the figure is inadequate to accommodate the symbols 'S' and 'T.'

Examples of the computer-plotted output are shown in figures 6 to 12.

4. DISCUSSION OF SCATTER DIAGRAMS

Although all the empirically derived adjustments, for levels 700, 500, 300, 200, 100, 50, 30, 20, and 10 mb, will be presented as tables (in a form suitable for ready insertion into computer programs), it is instructive to examine a few of the scatter diagrams. It is not appropriate to present all of them since most of the information contained in these is presented in other forms throughout this paper. The diagrams shown here were chosen for no other particular reason than that each of these illustrates at least one important point. An understanding of these examples will facilitate the interpretation and application of the tables which follow.

Figure 6 is the diagram for the day-night differences in temperature at 200 mb (0000 GMT sunlight) for the U.S.A. NOAA (VIZ) instrument. The amount of data represented can be estimated from the knowledge that each asterisk and oval-shaped symbol stands for an entire monthly-mean day-night temperature difference for a single station; hence each symbol is derived from more than 5 and less than 60 observations, in accordance with the convention explained in the previous section. The decrease in the amount of data with height, and the increase in scatter for this particular instrument, can be estimated by comparing this figure with that for 10 mb (fig. 12). The amount of adjustment needed is also seen to be much less at 200 mb than at 10 mb. However, there is still a slight adjustment to be made even at 200 mb, where it is approximately 0.5°C for most daytime solar elevation angles.

The visible scatter in these diagrams is due to intermonth, interstation variability, since each symbol represents a monthly mean for one station of day-night temperature differences. Each symbol therefore corresponds to a stationmonth, and the amount of scatter of these symbols can provide a measure of intermonth, interstation variability. The intramonth, intrastation variability is of course determined by the second moment of daily difference values about their monthly mean; this variability is hidden from us in these diagrams. However, both intramonth, intrastation variability and intermonth, interstation variability are taken into account in computing standard deviations of day-night differences for various instrument types; these standard deviations will be discussed further on. For a more complete discussion of intramonth, intrastation variability and of intermonth, interstation variability, see McInturff and Finger (1968).

Figures 7 and 8, for metropolitan France and for overseas stations making use of the French instrument (the Mesural), respectively, both groups employing (presumably) the same type of instrument, illustrate how different the results can be in spite of supposed similarities in equipment. The scatter in figure 7 (as measured, for example by the distance between the mean and the S-symbols near the top) is much greater than in figure 8; also the sample used for figure 7 is much larger than that used for figure 8. Of course there is always the possibility that the overseas stations are using some of the old rawinsonde equipment, manufactured before the thermistor was changed (1970); in this case, figure 7 and figure 8 would reflect differences between two instrument types.

Figure 9 is an example of a scatter diagram in $\overline{\Delta T}$ for the Chinese instrument at 100 mb. It may be readily seen that the mean value of $\overline{\Delta T}$ hardly ever deviates significantly from zero. The sample size is large, but because of Earth-Sun geometry the data are restricted to low daytime solar angles.

Figures 10 and 11 are scatter diagrams of $\overline{\Delta T}$ for 30 mb generated by data from the West German and Japanese radiosonde instruments, respectively. The amounts of scatter are similar on the two diagrams. The one for the Federal Republic of Germany (fig. 10) shows the means of the $\overline{\Delta T}$'s (represented by the dash-symbol) constituting approximately a straight horizontal line; this is due to the fact that pretransmission corrections based on sets of historical day-night difference data have been applied. Ideally, the means of the $\overline{\Delta T}$'s would be zero; the fact that they are not suggests that the pretransmission adjustments are not quite so large as they should be.

On the other hand, the 30-mb scatter diagram of $\overline{\Delta T}$ for the Japanese instrument (fig. 11) shows unmistakable evidence of a pretransmission correction system which is adequate at daytime solar angles above 60° but not quite adequate at lower solar angles.

Figure 12, showing the $\overline{\Delta T}$-scatter diagram for the NOAA (VIZ) instrument at 10 mb, has already been compared with figure 6. 10 mb is the highest level for which we present results. The reason is not hard to find: data are already quite sparse at 10 mb (as evidenced by the preponderance of oval symbols), and become much too sparse at higher levels. The reader should compare figure 12 with figure 11 in McInturff and Finger (1968). (S)He will note the same general configuration of the curve of mean ΔT, indicating that this particular instrument is performing at 10 mb in much the same manner as it did 10 years earlier.

5. UNEXPLAINED VARIABILITY

As already indicated by McInturff and Finger (1968), at least five sources contribute to the standard deviations of ΔT about the mean of the day-night differences (for a standard height, a given daytime solar elevation angle, for any of the instrument types under study): (1) Differences between individual sondes of a given type and between items of ground equipment; (2) differences in station procedure, even for several stations using the same type of equipment; (3) day-to-day changes in the albedo of Earth and cloud, which cause variations in the amount of reflected sunlight reaching the radiosonde; (4) synoptic changes; and (5) the true diurnal temperature variation. Since it is impossible to separate out all these influences, or even to measure some of then precisely, it seems justifiable to combine them as factors in the unexplained variability of observations.

The standard deviations σ of $(\Delta T)_i$ about the average of the monthly means for all 10°-interval of daytime solar elevation angle have been calculated (for the 30-mb level). The results are shown in figure 13, where $\overline{\sigma}$ is the result of averaging the σ's over all the intervals of daytime solar elevation angle. These results should be compared with those shown in figure 30 in the paper by McInturff and Finger (1968). In the latter, it should be emphasized, we dealt with average *variances*, for reasons given in the text. In the present study, owing to a higher degree of automation in dataprocessing, it was easy enough to calculate the standard deviations in a more straightforward fashion.

Figure 13 contains many interesting features, but perhaps the most significant is the behavior of the French instrument in the country of its manufacture in comparison to its behavior overseas; and the analogous behavior of the Vaisala instrument in the country of its manufacture (Finland) in comparison to its behavior in other countries. The utility of any posttransmission adjustment is inversely proportional to the σ-value associated with it.

6. CONCLUDING REMARKS

Tables 3 to 19 summarize all the information from the scatter diagrams needed for adjustments in rawinsonde-reported temperatures and geopotential heights of constant-pressure surfaces. In this form, they are easily incorporated into programs for analyzing tropospheric and lower stratospheric data. The greater need for adjustments at stratospheric levels is clearly in evidence.

We recommend that the adjustment system for upper-air data presented here be applied only at analysis centers. Certainly it should not be applied as a pretransmission correction scheme in any one country; this would make it difficult to determine which stations require further adjustment and which do not.

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APPENDIX: COMPUTATION OF SOLAR ELEVATION ANGLE

The solar elevation angle α is calculated for the time at which the radiosonde balloon passes through each mandatory level at 100 mb and above. It is found from the formula:

$$\sin \alpha = \sin \phi \sin \delta + \cos \phi \cos h \cos \delta$$

where ϕ is station latitude, δ is solar declination angle, and h is solar hour angle. The angle δ is obtained by [1]

$$\sin \delta = \sin (23°26'37.8'') \sin \sigma,$$

where σ is in degrees and is given by

$$\sigma = 279.9348 + d + 1.914827 \sin d - 0.079525 \cos d + 0.019938 \sin 2d - 0.001620 \cos 2d;$$

d is the number of the day in the year minus one, multipled by the constant 0.98565; e.g., for January 30, d = 29 x 0.98565. The solar hour angle h, the angular (longitudinal) distance of the sun from the observation point, can be expressed in terms of time of observation and longitude relative to Greenwich. The relation takes the form

$$h \text{ (deg.)} = 15 (C + H - M) - L$$

where M, the time of meridian passage or true solar noon, is given by

$$M \text{ (hr.)} = 12 + 0.123570 \sin \phi - 0.004289 \cos d + 0.153809 \sin 2d + 0.060783 \cos 2d,$$

with d as defined above; C (in hours) is a function of the difference between actual radiosonde release time and nominal observation time; and also of balloon ascent rate (table 25); H is nominal observation time, expressed as the number of hours after 0000 GMT; L is longitude of station is degrees and tenths, counted positive west of Greenwich.

Since station latitude and longitude are known, and solar declination angle and time of meridian passage can be determined with high precision, the only source of uncertainty in the calculation of solar elevation angle is the time of radiosonde arrival at each mandatory level. As no indication of this parameter is given in the coded rawinsonde message, an approximate release time and ascent rate must be assumed. From an inspection of individual station records, "normal" release times, to the nearest quarter hour, and typical rates of ascent have been determined for North American stations. However, since these records are not available for most of the remaining stations in the Northern Hemisphere, a release time of 20 minutes prior to nominal observation time is utilized.

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[1] Relations involving δ and σ were derived from information provided by the U.S. Naval Observatory, Washington, D.C.

Table 1.--Types of radiosondes in use in the world. This representation cannot be considered current, in view of the changes that are continually taking place in the network.

Instrument type	Where employed	Pretransmission corrections applied?
Bendix-Friez duct-type (403 NHz)	Brazil	No
	Indonesia	No
Chinese	People's Republic of China	Unknown
Diamond Hinman	Australia	No
	New Zealand	No
Freiberg	German Democratic Republic (09486 only)	No
Graw M-60	Belgium	No
	Congo	No
	Federal Republic of Germany	Yes
	Mauritius	No
	Zaire	Unknown
Indian	India	Yes
Japanese "code-sending" Type RSII56	Indonesia	No
	Japan	Yes
Kew (Mark IIB)	Cyprus	Yes
	Gibraltar	Yes
	Ireland	Yes
	Malta	Yes
	Netherlands	Yes
	United Kingdom	Yes

Table 1 (continued)

Instrument type	Where employed	Pretransmission corrections applied?
Mesural	Algeria	No
	Central African Empire	No
	Chad	No
	France	No
	Ivory Coast	No
	Mali	No
	Madagascar	Unknown
	Mauritania	No
	Morocco	No
	Niger	No
	Senegal	No
	United Republic of Camoroon	No
	Vietnam	No
Pakistani	Pakistan (41594, 41675, 41756)	Unknown
Sangamo	Canada	No
	Portugal	No
Swiss	Switzerland	Yes
U.S.A. AN/AMT-4	Austria	No
	Bahamas	No
	Bermuda	No
	Egypt	No
	Greece	No
	Greenland (04202 only)	No
	Iceland	No
	Italy	No
	Korea (Republic of) (47138)	No
	Netherlands Antilles	No
	Pakistan (41530 and 41780 only)	No
	Spain	No
	Taiwan	No
	Turkey	No
	Vietnam	No
	Yugoslavia	No

Table 1 (continued)

Instrument type	Where employed	Pretransmission corrections applied?
U.S.A. NOAA	Angola	Unknown
	Colombia	No
	Costa Rica	No
	Cuba (Guantanamo Bay NAS)	No
	Dominican Republic	No
	Egypt (62378 and 62414)	No
	Guadeloupe (France)	No
	Guam	No
	Guatemala	No
	Honduras	No
	Israel	No
	Jamaica	No
	Korea (Republic of)	No
	Mexico	No
	Mozambique	Unknown
	Netherlands	No
	Panama	No
	Portugal (08509 only)	No
	Spain (08001 and 08302)	No
	Trinidad	No
	U.S.A.	No
	Venezuela	No
U.S.S.R. A-22	Afghanistan	No
	Bulgaria	No
	Czechoslovakia	Yes
	Hungary	Yes
	Poland (12425)	No
	Romania	No
	U.S.S.R.	Yes
U.S.S.R. RKZ	German Democratic Republic	Unknown
	Hungary	Unknown
	Poland (12330 and 12374)	Unknown
	U.S.S.R.	Yes

Table 1 (continued)

Instrument type	Where employed	Pretransmission corrections applied?
Väisälä	Argentina	Yes
	Brazil	Unknown
	Burma	Yes
	Denmark	Yes
	Ethiopia	Yes
	Finland	Yes
	Greenland (except 04202)	Yes
	Hong Kong	Yes
	Indonesia	Yes
	Iraq	Yes
	Iran	Yes
	Jordan	Yes
	Kenya	Yes
	Lebanon	Yes
	Libya	Yes
	Malaysia	Yes
	Nigeria	Unknown
	Norway	Yes
	Philippines	Yes
	Saudi Arabia	Yes
	South Africa	Yes
	Sudan	Yes
	Sweden	Yes
	Syria	Yes
	Tanzania	Yes
	Thailand	Yes
	Tunisia	Yes
	Uganda	Yes
	Zambia	Yes

Table 2.--Numbers of observed height differences

Instrument type	Solar angle (degrees) -10-0	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	Total	850-mb as 100%
W. German Graw												
850 mb	0	0	605	824	693	750	467	242	0	0	3581	100%
100 mb	0	0	612	654	567	606	224	145	0	0	2808	79%
10 mb	0	1	99	147	167	192	55	0	0	0	661	19%
U.K. Kew												
850 mb	0	333	1592	1192	1376	1521	631	282	63	0	6990	100%
100 mb	0	188	1399	1042	1081	1292	541	224	33	0	5800	83%
10 mb	0	38	142	153	111	152	33	0	0	0	629	9%
French Mesural (metropolitan France)												
850 mb	0	0	148	662	563	526	634	274	0	0	2807	100%
100 mb	0	0	86	578	471	331	477	214	0	0	2157	77%
10 mb	0	0	62	81	53	127	87	13	0	0	423	15%
French Mesural (overseas)												
850 mb	0	0	0	22	189	131	43	116	94	0	595	100%
100 mb	0	0	0	19	48	81	84	77	47	0	356	60%
10 mb					INSUFFICIENT DATA							
Finnish Väisälä												
850 mb	1400	3625	4075	4372	3559	2333	1766	1251	541	101	23023	100%
100 mb	1216	3368	3582	2715	2436	1762	697	436	53	0	16265	71%
10 mb	38	108	119	147	118	45	4	5	2	0	586	3%
Japanese "code-sending"												
850 mb	0	172	4190	2905	4176	943	291	0	0	0	12677	100%
100 mb	0	2	494	3150	2375	3370	835	144	0	0	10370	82%
10 mb	0	0	0	19	35	35	37	8	0	0	134	1%
U.S.S.R. A-22 (afternoon daylight)												
850 mb	2633	3227	3916	3182	2445	1617	712	133	0	0	17865	100%
100 mb	1927	2850	2878	1808	1090	317	158	0	0	0	11028	62%
10 mb	167	212	225	156	75	42	0	0	0	0	877	5%

Table 2.--Numbers of observed height differences (continued)

Instrument type				Solar angle (degrees)							850-mb
	-10-0	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	Total	as 100%
U.S.S.R. A-22 (morning daylight)												
850 mb	3636	3987	2666	1925	839	487	64	0	0	0	13604	100%
100 mb	2552	2989	2712	1831	1151	444	257	0	0	0	11936	88%
10 mb	340	527	576	468	282	105	26	19	0	0	2343	17%
U.S.S.R. RKZ (afternoon daylight)												
850 mb	1463	3183	5870	6426	4745	3178	1675	279	0	0	26819	100%
100 mb	2378	4207	4682	3299	2430	1205	297	0	0	0	18498	69%
10 mb	144	241	287	239	160	22	0	0	0	0	1093	4%
U.S.S.R. RKZ (morning daylight)												
850 mb	1772	2225	2931	1491	1222	447	45	0	0	0	10133	100%
100 mb	1830	2137	2487	1231	1150	648	274	0	0	0	9757	96%
10 mb	80	305	414	337	301	234	123	61	0	0	1855	18%
U.S.A. NOAA (afternoon daylight)												
850 mb	9026	13022	14319	10798	8046	4270	1818	1378	982	672	64331	100%
100 mb	6725	7830	6296	3248	2045	1554	1517	746	450	94	30505	47%
10 mb	458	343	224	67	118	236	229	139	84	13	1911	3%
U.S.A. NOAA (morning daylight)												
850 mb	4266	1897	764	427	241	251	279	188	27	0	8340	100%
100 mb	5522	5732	2878	1388	586	156	111	66	0	0	16439	197%
10 mb	471	810	766	617	259	79	7	0	0	0	3009	36%
U.S.A. AN/AMT												
850 mb	523	1351	3023	3217	2567	1972	1878	836	233	0	15600	100%
100 mb	137	785	1298	2458	2154	1398	1102	548	58	0	9938	64%
10 mb	16	19	217	574	539	541	261	55	18	0	2240	14%

Table 2.--Numbers of observed height differences (continued)

	Solar angle (degrees)											
Instrument type	-10-0	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	Total	850-mb as 100%
Australian "Diamond Hinman"												
850 mb	61	149	605	484	741	1059	527	221	189	22	4058	100%
100 mb	0	0	204	423	343	512	638	254	72	17	2463	61%
10 mb					INSUFFICIENT DATA							
Chinese												
850 mb	8483	15481	6965	2508	0	0	0	0	0	0	33437	100%
100 mb	1724	4400	7159	5894	3268	170	0	0	0	0	22615	68%
10 mb					INSUFFICIENT DATA							
Sangamo (Canada and Portugal)												
850 mb	4057	2558	1603	885	847	253	223	111	0	0	10537	100%
100 mb	3263	2580	1488	471	301	132	94	108	37	0	8474	80%
10 mb	80	86	46	74	65	14	20	21	7	2	415	4%

Table 3.--W. German "Graw" instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
5°	$\overline{\Delta T}$	-	-	-	-	-	-	*0.9*	*1.0*	-
	$\overline{\Delta H}$	-	-	-	-	-	-	*17*	*44*	-
15°	$\overline{\Delta T}$	0.1	0	0	0.1	0.4	0.6	0.6	0.5	0.7
	$\overline{\Delta H}$	-2	-1	-1	0	5	11	17	23	28
25°	$\overline{\Delta T}$	-0.1	-0.1	0.1	0.2	0.5	0.5	0.6	0.6	0.3
	$\overline{\Delta H}$	0	1	-1	3	12	16	23	27	38
35°	$\overline{\Delta T}$	0	-	0	0.3	0.3	0.6	0.8	0.6	0.7
	$\overline{\Delta H}$	2	2	4	4	11	13	23	25	35
45°	$\overline{\Delta T}$	0.1	-	0	0.3	0.4	0.2	0.1	-0.1	-0.2
	$\overline{\Delta H}$	3	3	6	6	13	14	11	13	10
55°	$\overline{\Delta T}$	0	-	0	0.1	0.3	0.4	0	0.4	-0.3
	$\overline{\Delta H}$	4	2	4	6	12	18	15	19	5
65°	$\overline{\Delta T}$	-0.2	0.2	0	0.2	0.6	*0.5*	-	-	-
	$\overline{\Delta H}$	3	4	5	5	17	*21*	-	-	-
75°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-

Table 4.--U.K. Kew instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
5°	$\overline{\Delta T}$	-0.3	-0.2	-0.2	-0.1	-0.2	-1.0	-0.5	0.3	3.2
	$\overline{\Delta H}$	-3	-5	-8	-9	-12	-20	-31	-39	10
15°	$\overline{\Delta T}$	-0.1	0	0	-0.1	0.1	-0.3	-0.1	0.4	3.3
	$\overline{\Delta H}$	-1	-2	-1	-1	-1	-3	-14	-18	36
25°	$\overline{\Delta T}$	-0.1	0	0	0	0.3	0.1	0.8	1.6	4.3
	$\overline{\Delta H}$	-1	-1	1	-2	1	3	5	27	113
35°	$\overline{\Delta T}$	0	0	0.2	0	0.2	-0.1	0.3	1.5	3.3
	$\overline{\Delta H}$	-1	-4	-1	3	5	-1	5	24	56
45°	$\overline{\Delta T}$	-0.1	0	0.1	0	0	-0.3	0.1	1.1	2.8
	$\overline{\Delta H}$	-2	-3	-3	-3	0	-5	-2	11	56
55°	$\overline{\Delta T}$	-0.1	0	0.1	-0.2	-0.3	0	0.4	0.8	1.4
	$\overline{\Delta H}$	-2	-2	-3	-4	-1	-9	-10	2	34
65°	$\overline{\Delta T}$	-0.1	-0.1	0	0	-0.1	0.3	-0.1	-	-
	$\overline{\Delta H}$	-2	-2	-5	-4	4	0	1	-	-
75°	$\overline{\Delta T}$	-	-0.6	-0.3	-	-	-	-	-	-
	$\overline{\Delta H}$	-2	*-10*	*-12*	*-12*	-	-	-	-	-

Table 5.--French Mesural instrument used in Metropolitan France. Values of mean ΔT and mean ΔH as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, ΔH's on lower line.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
15°	$\overline{\Delta T}$	0.3	0.4	0.3	-0.1	0.4	0.9	1.1	1.2	1.9
	$\overline{\Delta H}$	4	5	7	7	16	14	4	6	10
25°	$\overline{\Delta T}$	0.2	0.2	0.2	0.5	0.6	0.8	1.2	1.3	2.2
	$\overline{\Delta H}$	4	6	8	12	19	29	5	7	12
35°	$\overline{\Delta T}$	0.3	0.3	0.4	0.5	0.6	0.8	1.0	1.8	2.6
	$\overline{\Delta H}$	4	6	11	14	23	31	5	7	10
45°	$\overline{\Delta T}$	0.2	0.6	0.5	-0.1	0.3	0.8	1.3	1.2	3.2
	$\overline{\Delta H}$	4	9	16	21	27	34	4	7	10
55°	$\overline{\Delta T}$	0.2	0.3	0.3	0.5	0.6	0.8	1.1	1.6	1.1
	$\overline{\Delta H}$	2	1	8	11	19	27	5	6	8
65°	$\overline{\Delta T}$	-0.2	0.2	0.1	0.2	0.5	1.2	0.9	1.8	0.9
	$\overline{\Delta H}$	2	0	3	5	7	25	4	6	14
75°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-

Table 6.--French Mesural instrument, used outside France. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
15°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
25°	$\overline{\Delta T}$	0.8	0.5	1.3	2.3	3.7	*6.2*	*7.6*	*11.4*	-
	$\overline{\Delta H}$	10	13	27	40	123	*288*	*279*	*510*	-
35°	$\overline{\Delta T}$	0.6	0.8	0.9	2.2	2.5	4.2	6.6	*8.8*	-
	$\overline{\Delta H}$	8	15	27	41	105	16	229	333	-
45°	$\overline{\Delta T}$	0.8	0.9	1.4	5.5	2.4	*4.3*	*5.1*	*8.5*	-
	$\overline{\Delta H}$	12	8	31	36	60	22	323	*407*	-
55°	$\overline{\Delta T}$	0.5	0.7	1.1	4.9	2.7	0.4	*5.1*	*9.3*	-
	$\overline{\Delta H}$	9	19	32	46	81	*96*	*220*	*314*	-
65°	$\overline{\Delta T}$	0.2	0.5	0.8	7.6	2.3	3.7	*5.3*	*5.0*	-
	$\overline{\Delta H}$	8	12	26	31	54	86	*102*	*212*	-
75°	$\overline{\Delta T}$	0	0.4	0.6	3.8	1.2	*2.4*	-	-	-
	$\overline{\Delta H}$	1	3	8	8	30	*38*	-	-	-

Table 7.--Finnish Väisälä instrument used both in Finland and several foreign countries. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics represent best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-0.2	0.2	-0.1	0	0.1	0.1	0.1	0.1	2.6
	$\overline{\Delta H}$	-2	-2	-5	-3	-2	-6	3	0	83
5°	$\overline{\Delta T}$	0.1	0.1	0.1	0.1	0.3	0.8	2.0	1.9	3.1
	$\overline{\Delta H}$	-1	0	1	2	4	11	28	42	83
15°	$\overline{\Delta T}$	0.1	0	0.1	0.1	0.3	1.0	2.4	2.4	4.0
	$\overline{\Delta H}$	1	2	4	4	7	18	37	65	127
25°	$\overline{\Delta T}$	0.3	0.1	0.2	0.1	0.4	1.0	2.2	2.0	1.8
	$\overline{\Delta H}$	3	4	6	7	12	26	43	65	91
35°	$\overline{\Delta T}$	0.1	0.2	0.2	0.2	0.6	1.2	2.0	2.0	3.3
	$\overline{\Delta H}$	6	8	11	11	18	32	55	74	77
45°	$\overline{\Delta T}$	0.2	0.2	0.3	0.3	0.5	1.2	1.5	1.6	1.4
	$\overline{\Delta H}$	6	8	14	15	15	30	43	48	53
55°	$\overline{\Delta T}$	0.3	0.3	0.3	0.5	0.8	1.0	0.4	0.4	2.5
	$\overline{\Delta H}$	9	13	16	17	30	11	29	38	73
65°	$\overline{\Delta T}$	0.5	0.4	0.5	0.6	1.3	0.8	*0.1*	*0.1*	-
	$\overline{\Delta H}$	8	12	17	23	37	35	*29*	*61*	-
75°	$\overline{\Delta T}$	0.3	*0.6*	*0.6*	0.6	1.3	-	-	-	-
	$\overline{\Delta H}$	10	14	19	23	26	-	-	-	-
85°	$\overline{\Delta T}$	0.2	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	10	11	-	-	-	-	-	-	-

Table 8.--Väisälä instrument used in Finland. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line.

Solar elevation angle (degrees)		Pressure level (mb)						
		700	500	300	200	100	50	10
-5°	$\overline{\Delta T}$	-0.1	-0.1	-0.3	-0.1	0.0	-0.4	0.3
	$\overline{\Delta H}$	- 5	- 4	- 3	2	- 2	- 2	12
5°	$\overline{\Delta T}$	0.1	0.2	0.0	0.1	-0.1	-0.2	0.0
	$\overline{\Delta H}$	1	0	8	7	0	- 18	- 23
15°	$\overline{\Delta T}$	0.1	0.4	0.2	-0.2	0.0	0.0	-0.4
	$\overline{\Delta H}$	3	4	9	6	1	7	8
25°	$\overline{\Delta T}$	0.1	-0.2	0.1	-0.2	-0.1	0.1	0.5
	$\overline{\Delta H}$	3	4	6	8	7	14	7
35°	$\overline{\Delta T}$	0.1	0.4	0.1	0.1	0.0	0.4	0.2
	$\overline{\Delta H}$	4	7	10	11	8	21	21
45°	$\overline{\Delta T}$	0.1	-	-	-	-	-	-
	$\overline{\Delta H}$	10	-	-	-	-	-	-

Note: Data were insufficient above 30 mb for derivation of meaningful numbers. Data were also insufficient for daytime solar elevation angles higher than 50°.

Table 9.--Japanese "code-sending" instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. ΔT's are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb) 700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
5°	$\overline{\Delta T}$	0.3	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-4	*3*	-	-	-	-	-	-	-
15°	$\overline{\Delta T}$	0	0.2	0.6	0.4	0.7	1.3	2.6	-	-
	$\overline{\Delta H}$	2	4	8	13	25	43	82	-	-
25°	$\overline{\Delta T}$	0.1	0.3	0.4	0.6	0.8	1.2	1.9	3.0	4.1
	$\overline{\Delta H}$	3	4	10	18	28	43	70	102	173
35°	$\overline{\Delta T}$	0.2	0.3	0.3	0.6	0.7	1.0	1.6	2.8	3.5
	$\overline{\Delta H}$	2	5	10	15	28	44	59	90	142
45°	$\overline{\Delta T}$	0.2	0.4	0.4	0.4	0.8	0.8	1.2	1.9	1.6
	$\overline{\Delta H}$	2	5	11	13	26	39	53	70	94
55°	$\overline{\Delta T}$	0.2	0.5	0.5	0.4	0.8	0.9	1.1	1.3	1.8
	$\overline{\Delta H}$	4	7	14	17	27	31	43	60	99
65°	$\overline{\Delta T}$	0.3	0.7	0.6	0.5	0.4	0.2	1.0	1.4	1.4
	$\overline{\Delta H}$	-	10	17	20	25	35	61	84	*128*
75°	$\overline{\Delta T}$	-	-	-	-	-	0.1	-0.5	-1.0	-
	$\overline{\Delta H}$	-	-	-	-	-		28	20	-

Table 10.--Afternoon daylight (12Z), U.S.S.R. A-22 instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle of pressure level. Units are degrees Celsius and meters. ΔT's are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small sample sizes.

Solar Elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	0.1	0.2	0.1	0.1	0.2	0.3	0.2	0.3	-0.2
	$\overline{\Delta H}$	3	5	6	7	14	20	27	42	18
5°	$\overline{\Delta T}$	0.3	0.2	0.3	0.3	0.5	0.6	0.3	0.5	0.2
	$\overline{\Delta H}$	4	6	11	14	22	30	39	39	60
15°	$\overline{\Delta T}$	0.3	0.3	0.2	0.2	0.4	0.7	0.8	1.0	2.5
	$\overline{\Delta H}$	4	8	11	12	16	33	46	63	121
25°	$\overline{\Delta T}$	0.5	0.3	0.1	0.3	0.5	0.7	0.9	0.1	0.3
	$\overline{\Delta H}$	6	9	11	12	20	32	45	54	84
35°	$\overline{\Delta T}$	0.2	0.2	0.4	0.1	0.5	0.9	0.9	1.2	1.8
	$\overline{\Delta H}$	7	9	13	15	23	31	44	62	80
45°	$\overline{\Delta T}$	0.2	0.2	0.4	0	0.3	0.6	0.5	1.0	0.2
	$\overline{\Delta H}$	8	10	15	17	13	16	18	28	11
55°	$\overline{\Delta T}$	0.1	0.3	0.2	-0.2	0	0.4	0.8	*0.2*	-
	$\overline{\Delta H}$	9	11	12	12	5	8	14	*-14*	-
65°	$\overline{\Delta T}$	0.1	0	0.4	-	-	-	-	-	-
	$\overline{\Delta H}$	6	5	11	-	-	-	-	-	-
75°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-

Table 11.--Morning daylight (00Z), U.S.S.R. A-22 instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	0	-0.1	0	0	0	-0.1	-0.2	-0.1	0.1
	$\overline{\Delta H}$	-4	-5	-4	-5	-6	-7	-9	-10	-16
5°	$\overline{\Delta T}$	0.1	0	0	0.2	0.2	0.3	0.4	0.6	0.9
	$\overline{\Delta H}$	-3	-3	-5	-4	-1	8	11	18	18
15°	$\overline{\Delta T}$	0	0	0	0.1	0.2	0.5	0.6	0.9	1.9
	$\overline{\Delta H}$	-2	-3	-4	-3	1	5	13	25	51
25°	$\overline{\Delta T}$	-0.1	-0.1	0.2	0.2	0.3	0.5	0.5	0.9	2.8
	$\overline{\Delta H}$	0	-2	-2	-4	2	11	20	22	56
35°	$\overline{\Delta T}$	0	0	0.1	0.2	0.5	0.8	0.7	1.1	0.5
	$\overline{\Delta H}$	1	0	2	3	8	17	19	33	48
45°	$\overline{\Delta T}$	-0.1	0	0.2	-0.1	0.1	0.5	0.6	1.2	2.3
	$\overline{\Delta H}$	-1	0	-3	-5	-3	11	16	32	38
55°	$\overline{\Delta T}$	-0.2	-0.2	0.1	-0.2	0.3	0.3	0.4	0.9	2.4
	$\overline{\Delta H}$	-3	-5	-3	-7	-8	0	5	14	57
65°	$\overline{\Delta T}$	--	--	--	--	--	--	0.3	--	-0.6
	$\overline{\Delta H}$	--	--	--	--	--	--	-10	-11	--
75°		--	--	--	--	--	--	--	--	--
		--	--	--	--	--	--	--	--	--

Table 12.--Afternoon daylight (12Z), U.S.S.R. RKZ instrument. Values of mean ΔT and mean ΔH as functions of mean daytime solar elevation and of pressure level. Units are degrees Velsius and meters. ΔT's are given on upper line, ΔH's on lower line.

Solar elevation angle (degrees)		Pressure level (mb) 700	500	300	200	100	50	30	20	10
-5°	ΔT	0.1	0	0.1	0.2	0.2	0.5	0.7	0.8	1.8
	ΔH	5	5	6	7	15	29	44	55	82
5°	ΔT	0.2	0.2	0.4	0.3	0.5	0.8	1.0	1.1	2.8
	ΔH	5	7	13	20	28	42	54	67	120
15°	ΔT	0.3	0.3	0.3	0.4	0.5	0.7	0.9	1.1	1.7
	ΔH	6	10	16	18	25	35	44	53	73
25°	ΔT	0.3	0.3	0.3	0.2	0.2	0.5	0.7	0.6	0.5
	ΔH	7	10	15	18	21	30	35	38	59
35°	ΔT	0.3	0.3	0.3	0.3	0.1	0.2	0.4	0.6	0.5
	ΔH	7	10	14	17	20	23	28	34	22
45°	ΔT	0.3	0.3	0.4	0.2	0	0.3	0.2	0.1	0
	ΔH	8	10	15	18	18	15	12	18	8
55°	ΔT	0.1	0.2	0.2	0	0	0.3	-0.2	-	-
	ΔH	6	8	11	12	12	10	10	-	-
65°	ΔT	0.1	0.1	-	-	-	-	-	-	-
	ΔH	7	5	-	-	-	-	-	-	-
75°	ΔT	-	-	-	-	-	-	-	-	-
	ΔH	-	-	-	-	-	-	-	-	-

Table 13.--Morning daylight (00Z), U.S.S.R. RKZ instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-0.2	0	0	-0.1	0	0.1	0.1	0.2	0.5
	$\overline{\Delta H}$	-7	-8	-8	-8	-9	-10	-14	-20	0
5°	$\overline{\Delta T}$	0.1	0	0	0.1	0.3	0.4	0.7	0.9	1.5
	$\overline{\Delta H}$	-3	-5	-4	-5	-1	6	14	16	28
15°	$\overline{\Delta T}$	0	0	0.2	0.1	0.3	0.5	0.6	0.9	1.7
	$\overline{\Delta H}$	-3	-3	-3	-2	0	8	14	23	36
25°	$\overline{\Delta T}$	-0.1	-0.1	0.1	0.4	0.2	0.2	0.3	0.6	1.8
	$\overline{\Delta H}$	-2	-4	-3	-1	1	6	12	18	26
35°	$\overline{\Delta T}$	-0.3	-0.1	0	0.1	0.1	0.1	0.1	0.3	1.6
	$\overline{\Delta H}$	-4	-5	-6	-3	1	1	-1	3	27
45°	$\overline{\Delta T}$	-0.3	-0.1	0.1	0.1	0	0.1	0	0.1	0.5
	$\overline{\Delta H}$	-4	-4	-4	-6	-5	-6	-1	2	17
55°	$\overline{\Delta T}$	-0.3	-0.3	-0.1	-0.1	0.2	0.1	-0.1	0.3	0.1
	$\overline{\Delta H}$	-4	-2	-4	-5	-8	-11	-15	-17	-25
65°	$\overline{\Delta T}$	0	-	-	-	-	-	-0.2	0.2	0.9
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-
75°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-	-

Table 14.--Afternoon daylight (00Z), U.S. NOAA instrument. Values of mean ΔT and mean ΔH as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are based on small sample sizes, but nevertheless are reasonable estimates.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	0.2	0.2	0.2	0.1	0.2	0.5	0.9	1.2	1.9
	$\overline{\Delta H}$	1	3	7	9	15	27	46	70	116
5°	$\overline{\Delta T}$	0.3	0.3	0.4	0.5	0.7	1.1	1.6	1.9	2.4
	$\overline{\Delta H}$	1	4	11	16	30	49	74	100	143
15°	$\overline{\Delta T}$	0.5	0.4	0.6	0.6	0.9	1.3	1.8	2.3	2.9
	$\overline{\Delta H}$	3	8	16	24	38	60	88	116	178
25°	$\overline{\Delta T}$	0.6	0.5	0.6	0.7	1.0	1.4	2.1	2.6	3.2
	$\overline{\Delta H}$	7	12	21	27	42	66	98	132	175
35°	$\overline{\Delta T}$	0.6	0.5	0.6	0.7	1.0	1.4	1.9	2.4	2.6
	$\overline{\Delta H}$	9	13	21	27	40	65	94	129	172
45°	$\overline{\Delta T}$	0.3	0.4	0.5	0.6	1.0	1.2	1.4	1.8	2.8
	$\overline{\Delta H}$	6	8	15	19	35	56	88	107	158
55°	$\overline{\Delta T}$	0.4	0.4	0.5	0.7	1.0	1.1	1.4	1.5	2.3
	$\overline{\Delta H}$	4	7	11	19	34	49	71	100	132
65°	$\overline{\Delta T}$	0.5	0.5	0.5	0.7	1.0	1.3	1.0	1.3	2.5
	$\overline{\Delta H}$	3	8	15	22	36	49	65	95	134
75°	$\overline{\Delta T}$	0.5	0.5	0.5	0.7	1.2	1.0	1.6	*1.3*	1.1
	$\overline{\Delta H}$	3	8	13	22	34	*49*	*72*	*106*	*151*
85°	$\overline{\Delta T}$	*0.4*	*0.6*	*0.6*	*0.8*	*1.0*	*0.9*	*1.2*	*2.2*	*3.2*
	$\overline{\Delta H}$	*1*	*6*	*12*	*18*	*20*	*42*	*80*	*94*	*-13*

Table 15.--Morning daylight (12Z), U.S. NOAA instrument. Values of mean $\overline{\Delta T}$ (upper line) and of mean $\overline{\Delta H}$ (lower line) as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. Values in italics are besed on small sample sizes, but nevertheless are reasonable estimates.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-0.2	-0.2	-0.2	0	0.1	0	-0.1	-0.2	0
	$\overline{\Delta H}$	-3	-5	-7	-8	-8	-9	-14	-20	-39
5°	$\overline{\Delta T}$	-0.1	-0.1	.0	0.2	0.5	0.5	0.6	0.8	1.3
	$\overline{\Delta H}$	-2	-5	-6	-4	1	5	7	4	-7
15°	$\overline{\Delta T}$	0.2	0.2	0.2	0.5	0.7	0.7	1.0	1.1	1.3
	$\overline{\Delta H}$	0	2	2	3	12	18	25	29	30
25°	$\overline{\Delta T}$	0.4	0.4	0.2	0.4	0.7	0.9	1.1	1.1	1.1
	$\overline{\Delta H}$	5	7	7	8	17	31	34	39	44
35°	$\overline{\Delta T}$	0.5	0.4	0.4	0.8	0.8	1.1	1.4	1.5	1.3
	$\overline{\Delta H}$	10	13	17	18	23	36	44	64	71
45°	$\overline{\Delta T}$	0.4	0.5	0.7	1.5	1.2	1.4	1.3	1.2	*1.9*
	$\overline{\Delta H}$	8	9	24	23	29	50	59	59	*102*
55°	$\overline{\Delta T}$	0.8	*1.0*	*1.2*	*1.0*	*1.6*	*1.0*	*2.2*	*1.3*	*3.5*
	$\overline{\Delta H}$	9	*18*	*29*	*40*	*70*	*181*	*107*	*54*	*119*
65°	$\overline{\Delta T}$	*0.9*	*0.9*	*1.1*	*0.9*	*1.0*	*1.5*	*-0.4*	---	---
	$\overline{\Delta H}$	*20*	*26*	*32*	*40*	*32*	*77*	*47*	---	---

Table 16.--AN/AMT 4 instrument, used in various parts of the world. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	-0.1	-0.5	-0.2	0	-0.1	0.2	0.8	-	*1.5*
	$\overline{\Delta H}$	-1	-1	-6	-9	-11	-18	36	-	107
5°	$\overline{\Delta T}$	0	-0.1	0.1	0.5	0.4	0.8	1.2	1.7	1.4
	$\overline{\Delta H}$	-1	-1	-1	1	6	17	48	78	69
15°	$\overline{\Delta T}$	0	0	0.4	0.6	0.8	0.8	1.7	1.8	2.9
	$\overline{\Delta H}$	3	2	5	11	22	31	50	69	109
25°	$\overline{\Delta T}$	0.2	0.2	0.4	0.5	0.8	1.1	1.4	1.8	1.7
	$\overline{\Delta H}$	3	4	8	13	26	43	56	76	109
35°	$\overline{\Delta T}$	0.3	0.4	0.5	0.5	0.9	1.1	1.8	1.6	2.0
	$\overline{\Delta H}$	5	7	13	17	28	42	68	91	119
45°	$\overline{\Delta T}$	0.3	0.3	0.4	0.4	0.9	1.1	1.5	1.7	2.5
	$\overline{\Delta H}$	4	9	16	21	36	49	67	90	136
55°	$\overline{\Delta T}$	0.3	0.4	0.5	0.6	1.0	1.4	1.7	1.7	2.7
	$\overline{\Delta H}$	5	8	13	20	33	52	77	97	144
65°	$\overline{\Delta T}$	0.2	0.4	0.6	0.7	0.8	1.5	1.8	1.6	2.3
	$\overline{\Delta H}$	5	9	15	16	33	55	43	72	128
75°	$\overline{\Delta T}$	0.1	0.3	0.5	0.6	0.9	-	-	*1.2*	*1.9*
	$\overline{\Delta H}$	6	5	4	15	30	-	-	*53*	*89*

Table 17.--Australian ("Diamond Hinman") instrument, used also in New Zealand. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)							
		700	500	300	200	100	50	30	20
-5°	$\overline{\Delta T}$	-	-	-	-	-	-	-	-
	$\overline{\Delta H}$	-	-	-	-	-	-	-	-
5°	$\overline{\Delta T}$	0.3	0	0	0.2	-	-	-	-
	$\overline{\Delta H}$	-3	-2	-5	-3	-	-	-	-
15°	$\overline{\Delta T}$	0	0.2	0.2	0.4	0.6	0.9	0.8	*1.8*
	$\overline{\Delta H}$	0	1	3	9	17	36	55	-
25°	$\overline{\Delta T}$	0.3	0.1	0.2	0.4	0.8	1.0	1.7	*1.7*
	$\overline{\Delta H}$	3	5	7	9	19	44	52	-
35°	$\overline{\Delta T}$	0.2	0.2	0.2	0.5	0.7	1.1	1.7	*1.6*
	$\overline{\Delta H}$	4	6	8	9	19	31	52	*168*
45°	$\overline{\Delta T}$	0.1	0.2	0.3	0.6	0.9	1.3	1.7	2.8
	$\overline{\Delta H}$	2	4	9	11	24	41	59	*100*
55°	$\overline{\Delta T}$	0.3	0.4	0.2	0.5	1.0	1.1	1.8	2.2
	$\overline{\Delta H}$	2	5	3	9	25	44	61	*78*
65°	$\overline{\Delta T}$	0.7	0.5	0.2	0.6	1.1	1.4	1.4	1.7
	$\overline{\Delta H}$	4	3	12	22	32	48	67	*100*
75°	$\overline{\Delta T}$	0.3	0.4	0.1	0.5	1.0	1.4	2.4	*1.4*
	$\overline{\Delta H}$	1	2	5	14	35	10	48	-
85°	$\overline{\Delta T}$	0.4	*-0.3*	-	*0.9*	*0.8*	-	-	-
	$\overline{\Delta H}$	*2*	-	-	*4*	-	-	-	-

Table 18.--Canadian "Sangamo" instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics represent best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)								
		700	500	300	200	100	50	30	20	10
-5°	$\overline{\Delta T}$	0	0	0	0	0.1	0.1	0.4	0.5	1.5
	$\overline{\Delta H}$	-1	-1	-1	0	1	3	13	22	68
5°	$\overline{\Delta T}$	0.1	0	0.2	0.4	0.6	0.8	1.1	1.4	1.9
	$\overline{\Delta H}$	1	2	3	7	14	23	37	53	91
15°	$\overline{\Delta T}$	0.3	0.4	0.4	0.4	0.7	1.1	1.3	1.4	1.3
	$\overline{\Delta H}$	4	7	17	17	28	39	49	55	65
25°	$\overline{\Delta T}$	0.4	0.5	0.5	0.5	0.7	0.9	1.4	1.4	1.2
	$\overline{\Delta H}$	8	13	18	27	26	37	48	66	74
35°	$\overline{\Delta T}$	0.3	0.5	0.7	0.6	0.9	1.2	1.2	1.3	2.2
	$\overline{\Delta H}$	9	14	19	25	27	44	49	62	90
45°	$\overline{\Delta T}$	0.2	0.1	0.5	0.2	0.8	1.1	1.0	1.0	0.4
	$\overline{\Delta H}$	2	6	8	18	32	50	62	83	71
55°	$\overline{\Delta T}$	-0.1	0.3	0.5	0.6	1.3	0.7	0.8	1.4	1.7
	$\overline{\Delta H}$	-2	-1	0	9	31	19	45	95	98
65°	$\overline{\Delta T}$	-0.3	0.1	0.6	0.9	1.0	0.9	1.3	1.4	1.0
	$\overline{\Delta H}$	-2	-2	3	11	22	36	54	71	102
75°	$\overline{\Delta T}$	-	-	-0.1	1.0	0.8	1.7	1.6	1.2	*1.3*
	$\overline{\Delta H}$	-	-	1	18	22	*42*	*65*	*63*	*116*

Table 19.--Chinese instrument. Values of mean $\overline{\Delta T}$ and mean $\overline{\Delta H}$ as functions of mean daytime solar elevation angle and of pressure level. Units are degrees Celsius and meters. $\overline{\Delta T}$'s are given on upper line, $\overline{\Delta H}$'s on lower line. Values in italics are best estimates based on small samples.

Solar elevation angle (degrees)		Pressure level (mb)					
		700	500	300	200	100	Higher levels missing
-5°	$\overline{\Delta T}$	-0.2	0.1	0	0.1	0	
	$\overline{\Delta H}$	-1	-3	-2	-5	1	
5°	$\overline{\Delta T}$	-0.2	-0.1	-0.4	-0.4	-0.2	
	$\overline{\Delta H}$	-1	-2	-7	-12	-16	
15°	$\overline{\Delta T}$	-0.1	-0.1	-0.5	-0.3	0	
	$\overline{\Delta H}$	0	-1	-5	-11	-15	
25°	$\overline{\Delta T}$	-0.1	0	-0.6	-0.2	0.1	
	$\overline{\Delta H}$	1	0	-2	-9	-13	
35°	$\overline{\Delta T}$	-	*-0.4*	-0.3	-0.4	0.4	
	$\overline{\Delta H}$	-	*2*	2	-6	-4	
45°	$\overline{\Delta T}$	-	-	-	-	*0.6*	
	$\overline{\Delta H}$	-	-	-	-	*-8*	
55°	$\overline{\Delta T}$	-	-	-	-	-	
	$\overline{\Delta H}$	-	-	-	-	-	
65°	$\overline{\Delta T}$	-	-	-	-	-	
	$\overline{\Delta H}$	-	-	-	-	-	
75°	$\overline{\Delta T}$	-	-	-	-	-	
	$\overline{\Delta H}$	-	-	-	-	-	

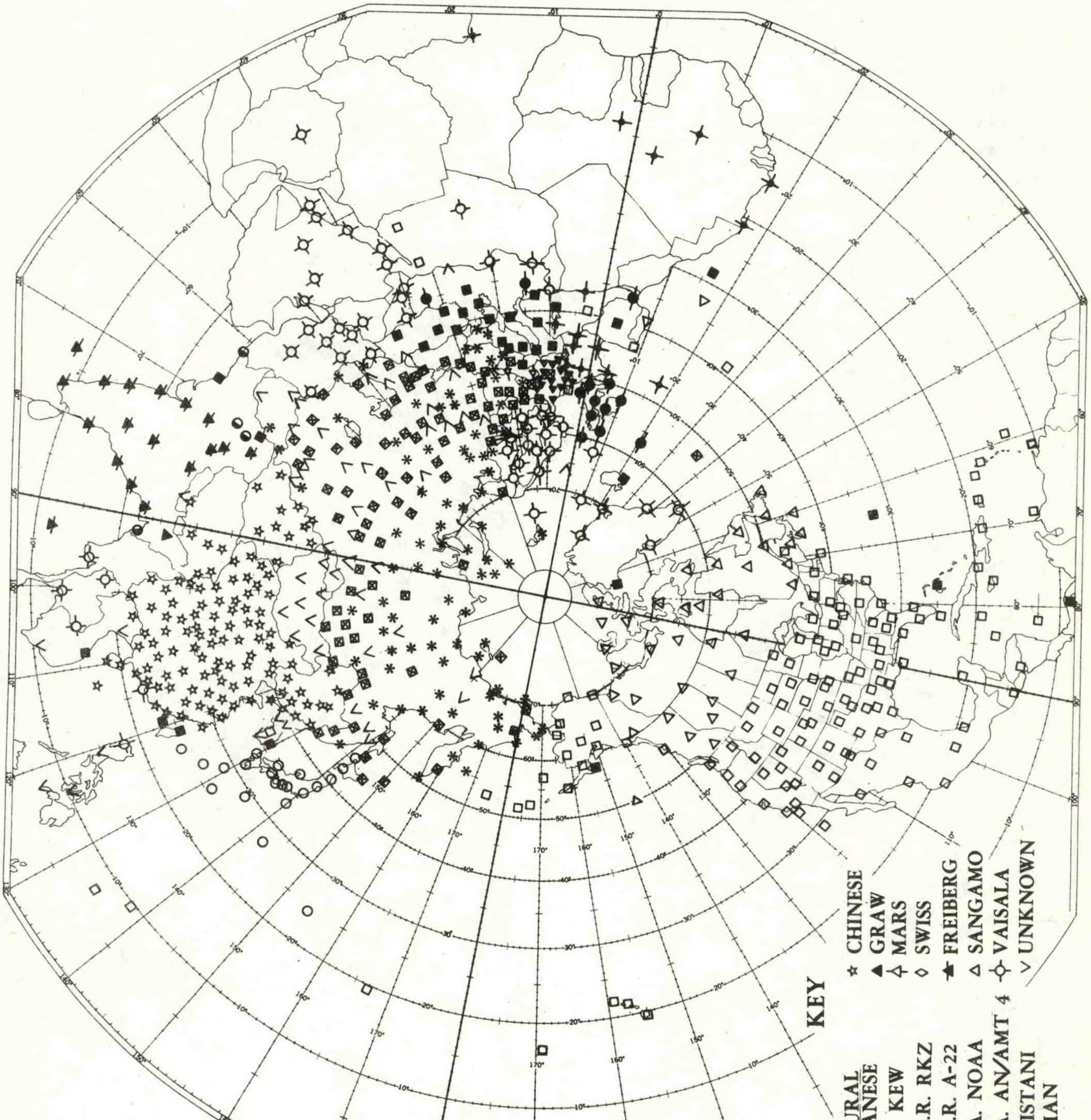


Figure 1.--Distribution of radiosonde instrument types throughout the Northern Hemisphere, as of July 1978. (This representation cannot be considered current because changes are continually taking place in the network.)

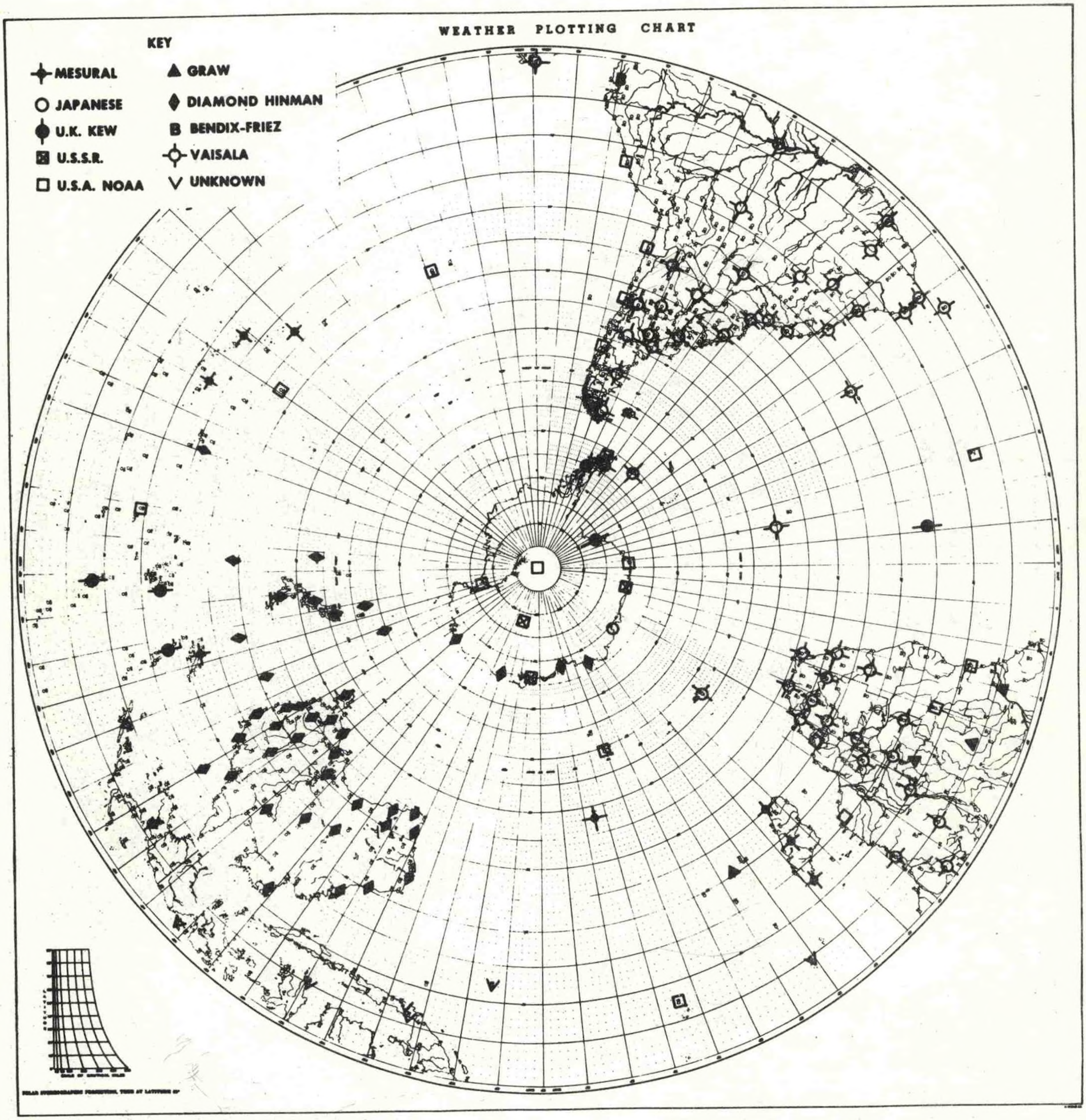


Figure 2.--Distribution of radiosonde instrument types over the Southern Hemisphere, as of July 1978. (Same caveat as for figure 1.)

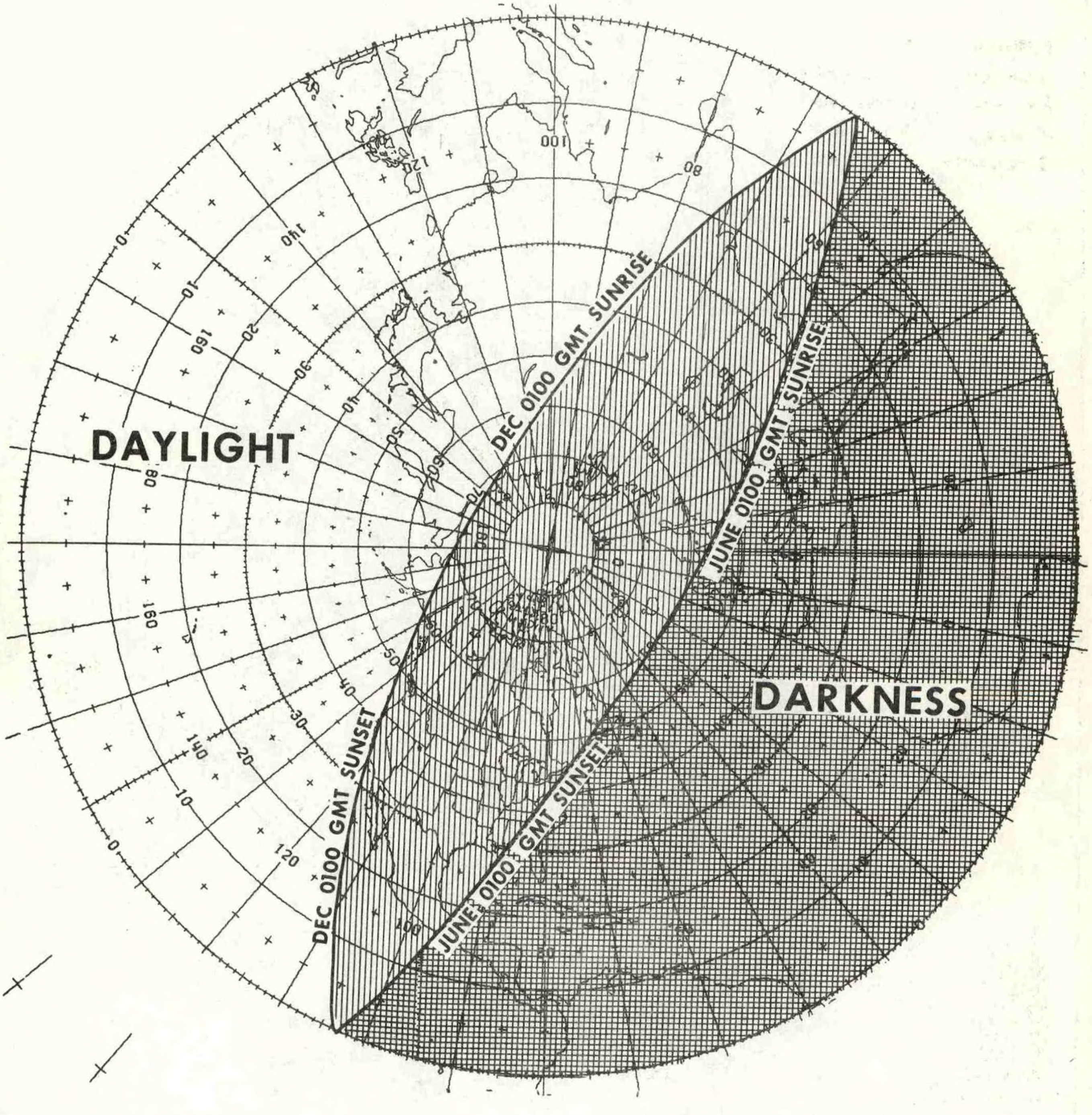


Figure 3.--Yearly migration of 0100 GMT sunrise line (for nominal 0000 GMT observations) at 10 mb.

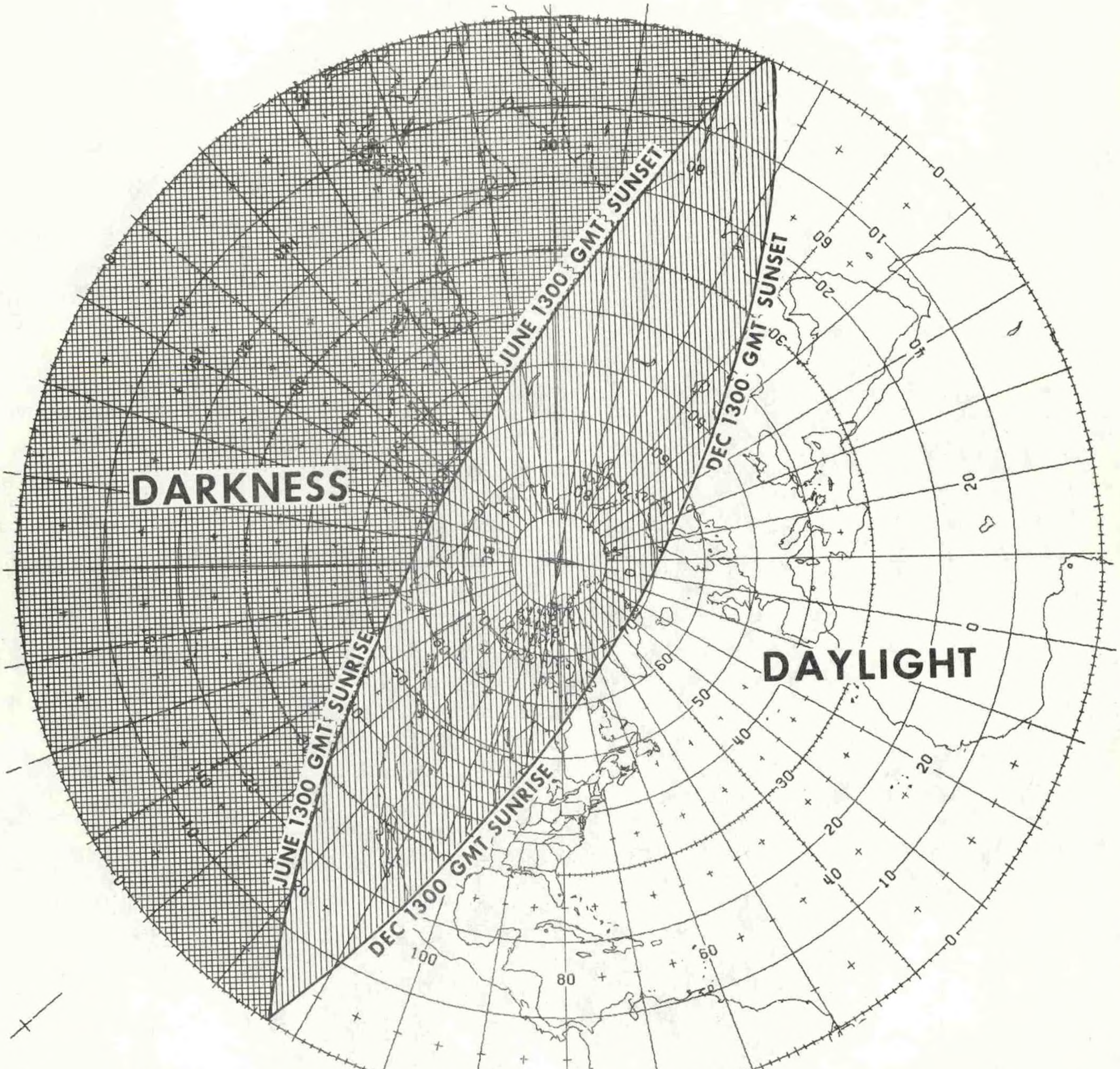
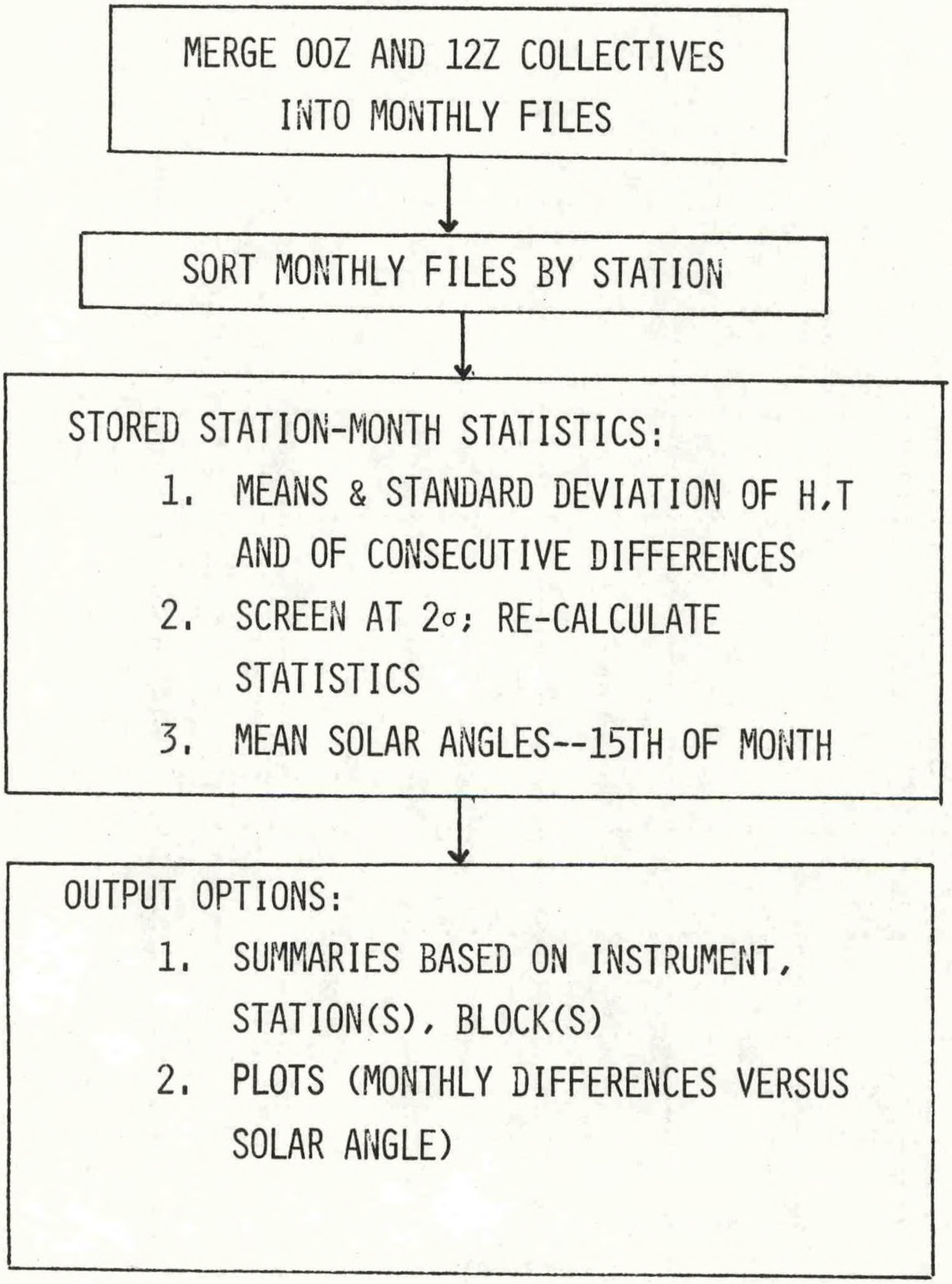


Figure 4.--Yearly migration of 1300 GMT sunset line (for nominal 1200 GMT observations) at 10 mb.



DATA PROCESSING--DAY/NIGHT DIFFERENCES

Figure 5.--Flow diagram for scheme of calculating day-night differences of temperatures and of geopotential heights.

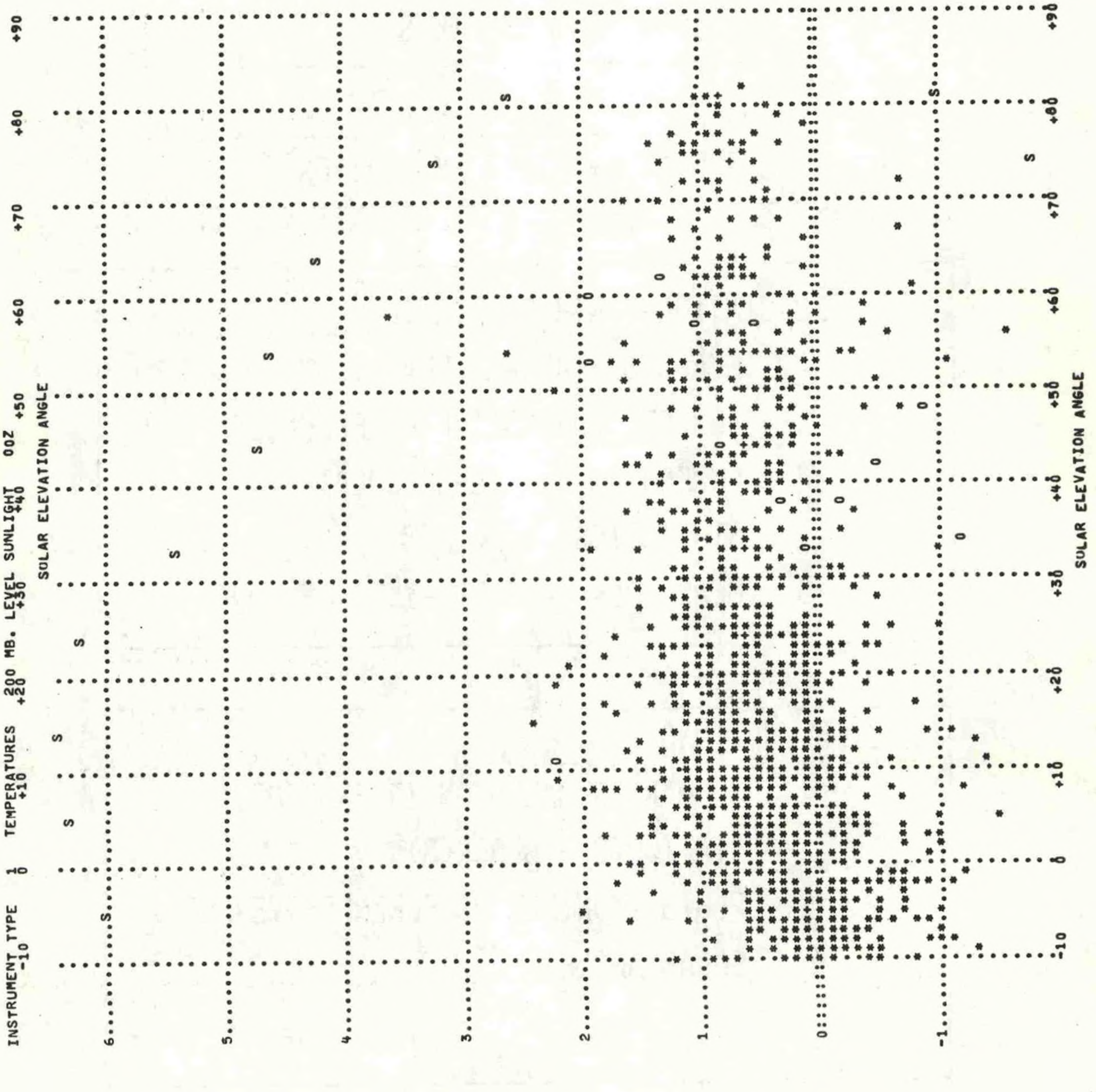


Figure 6.--Scatter diagram of $\overline{\Delta T}$ for the U.S. NOAA instrument (also known as the manufacturer's name VIZ) for 200 mb.

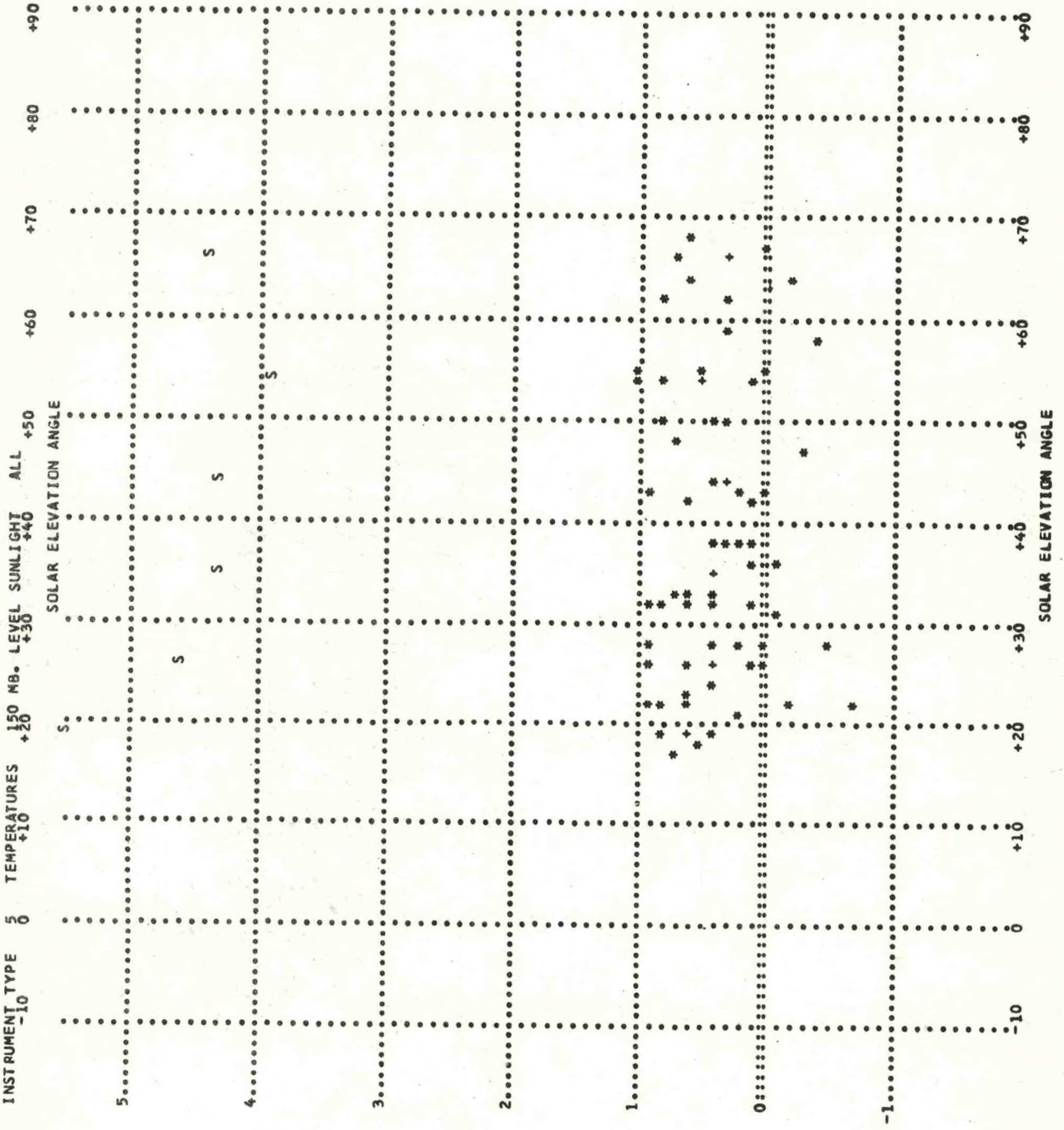


Figure 7.--Scatter diagram of $\overline{\Delta T}$ for the Mesural instrument used in metropolitan France, 150-mb level.

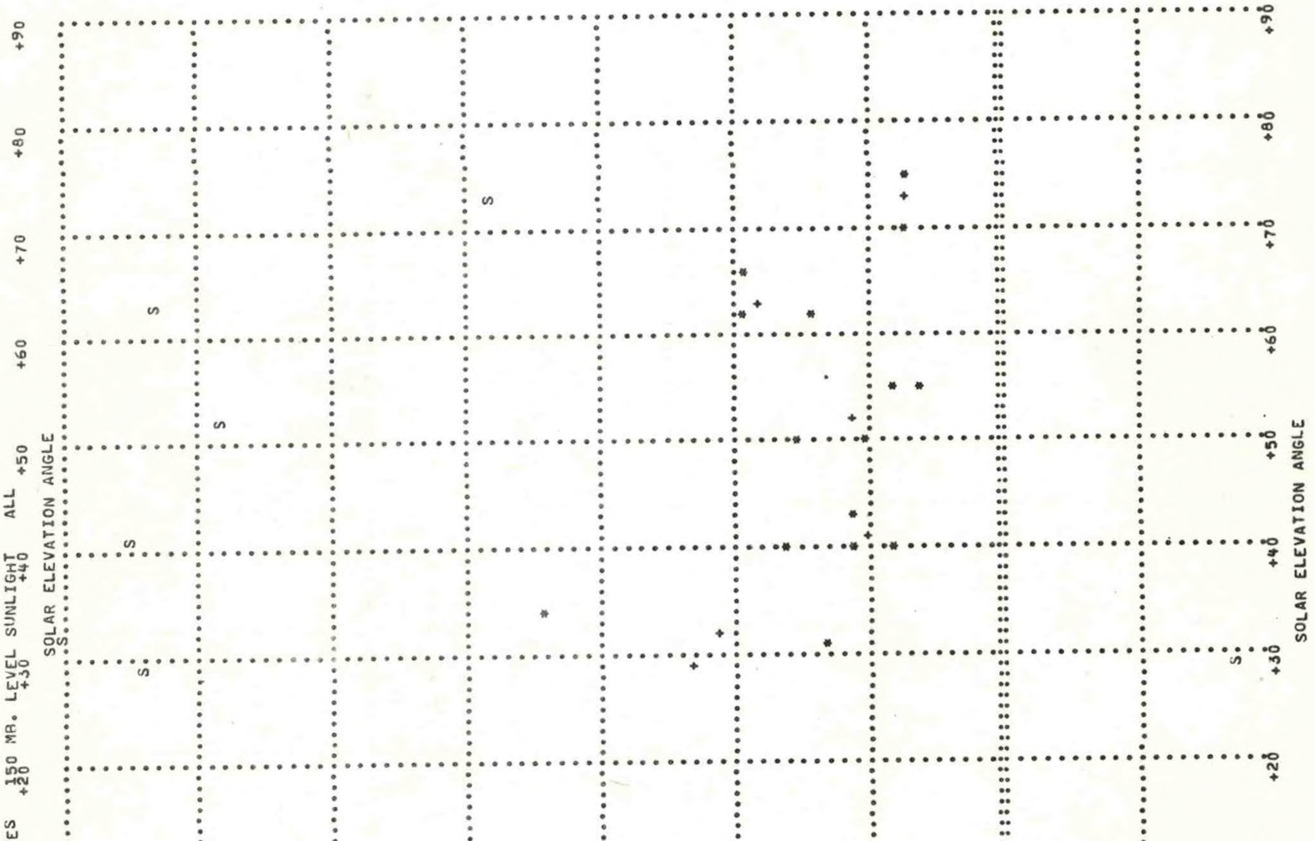


Figure 8.--Scatter diagram of $\overline{\Delta T}$ for the Mesural instrument used outside France, 150-mb level.

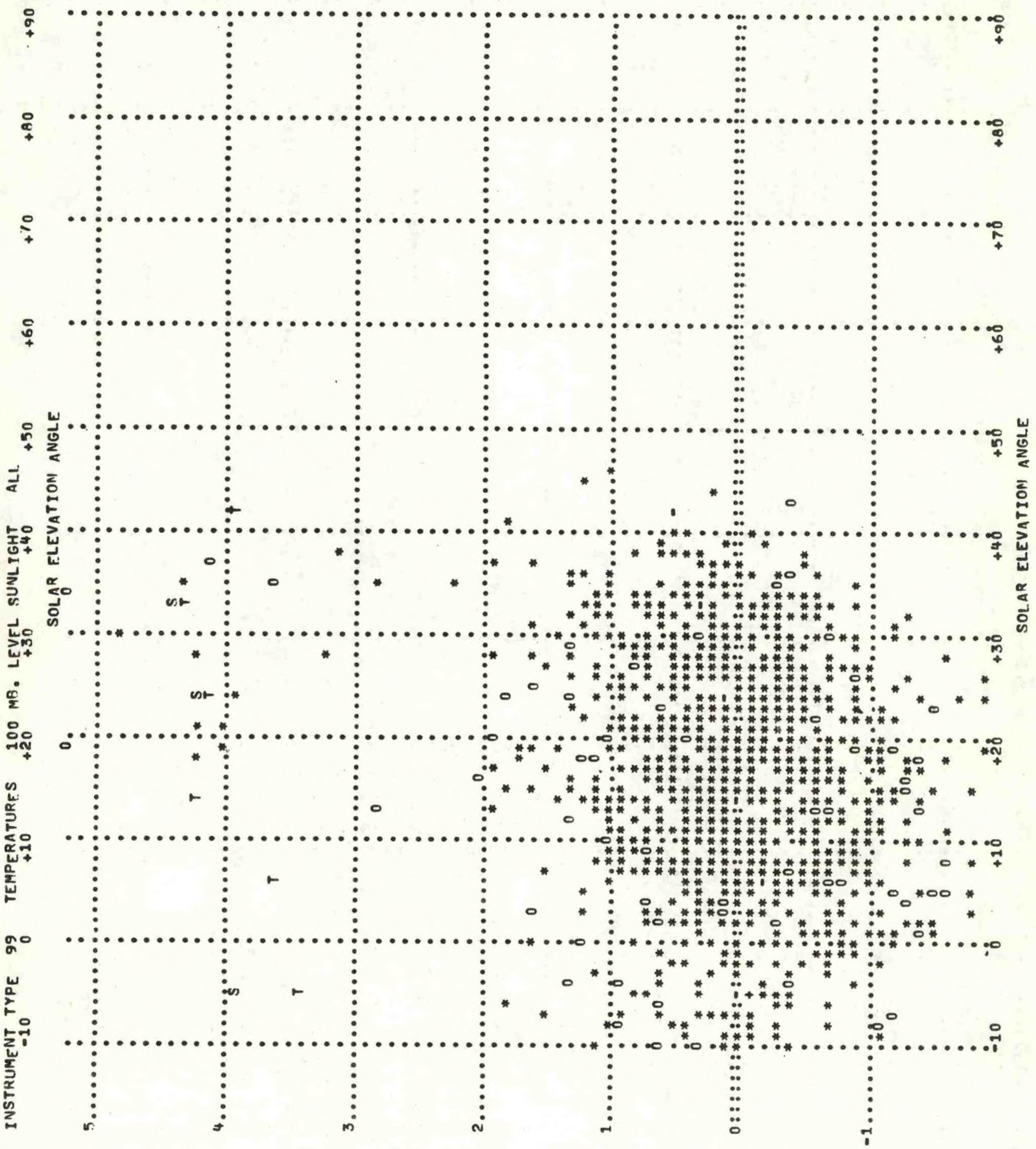


Figure 9.--Scatter diagram of $\overline{\Delta T}$ for the instrument used by the People's Republic of China, 100-mb level.

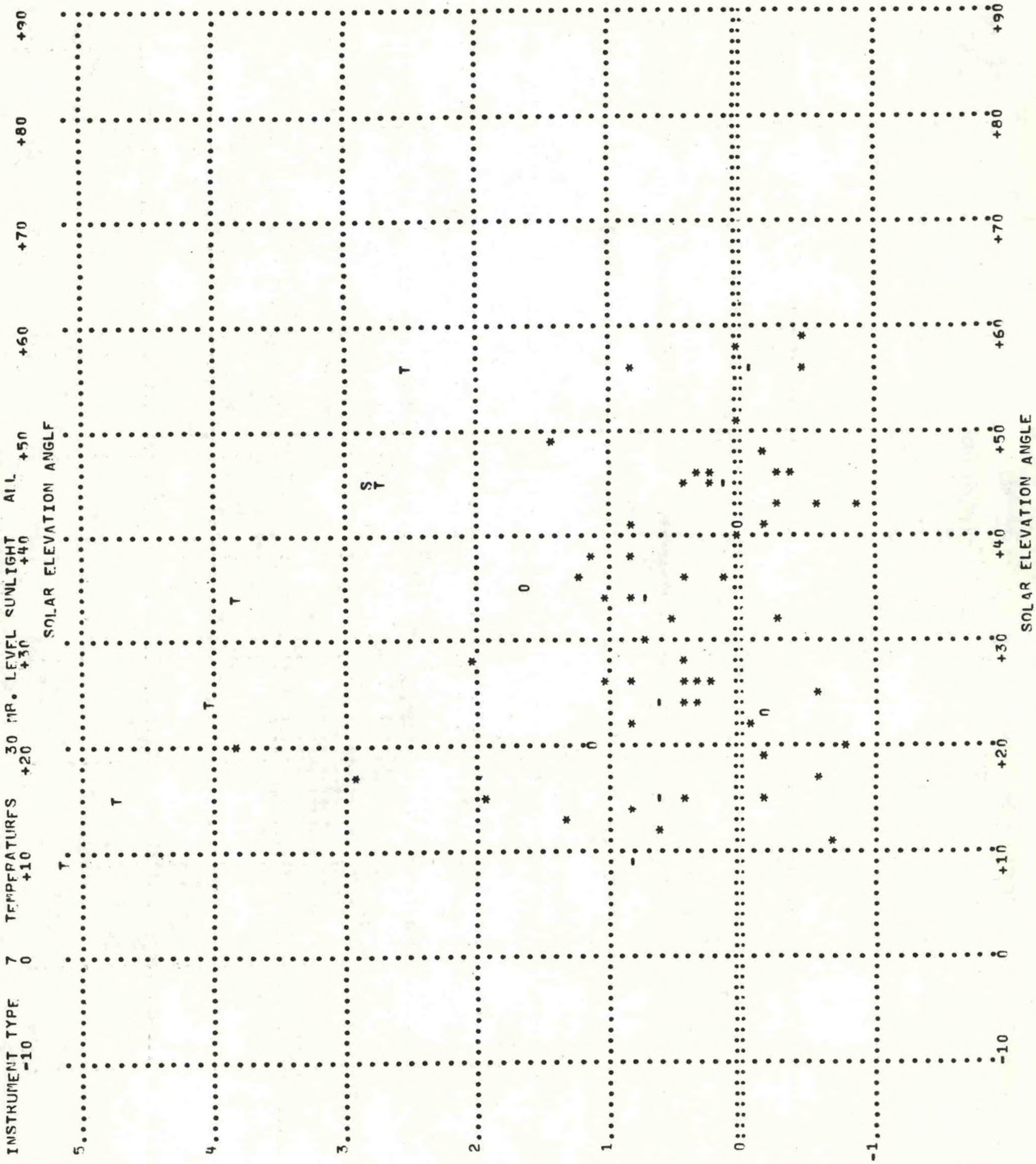


Figure 10.--Scatter diagram of $\overline{\Delta T}$ for the West German radiosonde, 30-mb level.

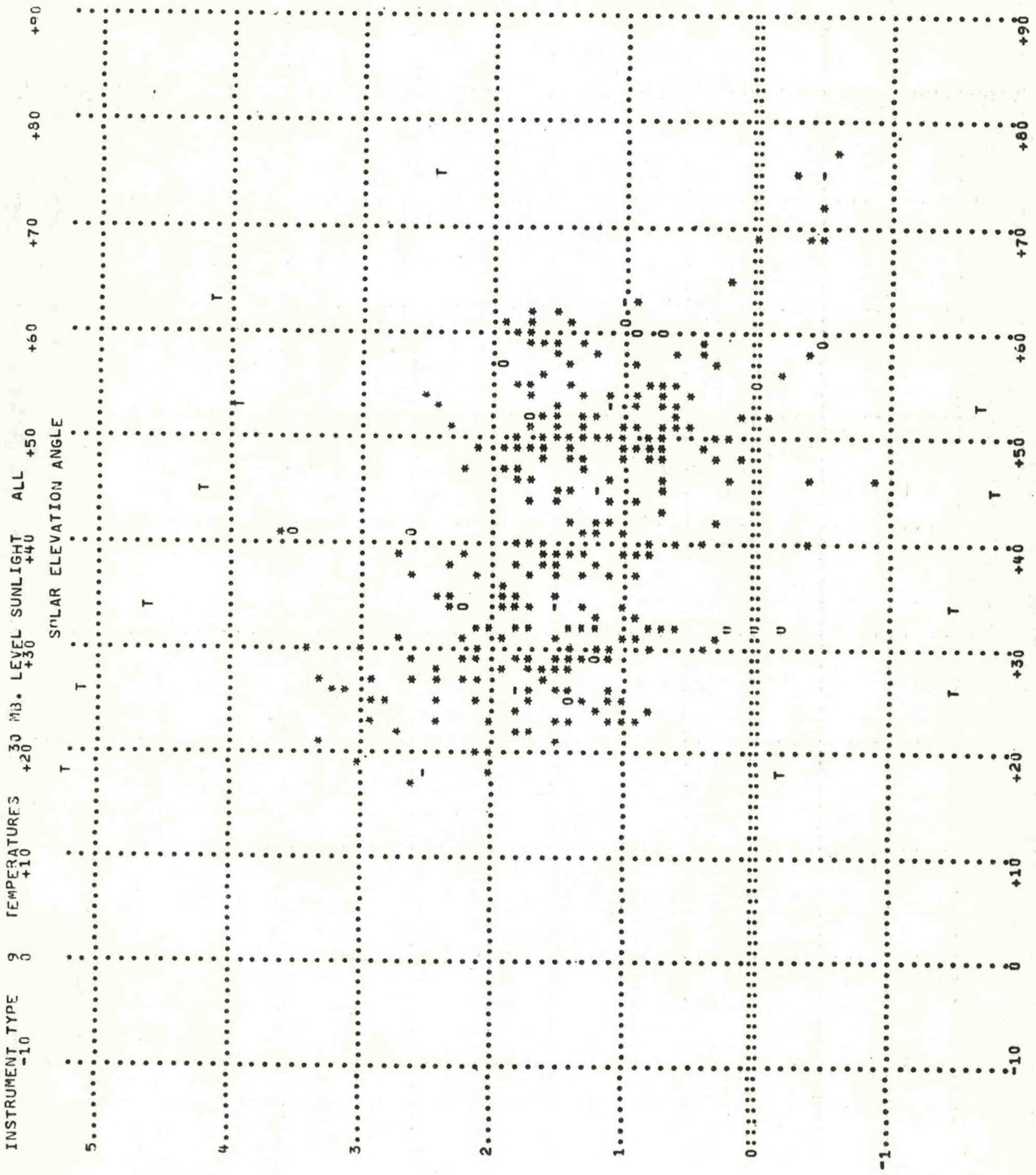


Figure 11.--Scatter diagram of $\overline{\Delta T}$ for the Japanese "code sending" radiosonde, 30-mb level.

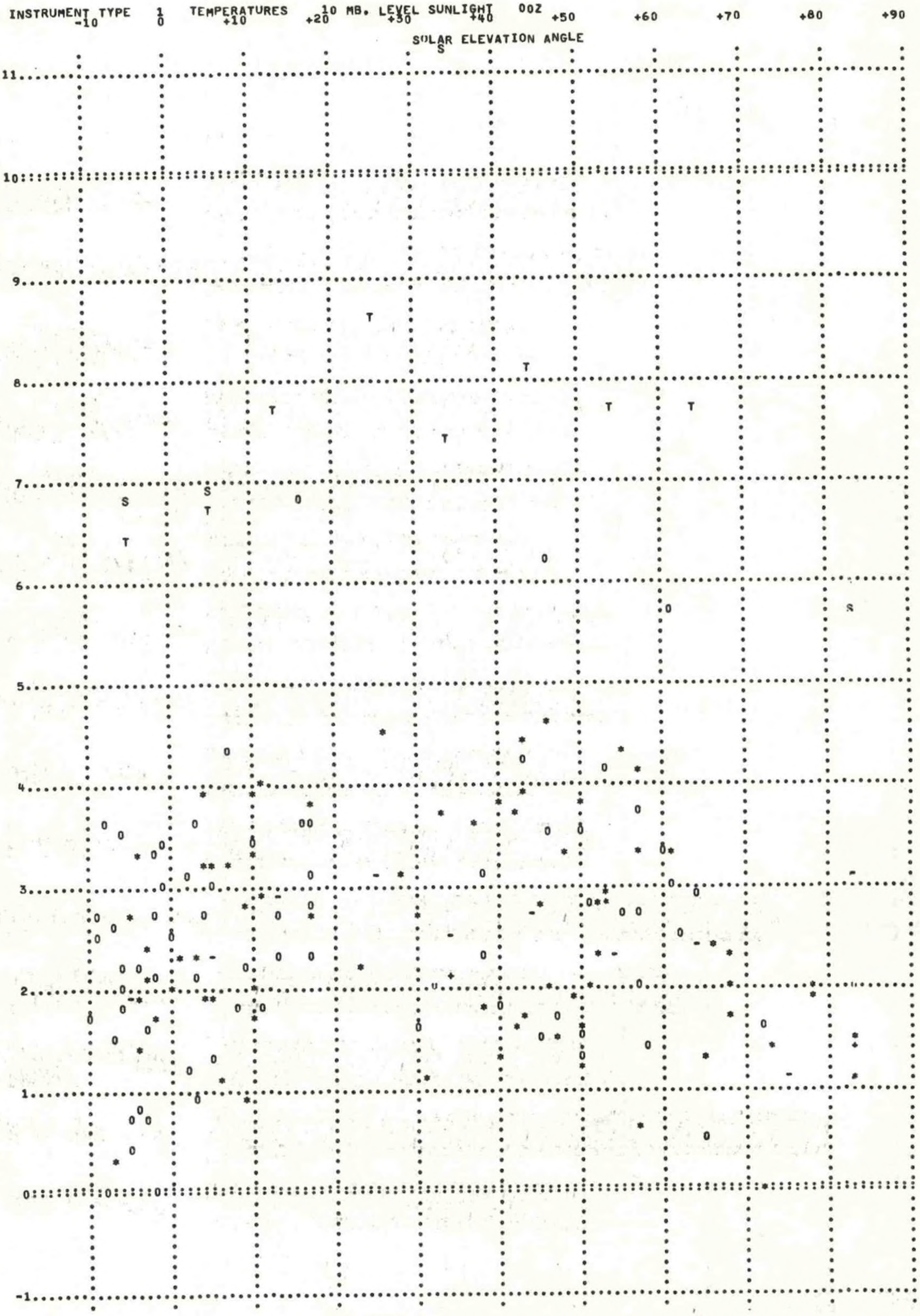


Figure 12.--Scatter diagram of $\overline{\Delta T}$ for the U.S. NOAA (VIZ) instrument, 10-mb level.

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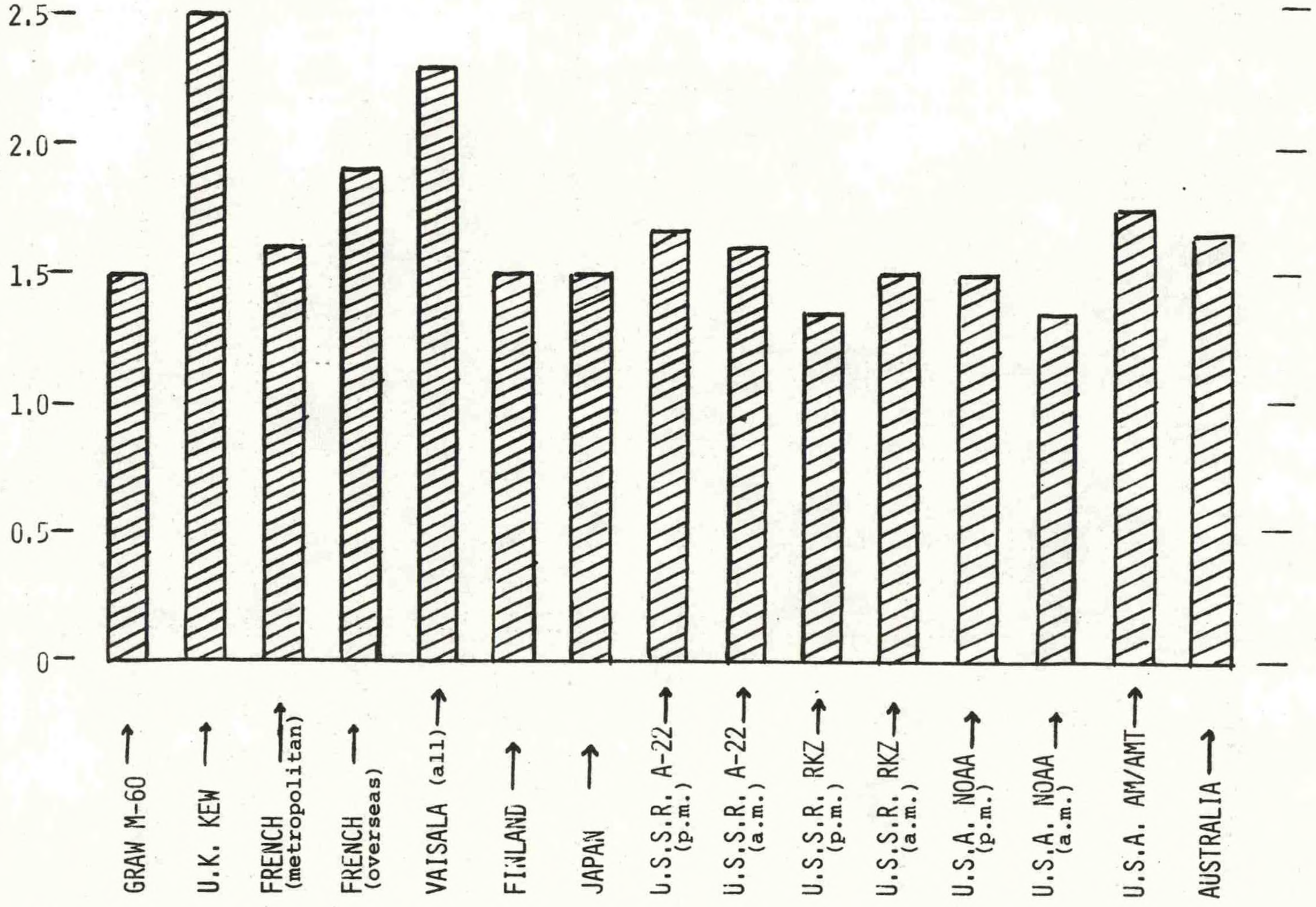

Figure 13.--Mean standard deviations of day-night temperature differences at 30 mb.

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