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Chile Site Survey
Technical Report No. 2

ASTRONOMICAL OBSERVING CONDITIONS IN NORTH-CENTRAL CHILE

By

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May, 1963
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ASTRONOMICAL OBSERVING CONDITIONS IN NORTH-CENTRAL CHILE

I. INTRODUCTION.

In Technical Report No. 1, hereafter referred to as TR 1, various means of site testing were discussed. An ideal survey would incorporate all methods explained in that report. However, many of the ideas expressed in TR 1 were actually a result of experiences gathered during this survey. Also, as will be explained in the history of the survey, its task developed during the program from a small-scale operation to the search for the optimum site in Chile.

The choice of Chile was based on its meteorological conditions, which were known to be superior to those encountered in South Africa or Australia. Due to Chile's location west of the Andes, it was expected that the meteorological and astronomical conditions would also be superior to those in Argentina.

II. CLIMATOLOGY OF CHILE.

It is not the intent of the author to give a complete climatology of the country. Only those factors that have been important for the selection of the sites will be discussed.

Chile extends from latitude 18°S to latitude 56°S. The latitude dependence of the general weather conditions is very pronounced, as the following brief table of annual rainfall shows:

TABLE I. ANNUAL RAINFALL

Station	Latitude	Rain
Iquique	20°.4 S	2 mm
Antofagasta	23.6	8
Copiapó	27.4	27
La Serena	29.9	130
Santiago	33.4	350
Concepción	36.8	1300
Puerto Montt	41.5	1950
San Pedro	47.6	4485

The data in Table I were supplied by the Meteorological Service of Chile. However, they are not in agreement with our own observations. More recent data, including our own, seem to indicate that for the past 10 years the average rainfall at Copiapó has been of the order of 10 mm, while for La Serena a value of 50 mm per year was obtained.

For South and Central Chile the winter is the rainy season, while for the extreme north of the country, particularly at high elevations, precipitation occurs more frequently during the summer. The same latitude dependence is exhibited by the cloudiness. During the winter there is a general decrease of cloudiness with decreasing latitude. During the summer, minimum cloudiness seems to occur around latitude 30°S.

The remarks made so far concerning cloudiness actually refer to nighttime clouds. There is a very pronounced diurnal effect in the cloudiness, particularly during the summer. Convective clouds form over the high mountains during the afternoon and vanish with sunset. In addition, coastal stratus exists during practically the entire year, with a tendency to move inland during the night and to retreat, at times even off the coast, during the day. The top of the coastal stratus is always below 1000 m. However, in the valleys it may penetrate over the land during the night by as much as 100 km.

The last remarks make it clear that, besides the latitude effect, there is a strong dependence of the climate on the elevation and on the distance from the coast. This behavior is borne out, for instance, by the diurnal temperature range. In Copiapó (elevation 380 m., distance from coast 60 km) and in Vicuña (elevation 600 m., distance from coast 55 km) the diurnal temperature range is about 20°C. In La Serena the temperature may stay constant during the day and the night in case the coastal fog persists all the time. In case the fog lifts, the temperature may vary by 10 to 15 degrees centigrade. On the other hand, on isolated mountains with elevations between 2000 m. and 3000 m. the diurnal range is of the order of 6° to 7°C. It is evident that the elevation and also the distance from the coast greatly affect the amount of rain.

During clear-weather periods the wind shows characteristic features depending on location and time of the day. From mid-morning until late in the afternoon, the wind is out of the west, and is particularly strong at low levels. In valleys extending east-west, the afternoon wind may blow with a speed of as much as 35 miles per hour. The velocities of daytime wind are considerably less at the 2000 m. to 3000 m. level. During nighttime a breeze out of the east is observed at low levels, while on mountain sites the wind at night is 90% of the time out of the north or northeast, the remaining 10% with wind out of the south. Other wind directions do not occur. During bad-weather periods, a southwesterly wind is observed at low levels, while at high levels the wind is then always out of the north.

The wind at night also shows a latitude dependence. This effect can be seen from our own data presented in a later section. The same impression is confirmed by airline pilots, who also have remarked that the area around 30°S latitude is the calmest of the country. Precise data on this phenomenon, however, are not available.

The relative humidity at sea level shows little seasonal variation, while at high elevations it undergoes characteristic changes with the seasons. If confined to clear weather periods, then at the 2000 to 3000 m. level the average relative humidity during the summer is of the order of 50% or more, and during the winter below 20%, while of course during bad weather periods it reaches saturation. Thus during the summer, although exhibiting large irregular variations, the relative humidity always stays at moderate values, while during the winter either extreme dryness - at times less than 5% - or high humidity are experienced.

The foregoing paragraphs make it clear that Chile possesses a great variety of climates, lacking only the moist-tropical conditions. The most favorable conditions for an astronomical observatory evidently will be found in the northern half of the country, and at an intermediate elevation.

III. HISTORY OF THE SITE SURVEY IN CHILE.

In April of 1959 the author - at that time a member of the University of Texas - went to Chile to organize a site survey. A reasonably good site for a modestly equipped 60-inch telescope in the vicinity of Santiago was envisioned at that time. Three sites were picked out in the general neighborhood of Santiago:

Cerro Robles (2200 m.) in the coastal mountain range,
Alto del Toro (2300 m.) in the Andes,
Cerro Colorado (3100 m.) in the Andes.

Haze-layer records collected by airline pilots indicated that a temperature inversion frequently occurred up to 1800 m. elevation. This fact led to the choice of elevation of the sites. The only other consideration taken into account was the accessibility.

Two 10-cm refractors, on loan from the Observatorio Astronómico Nacional de La Universidad de Chile, and with rather sturdy equatorial mountings, were available for image-motion measurements. Thermo-hygrographs for climatological studies were erected on all three sites.

During the first phase of the survey the observations were carried out entirely by personnel of the Observatory of the University of Chile. Guillermo Romero was in charge of the observing groups at first, and later Carlos Torres.

In August of 1959 the author returned to Chile for a second short stay. Five major steps were taken at that time:

(a) Cerro Colorado was removed from the program because of severe winter conditions.

(b) The erection of a 13-inch reflector on loan from the Yerkes Observatory was carried out on Alto del Toro. The telescope was supposed to be used for extinction studies, since it was equipped with a photoelectric photometer, and as a standard comparison instrument for seeing measurements.

(c) It was necessary to select a substitute for Cerro Robles because a powerful transmitter was planned for this site. Cerro Tabaco (2200 m.), a site near Cerro Robles, was chosen. Since it was not certain whether the radio transmitter would be erected, the studies of Cerro Robles were continued also.

(d) With the growing interest in the project, it was felt that the future observatory might not be a very modest one. A search for an optimum site, without the condition for easy access or nearness to Santiago, came into consideration. Better sites were more likely to be found in the north of Chile. After consideration of a number of sites chosen from maps up to 29°S latitude, Cerro Guamayuca (2200 m.) near Vicuña (latitude 30°S) was selected. It was clear that there were better sites in the same general area. However, they were too far from roads to make operation possible with the funds available at that time.

(e) The Yale and Columbia Universities were starting a test program in Chile, and coordination with their activities was arranged.

In February of 1960 the author took over the direction of the site survey in Chile. The experience gained so far on Guamayuca was such that soon all activities on the sites near Santiago were discontinued, and the entire survey was concentrated in the Vicuña area. Here many new sites were inspected, and the following ones added to the program:

Cerro Tololo	2200 m.	(7200 ft.)
Cerro Morado	2200	(7200 ft.)
Cerro Blanco	2700	(8850 ft.)

The map in Figure 1 shows the location of these sites. The actual test program on Cerro Tololo began in May of 1960. Work on Cerro Blanco was initiated in October of the same year, and on Morado in February of the following year.

In April of 1960 the image-motion refractors were replaced by double-beam telescopes of 10 cm. apertures and 165 cm. beam separation. A third double-beam telescope was added in August of 1961. The first two double-beam telescopes were built by Charles Riddell in Williams Bay, Wisconsin, the third by Boller & Chivens, South Pasadena, California.

During the course of the work in the Vicuña area, Guamayuca was eliminated for a number of reasons: (1) seeing conditions were found inferior to those on Tololo, (2) the surface of Guamayuca is rather small, and (3) easterly wind during the later part of the night is rather frequent on Guamayuca during periods when it is practically calm on Tololo. This condition is probably due to the location of Guamayuca right in the bend of the valley of the Elquí river, and its nearness to a considerably higher mountain (Cerro Negro de Vicuña, 3100 m.)

Work on Cerro Morado was discontinued after a comparison with Cerro Tololo showed that both sites have practically the same seeing conditions. There were two reasons, however, which led us to believe that, with very refined tests, Morado might prove to be slightly inferior to Tololo. Certainly it could not have better conditions than Tololo. Cerro Morado is located a few kilometers south of Tololo, and the prevailing wind at night is out of the north. Thus Morado might experience some slight turbulence caused by Tololo. Furthermore, Morado is a rather large flat-top mountain, several kilometers long, and about 500 m. wide. During calm nights, of which there are many, an inversion may build up over the plateau, although we were unable to prove its existence. Also, Morado forms an east-west barrier of long extension for the north wind, and thus it may have, locally, higher wind speeds than Tololo, which is an isolated peak. Until further tests are made, however, these objections are hypothetical, and it is entirely possible that Morado is as good a site as Tololo.

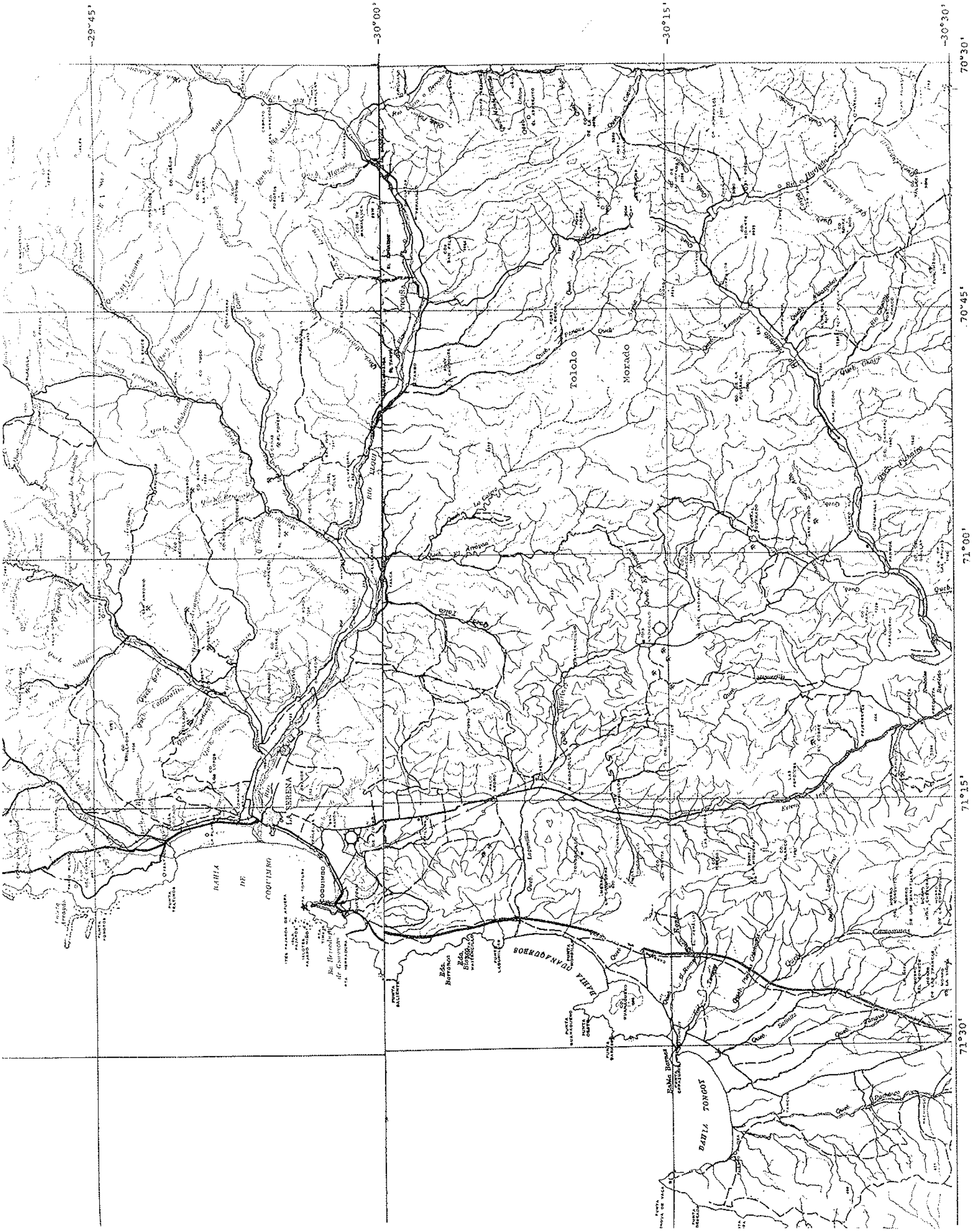
-29°45'
-30°00'
-30°15'
-30°30'
70°30'
70°45'
71°00'
71°15'
71°30'
Tololo
Morado
RIO ELQUI
LA SERENA
BAHIA DE COQUIMBO
COQUIMBO
BAHIA GUANAQUEROS
BAHIA TONGOY

FIGURE 1

Cerro Blanco had to be eliminated because of rather severe winter conditions. Snow cover lasting for months made access by pack animals impossible for long periods. The seeing during the summer seems to be superior to the conditions on Tololo, but wind speeds were about 50% higher.

Since September of 1961 only Cerro Tololo was left on the program in the Vicuña area. A 16-inch reflector with a photoelectric photometer was erected on this site in July of 1961. Since September of the same year this telescope has served for seeing tests and comparisons, as well as for an active program of photoelectric photometry.

It was always thought possible to find better conditions than those on Tololo farther to the north, although latitude considerations set a practical limit not far north of Vicuña. On the other hand, the very pronounced latitude dependence of cloudiness suggested that one might find still a considerable improvement by going only a degree or two in latitude to the north. In December of 1960 the Copiapó area was inspected by air, as well as sites near Vallenar. Cerro Checo (2400 m.) near Copiapó looked like a promising site. It was put on the program in February of 1961. However, providing access to the mountain and acceptable living conditions on the mountain proved to be difficult. Therefore, actual observing could not start until July of 1961. It was soon evident that, at least during the winter, this area had considerably less cloudiness than the Vicuña area. However, the occurrence of dust and haze made it desirable to choose a higher site. Cerro La Peineta (altitude 3100 m, or 10,200 ft) was chosen in December of 1961, and observations on that site started one month later.

The experience of the first few weeks on La Peineta showed that the seeing there was not distinctly different from Tololo, but the wind was considerably stronger on La Peineta than on Tololo. A more precise comparison of the wind velocities between La Peineta and Tololo - and as well Cerro Checo - became desirable. Two recording anemometers were installed in April of 1962, one on La Peineta, the other on Tololo. The comparison between La Peineta and Checo was made by using a precision hand anemometer on Checo. This instrument had been used also to intercompare and calibrate the two recording anemometers. The results of the comparison of wind velocities between Checo and La Peineta, which shall be presented in a later chapter, indicated that Checo was, during the winter, practically as windy as La Peineta, and therefore it was eliminated from the program.

Thus during the last phase of the survey the only problem left was the comparison between La Peineta and Tololo. An attempt was made to get the 13-inch reflector in operation on La Peineta. A large number of defects in the telescope and its drive system made it impossible to get the telescope ready on time. It could be used for only a few seeing observations, and it was not possible to get information on the extinction on La Peineta.

The ideal procedure would have been to rotate all observers and all instruments over all sites a number of times. Transportation problems made this course difficult. Also, some of the instruments arrived rather late during the survey. Furthermore, there was more change in the observing personnel than was desirable, as may be seen from the following Table II, which lists the observers and their observing periods:

TABLE II. LIST OF OBSERVERS

PAUL KUIPER (Tololo, Blanco, Checo, Peineta) August 1961 to May 1962 - full time.	358 obs.
WILLIAM MATHIAS (Tololo, Blanco, Morado, Checo) June 1961 to September 1961 - full time.	48 obs.
HUGO MORENO (Tololo) May 1962 to October 1962 - part time.	248 obs.
FERNANDO RICHARDS (Checo, Peineta) July 1961 to June 1962 - full time.	212 obs.
GUILLERMO ROMERO (Alto del Toro, Robles, Colorado, Guamayuca) April 1959 to April 1960 - part time.	48 obs.
JURGEN STOCK (all sites) February 1960 to October 1962 - full time.	551 obs.
CARLOS TORRES (all sites) May 1959 to May 1962 - part time. June 1962 to October 1962 - full time.	751 obs.
HERBERT WROBLEWSKI (Alto del Toro, Robles, Tabaco, Tololo) December 1959 to May 1960 - part time.	
ALVARO VALDIVIA (Alto del Toro, Robles) January 1960 to April 1960 - part time.	36 obs.

Carlos Torres and the author have the most extensive observing records and hence the comparison of the final sites is primarily based on their data.

IV. DISCUSSION OF THE OBSERVATIONAL MATERIAL

As explained in the foregoing section, the final task of the survey was a comparison of Cerro Tololo with Cerro La Peineta. The discussion of the data will be concentrated on this comparison. Results referring to other sites will be presented only in a more general way.

(1) The Seeing:

The primary objective of the seeing observations was a comparative study of the sites under consideration, in order to find the best site for an astronomical observatory in Chile. A comparison with other parts of the world, as well as a comparison of the data obtained with the survey equipment with seeing observed through large telescopes was equally important, but the latter could form part of the survey program only to a small extent. A few comparisons with sites in California were attempted, as well as a comparison with the Kitt Peak National Observatory. The latter program is still underway

A comparison of image motion, as measured with small-aperture telescopes, with image diameters as estimated in large telescopes, was carried out first by Tripp, Rohlfs, Bertiau, and the author in 1957 at the Boyden Observatory in South Africa. The material is unpublished. Image motion was measured in various small telescopes, while the 60-inch reflector yielded the large-aperture image diameters. A similar comparison was made by the author in 1959 at the McDonald Observatory, with a 10cm refractor and the 82-inch reflector. The results obtained may be summarized by the expression:

$$D = 2\,m' \qquad (1)$$

where D = seeing image diameter computed for large aperture,

m' = image motion observed with a single small-aperture telescope.

The subsequent discussion will be facilitated by the following definitions:

d_i = image diameter observed through a small-aperture objective;

d_n = natural image diameter given by a small-aperture telescope; i.e. perfect seeing image diameter;

d = seeing image diameter for small aperture telescope;

m'' = relative image motion observed through a double-beam small-aperture telescope.

Furthermore, D_o, d_o, m'_o, and m''_o are the values of D, d, m', and m'' reduced to the zenith.

A comparison of relative image motion, as measured with the double-beam telescope, with the Mt. Wilson 100-inch telescope, the Mt. Palomar 200-inch telescope, and the Lick Observatory 120-inch telescope was attempted in 1960 by Torres, Golson, and Mathias. The results remained rather inconclusive because the observing runs were too short, involved too many different observers at the large telescopes, because of lack of experience of the observers with the double-beam telescope, and because of serious optical defects of the latter. Nevertheless, a fair correlation between the double-beam telescope seeing and the large telescope seeing was found, as shown in Figure 2A.

Far more satisfactory comparisons were made in Chile itself. Figure 2B shows a direct plot of relative image-motion estimates, m'', made with the Boller and Chivens double-beam telescope (estimates made by P. Kuiper or C. Torres) versus image-diameter estimates made simultaneously at the 16-inch reflector by J. Stock. Each point in the figure represents one simultaneous observation at the two telescopes. The accuracy of both estimates is of the order of 0".2. Hence most of the scatter shown in Figure 2 is due to observational scatter. The natural or diffraction limited image diameter, d_n, of the 16-inch reflector is 0".35, as is also shown by Figure 2 (the mean line does not go through zero).

A similar run of observations was made by C. Torres using the same double-beam telescope versus the 13-inch reflector on La Peineta. The result is shown in Figure 3. In this case the diffraction-limited size of the image in the 13-inch telescope has been removed by:

$$d^2 \doteq d_i^2 - (0''.38)^2, \qquad (2)$$

with 0".38 being the natural image diameter, d_n, of the 13-inch telescope. The graph shows a plot of d versus m''.

A few additional observations were obtained by the author on Kitt Peak, by comparing relative image motion measured in another double-beam telescope made by Boller & Chivens, with image diameters estimated in the Kitt Peak 36-inch reflector. The three observations obtained are shown in Figure 2 as crosses. These points are of low weight, due to imperfect optics of the 36-inch reflector.

All observations just mentioned lead to the same conclusion, namely

$$D = 1.5\ m''. \qquad (3)$$

Theoretically, one expects

$$m'' = \sqrt{2}\ m'. \qquad (4)$$

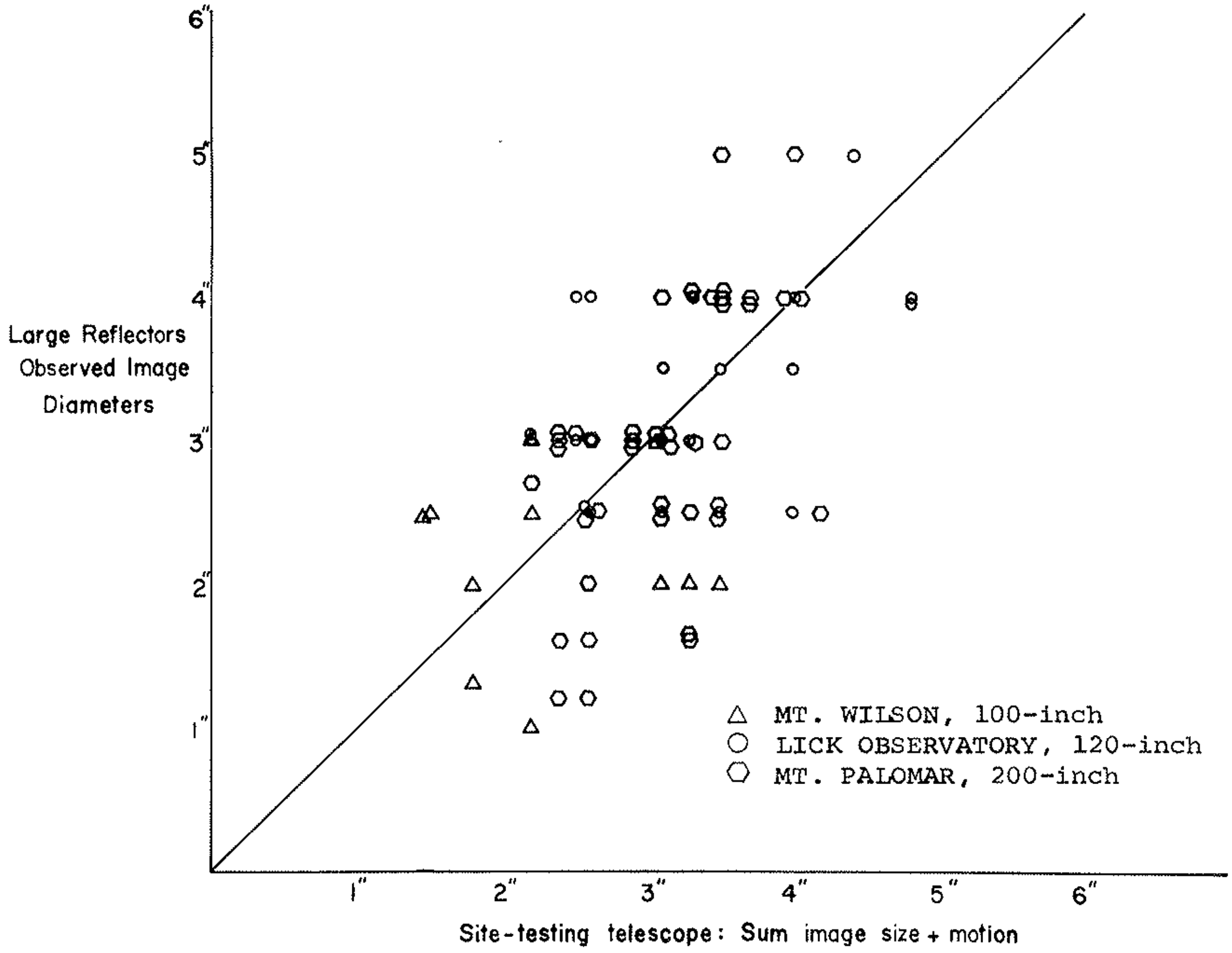

Figure 2A: Comparison of image diameters estimated with a double-beam telescope and with large reflectors.

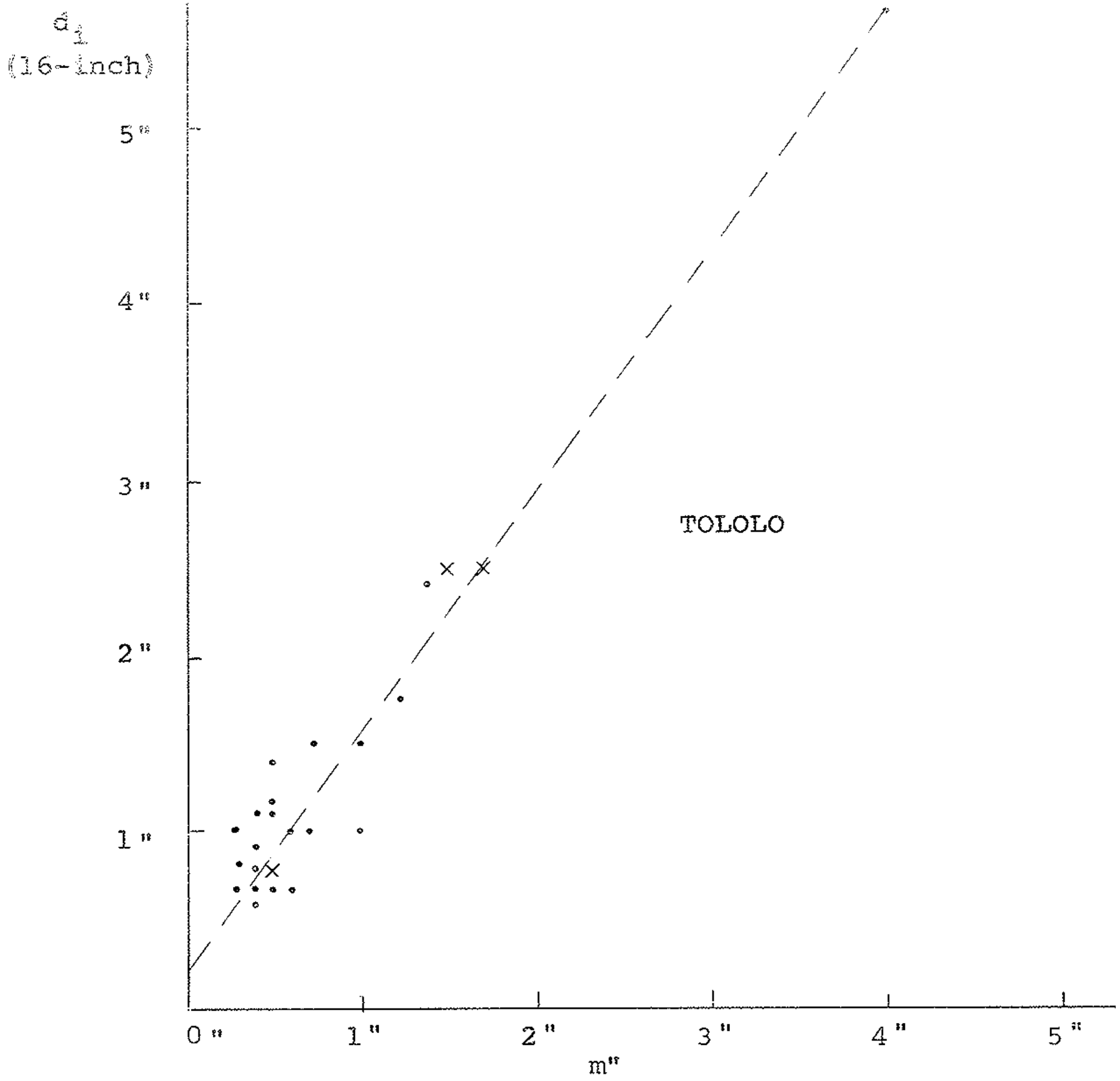

Figure 2 B. Plot of relative image motion measurements, m", made with the Boller & Chivens double-beam telescope by P. Kuiper, J. Stock, or C. Torres versus simultaneous image-diameter estimates, d_i, made at the Cassegrain focus of the 16-inch reflector on Tololo by J. Stock. Also shown (by crosses) are three pairs of observations made on Kitt Peak by J. Stock, observing m" with another double-beam telescope, and image diameters d_i with the 36-inch reflector.

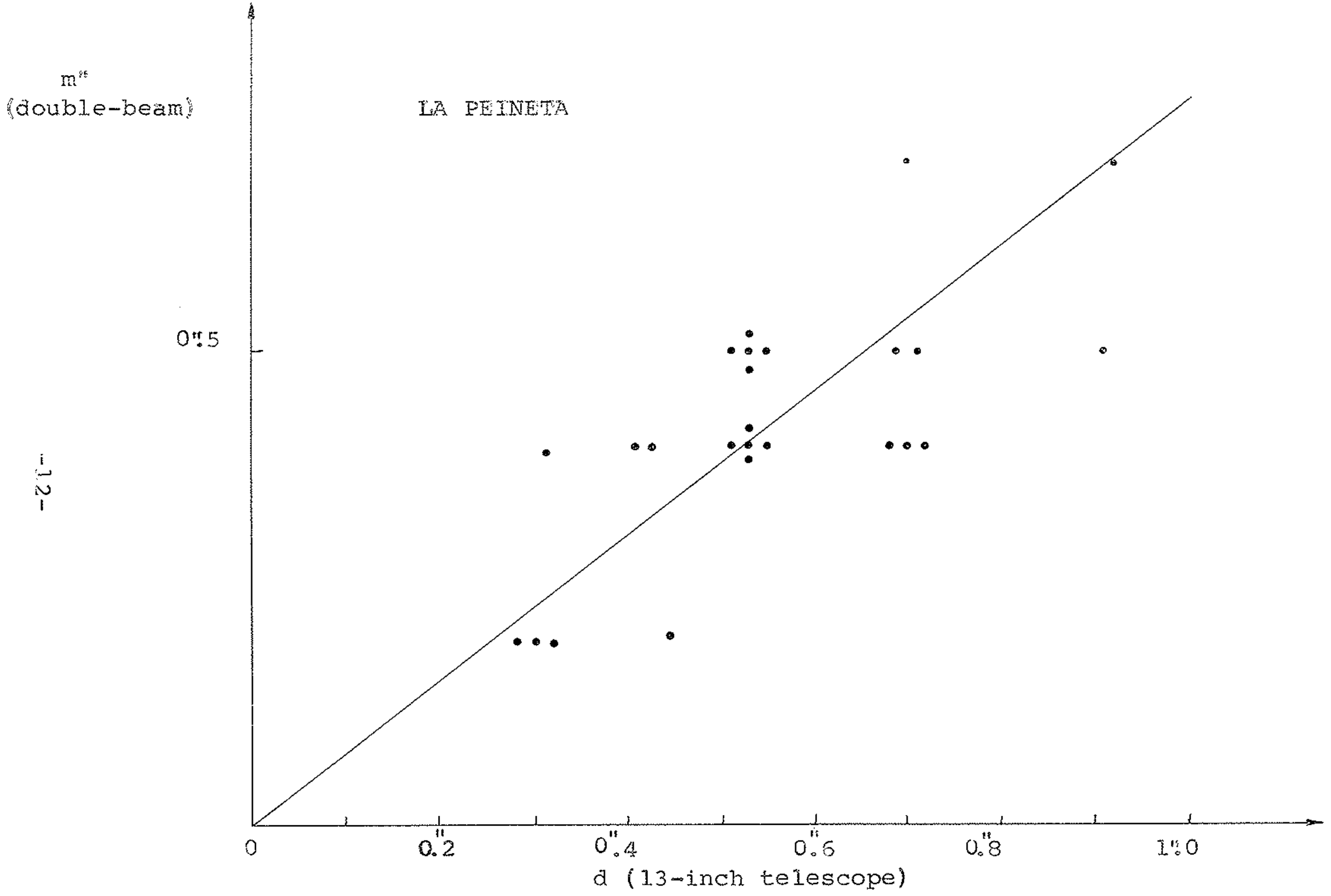

Figure 3. Comparison of relative image motion estimates made with the Boller & Chivens double-beam telescope, with seeing disk diameters estimated at the Cassegrain focus of the 13-inch reflector on La Peineta. Both components were observed by C. Torres. The diffraction component was removed from the image diameters according to equation (2).

A comparison of equations (1) and (3) shows that this expectation is nearly the case. Another conclusion may be derived at this point. Apparently the 16-inch seeing on Tololo, and the 13-inch seeing on La Peineta, are of the same order as large-aperture seeing. Otherwise, the relation given in equation (3), whose derivation involved observations with these two telescopes, would not hold. Equation (1) was derived with observations involving really large telescopes, namely a 60-inch and an 82-inch reflector. One may conclude, therefore, that large, optically effective, turbulent elements are rare on these two sites in Chile. In view of this result, it seems justified to incorporate into the reductions of the seeing observations made in Chile either equation (1), or equation (3), depending on the nature of the observation. Thus it is expected that the final seeing data derived will give the image diameters that would be observed with telescopes of large apertures. For telescopes of intermediate aperture, the diffraction-limited image size will have to be added when using equation (2) of TR 1.

As already stated, the seeing data for the sites in the vicinity of Santiago were all obtained with single-aperture instruments, by estimating image motion. From these, the average value of D_o was calculated by means of the expression

$$D_o = 2\frac{m'}{\sqrt{\sec z}} \qquad (5)$$

The empirical expression given in equation (1) was incorporated in this equation. The average values of D_o for three sites in the Santiago area are listed in Table III.

TABLE III. AVERAGE SEEING DISK DIAMETERS, SANTIAGO AREA

Station	$\bar{D}_o$	Number of Observations
Alto del Toro	1".68	249
Robles	1.30	230
Tabaco	1.32	31

The study of the seeing conditions on the sites in the north of Chile is, with the exception of a short period on Guamayuca, entirely based on estimates made with double-beam telescopes. To these were added, at a later phase, direct image-diameter observations made with the 16-inch telescope on Tololo. Seeing observations were made every two hours, if possible. After some experience it was found that it was not necessary to observe several stars in different parts of the sky. The seeing showed no dependence on the azimuth, and it showed the expected correlation with the zenith distance. From then on it was preferred to observe only one star each time, but spend a rather long time on it in order to check on variability of the seeing. This procedure allowed us to pick out the most conveniently located stars, which made the observations easier and probably more accurate. Also, because of the usually rather small seeing effects, it was preferred not to observe stars too close to the zenith.

As already mentioned, observations were made at two-hour intervals, on the average. For this purpose the night was divided into two-hour periods, and observations were made in the middle of each period. For the statistical analysis, each observation was given a weight representing the length (in hours) of the interval in the middle of which the observation was made. In no case was a weight of more than 3 given. This weighting is necessary in order to prevent some nights, which for experimental purposes had many seeing observations, from entering the statistics with too large a weight. Also, a night in which the observations are spread more apart than usual, will thus enter the statistics with the same weight as another night with the same length but having observations spaced closer than usual.

The possibility of a seasonal variation of the seeing conditions - which in fact seems to exist - makes another adjustment of weights necessary in order to arrive at the actual overall distribution of the seeing during a year, or even during a period of several years. An appropriate way is to sum up the weights for each month, and then to adjust them such that their total corresponds to the total number of clear hours during that month. If this is not done, a month with more-than-average observing activity will have an undue effect on the final statistics.

The problem of intercomparing the seeing conditions at various sites is illustrated by Table IV, which gives the average image diameter for five different times on Tololo. These intervals comprise roughly summer and winter.

TABLE IV.
AVERAGE SEEING VALUES FOR TOLOLO FOR DIFFERENT TIMES

Time Interval	$\bar{D}_o$
May 1960 - September 1960	$1\overset{\prime\prime}{.}00$
October 1960 - April 1961	1.66
May 1961 - September 1961	1.12
October 1961 - April 1962	0.90
May 1962 - September 1962	0.46

The data of Table IV are all based on seeing measures made by the author.

The comparison of Tololo with Morado and Blanco was made during the period of October 1960 to April 1961, when the seeing was particularly poor on Tololo. Morado, being very near Tololo and having the same elevation, certainly suffered from the same effect, and the data showed that the seeing on both sites is practically the same. The comparison between Tololo and Blanco indicated that the latter had considerably better seeing conditions. However, optical defects in the older double-beam telescope used on Blanco led us to believe that the difference might not be real. A new attempt was therefore made, in October 1961, with simultaneous observations on both sites. The observers were P. Kuiper and J. Stock. The Boller & Chivens newer double-beam telescope was used this time on Blanco. The results indicated identical seeing conditions on both sites, namely, averages of 1".10 for Tololo and 1".12 for Blanco. The higher wind velocities, and the rough winter conditions on Cerro Blanco, then led to the decision to abandon this site.

The comparison between La Peineta and Checo was carried out by P. Kuiper from January until March of 1962, with alternating use of the Boller and Chivens telescope at the two sites. This instrument was found to be the most reliable and precise telescope for seeing measurements, apart from the 16-inch reflector. The latter could not very well be transferred to La Peineta or Checo, because of the transportation difficulties. Thus simultaneous observations with two good telescopes were not possible. Although P. Kuiper found an average seeing value (D_o) of 0".64 for La Peineta and 0".52 for Checo, the difference is too small to conclude that Checo has better seeing conditions than La Peineta. The main reason for selecting La Peineta as an alternative site for Checo was that the latter is often imbedded in rather dense haze, while La Peineta with 700 m. more elevation usually remains above the haze. Wind speeds were rather low during the period when the comparison was made, which if anything favors La Peineta (see Figure 2). Also, both sites are well isolated mountains, and they should not suffer from any effects caused by other nearby mountains, particularly if the prevailing wind direction is taken into consideration. These factors, together with the smaller total air mass over La Peineta, led us to expect that the latter compared to Checo would have better, or at least the same, seeing conditions. The difference found in the opposite sense is small and near the limit of what can be detected with the equipment used. At any rate, the difference found in favor of Checo was not considered to be sufficient to compensate for the cleaner atmosphere and the easier access to La Peineta. Thus it was decided to give up Checo in favor of La Peineta.

Before continuing the discussion of the intercomparison of seeing conditions on different sites, it is necessary to make a number of remarks of a more general nature. Attempts were made to correlate the seeing with meteorological conditions, but no close correlations were found. There is no correlation at all between the seeing and the wind speed, up to the limit of wind speed to which seeing observations could be made (about 20 mph). A rapid drop of the temperature was, however, almost always accompanied by inferior seeing. A sudden deterioration of the seeing was usually followed by the formation of high clouds. During rapid and long-lasting changes of the relative humidity (at times 20% per hour, or more) the seeing, at least, does not show very small values. On the basis of meteorological observations alone, one cannot safely predict the seeing, but one probably could estimate the probability for good or poor seeing. On the whole, it seems that the seeing is correlated with the stability or instability of the atmosphere, which usually, but not necessarily, shows up in the local meteorological conditions. It seems reasonable to conclude that the seeing is caused by a rather thick ground layer of the atmosphere, and not by the immediate surroundings of the telescope. Thus one can assume that, when the seeing is poor on one site, it will also be poor on other nearby sites. For this reason, comparisons of nearby sites have been restricted to simultaneous observations, or at least to observations made in the same period.

For the comparison of the seeing conditions on two sites as distant as Tololo is from La Peineta (about 300 km), one cannot safely argue that the observations should be made simultaneously. It is not even certain whether it is justified to restrict the comparison to observing periods in common. For a well-founded argument, more knowledge about the mechanism that creates turbulence cells with temperature inhomogeneities is needed, as well as information about the lifetimes of the cells, the direction and speed of displacements of large air masses, etc. The problem presented here is that for Tololo there are available 30 months of seeing observations, but for La Peineta only 10 months. Table IV shows how this problem arises. Obviously, the comparison comes out quite differently if for Tololo the entire observing period is considered, or the comparison is restricted to the observing period in common with La Peineta (January to October 1962). Although it is the author's opinion that the two sites are sufficiently close to justify a restriction to the shorter observing period common to both sites, the comparison will be presented for Tololo with the full as well as with the restricted material.

The seeing data may be presented in a number of ways. For example, as explained in TR 1 (page 20) they may conveniently be combined with cloud data. The distribution of the image diameters determined in 1962 by three observers is shown in Figures 4, 5, and 6 for both Tololo and La Peineta. In these Figures the abscissae give the image diameters calculated for telescopes of large aperture, and the ordinates the number of hours during which these diameters occurred (January to October 1962 only). These Figures correspond to Figures 4 or 5 of TR 1.

It is also of interest to know for what fraction of the clear periods the seeing was equal to or smaller than a given limit. Figures 7, 8, 9, and 10 give this fraction in percent, as a function of the limit, for four observers for both sites. In three of the figures for Tololo two curves are shown, one including the entire material, the other only the observations obtained in 1962.

It is important to emphasize that all the seeing data used refer to clear-sky periods only. During partly cloudy periods, observations were also made, but they are not included in the statistics. Also, it should be mentioned that no seeing data could be obtained when the wind was above 20 mph. This limitation is particularly important for La Peineta.

The following Table V lists the total number of seeing observations obtained on five sites.

TABLE V.

TOTAL NUMBERS OF SEEING OBSERVATIONS ON DIFFERENT SITES

Site	Number
Tololo	877
Morado	76
Blanco	139
Peineta	410
Checo	440

2. Cloudiness.

Different types of cloud observations have contributed to the statistics of cloudiness. When the stations were occupied, the observers made cloud cover estimates. In one case (Robles) a special cloud observer was maintained for nearly two years. Daytime cloud observations were also made from either Vicuña or Copiapó, in case the mountain sites in the area were not occupied. Since Copiapó in particular is often fog-covered at night, only some gaps in the daytime cloud data could be filled that way. A Photographic sky-watch camera, as suggested in TR 1 (page 32), was first used on Alto del Toro, then on Guamayuca, and finally on Checo. A second camera of this type came too late to contribute materially to the cloud data. In the analysis, highest weight

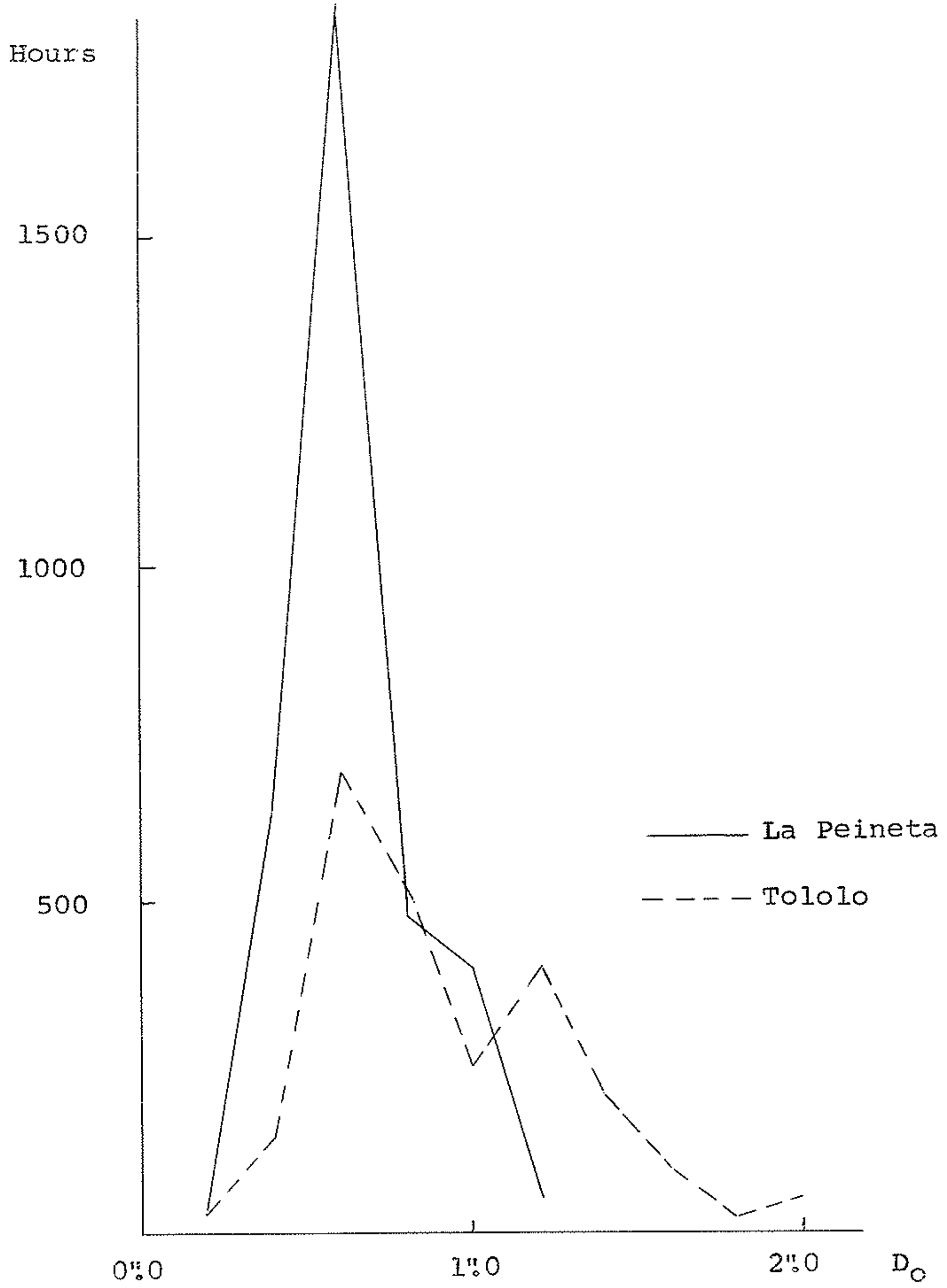

Figure 4. The distribution of seeing diameters D_c for Tololo and La Peineta, as observed from January to October 1962 by P. Kuiper. Abscissae are values of D_c, ordinates are the total number of hours during which these values occurred in the above period.

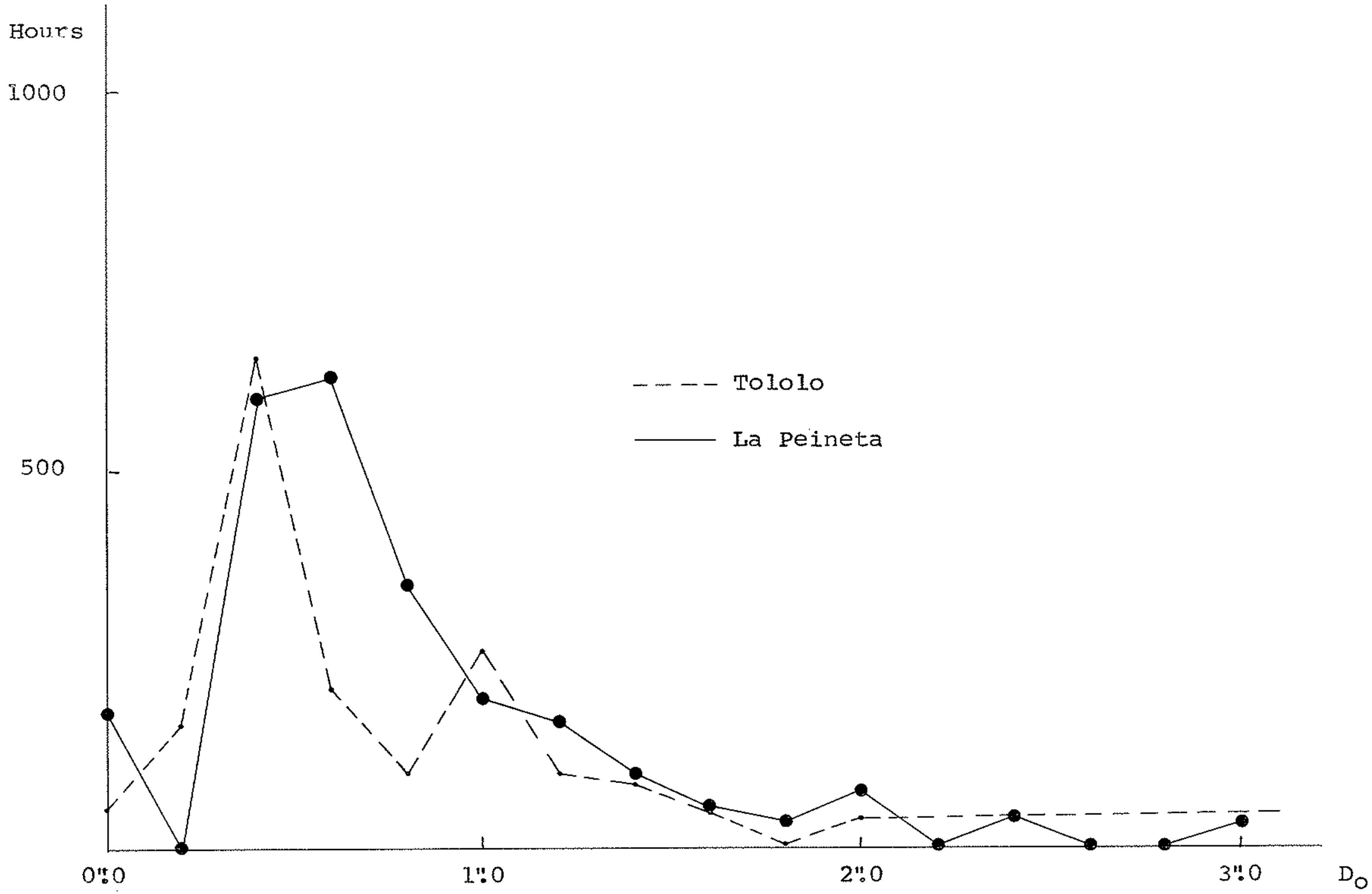

Figure 5. The distribution of seeing diameters D_o for Tololo and La Peineta, as observed from January to October 1962 by J. Stock. Abscissae are values of D_o, ordinates are the total number of hours during which these values occurred in the above period.

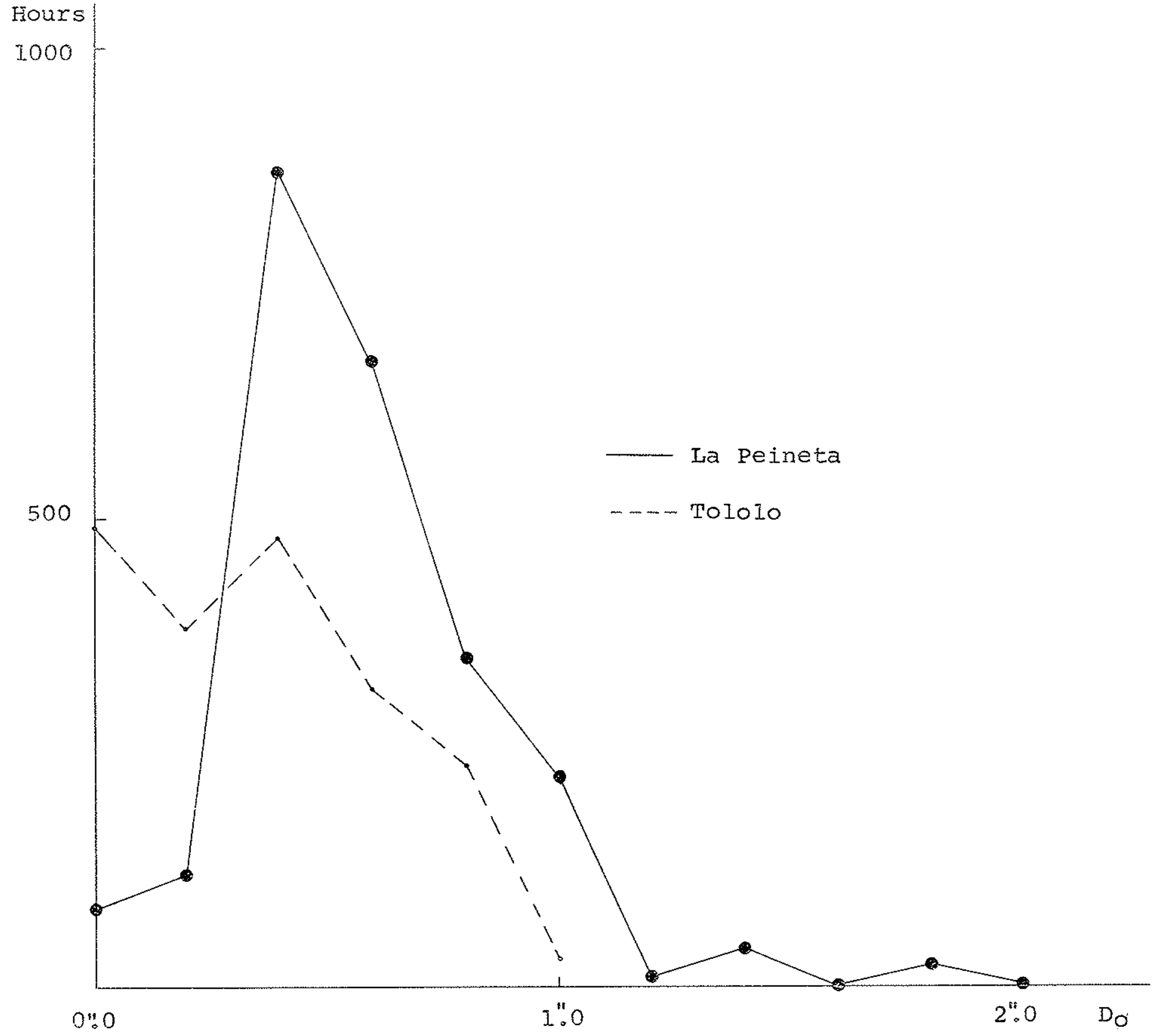

Figure 6. The distribution of seeing diameters D_o for Tololo and La Peineta, as observed from January to October 1962 by C. Torres. Abscissae are values of D_o, ordinates are the total number of hours during which these values occurred in the above period.

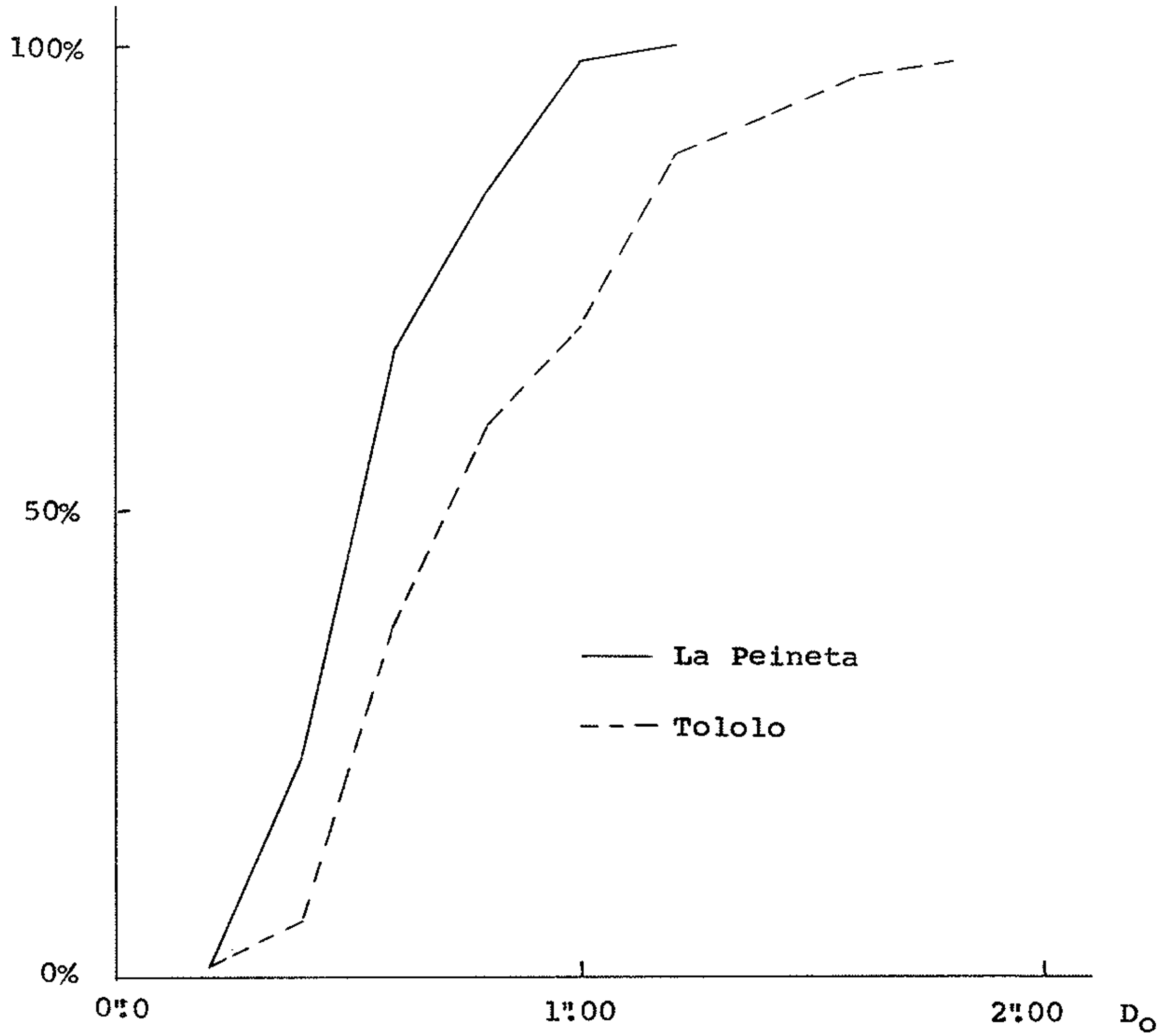

Figure 7. Cumulative, seeing-frequency diagram showing for what percentage of clear sky time the seeing diameter D_o was equal to or smaller than the value indicated by the abscissa. P. Kuiper observer.

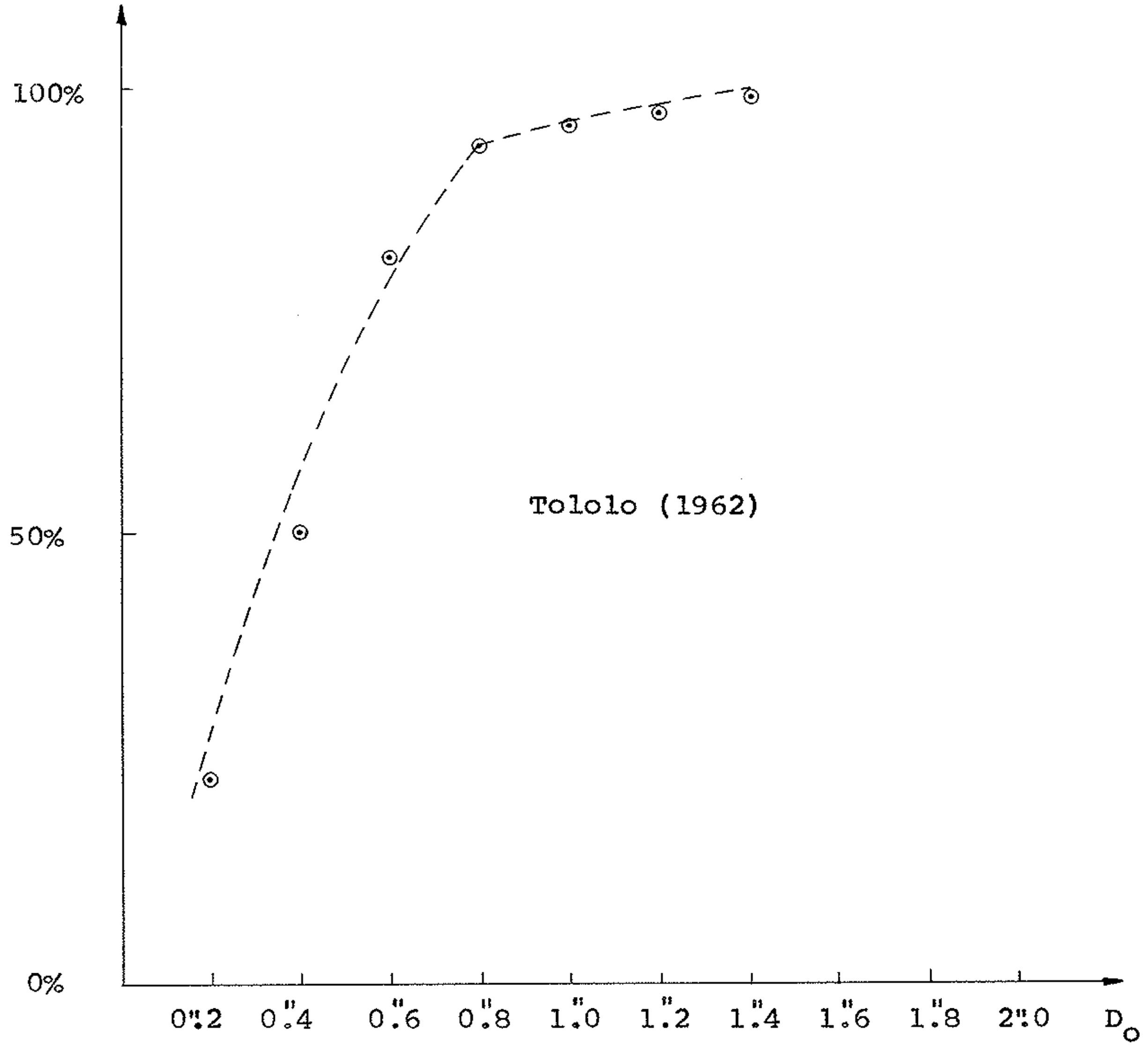

Figure 8. Cumulative, seeing-frequency diagram showing for what percentage of clear sky time the seeing diameter D_o was equal to or smaller than the value indicated by the abscissa. H. Moreno observer.

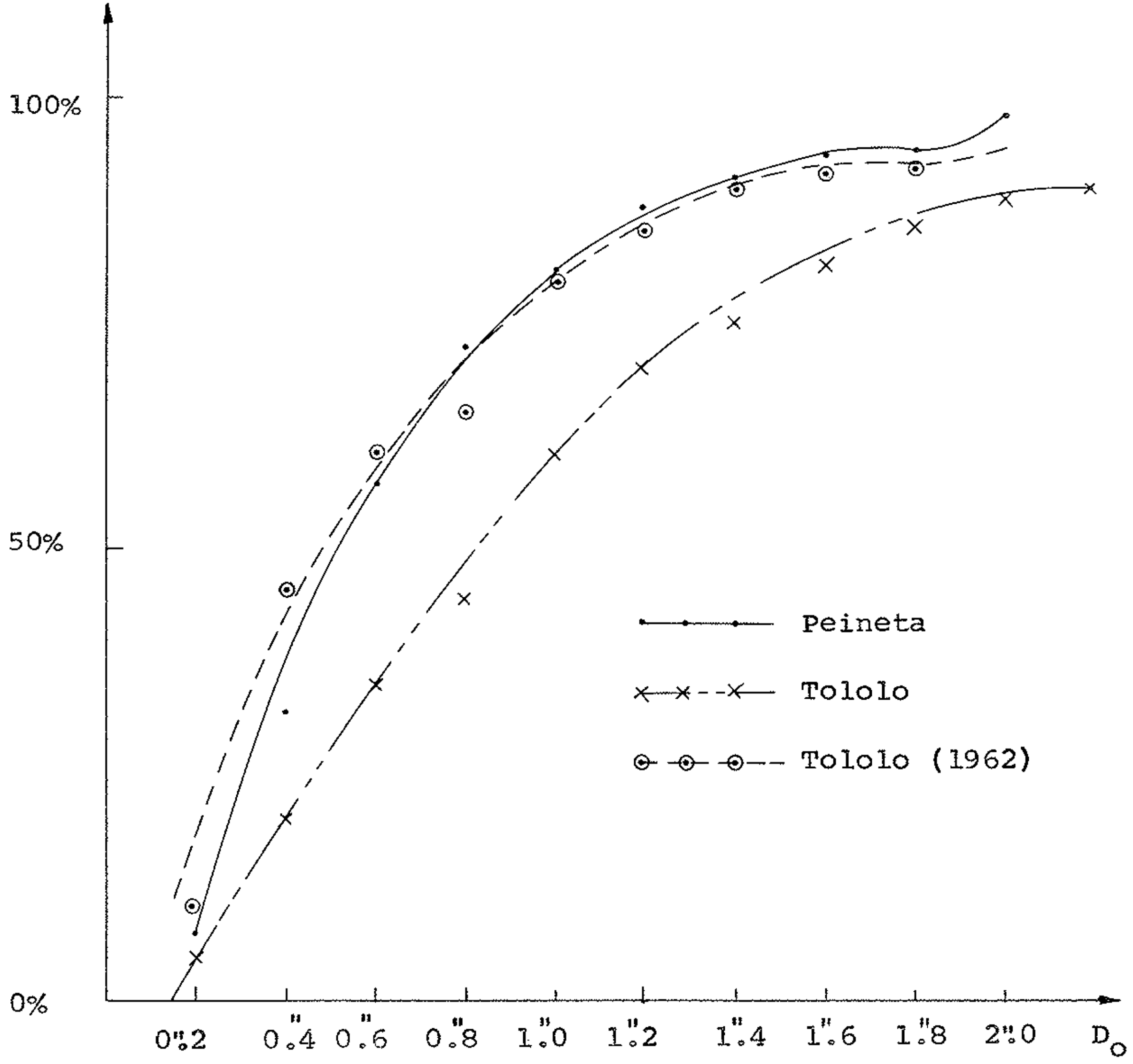

Figure 9. Cumulative seeing-frequency diagram showing for what percentage of clear sky time the seeing diameter D_o was equal to or smaller than the value indicated by the abscissa. J. Stock observer.

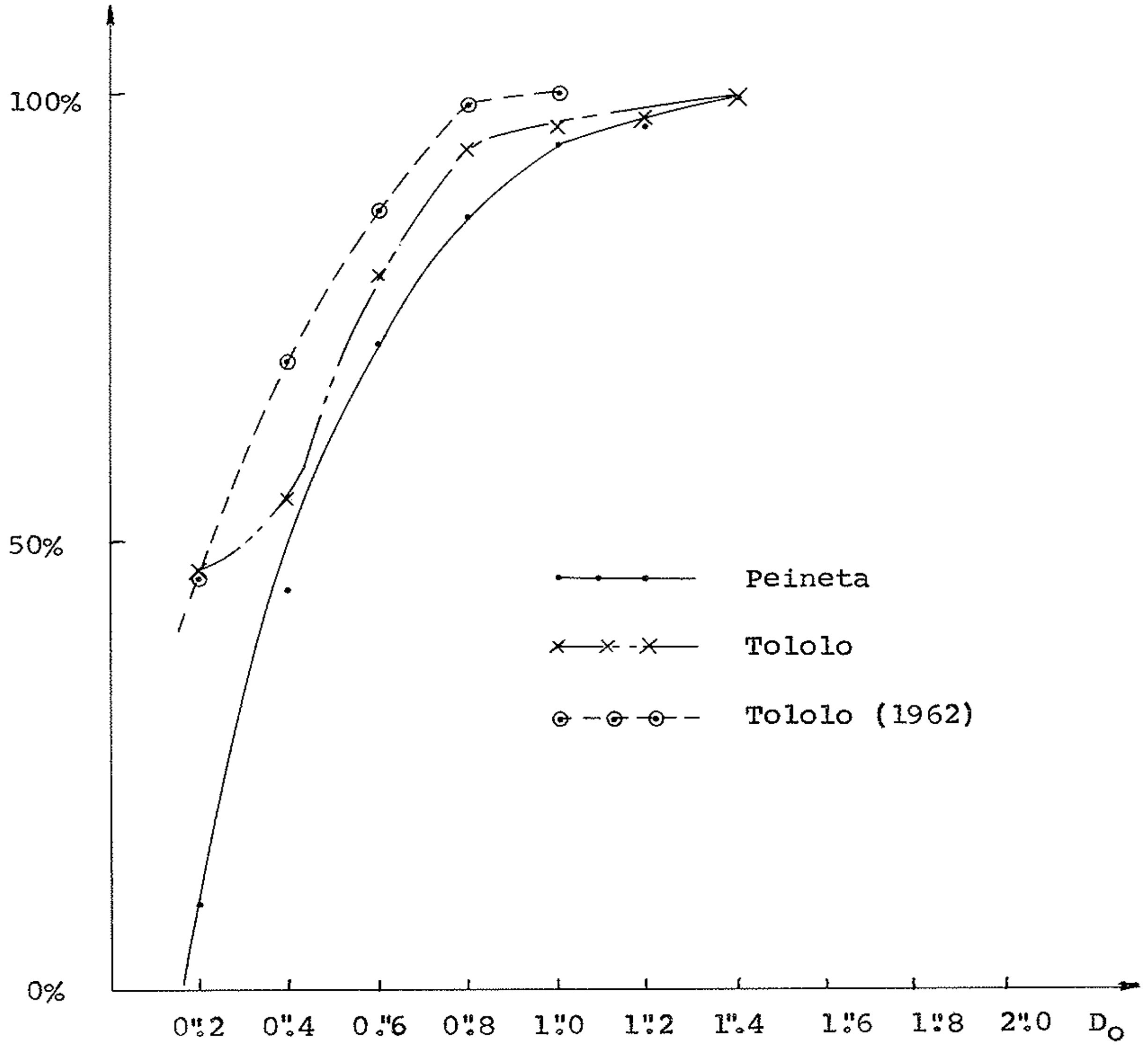

Figure 10. Cumulative, seeing-frequency diagram showing for what percentage of clear sky time the seeing diameter D_o was equal to or smaller than the value indicated by the abscissa. C. Torres observer.

was given to the visual observations on the mountain sites.

The analysis of the cloud observations was made as suggested in TR 1, Section IX. The results are presented in the Figures 11, 12, 13, and 14. Data from several years were averaged for each of the three regions. No striking difference was found from one year to another, although one month may have been particularly clear during one year, and rather cloudy during the next. However, the next month may show the same thing in reverse. On the whole, the winters were found to bring about the same cloudiness every year. During the summer, the cloud occurrence is too small to show significant differences from one year to another.

Figure 11 gives the number of clear night hours for every month, regardless of whether they came in long, clear spells, or were broken up in short, clear periods. The following Figures take this into account. Figures 12, 13, and 14 give for every month the percentage of useful nights and of photometric nights for the same three regions. A photometric night is defined as a night with at least six successive hours of photometrically clear sky. A useful night is defined as a night with at least six successive hours with less than half the sky covered by clouds.

The total number of clear night hours per year for the three regions is given in the following Table VI.

TABLE VI.

TOTAL NUMBER OF CLEAR NIGHT HOURS PER YEAR FOR THREE REGIONS

Region	Hours
Santiago	1675
Vicuña	2300
Copiapó	2760

3. Wind.

During the first year of the site survey, suction-type anemometers were used for the measurements of wind velocities. These instruments are practically useless for low wind speeds. As may be seen from the results that follow, low wind speeds (0 to 5 mph) are rather common, and most current anemometers are rather inaccurate in this range. In fact, estimates without any equipment can be made almost as accurately, or even better. With some experience, wind speeds up to 20 mph, or more, can be estimated quite well, with errors not exceeding 15% except for the lowest velocities, where the estimates will be within 1 mph from the correct value. Such observations were made routinely by the observers, and calibrations

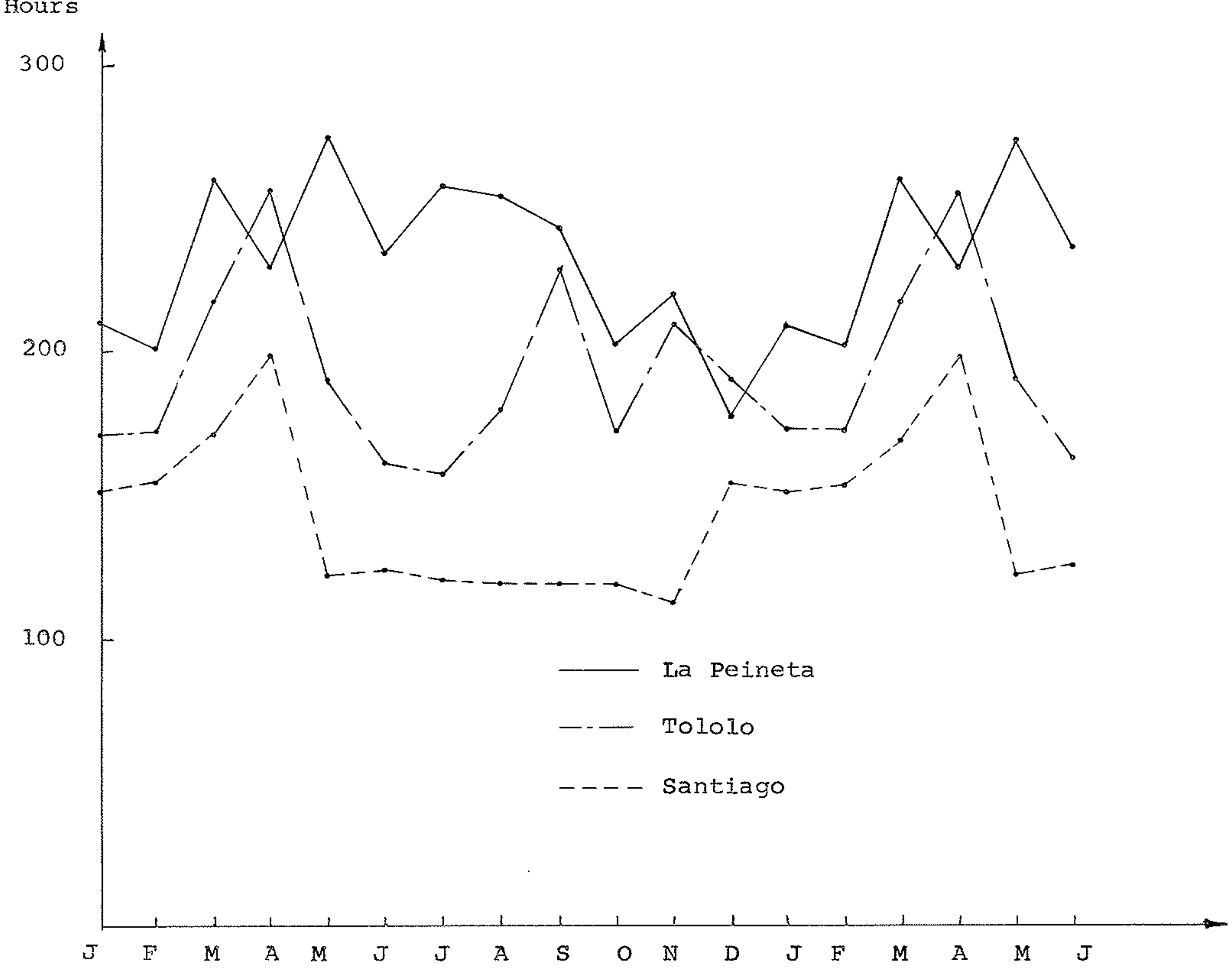

Figure 11. Average number of clear night hours per month for three regions. The first half of the year is repeated at the right-hand end of each graph. The representation of the cloudiness in this form is affected not only by the frequency of cloud occurrence, but also by the varying length of the night from month to month, as well as by the varying length of the month.

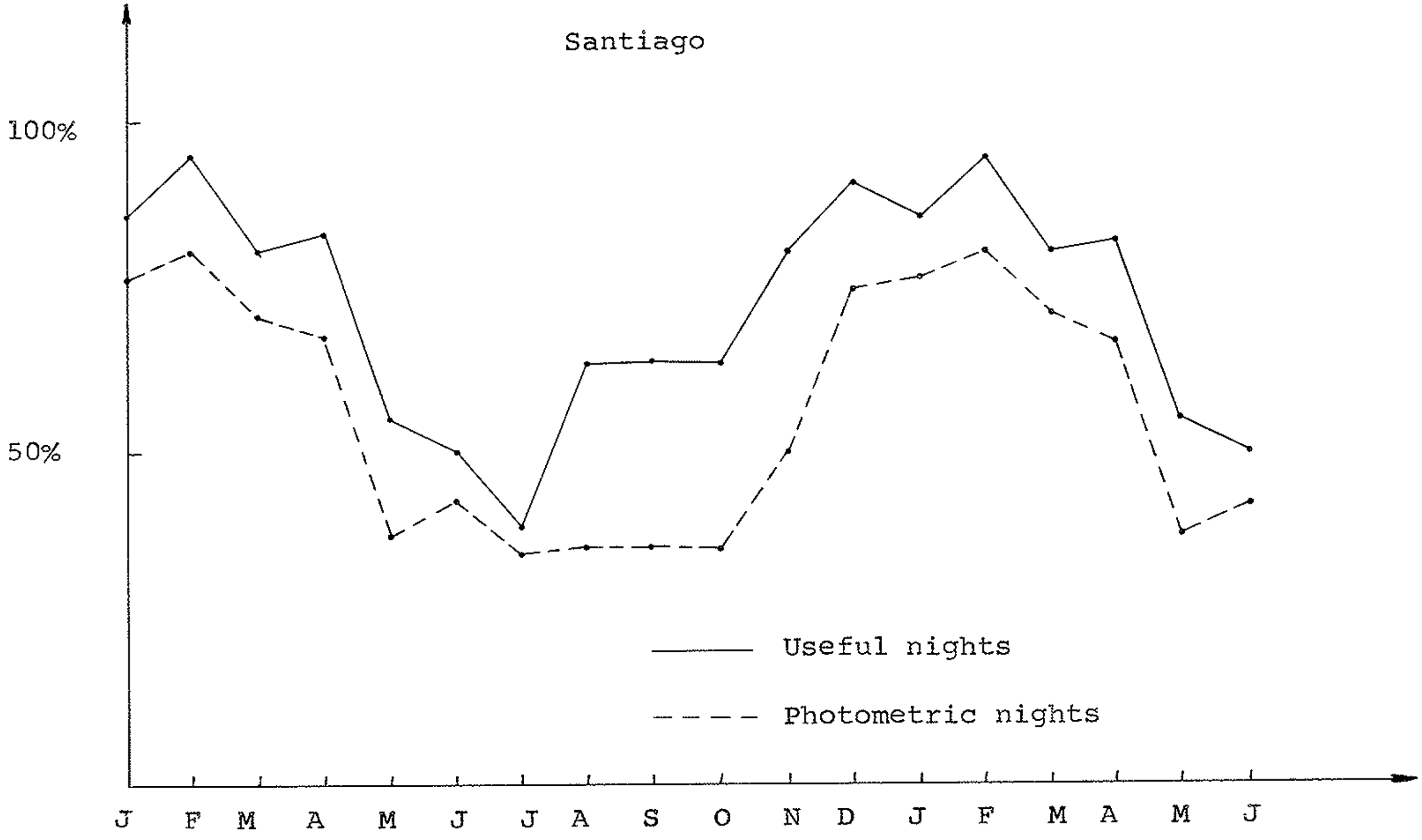

Figure 12. Distribution of photometric and useful nights through the year for Santiago. For definitions, see text. The first half of the year is repeated.

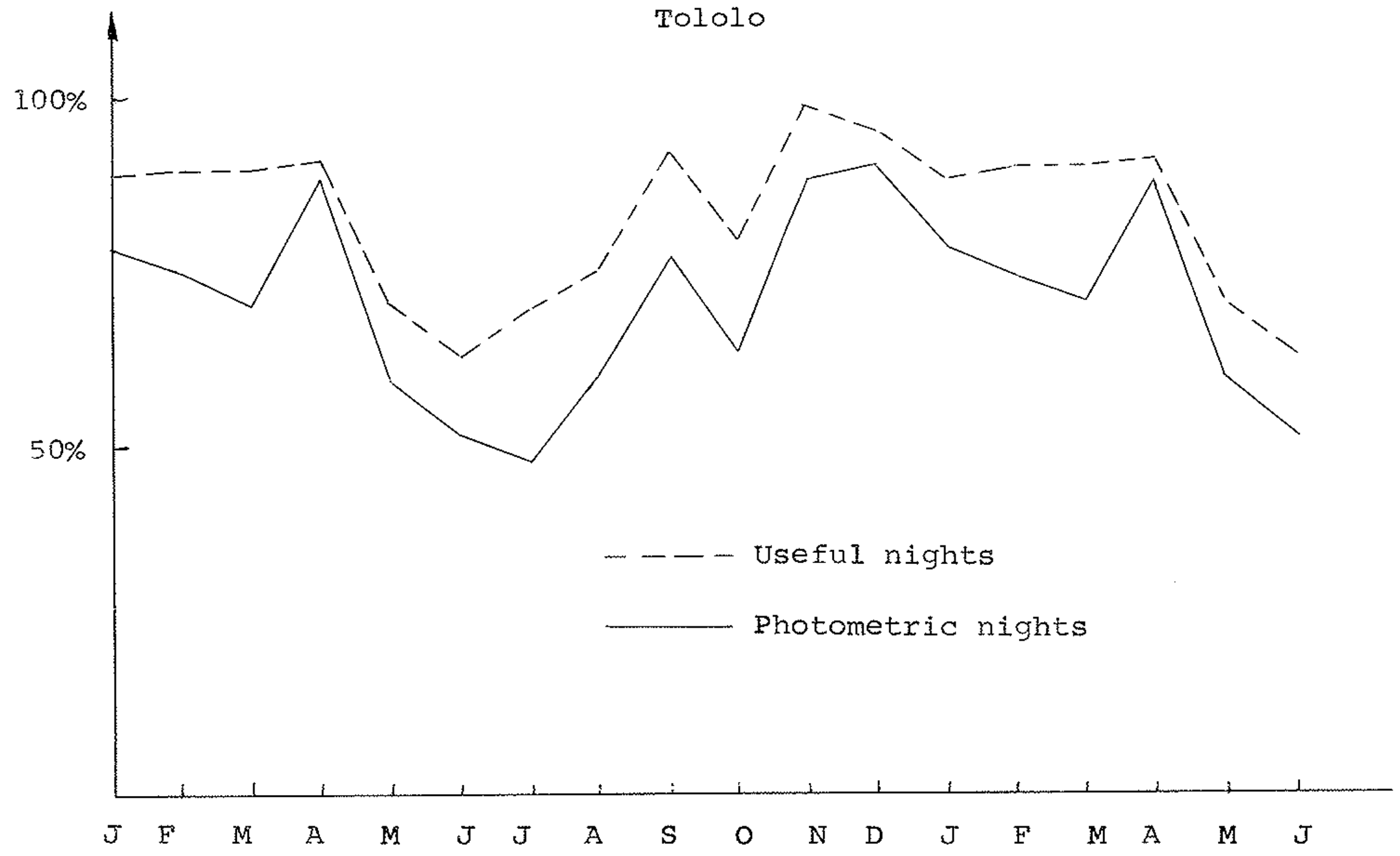

Figure 13. Distribution of photometric and useful nights through the year for Tololo. For definitions, see text. The first half of the year is repeated.

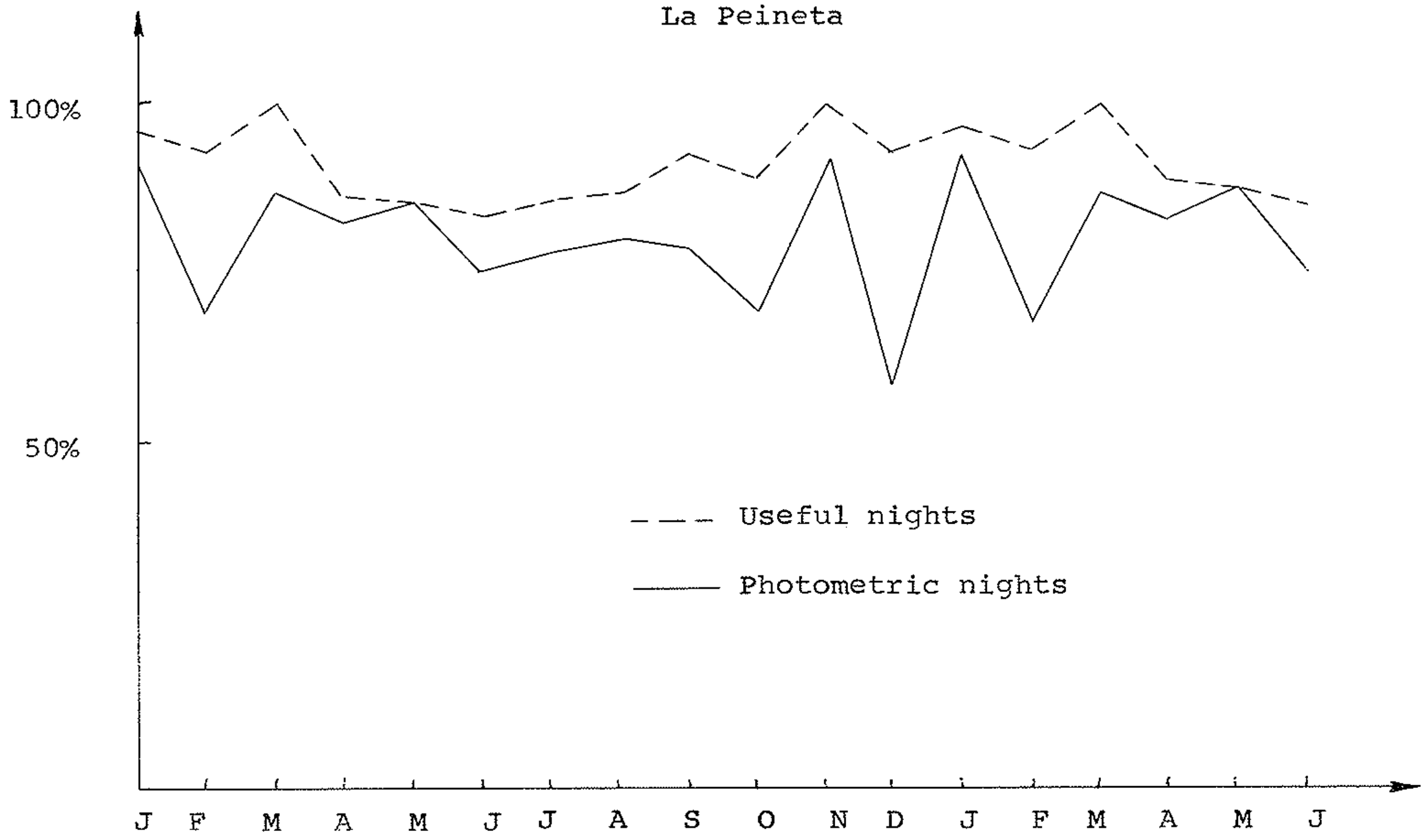

Figure 14. Distribution of photometric and useful nights through the year for La Peineta. For definitions, see text. The first half of the year is repeated.

were made against an anemometer whenever possible. Two special, low-wind speed anemometers were purchased in 1960, but they turned out to be too delicate for field work. During the last phase of the survey (from April 1962 on) two recording anemometers were used.

For the period when the recording anemometers were available, a rather detailed analysis of the wind data could be made. The distribution of wind velocities can be derived, as well as average wind velocities for individual nights or months. Likewise, peak values for each night, or for an entire month, can be read off the record. During the period when only estimates and some scattered measurements with portable anemometers were made, the distribution of the wind velocities could also be derived, but with less certainty. Average wind velocities should, however, still be rather accurate. Of course, there is no information on peak values. This is not a serious loss since the average wind velocity and the peak wind velocity of individual nights are well correlated, as shown in Figure 15. In this graph, to which both Tololo and La Peineta have contributed, the average wind velocities of nights selected at random were plotted versus the peak velocities of the same nights.

The result shown in Figure 15 needs a number of comments. The anemometers used are fast-reacting. Hence it is expected that the recorded maxima are close to the actual maxima. The wind at night (daytime wind is not considered here) on the sites under consideration is more of the nature of a laminar stream of air, rather than of gusty character. Furthermore, these laminar streams are usually of a long duration. This result is brought out by the fact that the peak velocity, which may have occurred at any time of the night, is only 50% higher than the average value of the wind velocity for the entire night. The relatively small scatter in Figure 15 also indicates the steadiness of the air stream.

Average wind velocities on clear nights were derived for every month for both La Peineta and Tololo. In the case of Tololo, only observations made in 1962 were used for the comparison. The results are shown in Figure 16 and are listed in Table VII. The same table also gives the maximum for every month, regardless of the time of the day or the cloudiness.

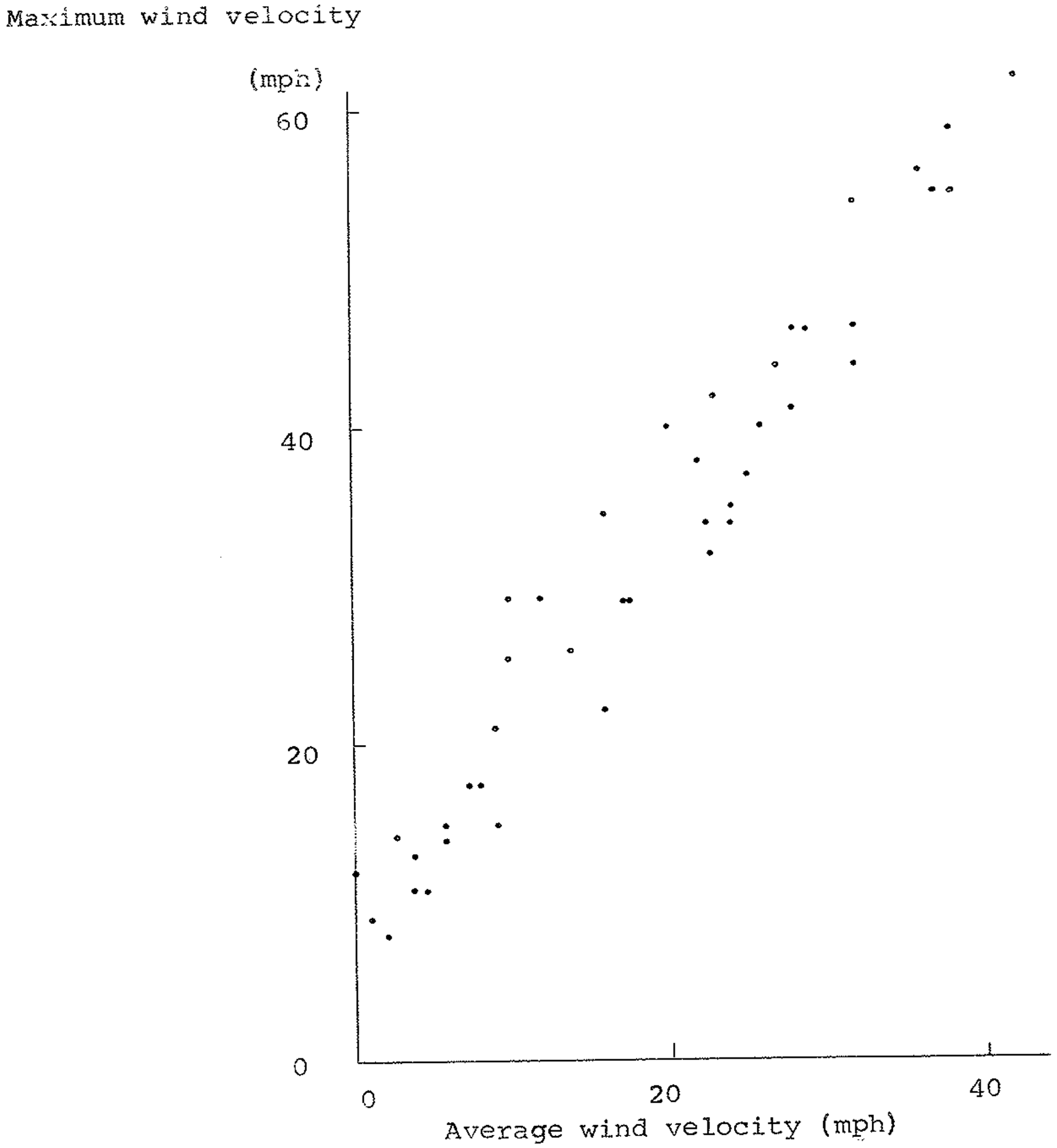

Figure 15. Plot of average wind velocities of individual nights versus peak velocities of the same nights. Data were taken at random from both Tololo and La Peineta.

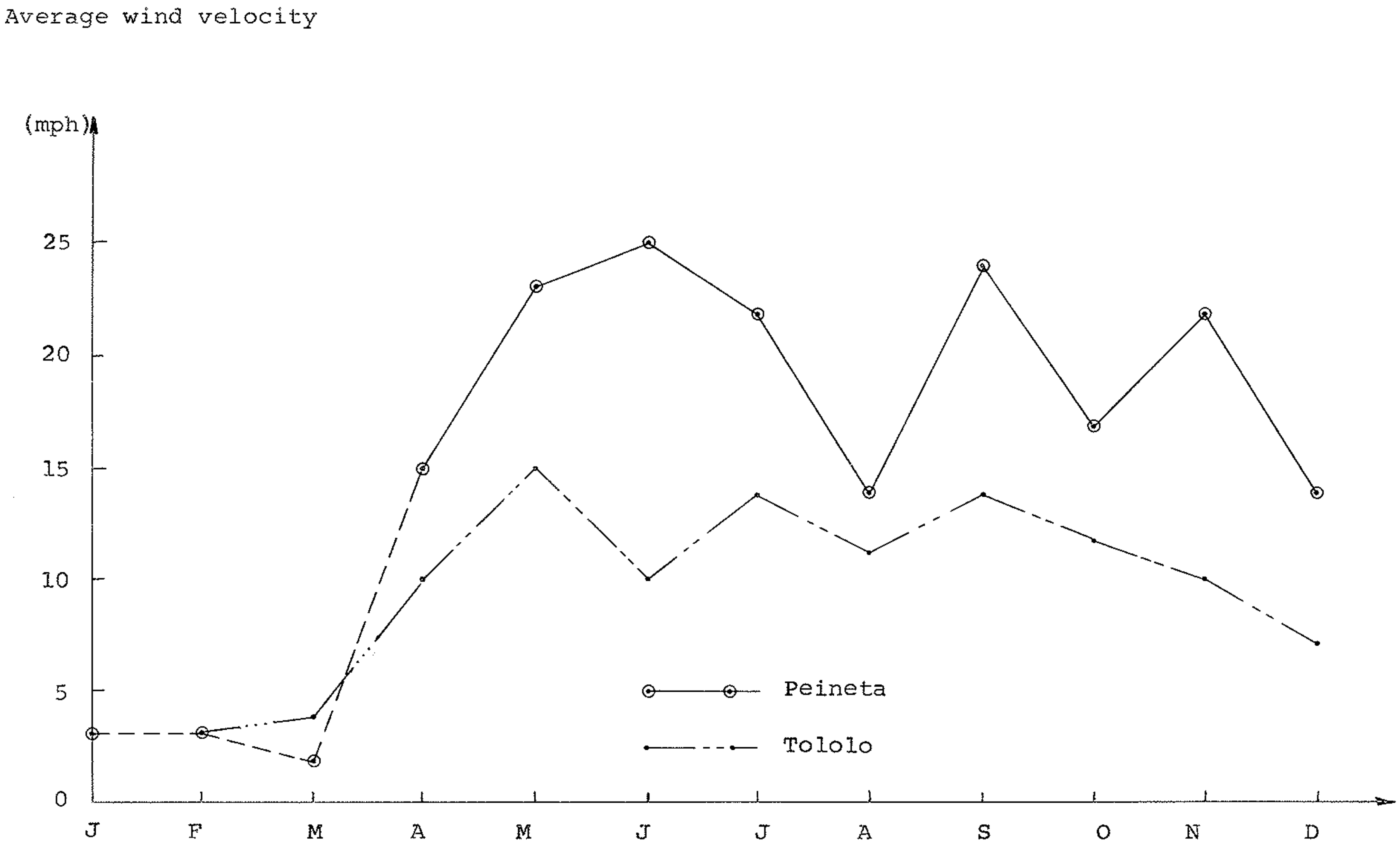

Figure 16. Distribution of average nighttime wind velocities for Tololo and La Peineta through the year (1962 only).

TABLE VII.
AVERAGE AND MAXIMUM WIND VELOCITIES FOR TOLOLO AND LA PEINETA

	Tololo		La Peineta	
Month, 1962	average	max.	average	max.
January	(1) mph	--	3 mph	--
February	3	--	3	--
March	6	--	2	--
April	12	46 mph	9	--
May	15	44	18	62 mph
June	10	62	25	62
July	14	52	22	59
August	11	59	14	63
September	14	56	24	59
October	12	48	17	56
November	9	35	13	55
December	7	45	14	52

During the time this report was written (February 1963), the data already available indicate that the results for January 1963 again give very low average wind velocities on both sites.

The data in Table VII and in Figure 16 show that, on the basis of the wind velocities, the year can be divided into two characteristic seasons, namely, the summer from November until April with low wind, and the winter from May until October with high wind. For these two seasons, the distribution of the wind velocities on both sites is shown in Figures 17 and 18. In these figures the abscissae give the wind velocities, and the ordinates the total number of clear hours during 1962 on which these velocities occurred.

Above a certain limit, the wind velocity may be considered to be excessive, and hence clear hours with wind above this limit are useless for astronomical observations. There may be disagreement as to what this limit is. A diagram showing the cumulative number of clear night hours with wind speeds below a certain limit, as a function of this limit, may help to come to a conclusion. Such diagrams are shown in Figures 19 and 20. They were prepared separately for the two characteristic seasons mentioned above. In these figures the abscissae are the limiting wind speeds, and the ordinates the total number of clear hours with wind less than or equal to the value indicated by the abscissae. Thus, for instance, Figure 20 shows that during the winter La Peineta has about 360 more clear hours than Tololo. However, if only hours with wind velocities of 20 mph or less are considered to be useful - in this case the expected peak velocities are of

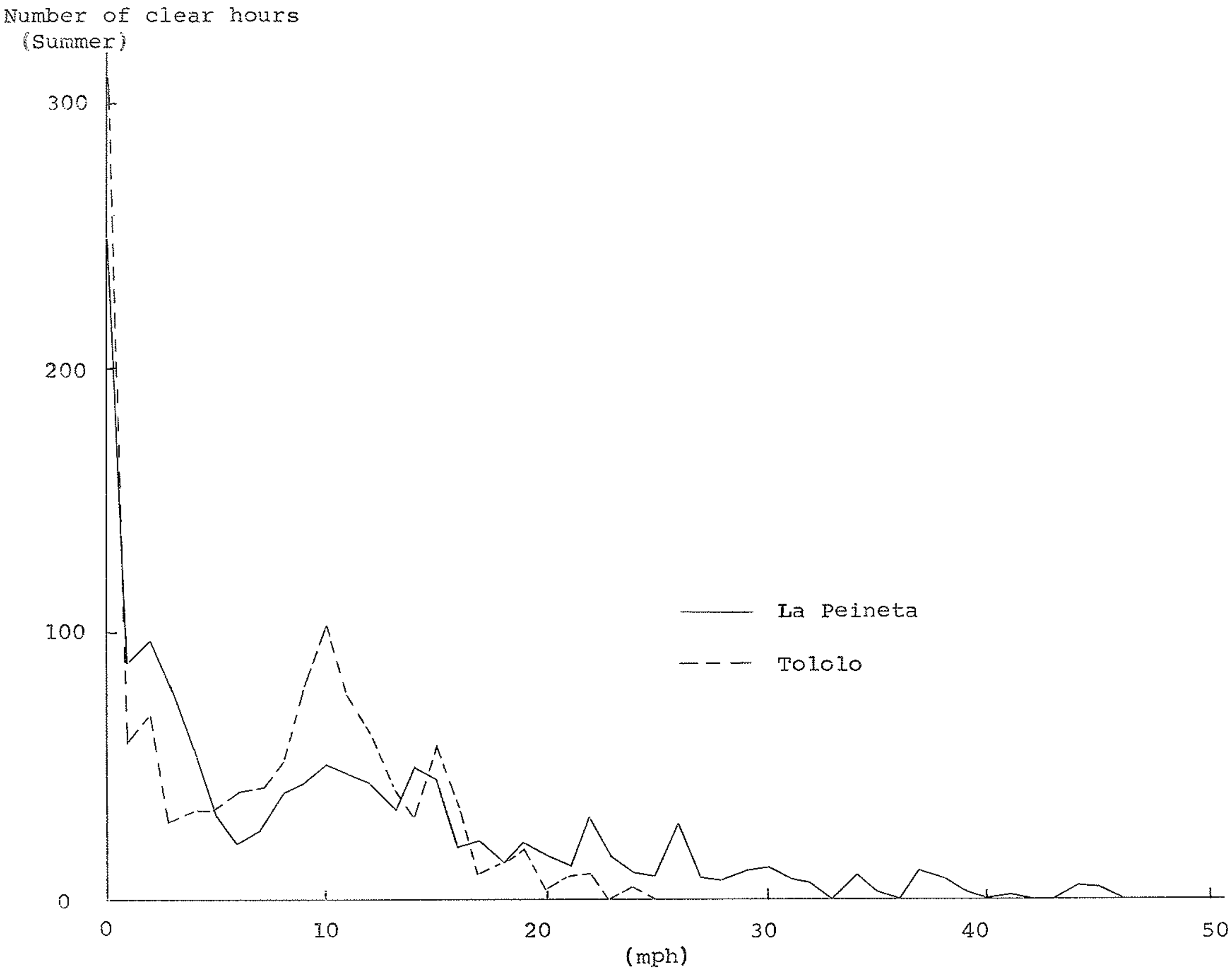

Figure 17. Distribution of wind velocities on Tololo and La Peineta during the summer (Nov. to April). Abscissae are wind velocities in miles per hour, ordinates total number of clear hours during which these velocities occurred.

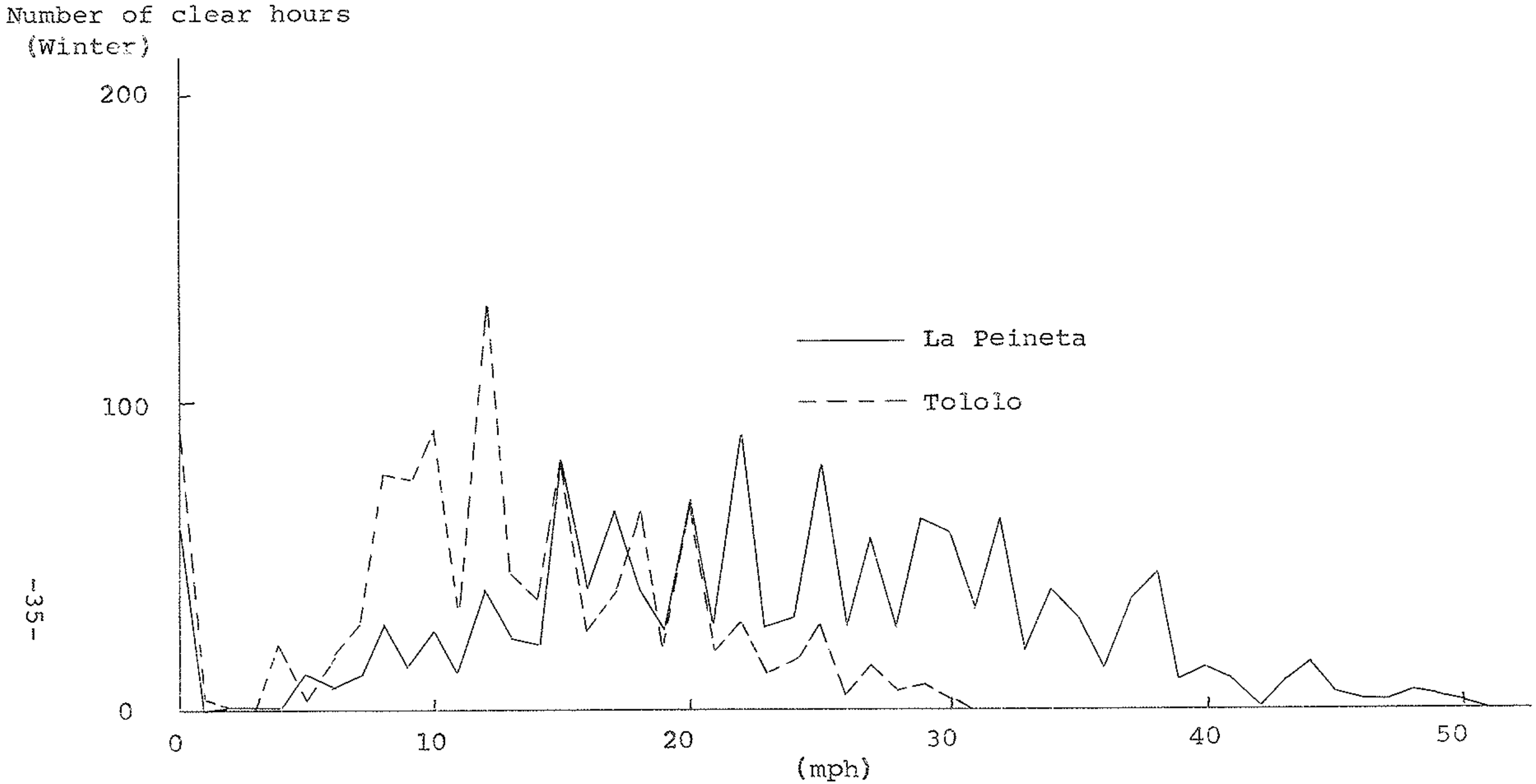

Figure 18. Distribution of wind velocities on Tololo and La Peineta during the winter (May to Oct). Abscissae are wind velocities in miles per hour, ordinates total number of clear hours during which these velocities occurred.

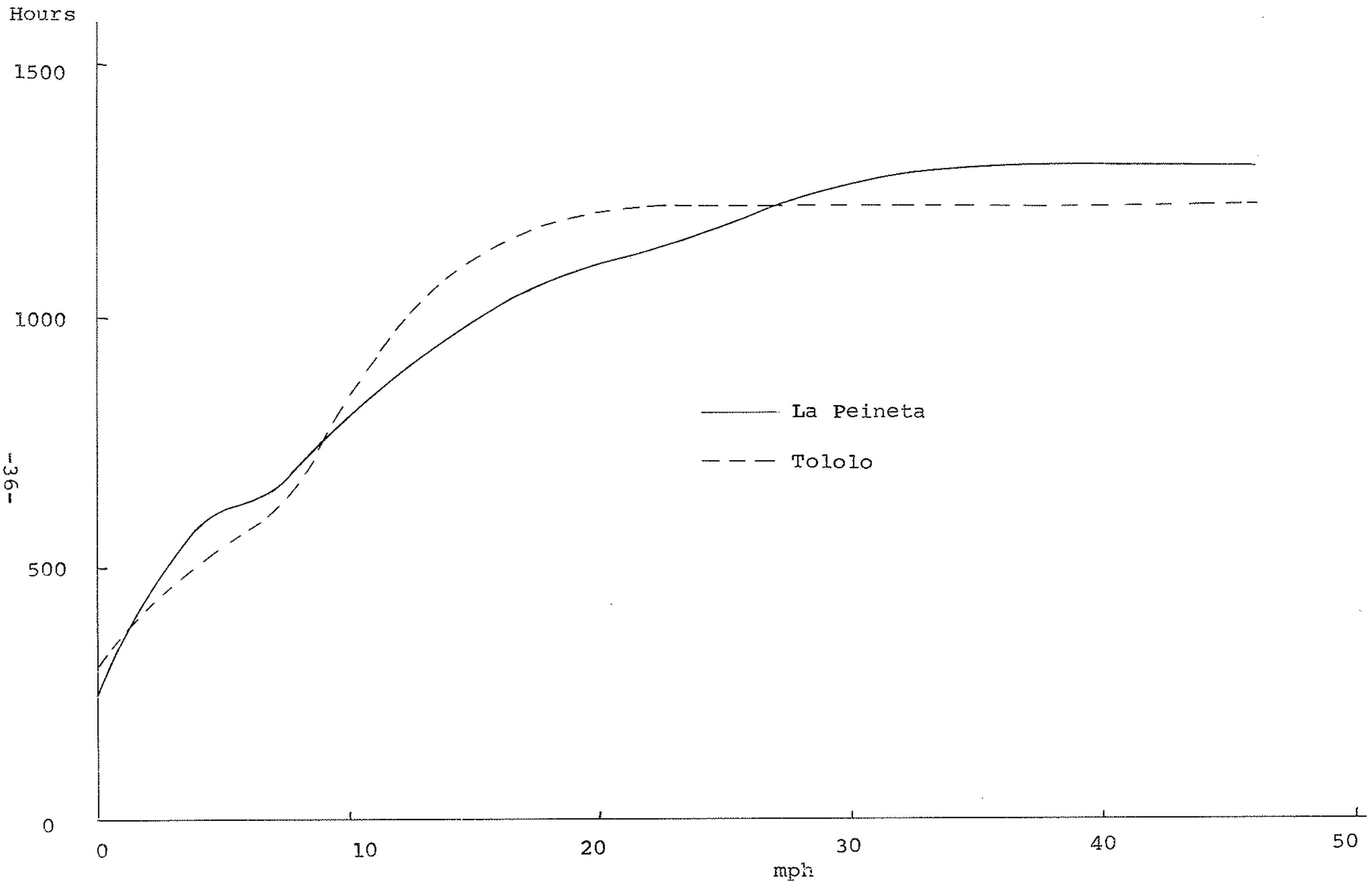

Figure 19. Cumulative wind velocity diagram for the summer for Tololo and La Peineta. The abscissae give wind velocities in miles per hour, the ordinates the total number of clear night hours with wind velocities equal to or less than those indicated by the abscissa.

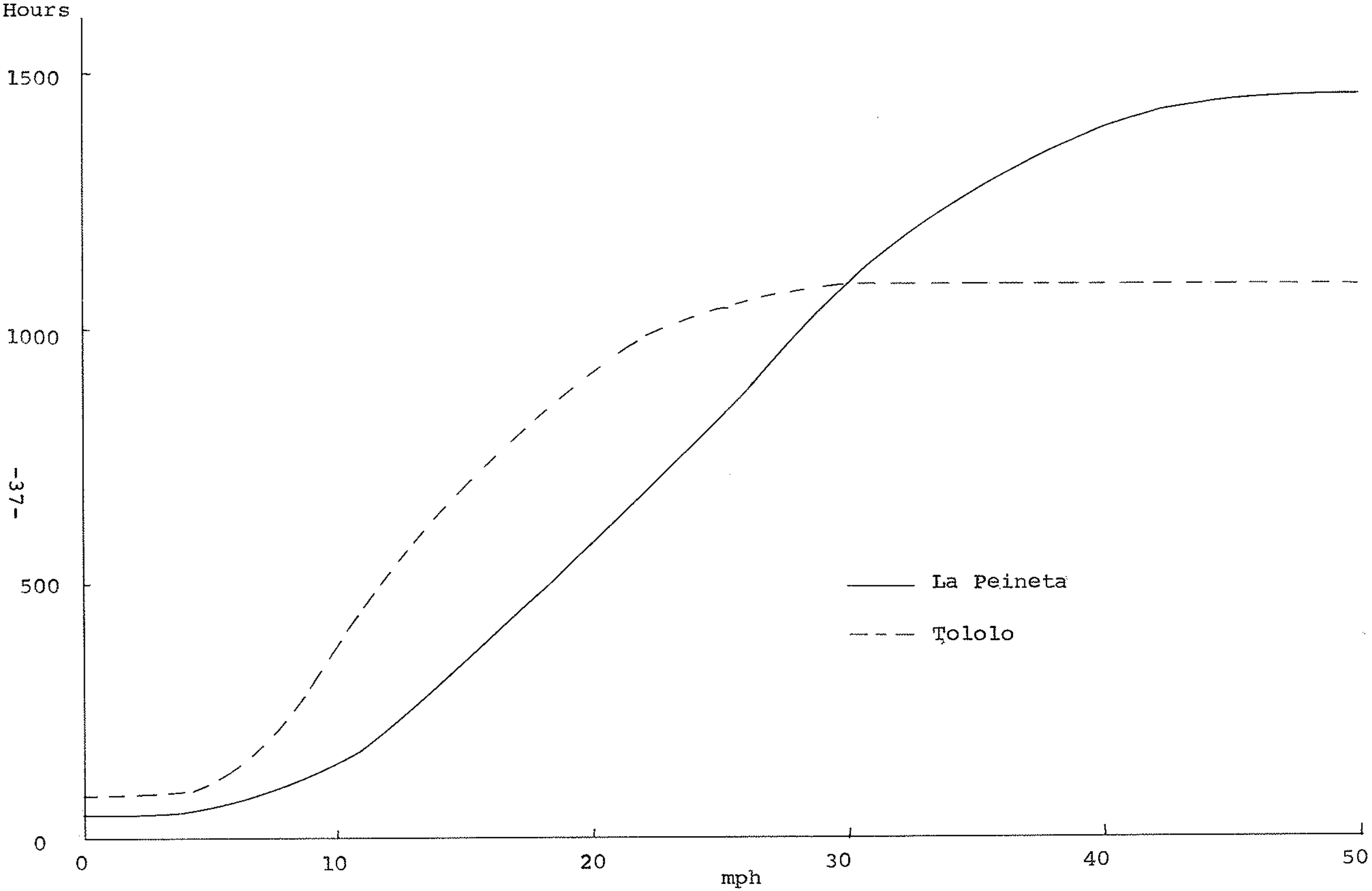

Figure 20. Cumulative wind velocity diagram for the winter for Tololo and La Peineta. The abscissae give wind velocities in miles per hour, the ordinates the total number of clear night hours with wind velocities equal to or less than those indicated by the abscissa.

the order of 30 mph according to Figure 15 - then Tololo actually has 350 more useful hours than La Peineta.

Another important result is presented in Figure 21, namely, the direct comparison of wind speeds between La Peineta and Checo. Each point in the diagram represents one pair of simultaneous observations of wind speeds on the two sites. These observations confirmed the impression gained by the observers before, namely, that conditions on La Peineta are usually calm when Checo has wind speeds up to 10 mph. Only with high wind speeds, which mostly occur during bad weather periods, are conditions on La Peineta more severe than those on Checo.

Besides the seasonal variation of the wind, there is also a characteristic diurnal behavior, particularly during the summer. Nights are usually nearly calm. The calm conditions prevail until about 10 a.m., when westerly wind sets in and lasts until sunset. This daytime wind can reach 30 mph or more, and it is usually very gusty. This characteristic diurnal behavior of the wind is even more pronounced in the valleys, especially in those extending in an east-west direction.

It is also of interest to note that nighttime wind comes, in nearly 90% of the cases, out of the north or northeast. In fact, strong winds (above 25 mph) are always out of the north. On a few nights during the summer, wind out of the south is observed. Other wind directions do not seem to occur. Of course, these remarks refer to mountain sites only.

4. Temperature and Humidity.

Thermo-hygrographs, Casella - type, were installed on all sites and maintained either by the observers or by local personnel. Their performance was checked by a precision psychrometer. In all cases the instruments were located in white screens 1.5 m above the ground. On La Peineta and on Cerro Blanco it was necessary to locate the thermo-hygrograph in a place with some wind protection, because vibrations caused by wind had the tendency to lift the pens off the paper, after which they ceased to record.

For Tololo, continuous records are available from May 1960, for La Peineta from January 1962. For each day the maximum temperature was read off, as well as the minimum for the following night. Average maxima and minima for each month were then computed. Also, the highest and the lowest maximum, and the highest and lowest minimum, of each month were determined. These data were derived regardless of cloudiness. Average values for the monthly

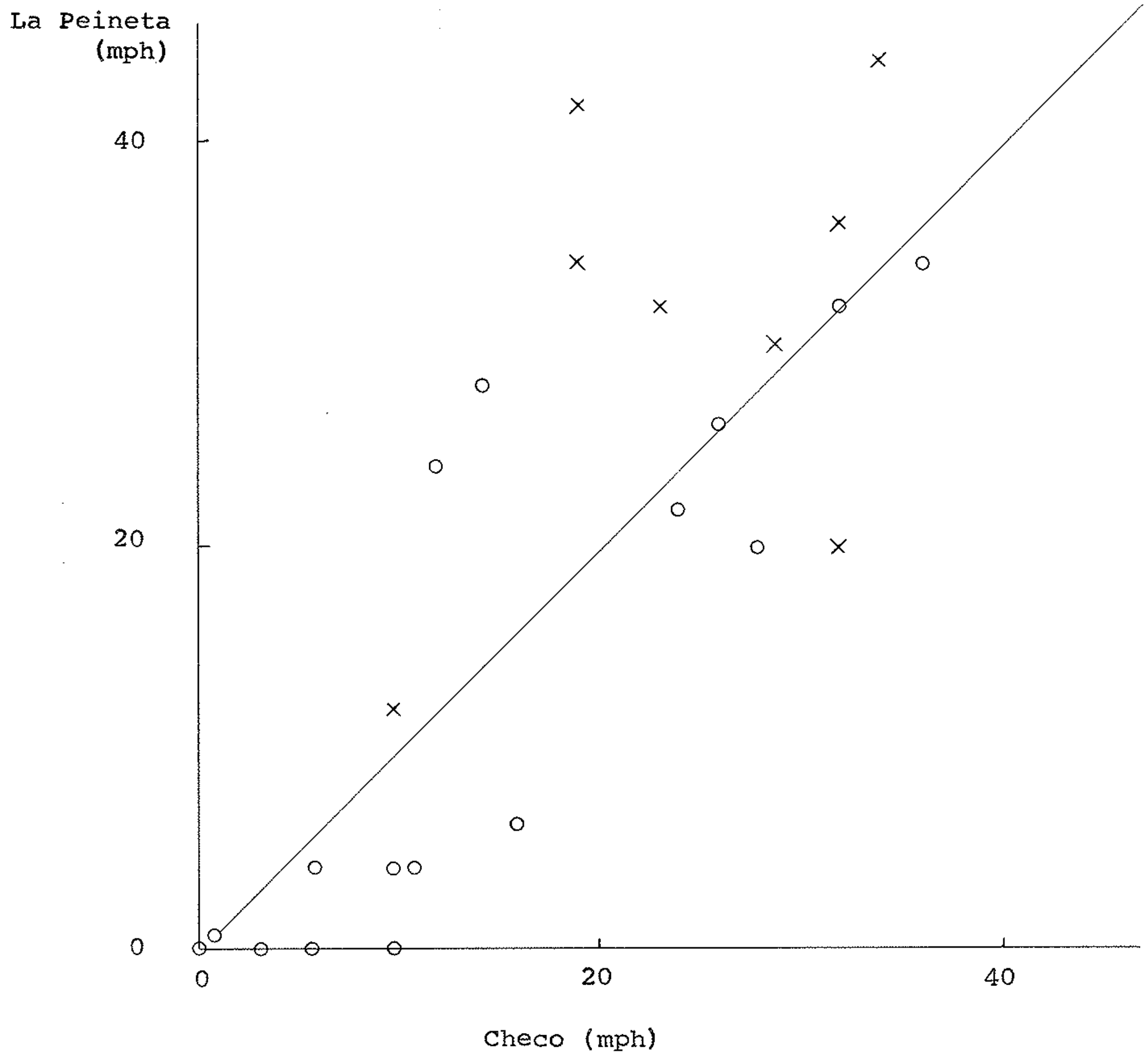

Figure 21. Comparison of wind velocities on La Peineta and Checo. Each point represents one pair of simultaneous readings. Crosses indicate non-clear, circles clear night hours.

maxima and minima for clear weather periods were also calculated. Data for Tololo and La Peineta are listed in Table VIII. The clear-weather data are also shown in Figure 22.

The data in Table VIII give some idea about the climatological conditions on Tololo and La Peineta. Some general remarks may help to interpret them. The diurnal variation of the temperature shows some characteristic features of mountain sites in desert areas, and others that are due to the nearness of the ocean. At sunrise, a sharp temperature increase sets in (see Figure 23, which shows a typical winter temperature record of Tololo). Four or five hours after sunrise, the westerly breeze begins and terminates the temperature rise. Rapid fluctuations of the temperature, with small amplitudes and with no appreciable change in the overall temperature, prevail until midafternoon when the temperature decline sets in. Not long after sunset the minimum temperature is reached. On calm nights the temperature shows slow irregular variations of a few degrees, with little tendency for a general rise or fall. On windy nights, particularly on La Peineta, the temperature is more constant than on calm nights.

As can be seen from Figure 22, the average minimum temperature during clear weather, which is nearly identical to the average nighttime temperature, shows only a small systematic variation with the seasons. Considerably different conditions occur only during bad-weather periods, and these are practically confined to the winter. Then the temperature will drop below freezing. Afterwards, following one or two sunny days, the temperature recovers normal values. It is of interest to note here that during 1962 Tololo has had a total of 500 hours with temperatures below freezing, while La Peineta only 270 hours. This result may be surprising, in view of the fact that, in general, the temperatures are lower on La Peineta than on Tololo. This result is caused by the considerably larger number of sunny hours during the winter on La Peineta (note that in the number of freezing hours quoted, daytime is included). Clear nights with freezing temperatures are not frequent on either site.

The diurnal temperature range on Tololo is between 10° and 15°, and possibly a little higher on La Peineta. However, here one has to keep in mind that the thermographs were installed rather close to the ground. This location has the effect of increasing the daytime reading, but it has practically no effect on the nighttime reading. The diurnal temperature range at the higher level of a large telescope may be well below the values quoted above.

For comparison, the diurnal range for a valley site may be quoted also: the average temperature difference between the daytime maximum and the nighttime minimum at Copiapó is 32°F.

TABLE VIII
TEMPERATURE DATA FOR TOLOLO AND LA PEINETA

Tololo

		Maximum Temperature, $^{\circ}$F			Minimum Temperature, $^{\circ}$F			Average During Clear Nights	
		High	Low	Aver.	High	Low	Aver.	Max.	Min.
960	August	71	44	61	56	26	46		
	September	73	36	62	59	18	46		
	October	73	34	63	58	32	47		
	November	76	62	70	62	48	54		
	December	73	66	71	66	47	56		
961	January	79	65	71	64	46	55		
	February	75	65	72	61	49	56		
	March	77	47	70	63	42	55	70	56
	April	71	58	65	57	43	51	64	52
	May	71	40	61	57	33	49	66	53
	June	69	25	45	55	18	36	51	41
	July	67	28	52	56	23	43	57	47
	August	69	28	54	60	23	42	58	46
	September	67	31	48	56	21	37	50	39
	October	67	34	57	54	24	44	61	47
	November	70	51	60	56	35	45	62	46
	December	67	56	62	56	40	47	62	49
962	January	68	53	62	54	37	48	62	48
	February	68	58	63	53	42	49	63	49
	March	69	51	61	55	35	48	61	48
	April	67	43	58	54	30	46	59	48
	May	65	29	53	52	26	42	56	44
	June	60	30	45	53	22	35	49	39
	July	60	32	48	53	23	38	50	39
	August	64	22	51	53	16	39	56	44
	September	62	33	50	46	22	32	52	38
	October	62	32	52	53	22	40		
	November	69	49	58	53	33	45		
	December	63	53	59	52	39	46		

TABLE VIII (contd.)
TEMPERATURE DATA FOR TOLOLO AND LA PEINETA

La Peineta

		Maximum Temperature, °F			Minimum Temperature, °F			Average During Clear Nights	
		High	Low	Aver.	High	Low	Aver.	Max.	Min.
1962	January	65	53	58	51	38	42	58	42
	February	65	56	61	50	42	46	61	46
	March	65	55	60	49	40	44	60	44
	April	67	44	58	50	33	44	59	44
	May	63	42	54	49	26	40	56	40
	June	60	39	49	46	26	36	50	36
	July	59	32	48	46	20	35	48	36
	August	60	35	54	46	22	40	54	40
	September	62	43	54	46	30	38		
	October	64	36	53	48	24	38		
	November	64	51	58	47	35	42		
	December	61	55	55	48	32	40		

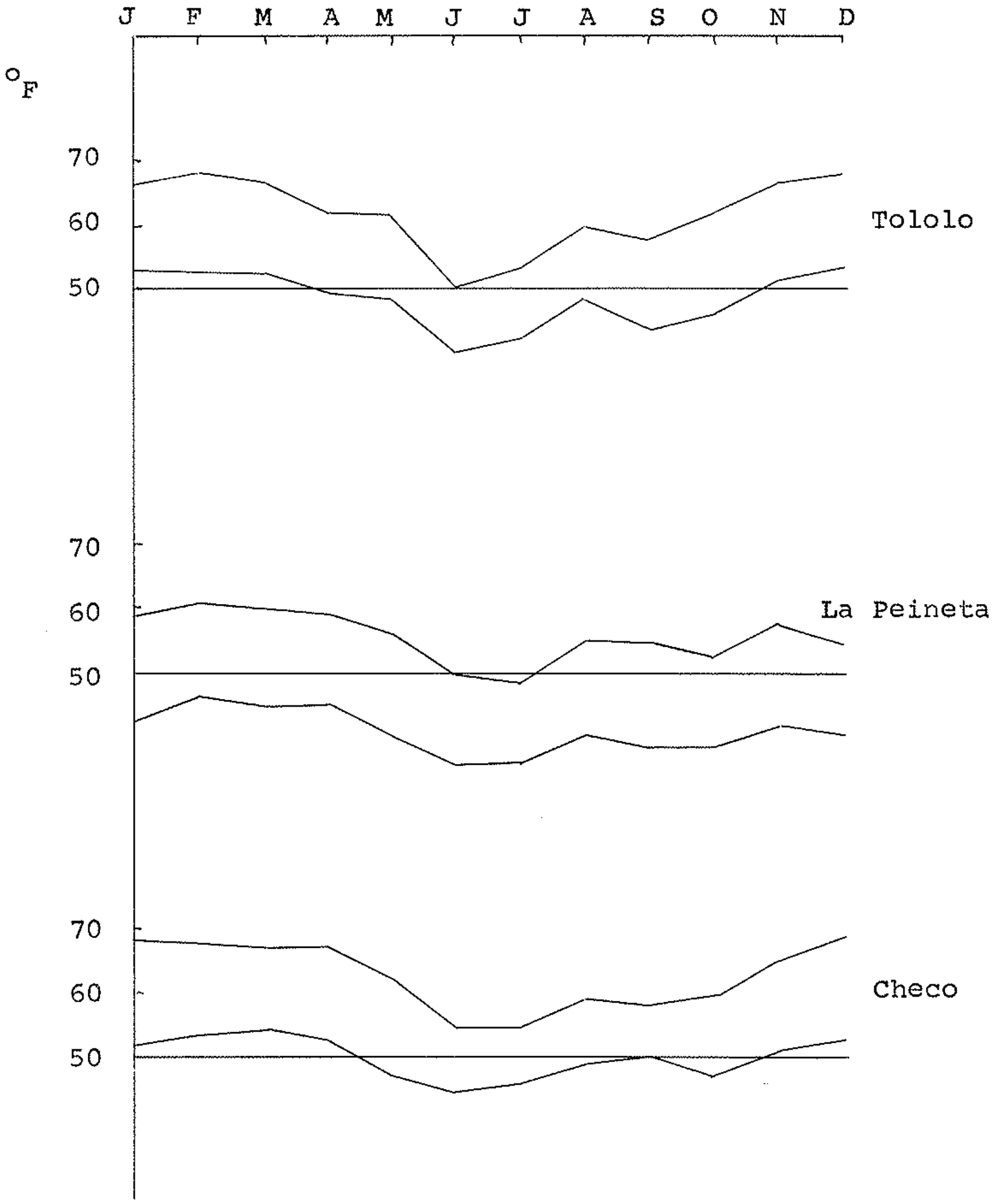

Figure 22. Average maximum and minimum temperatures during clear-weather periods for three sites.

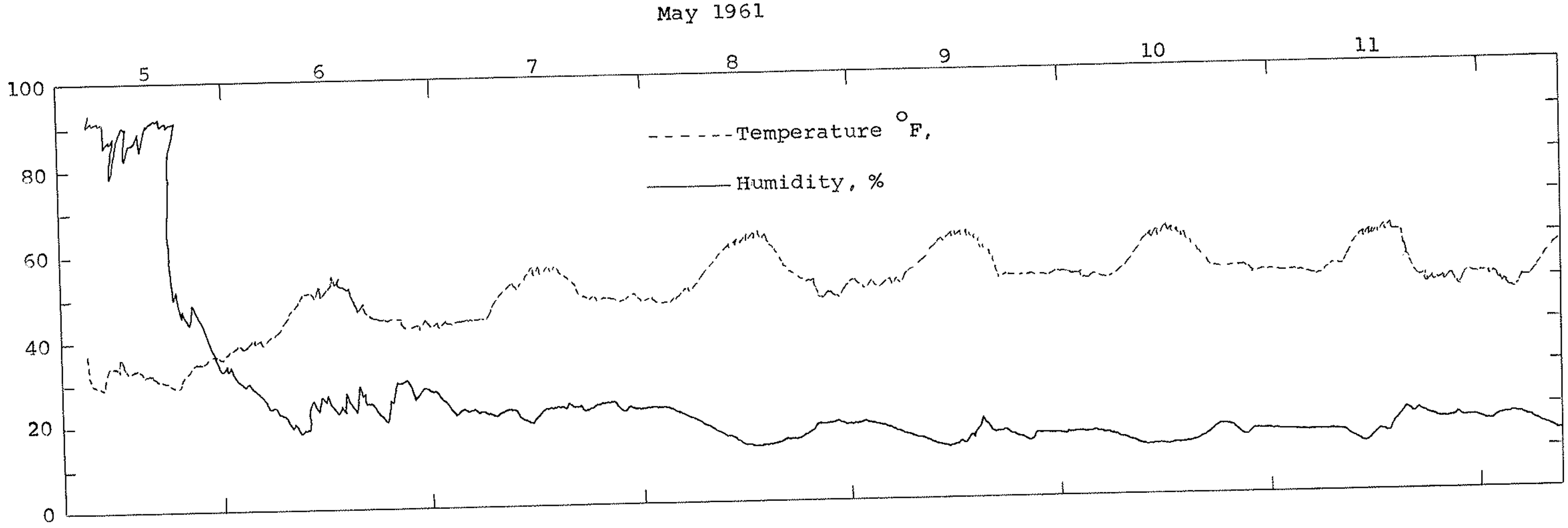

Figure 23. Typical winter thermo-hygrograph record from Tololo.

The behavior of the relative humidity with the time of the day and with the season depends greatly on the elevation. In the low valleys the humidity record is an inverted replica of the temperature record (see Figure 24 which shows a week's record taken at Copiapó). On the mountain sites there is hardly a characteristic diurnal variation of the relative humidity. During the summer the humidity is relatively high and shows large irregular fluctuations (see Figure 25, which shows a typical summer record of La Peineta). During clear winter periods the relative humidity is extremely low (see Figure 23). Of course, during bad-weather periods it reaches saturation. Figure 26 shows the dependence of the average relative humidity at nighttime (clear nights only) on the time of year, for both Tololo and La Peineta. In contrast to the results obtained for the mountain sites, the relative humidity at the coast is always high, and it is higher during the winter.

5. Haze.

Haze estimates were made with strong flashlights on dark nights. On moonlit nights the darkness of the sky was used as a haze indicator. Also, the contrast of mountaintops along the horizon proved to be a sensitive criterion for the presence of haze. However, while the flashlight test checks only on the local haze at the level of the observer, the scattered-moonlight test refers to the entire atmosphere above the observer. The test with distant mountaintops determines the amount of haze essentially at the elevation of the observer, but integrated over a large distance. It was not possible to obtain, with either method, a uniform scale. Even so, the estimates served the purpose of intercomparing the haze conditions at various sites. There is agreement between all observers that Checo was inferior to all other sites in this respect. Also, there is agreement that there is no large difference between Tololo and La Peineta in this respect.

The haze shows, in general, a characteristic buildup during the day. In the morning, haze may readily be seen in the valleys with a sharply defined top. During the day the sharp haze top dissolves, and the haze rises to great altitudes, particularly during the summer. Before sunset, the haze begins to settle down again, and it usually sinks before darkness below the level of the sites that were studied. Only on Checo was it often observed that this process is delayed well into the night.

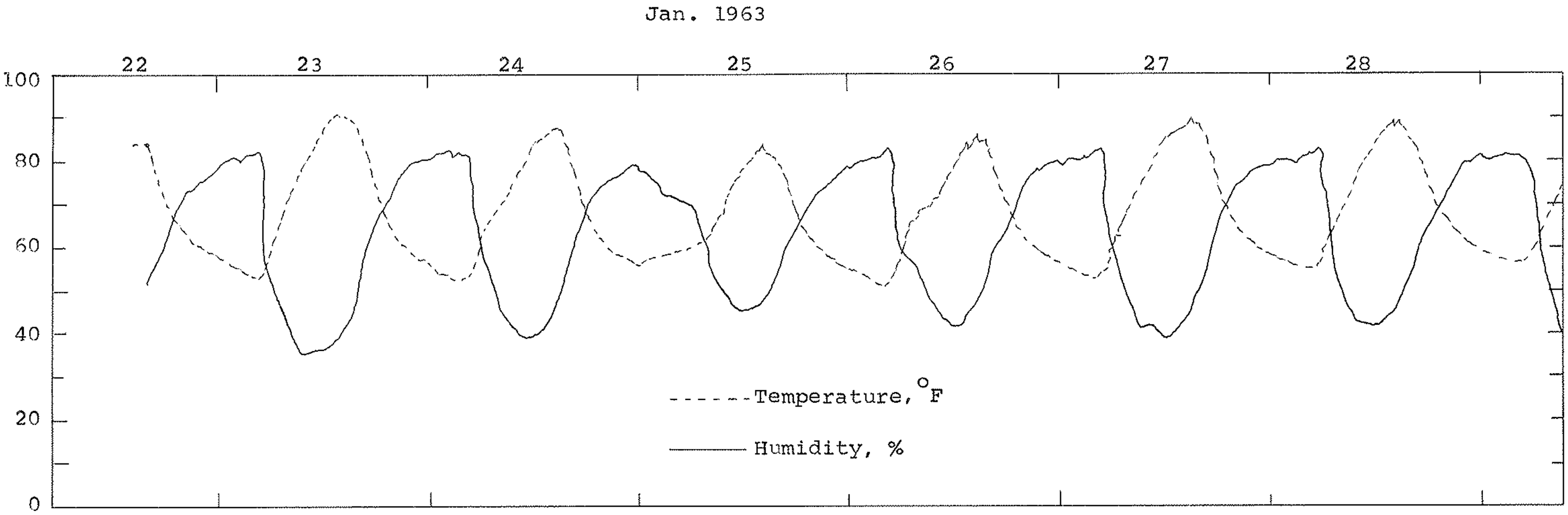

Figure 24. Typical thermo-hygrograph record from Copiapó

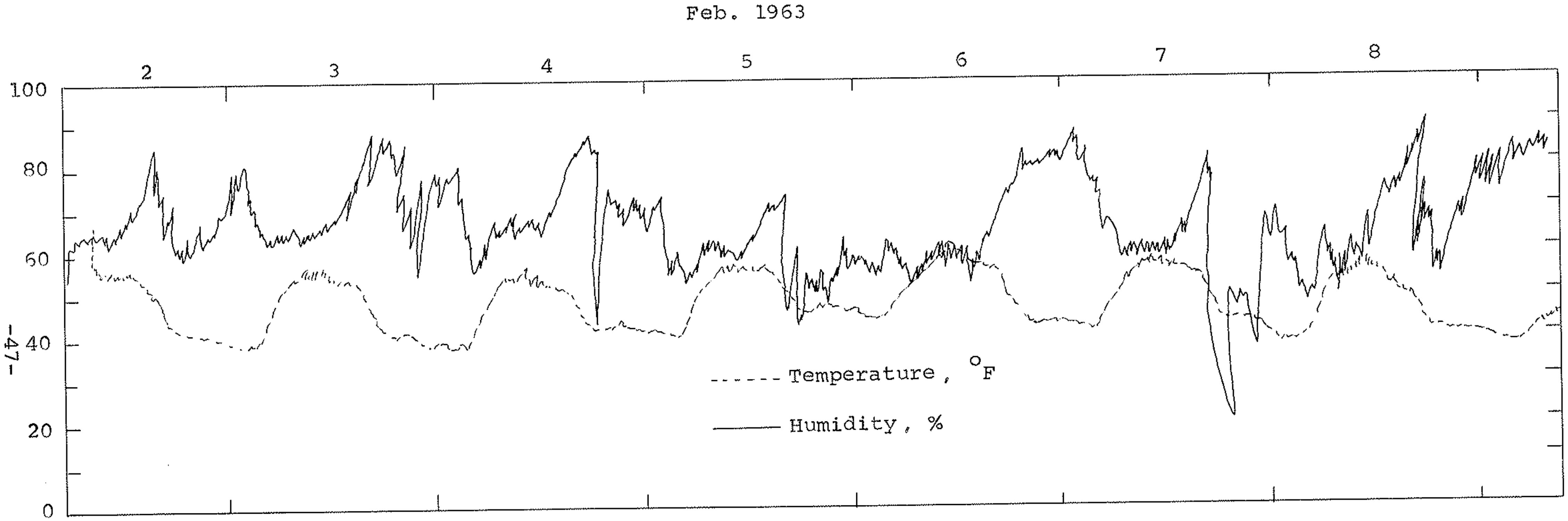

Figure 25. Typical summer thermo-hygrograph record from La Peineta.

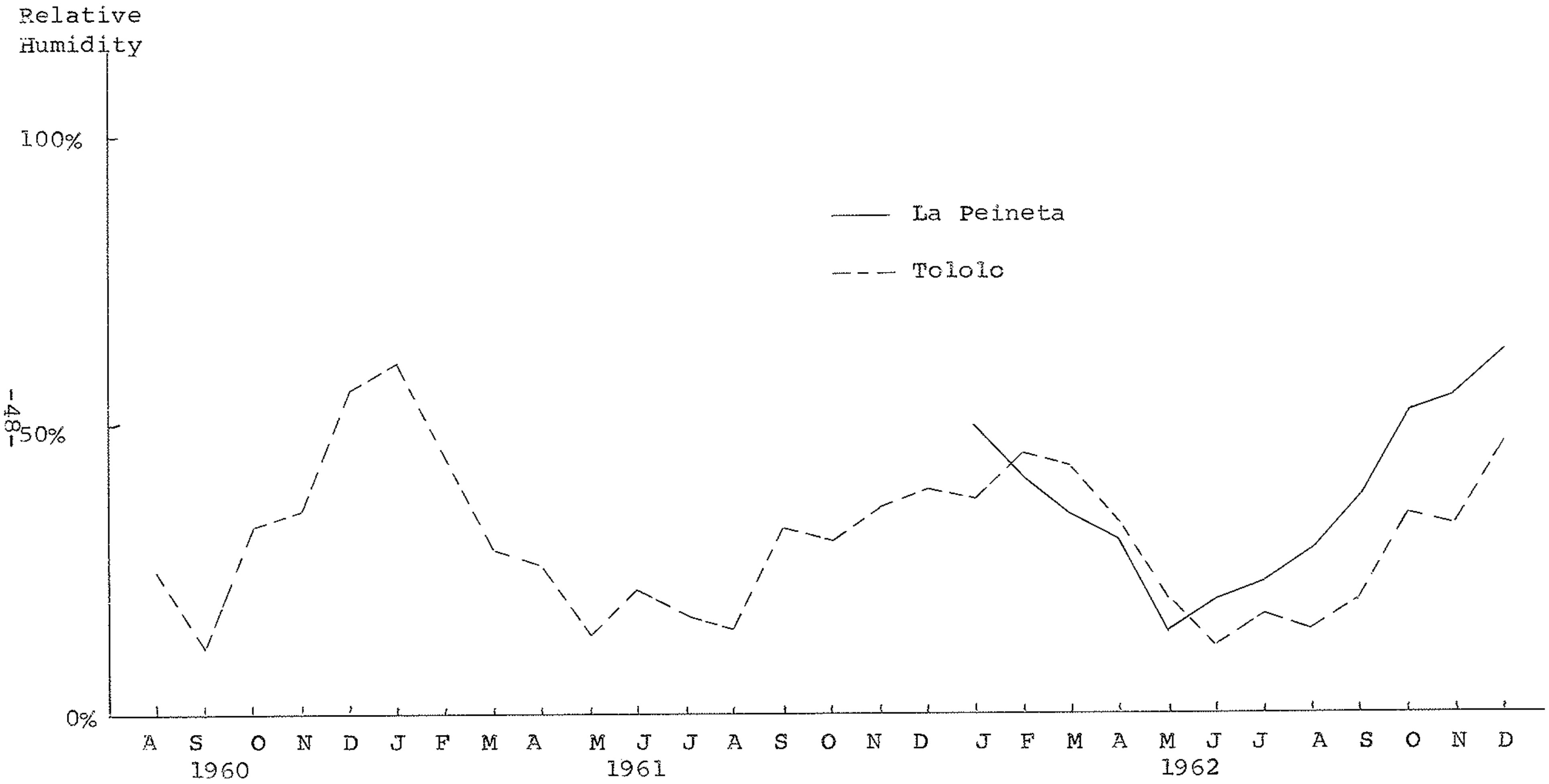

Figure 26. Average nighttime relative humidity per month for Tololo and La Peineta.

6. Extinction

Extinction measurements are available only for Tololo, where since September 1961 the 16-inch reflector has been actively used for photometric programs. Reductions are still far from complete. A program of photoelectric three-color photometry of members of the Scorpio-Centaurus association was started in May of 1962 by Adelina Gutierrez de Moreno and Hugo Moreno. The reductions of this program are well advanced, and some results concerning the extinction were kindly made available by the two authors. The data are listed in Table IX. Extinction coefficients are given for (B-V) and (U-B), and for the V-magnitudes. The coefficients are in all cases for the star δ Scorpii. For each night, the extinction was determined from several color and magnitude measurements, and thus mean errors of the listed coefficients could be derived. The mean errors of the color extinction coefficients are $\pm\, 0\overset{m}{.}002$ for the first section of the Table IX, and $\pm\, 0\overset{m}{.}004$ for the second section. The mean error of the magnitude extinction coefficient, determined so far only for nights of the second period, is $\pm\, 0\overset{m}{.}011$. The remaining scatter shown by the data in Table IX is likely to be due to variations in atmospheric absorption.

V. CONCLUSIONS DERIVED FROM THE OBSERVATIONAL MATERIAL

From the discussions in the foregoing sections it is evident that neither of the two sites kept under consideration until the termination of the site survey is favored on all points. Therefore, the differences have to be evaluated point by point, and it may even become necessary also to take into account non-astronomical considerations in order to come to a choice between the two sites.

The seeing data indicate that Tololo and La Peineta are nearly equivalent. There remains some uncertainty, however, about this conclusion. During the summer, La Peineta probably has better seeing conditions. On the other hand, summer is the season of poorer seeing for Tololo, but during the winter Tololo has its best seeing conditions. There is no complete knowledge of the seeing conditions on La Peineta during the winter, because the strong winds do not permit its investigation with field equipment. Measurements, obtained under the rare circumstance of low wind, indicate that during the winter the seeing is better on Tololo.

Cloud occurrence during the summer is about the same on both sites, and it is insignificant. During the winter, La Peineta has a considerable advantage. However, even during the winter

TABLE IX

EXTINCTION COEFFICIENTS FOR δ SCO AS OBSERVED ON TOLOLO

Date	$E_{(B-V)}$	$E_{(U-B)}$	Date	E_V	$E_{(B-V)}$	$E_{(U-B)}$
1962 May 3	$0\overset{m}{.}123$	$0\overset{m}{.}294$	July 17	0.151	$0\overset{m}{.}129$	$0\overset{m}{.}287$
4	.130	.300	18	.113	.128	.286
5	.122	.293	19	.166	.124	.291
6	.125	.305	21	.129	.127	.285
8	.128	.302	22	.139	.125	.292
9	.123	.300	24		.125	.282
10	.121	.301	28	.129	.126	.288
11	.123	.301	29		.119	.289
12	.117	.300	30		.121	.290
13	.127	.306	31		.125	.286
June 2	.122	.299	Aug. 1		.118	.285
3	.120	.303	2	.132	.120	.285
4	.120	.304	3	.117	.124	.282
5	.124	.303	4	.125	.118	.286
6	.122	.306				
7	.128	.304				
8	.123	.306				
9	.122	.303				
10	.123	.306				
11	.125	.306				
12	.120	.304				
13	.117	.304				
14	.122	.300				
15						

one can count on Tololo for at least half the nights being useful for photometric work, and more so for other types of astronomical work.

During the summer, wind speeds are low on both sites, although somewhat higher on La Peineta. During the winter, there is a considerable difference between the two sites with respect to the wind. There are only a few clear nights on Tololo when the wind would impair the operation of a large telescope. With conventional domes and telescopes, a considerable number of clear nights would be lost on La Peineta during the winter, because of high winds.

The diurnal temperature range, and the stability of the temperature at night, are about the same on both sites. However, the conditions both in daytime and at night are more agreeable on Tololo because of the higher temperature. Thus, considering only the performance of the equipment, both sites are equivalent. However, for the observer the conditions are more pleasant on Tololo.

During the summer, Tololo seems to have more haze than La Peineta, while during the winter Tololo has the cleaner atmosphere. It must be remembered here that in the term "haze" all kinds of scattering particles in the air are included, such as moisture, dust, or smoke. During the summer, one is probably dealing with droplets, and during the winter with dust.

There is no comparison available for the extinction on both sites. The Rayleigh scattering component, of course, will be less on La Peineta because of its higher elevation. Apart from that, one would expect slightly more constant extinction on La Peineta during the summer, and more constant on Tololo during the winter.