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PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKSUNIVERSITEIT TE UTRECHT, OP GEZAG VAN DEN RECTOR MAGNIFICUS DR. C. W. VOLLGRAFF, HOOGLEERAAR IN DE FACULTEIT DER LETTEREN EN WIJSBEGEERTE, VOLGENS BESLUIT VAN DEN SENAAT DER UNIVERSITEIT TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP MAANDAG 8 JUNI 1936, DES NAMIDDAGS TE 3 UUR

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GERRIT WILLEM POSTMA
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Aan mijn Moeder.
Aan mijn aanstaande Vrouw.

Promotor: Dr. L. S. ORNSTEIN.

Aan Prof. ORNSTEIN betuig ik mijn groote erkentelijkheid voor zijn vele steun en belangstelling.

Aan mej. Dr. J. G. EYMERS, Dr. D. VERMEULEN en J. H. HEIËRMAN mijn hartelijke dank voor de samenwerking.

INTRODUCTION.

A few years ago the town-council of the Hague requested Prof. ORNSTEIN to give his advice on the lighting-system to be applied in the Municipal Museum of that town, designed by Dr. BERLAGE the architect.

While the plans were in course of preparation, it turned out, that the data necessary for the planning of any adequate lighting-system, namely those concerning the intensity and the spectral distribution of daylight, did not exist for our country. This induced us to enter upon a preliminary investigation of the constitution of daylight. This investigation showed us the advisability of attacking the whole subject more systematically than it had been possible to do in the time available for sending in our plans.

The outcome of this was that intensity-measurements in the visible part of the spectrum were carried out by us for nearly a year at a stretch. In Chapter I of the present publication the method of measuring and the way in which we described the meteorological conditions are explained. Chapter II contains the raw material and the optical and meteoroligical details belonging to it. Chapter III outlines the treatment of the material according to certain leading aspects and gives analytical expressions, comprising the results. The latter are divided into two principal groups, namely, those concerning the total illumination (due to the scattered light from the sky + the direct light from the sun) and those concerning the indirect illumination (due to the scattered light from the sky only). Chapter IV contains the observed values (arranged according to the solar altitude and the degree of covering) expressed in lux-units and further tables giving for every month of the year and for certain hours of the day the average value to be expected, of the total as well as of the indirect illumination.

In Chapter V we considered the influence of the atmosphere from a more theoretical point of view.

CHAPTER I.

Method of measuring.

The illumination of an object by daylight is effected by radiation, which either reaches the object straight from the sun or has been previously affected by scattering, reflection, diffraction etc. The illumination is, therefore, dependent on the position of the sun with respect to the earth, on the atmospherical conditions and on the surroundings of the illuminated object. The latter influence is variable in many ways. We shall not include it in the present considerations and study only the influence of the sun and the atmosphere; indeed we must first know how the light reaches the earth before we can form a complete picture of the illumination by daylight, in which the surroundings also play their part.

In order to ascertain this, our measuring arrangement was mounted on the roof of the Physical Laboratory — a rather high building in the town of Utrecht; from this roof a considerable part of the sky is visible. In measuring the illumination, we must distinguish between the illumination by direct sunlight (*direct* illumination) and that by the scattered light from the sky (*indirect* illumination). It is the direct sunlight that causes in the majority of cases a marked shadow. The direct and indirect illumination together give the *total* illumination. In our experiments the daylight illuminates a nearly horizontal white surface and the brightness of the latter, which is determined with the aid of a spectral pyrometer,[1]) serves as a measure for the illumination. If the illumination is to be readily obtained from the observed brightness (i.e. the one in the direction of the pyrometer), the latter must be dependent only on the total amount of energy incident on the observed surface-element and not on the direction of incidence. For, if this condition is complied with, the illumination is simply proportional to the observed brightness. Now, a magnesium-oxide surface meets these demands very satisfactorily for all wavelengths within the range of the visible spectrum, provided the angle between the surface and the direction of incidence be not too small. Accordingly, our white surface consisted of a layer of magnesium-oxide, precipitated on a flat metal plate. The factor of proportionality between brightness and illumination is readily determined by illuminating the white surface by a standardized lamp from the Utrecht Institute, and by then measuring the brightness corresponding to that known amount. The spectral pyro-

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1) L. S. ORNSTEIN, Miss J. G. EYMERS, D. VERMEULEN. Zeitschr. f. Phys. **75**, 575 (1932).

meter used for our measuring consists of a monochromator M (see fig. 1) a lamp L, a few lenses and the electrical implements for feeding and

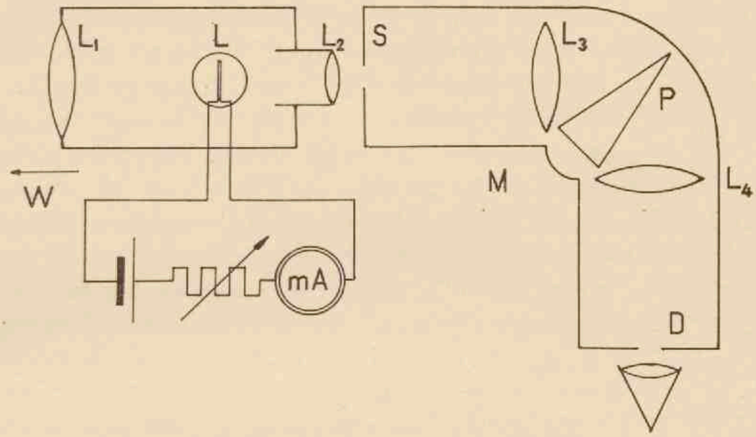

Fig. 1. Measuring arrangement.

controlling the lamp. The way it works is as follows. The lens L_1 forms an image of the white surface W on the filament of L, bent in the shape of a reversed U, which lies in a plane perpendicular to the optical axis of the system L_1, L_2, L_3. The lens L_2 forms an image of the filament and therefore also of the white surface very near the prism of the monochromator; finally, the prism P and the lens L_4 form a spectrum on the lid of the second monochromator tube. In this lid is an aperture D. Through it the filament and the white surface are seen in the light of the wavelength, determined by the position of the prism. By turning the latter, any part of the spectrum can be brought to fall on the diaphragm. The filament is part of an electrical circuit, which further contains a 4 volt accu, an adjustable resistance and a milliampèremeter. To a certain current corresponds a certain brightness in each part of the wavelength-region. When we look through the diaphragm at the filament and the surface, we see each with its own brightness, so that, when the filament is brighter we see it light against a dark background. When the surface is brighter, we see the filament dark against a light background. If they are equally bright that part of the filament, for which the brightness is constant cannot be distinguished from the background. In order to measure the illumination of the white surface, we must adjust the current in such a way, that the filament becomes invisible, and we must know the amount of energy per cm^2, per Å and per second, incident on the white surface, corresponding to the current, adjusted in that way. To that end the surface is illuminated by an absolutely standardized lamp (that is to say, one of which the amount of energy radiated per unit of solid angle, per Å and per second is known for the various wavelengths) and the current corresponding to that illumination is then measured. In this way a set of curves is obtained, representing the connection between the pyrometer current and the illumination of the white surface.

By the use of this white surface, errors are avoided, which otherwise might arise from the fact that daylight is partly polarized, whereas the standardizing is performed with ordinary light. For, by the reflection at the white surface, the light is completely depolarized so that by this device the spectral pyrometer receives ordinary light when the daylight is measured, as well as when the standardizing takes place. The precision of our determinations depends on the precision with which the radiated energy of the standardized lamp is known and on the precision of our adjustments and readings. As regards the former, the error is certainly less than 2 % of the amount of energy, actually brought into account; as for the latter, the error in the adjustment on equal brightness of filament and background is less than 0.2 of a scale division of the mA meter and the error in the reading of this instrument less than 0.1 of a scale division. Now, an error of 0.2 of a scale division corresponds in the central parts of the standardizing curves to a relative energy deviation of less than 2%. We may, therefore, safely assume the total error to remain, in general, under 5 %.

The filament of the pyrometerlamp may not be run at a higher current than corresponds to 130 scale divisions, in order to prevent changes in its condition invalidating the standardizing [1]). In the case of short wavelengths the brightness of the wire is often insufficient for a direct comparison with that of the white surface. The latter brightness is then diminished by means of a reducer V, inserted in front of the lens L_1. In order to obtain the most advantageous conditions, we made use of two reducers of unequal transmission-powers. We ascertained, by measuring, that they were nearly grey, i.e. that the reduction factor was nearly the same for all the wavelengths that concerned us. (The reducers were made by some time exposing a photographic plate to the light and by then developing and fixing it.) The reduction factor depended also on the position of the reducer in front of the lens.

The actual measuring was carried out as follows: We began to measure without reducer the brightness at the various wavelengths from $\lambda = 6800$ Å downward, until the mA meter read somewhere between 120 and 130 scale divisions. The brightness at the corresponding wavelength was then again measured with the reducer inserted and the reduction factor obtained from these two measurements was applied to the determinations (with the same reducer inserted) of the brightness at the wavelengths further down to $\lambda = 4500$ Å. By this way of proceeding the results are liable to errors

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[1]) It is necessary to re-standardize from time to time in order to ascertain, whether the standardizing curves must be altered on account of certain alterations in the condition of the filament connected with the life-time of the lamp and with the strength of the current which the filament has had to stand.

since the illumination is under certain conditions of the weather not constant while the set of measurements is being obtained, but may fluctuate considerably in a short interval.

The white surface was protected from rain by a bellglass. That part of the glass, which the radiation from the surface actually passed on its way to the pyrometer was protected against trickling water by a small glass roof. The reduction factor of the bellglass was found to be 1.2 (whether wet or dry). The observed brightnesses must therefore be multiplied by 1.2 to allow for the influence of the bellglass. In order to be able to measure the total, as well as the indirect illumination, the direct light from the sun could be intercepted by means of a wooden screen placed at some distance from the surface. This screen intercepted also a certain amount of scattered light from the sky in the immediate vicinity of the sun, but this amount can be neglected.

The pyrometer and accessories were mounted in a wooden shed on the roof of the Physical Laboratory where there are comparatively few obstacles. When the sun was low in the western sky the pyrometer shed itself was in front of it, and in midwinter the sun set behind the shed belonging to the heliostate of the heliophysical department somewhat further away on the roof. But towards the north, the east and the south the view was practically unobstructed.

The white surface formed a small angle with the horizontal plane — as did also the optical axis of the system L_1, L_2 and L_3 so that the surface could be conveniently observed through the pyrometer.

Since there appeared to exist a distinct connection between the illumination on the one hand and the solar altitude and the cloudiness on the other hand, we tried to determine the data concerning the latter quantities more closely. Now, as regards the solar altitude, this is completely determined by the time at the moment of measuring. As regards the cloudiness, notes were made of the degree of covering, the type of clouds and their height. The degree of covering was estimated in tenths of the total hemisphere [1]), the type of the clouds was assigned to them in the usual way according to their shape and level.

At all levels we distinguished between cumulus- and stratus-types. We denoted by "cumulus" more or less isolate clouds, in the majority of cases of rounded shapes and vertical sides; by "stratus", clouds extending like a sheet over part or over the whole of the sky, without clearly marked individual clouds. Between these extreme types there are various intermediate ones. We distinguished three levels.

In the lowest level we distinguished between cumulus, stratocumulus and stratus. Stratocumulus is intermediate between stratus and cumulus, it shows clearly separate formations in the layer of clouds, though distinct

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[1]) In estimating the degree of covering we chiefly considered the zenithal part of the sky.

vertical sides are as yet not present. This level reaches as high as 2000 to 2500 M.

In the middle level we find the altocumulus and altostratus type. Altocumulus does not show definite vertical parts. The clouds give the impression of rounded crowded masses, hanging more or less loosely together. Altostratus often shows very little detail. (Height about 3000 M.)

The highest clouds are the cirri, subdivided into cirrostratus, cirrus and cirrocumulus. The cirrustype has often a kind of filigree structure. As an effect of perspective, the threads of clouds seem at times to meet in one point. Cirrostratus covers the sky like a transparant veil. Cirrocumulus often occurs together with altocumulus. The cirri produce the halos round the sun and the moon.

Generally speaking the same type of clouds is lower in winter than in summer, so that one cannot suffice with simply assigning to each of the three levels one definite height above the surface of the earth.

For the lower level clouds we have added the estimated height above the earth of their lowest parts. The clearness of the atmosphere in a horizontal direction was expressed by the degree of visibility of the horizon — varying from "very clear" to "invisible". Particulars, such as rain or snow etc. were duly registered.

CHAPTER II.

In this chapter the measurements concerning the illumination are given, obtained during the interval from 8th Aug. 1932 to 6th July 1933 inclusive. We shall give a few comments and an explanation of the abbreviations used in connection with the various terms separately.

Time: Time is recorded in Amsterdam time = G.M.T. + ∽ 20 min.

Solar Altitude. The altitude is determined with an accuracy of about 2°.

Total or *Indirect.* By Indirect (I) are denoted those observations during which the direct radiation of the sun was intercepted at about 2 m from the white surface by a screen of about 20 × 40 cm.

Cloudiness. The cloudiness for the observations 1—180 is only occasionally, but for the observations 181—706 it is stated regularly by *a.* the degree of covering in tenths of the whole hemisphere, *b.* the type of clouds and *c.* the height (in m) above the earth of the cloud basis — as far as the lower types (st, cu, stcu, ni) are concerned. The meaning of the abbreviations is:

st = stratus	ast = altostratus	ci = cirrus
stcu = stratocumulus	acu = altocumulus	cist = cirrostratus
cu = cumulus		cicu = cirrocumulus
ni = nimbus		

(See also Chapter I.)

For the other observations we have introduced the distinctions:

a. heavily clouded sky (h), *b.* moderately clouded sky (m), and *c.* slightly clouded or cloudless sky (l, no cl.). Again *br. sun* means, that the sun was shining brightly and continuously, and *occ. sun* that it was shining at intervals.

Horizon. The indications here given refer to the visibility of the horizon. The meaning of the abbreviations is:

inv. = invisible	v. cl. = very clear
v. hazy = very hazy	m. cl. = moderately clear.
m. „ = moderately hazy	
sl. „ = slightly hazy	

Wavelength. The wavelength of the light of which the intensity is determined, is given in Å (1 Å = 10^{-8} cm).

Illumination. Owing to the way our instruments are read, the illumination is expressed in relative units.

1 *relative unit* corresponds to 1.39 × 10^{-8} W/Å cm^2. The fact that a reducer is used (B, weak; G, strong) is indicated by the reduced amount of energy in brackets under the computed actual amount. All values

following such a one are obtained with that same reducer inserted, while the reducing factor is taken to be constant as regards the wavelength. A few observations were carried out with the reducer applied from the beginning: this is duly mentioned under: "remarks". Whenever the bellglass has been used in case of rain or other atmospherical condensationproducts, special mention has been made. The reducing factor 1.2 has already been accounted for in the values given.

From observation N⁰. 222 onward, the result from a new standardizing of the pyrometer was employed, which differed from the old one by the constant factor 1.17. The results from the observations 1—222 have been put in line with those of the others, by multiplying them by this factor, since we had reason to consider the last standardizing as the most accurate.

Our measurings were always begun at $\lambda = 6800$ Å and finished at $\lambda = 4500$ Å.

Class. The observations are divided into three classes *A*, *B*, *C*, and a further group of unreliable or incomplete observations indicated by ?. (For more details see Chapter III.)

Observation No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Date	8 Aug. 1932	8 Aug.	8 Aug.	8 Aug.	8 Aug.	8 Aug.	8 Aug.	8 Aug.	8 Aug.	11Aug.	11Aug.	11Aug.	11Aug.	11Aug.	11Aug.	11Aug	11Aug.	11Aug.	11Aug.	19Aug.
Time	9.15	9.30	10.05	10.35	12.00	12.20	14.05	14.20	15.55	9.10	9.20	10.00	10.10	12.05	12.10	14.05	14.10	15.55	16.00	8.45
Solar altitude	41°	43°	48°	50°	54°	53°	46°	44°	31°	40°	41°	46°	47°	53°	53°	44°	43°	31°	30°	35°
Total or indirect	I	T	I	T	T	I	T	I	I	T	I	T	I	T	I	T	I	I	T	T
Cloudiness	h.	h. br.sun	h. occ. sun	m. occ. sun	m. br.sun	m. occ. sun	m. br.sun	m. occ. sun	m. occ. sun	l.	l.	l.	l.	l.	l.	l.	l.	l.	l.	no cl.
Horizon		sl hazy	m. cl.	sl.hazy	sl.hazy	m. cl.	sl.hazy	sl.hazy	sl.hazy	hazy	hazy	hazy	hazy	sl.hazy	sl.hazy	sl.hazy	sl.hazy	sl.hazy	sl.hazy	inv.
Remarks																				
Wavelength (Å)																				
6800	510	990	505	1200	1210	510	975	309	258	925	265	780	270	980	205	750	185	170	645	770
6600	440	—	455	1100	1120	525	910	298	246	870 (154)	275	710	260	990 (175)	200	700	180	150	650	730
6400	440	970	455	850?	1190	550	940	282	241	960	275	680 (151)	300	885	205	680	210	155	630	755 (135)
6200	440	—	505	1180	1230	610	980	296	256	910	295	665	315	1020	225	730 (121)	215	160	660 (120)	815
6000	415	—	495	1210	1220	615	960	306	268	890	285	670	320 (55)	1000	235	630	220 (43)	175	640	795
5800	440	1115	540	1290	1340	680	1040	335	314	910	320	640	330	1065	260 (50)	575	245	190	695	850
5600	450	—	590	1320	1340	690	1140	377	344	980	350	685	390	1095	310	660	275	220	720	910
5400	470	1300	605	1530	1440	715	1200	405	358	1060	355	790	405	1070	315	775	305	230	730	900
5200	445	1260 (200)	570	1440 (218)	1440 (218)	665	1195 (184)	405	344	980	315 (65)	675	355	995	270	775	315	235 (46)	730	865
5000	505 (180)	—	615 (217)	1500	1490	700 (233)	1285	460 (172)	366 (132)	940	335	635	420	1025	350	825	330	240	750	870
4900	520	1285	540	1450	1470	745	1300	470	360	965	350	650	445	990	360	790	360	235	720	830
4800	—	—	570	1590	1450	780	1240	510	384	1010	360	815	465	1020	355	775	355	290	780	790
4700	—	1240	575	1570	1440	795	1030	510	363	890	370	750	430	930	380	740	317	275	715	895
4600	—	—	620	1560	1390	805	1080	540	363	950	345	800	500	940	400	740	340	305	740	825
4500	—	1240	640	1550	370?	840	1200	575	380	965	330	795	445	860	355	840	370	310	760	790
Class	B	A	B	A	A	B	B	A	A	B	B	B	B	A	B	C	A	A	A	A

Observation No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Date	19Aug. 1932	19Aug.	19Aug.	19Aug	19Aug.	19Aug.	19Aug.	19Aug.	19Aug.	22Aug.	22Aug.	22Aug.	22Aug.	22Aug.	22Aug.	22Aug.	24Aug.	24Aug.	24Aug.	24Aug.
Time	9.00	10.00	10.15	12.05	12.20	14.05	14.25	16.00	16.20	9.05	9.25	10.00	10.15	13.00	14.10	15.50	9.20	10.15	11.55	14.10
Solar altitude	37°	43°	46°	50°	50°	43°	41°	28°	24°	37°	39°	43°	44°	48°	41°	29°	37°	44°	49°	40°
Total or indirect	I	T	I	T	I	T.	I	T	I	I	T	T	I	I	I	I	I	I	T	T
Cloudiness	ci	ci	ci	l. ci	l. ci	ci	faint sun	ci	ci br. sun	h. ni.	m. occ.sun	m. occ.sun	m. occ.sun	h. occ.sun	h. occ.sun	h. occ.sun	h. occ.sun	h. occ.sun	h.	h.
Horizon	inv.	inv.	inv.	inv.	inv.	hazy	hazy	hazy	hazy	hazy	hazy	hazy	hazy	sl.hazy	m. cl.	cl.	hazy	hazy	cl.	v. cl.
Remarks																		drizzle bell glass		
Wavelength																				
6800	350	800	360	890	375	565	395	610	265	118	985	1080	285	500	395	345	620	355	300	410
6600	335	760	335	880	345	535	340	540	250	113	—	—	255	385	340	285	605	335	250	380
6400	330	805	360	910	360	560	380	555	245	120	935	1020	275	410	365	300	615	355	240	400
6200	360	830	370	900	395	610	450	555	255	148	—	—	295	450	400	320	620	395	230	410
6000	360	850	375	825	405	605	395	550	260	161	950	1110	295	440	410	295	580	410	205	425
5800	380	890	400	1050	425	635	420	570	270	208	—	—	345	560	510	320	620	480	230	460
5600	425	960	435	1110	445	670	445	630	300	250	1140	1245	405	620	540	370	695	530	230	490
5400	425 (83)	1010	435	1200	470	655	465	625	305	300	—	—	425	620	555	395	725	560	225	510
5200	435	965	410	1130 (170)	445	605	445	570	290	410	1150 (182)	1430 (210)	430	575	570	395	720	600	210	475
5000	460	1090 (165)	465 (165)	1130	500 (175)	665 (220)	475 (185)	555 (99)	310 (113)	475 (176)	—	—	500 (174)	665 (119)	605 (217)	410 (164)	975 (147)	720 (120)	215	475 (168)
4900	475	1100	485	1220	520	675	475	610	320	475	1190	1320	485	575	600	395	970	655	215	480
4800	465	1130	510	1340	540	725	490	635	360	545	—	—	540	595	660	415	1010	665	240	510
4700	465	1110	475	1165	525	680	490	620	340	595	1140	1360	525	530	585	455	1010	600	240	460
4600	455	1130	500	1165	520	700	485	600	355	670	—	—	585	525	700	495	1040	590	285	460
4500	400	1000	510	1200	515	780	500	590	315	495	1320	1260	595	515	640	500	965	570	305	410
Class	A	A	A	B	A	A	B	B	A	C	A	A	A	B	A	A	A	A	A	A

Observation No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Date	24Aug. 1932	26Aug.	26Aug.	26Aug.	26Aug.	26Aug.	26Aug.	26Aug.	31Aug.	31Aug.	31Aug.	31Aug.	31Aug.	2Sept.	2Sept.	2Sept.	2Sept.	5Sept.	5Sept.	5Sept.
Time	16.10	9.10	9.30	10.05	10.20	14.10	14.25	16.05	10.10	10.35	11.50	14.10	15.55	9.10	10.00	12.05	16.05	9.20	10.00	12.00
Solar altitude	24°	36°	38°	42°	43°	40°	39°	24°	42°	43°	47°	39°	26°	34°	39°	46°	23°	34°	39°	45°
Total or indirect	T	T	I	T	I	T	I	T	I	T	I	I	I	T	T	T	T	T	I	I
Cloudiness	h.	l. br.sun	l. br.sun	l. br.sun	l. br.sun	l. br.sun	l. br.sun	h.	m. occ.sun	m. br.sun	m. occ.sun	m. occ.sun	h. occ.sun	h.	h.	h.	h.	h.	h.to m. occ.sun	m. occ.sun
Horizon	v. cl.	hazy	hazy	m.hazy	m.hazy	v.hazy	v.hazy	v.hazy	v.hazy	v.hazy	m.hazy	cl.	m.hazy	inv.	inv.	inv.	inv.	hazy	m.hazy	m.hazy
Remarks																				
Wavelength																				
6800	315	795	191	890	164	880	230	300	500	990	370	550	395	67	100	90	134	445	575	445
6600	290	760	167	850	162	825	220	260	480	925	380	510	380	43	84	76	125	430	535	355
6400	300	765	183	905	180	830	245	275	410	920	400	525	400	52	95	92	134	435	540	350
6200	295	805	200	905	199	855	260	270	425	910	410	560	410	65	110	98	125	450	555	325
6000	290	790	206	950	206	865	270	265	450	890	415	550	405	60	92	90	86	440	550	305
5800	305	880	236	975	235	920	290	285	520	970	480	580	435	71	111	106	94	465	565	320
5600	320	925	269	1050	268	960	335	305	540	960	535	625	405	84	124	122	97	490	580	335
5400	330	975	291	1110	290	1020	350	305	520	1120	570	655	430	82	126	118	104	510	620	360
5200	295	950	290	1180 (171)	285	1025 (164)	350	290	540	1160 (183)	570	610	380	85	118	109	96	510	525	345
5000	310 (112)	1075 (168)	335 (67)	1120	330 (122)	1030	395 (145)	310	605 (210)	1260	615 (217)	645 (215)	395 (130)	86	121	112	107	605 (215)	515 (166)	385 (148)
4900	290	1040	320	1140	345	975	420	310 (112)	615	1200	590	625	390	86	114	116	109	900	525	410
4800	315	1100	345	1080	385	1080	415	330	690	1260	700	700	375	93	118	129	136	910	535	485
4700	300	1000	360	1100	385	990	425	300	600	1185	640	650	350	91	119	131	137	880	515	480
4600	300	1020	405	1120	430	1065	420	320	660	1180	660	700	355	86	131	135	141	850	550	535
4500	290	1015	340	1100	420	1060	425	295	630	965	675	720	365	80	144	133	130	780	555	470
Class	A	A	A	A	A	A	A	A	B	A	A	A	A	B	B	B	C	C	B	A

Observation No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Date	5 Sept. 1932	5 Sept.	7 Sept	7 Sept.	7 Sept.	7 Sept.	7 Sept.	7 Sept.	7 Sept.	9 Sept.	9 Sept.	9 Sept.	9 Sept.	9 Sept.	9 Sept.	14 Sept.	14 Sept.	14 Sept.	15 Sept.	15 Sept.
Time	14.05	1600	9.20	10.00	11.50	12.10	14.00	14.15	16.00	9.20	10.00	10.40	12.00	14.00	15.55	9.30	10.05	12.10	9.25	13.40
Solar altitude	37°	23°	33°	38°	44°	44°	38°	37°	23°	33°	37°	40°	44°	38°	23°	34°	39°	42°	31°	37°
Total or indirect	I	I	I	I	T	I	T	I	I	T	I	T	T	T	T	T	T	I	I	T
Cloudiness	m. occ.sun	m. occ.sun	h. occ.sun	h. occ.sun	m. occ.sun	m. occ.sun	m. occ.sun	m. occ.sun	m. occ.sun	m.	h.	m. br.sun	h.	h.	h.	h.	h.	h. occ.sun	h.	m. br.sun
Horizon	sl.hazy	m.hazy	v.hazy	v.hazy	m.hazy	m.hazy	cl.	cl.	cl.	v.hazy	v.hazy	hazy	hazy	hazy	m.hazy	inv.	inv.	v.hazy	m.cl.	hazy
Remarks																drizzle bell glass	drizzle bell glass			
Wavelength																				
6800	390	355	485	665	1030	295	1030	300	320	640	515	1040	345	182	72	108	197	370	310	915
6600	385	330	440	585	975	290	1000	270	290	550	460	1000	305	171	62	110	144	430	294	835
6400	450	320	450	620	1010	310	1010	280	285	550	505	1000	330	156	64	110	133	615	300	830
6200	460	335	425	620	1050	325	1020	290	290	540	600	900	360	166	76	140	131	715	320	870
6000	455	335	460	605	1080	330	1040	305	290	505	485	985	360	149	71	139	123	425	300	795
5800	475	355	475	635	1140	350	1050	330	295	570	480	1140	395	162	82	148	129	440	325	915
5600	485	400	420	680	1240	340	1150	370	330	635	535	1220	440	178	96	173	140	455	370	950
5400	470	390	395	655	1310	360	1200	390	335	670	550	—	470	166	101	162	144	510	355	1020
5200	450	370	375	610	1440 (217)	440	1150 (181)	375	335	670	525	—	470	165	97	186	136	560	365	1010
5000	465 (165)	375 (136)	370 (150)	715 (235)	1400	470 (183)	1150	430 (157)	360 (132)	715 (230)	565 (195)	—	520 (192)	182	87	200	145	650 (173)	390 (135)	1100 (182)
4900	460	360	355	695	1350	485	1190	435	365	670	610	—	495	202	99	189	154	455	395	1010
4800	445	390	360	685	1300	545	1200	470	330	720	680	—	545	239	101	180	158	480	375	1030
4700	435	370	345	615	1320	470	1090	465	325	730	610	—	550	244	92	171	161	505	370	1030
4600	425	375	380	535	1330	405	1070	500	325	720	675	—	520	255	88	198	188	620	405	1020
4500	410	330	375	495	1350	410	1070	470	310	690	650	—	540	249	81	238	172	635	405	930
Class	A	B	B	B	A	A	A	A	A	B	C		A	B	B	B	A	?	A	A

Observation No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Date	16Sept. 1932	16Sept.	16Sept.	16Sept.	16Sept.	16Sept.	16Sept.	16Sept.	16Sept.	16Sept.	19Sept.	19Sept.	19Sept.	21Sept.	21Sept.	21Sept.	21Sept.	21Sept.	21Sept.	21Sept.
Time	9.00	9.15	10.00	10.15	12.25	12.50	14.00	14.15	16.00	16.25	9.25	10.00	12.00	9.05	9.30	10.00	10.15	12.10	14.00	16.00
Solar altitude	28°	30°	35°	37°	40°	40°	35°	33°	20°	17°	30°	33°	38°	29°	30°	33°	34°	38°	33°	18°
Total or indirect	T	I	T	I	T	I	T	I	T	I	I	T	I	T	I	T	I	I	T	T
Cloudiness	no cl.	no cl.	no cl.	no cl.	no cl.	no cl.	no cl.	no cl.	no cl.	no cl.	h.	h.	h.	m.	m.	m. occ.sun	m. occ.sun	m.	m.	—
Horizon	hazy	hazy	hazy	hazy	m.hazy	m.hazy	m.hazy	m.hazy	hazy	hazy	m.hazy	—	m.hazy	cl.	cl.	cl.	cl.	—	—	—
Remarks												occ.rain bell glass from λ=5000	rain							
Wavelength																				
6800	770	185	870	197	805	168	780	161	400	115	340	560	185	840	405	1040	221	243	300	239
6600	730	213	835	187	840	164	735	149	420	131	310	585	159	785	435	910	235	250	410	193
6400	730	210	840	193	820	164	745	156	415	136	300	690	171	800	425	287	207	252	560	237
6200	805	196	840	212	870	188	785	180	410	149	294	605	196	815	400	930	223	288	465	201
6000	805	252	835	226	865	184	780	179	405	153	280	510	202	800	400	860	224	297	380	203
5800	815	278	870	251	940	212	840	210	385	164	285	530	218	835	405	940	236	310	695	201
5600	880	300	965	280	980	257	870	229	400	190	298	560	224	900	410	395	280	335	790	224
5400	925	315	965	268	1070	272	920	260	228	196	300	560	200	930	430	280	282	360	810	235
5200	850	315	1010	300	1025	281	855	281	233	185	294	590	165	915	425	1040	260	340	340	240
					(176)											(315)				
5000	980	355	1050	335	980	288	975	295	360	217	305	400	154	1060	455	1120	283	375	325	243
	(154)		(166)	(119)			(159)	(108)	(77)		(125)			(168)			(120)			
4900	980	415	1145	460	995	320	975	284	350	220	265	360	143	1030	450	1040	293	467	325	252
4800	990	450	1180	525	1015	320	910	320	325	212	265	325	143	1000	480	1080	310	405	355	252
4700	1030	370	990	485	950	375	800	295	275	212	265	331	157	1050	500	1080	290	380	305	248
															(182)					
4600	850	345	965	430	720	340	810	345	305	226	225	305	175	1000	485	1130	293	—	335	245
4500	780	285	1070	350	710	295	630	345	340	235	233	278	222	1030	510	995	270	—	280	255
Class	B	A	A	B	A	A	B	A	B	A	A	C	C	A	A	C	B	B	?	B

Observation No.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Date	23Sept. 1932	23Sept.	23Sept.	23Sept.	23Sept.	26Sept.	26Sept.	26Sept.	26Sept.	26Sept.	27Sept.	27Sept.	27Sept.	27Sept.	27Sept.	27Sept.	27Sept.	27Sept.	27Sept.	28Sept.
Time	9.00	10.05	12.15	14.05	17.00	9.05	10.00	12.35	14.00	16.00	9.15	9.30	10.00	10.15	12.05	12.15	14.00	16.00	16.15	9.00
Solar altitude	25°	33°	38°	32°	9°	26°	31°	37°	31°	17°	26°	28°	31°	32°	37°	37°	31°	17°	14°	24°
Total or indirect	T	T	T	T	T	T	T	T	T	T	T	I	T	I	T	I	I	T	I	T
Cloudiness	h.	h.	10	h.	h.	h.	h.	10	10	10	1	1	1	1	4	4	6	1.	1.	no cl.
Type of clouds Height of clouds			nb 200					cu 800	stcu 600	stcu 600	stcu 1500	stcu 1500	stcu 1500	stcu 1500	cu 2000	cu 2000	cu 1500			
Horizon	hazy	hazy	—	—	—	hazy	hazy	m. cl.	m.hazy	m.hazy	v.hazy	v.hazy	v.hazy	v.hazy	m. cl.	m. cl.	m. cl.	m. cl.	m. cl.	m.hazy
Remarks	rain bell glas		h. rain bell glas		rain bell glas		measured with reduce													
Wavelength																				
6800	169	390	235	208	21	390	550	540	209	158	640	244	820	278	950	345	284	203	152	690
6600	133	405	161	176	24	370	475	670	202	129	620	235	800	235	865	320	335	193	144	680
6400	101	435	126	185	28	335	400	625	207	115	640	235	735	249	890	320	252	187	139	670
6200	81	475	112	185	31	335	475	505	226	114	555	248	750	276	875	345	232	238	159	665
6000	72	475	96	188	33	330	460	485	214	105	510	271	770	294	890	340	235	235	149	665
5800	83	455	125	196	35	355	460	485	212	115	690	287	820	340	925	370	239	225	154	690
5600	95	490	141	221	32	380	520	435	247	125	740	315	850	405	980	405	248	250	176	740
5400	94	640	151	254	45	380	325	490	250	130	755	330	865	430	1020	430	262	283	182	760
5200	92	515	218	275	39	365 (126)	315	390	226	127	715	325	875	435	960	420	246	304	180	730
5000	99	400	191 (84)	294	42	390	271	380	240	139	835 (126)	355	940 (154)	500 (92)	1050 (134)	445 (155)	269 (101)	284 (105)	193	790 (120)
4900	90	380	147	300	44	375	370	345	226	136	900	350	880	475	1060	435	254	271	186	735
4800	94	400 (89)	—	350	47	385	310	345	252	153	835	370	905	520	1110	480	264	256	188	730
4700	109	226	—	315	47	340	315	300	242	136	800	380	830	460	980	445	249	238	183	710
4600	112	220	—	330	50	295	271	290	244	131	720	375	735	455	970	345	249	228	189	665
4500	125	123	—	280	46	276	285	300	233	128	700	—	720	395	840	420	228	228	186	660
Class	A	?	?	A	B	A	C	B	A	A	C	A	A	A	A	A	B	B	A	A

Observation No.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Date	28Sept. 1932	28Sept.	28Sept.	28Sept.	28Sept.	28Sept.	28Sept.	28Sept.	28Sept.	29Sept.	29Sept.	29Sept.	29Sept.	29Sept.	29Sept.	29Sept.	29Sept.	29Sept.	29Sept.	30Sept.
Time	9.15	10.00	10.15	12.00	12.20	14.00	14.15	16.00	16.15	9.00	9.15	10.00	10.15	12.10	12.20	14.08	14.28	15.00	15.20	9.30
Solar altitude	26°	31°	32°	37°	36°	30°	29°	16°	14°	24°	26°	30°	31°	36°	36°	30°	28°	22°	21°	27°
Total or indirect	I	T	I	T	I	T	I	T	I	T	I	T	I	T	I	T	I	T	I	T
Cloudiness	no cl.	no cl.	no cl.	no cl.	no cl.	l.	l.	no cl.	no cl.					3	3	1	1	4	4	10
Type of clouds Height of clouds						ci	ci			ci	ci	ci	ci	ast	ast	ast	ast	ast	ast	cuni
Horizon	m.hazy	m.hazy	m.hazy	cl.	cl.	cl.	—	—	—	hazy	hazy	hazy	—	m. cl	m. cl.	cl.	cl.	cl.	cl.	hazy
Remarks																		measured with reclucer B		
Wavelength																				
6800	192	800	182	875	170	665	248	485	113	715	240	890	295	810	293	790	169	405	239	167
6600	164	740	166	810	178	775	228	500	109	625	221	855	281	745	287	705	162	420	226	134
6400	160	730	156	800	182	770	239	490	112	650	255	850	278	740	315	695	180	189	226	146
6200	178	770	178	835	196	810	248	500	137	575	256	775	290	735	320	720	203	234	227	134
6000	186	780	183	875	199	825	247	465	135	555	288	810	280	705	330	705	210	234	219	134
5800	203	810	220	890	226	875	273	480	143	610	285	885	305	750	355	750	231	278	225	146
5600	227	850	235	960	255	900	315	485	165	655	330	1000	370	810	390	775	260	465	267	163
5400	248	880	252	1010	275	900	380	515	182	725	335	1020	365	810	410	840	277 (108)	440	280	162
5200	251	875	255	960 (151)	272	875	320	555	176	630	335	1010 (148)	345	750	405	795	275	380	282	175
5000	284 (101)	965 (140)	274	940	295 (124)	975 (144)	340 (129)	565 (135)	188	650 (96)	360 (136)	990	385 (143)	830 (113)	450	840 (112)	280	460	280	180
4900	330	955	286	890	280	670	330	670	181	610	340	940	385	760	445 (148)	840	270	450	280	173
4800	355	940	313	1000	305	720	335	660	190	650	375	910	400	770	495	805	282	430	286	183
4700	325	890	310	865	276	765	335	600	191	600	325	820	375	710	450	725	280	350	286	186
4600	345	840	330	785	250	800	300	600	212	610	340	830	355	700	430	740	278	310	310	186
4500	335	790	320	850	263	800	330	575	183	555	325	780	375	645	420	640	258	390	330	150
Class	A	A	A	A	A	C	B	B	A	C	A	A	A	A	A	A	A	?	B	A

Observation No.	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Date	30Sept. 1932	30Sept.	30Sept.	30Sept.	30Sept.	30Sept.	3 Oct.	3 Oct.	3 Oct.	3 Oct.	4 Oct.	4 Oct.	4 Oct.	5 Oct.	5 Oct.	5 Oct.	5 Oct.	5 Oct.	6 Oct.	6 Oct.
Time	10.00	12.05	14.05	14.15	15.05	15.20	10.00	11.45	14.00	16.15	14.00	14.15	16.00	10.05	12.15	12.30	14.10	16.00	12.05	12.30
Solar altitude	30°	36°	29°	29°	22°	21°	29°	34°	29°	13°	30°	29°	14°	29°	34°	33°	27°	14°	34°	33°
Total or indirect	T	T	T	I	T	I	T	T	T	T	T	I	T	T	I	T	T	T	T	I
Cloudiness	10	10	3	3	0	0	h.	h.	h.	h.	4	4	h.	h.	fog	fog	6	0	sl.mist	sl.mist
Type of clouds Height of clouds	cuni	cu+stcu 400	st. 2000	st. 2000				cuni	ni	ni	cu+stcu 600	cu+stcu 600				s.appears	stcu 700			
Horizon	hazy	hazy	hazy	hazy	m. cl.	m. cl.	hazy	hazy	m. cl.	v.hazy	cl.	cl.	cl.	inv.			foggy	m.hazy	v.hazy	v.hazy
Remarks	bell glass								h. rain bell glass	bell glass	showery	rain bell glass				measured with reducer	occ sun			
Wavelength																				
6800	120	198	740	140	605	204	370	385	27,0	107	650	520	375	59	294	500	219	214	665	340
6600	92	193	755	153	560	182	330	365	30,0	75	670	490	270	47	325	480	300	225	620	310
6400	86	188	740	153	540	179	320	345	29,5	68	290	485	105	49	274	400	360	210	480	330
6200	87	210	730	176	545	193	320	340	33,5	68	335	480	127	53	300	480	545	214	520	355
6000	86	206	755	176	510	185	325	335	30,0	60	400	435	135	51	315	520	590	185	645	360
5800	89	208	780	198	520	207	350	355	38,0	69	460	470	104	49	310	520	610	172	670	395
5600	98	235	810	218	570	219	370	380	46,5	76	385	505	135	47	345	571	625	125	680	410
5400	122	240	820	237	565	240	365	365	46,5	74	345	495 (182)	138	47	355	560	625	132	730	425
5200	131	234	840 (110)	257	530 (84)	240	335	345	44,0	72	335	490	132	44	340	570	490	136	690	420
5000	148	244	780	290	560	265	305 (120)	335 (124)	44,0	60	475	485	153	56	385	565	455	134	755 (126)	440 (172)
4900	157	238	735	290	515	244	305	300	45,5	52	750 (229)	450	145	33	390	540	395	139	725	415
4800	178	253	760	320 (120)	490	281	—	295	51	52	1020	460	143	34	470	560	420 (83)	137	730	440
4700	176	250	540	300	445	265	—	277	55	53	990	410	136	—	435 (142)	535	550	119	695	440
4600	150	262	460	305	520	305	—	257	54	54	990	410	129	—	435	500	590	135	650	430
4500	108	214	—	266	—	263	—	243	59	47	805	315	165	—	440	490	560	121	605	390
Class	A	A	A	A	B	A	A	A	B	?	?	B	?	B	B	B	?	B	C	A

Observation No.	161	162	163	164	165	166	167	168	169	170
Date	6 Oct. 1932	6 Oct.	6 Oct.	6 Oct.	7 Oct.	7 Oct.	7 Oct.	7 Oct.	7 Oct.	7 Oct.
Time	14.00	14.15	16.00	16.15	10.00	10.15	14.00	14.20	16.00	16.05
Solar altitude	28°	27°	14°	12°	28°	29°	28°	27°	13°	12°
Total or indirect	T	I	T	I	T	I	T	I	T	I
Cloudiness	2	2	0	0	0	0	1	1	0	0
Type of clouds Height of clouds	acu+ast	acu+ast					cu 2000	cu 2000		
Horizon	hazy	hazy	hazy	hazy	v.hazy	—	cl.	cl.	sl.hazy	sl.hazy
Remarks										
Wavelength										
6800	490	192	208	101	780	191	530	150	220	87
6600	445	211	165	82	725	208	465	161	162	93
6400	425	212	139	84	610	212	440	185	170	103
6200	435	218	145	93	625	233	440	190	175	110
6000	455	235	146	88	660	235	455	210	173	103
5800	470	244	143	92	695	267	470	227	173	111
5600	495	272	157	108	740	300	490	238	175	121
5400	490	285	157	109	770	327	505	242	182	129
5200	480	285	153	113	780	321	465	250	168	133
5000	510	296	161	120	775 (126)	345 (135)	480 (91)	274	172	144
4900	580 (193)	315	159	120	805	360	495	275	185	139
4800	555	315	161	120	810	345	480	298	190	136
4700	500	310	156	121	695	350	465	315	162	132
4600	460	335	137	117	635	320	490	325	142	120
4500	420	272	153	115	575	265	465	295	151	127
Class	B	A	B	A	C	A	A	A	B	A

Observation No.	171	172	173	174	175	176	177	178	179	180
Date	10 Oct.	10 Oct.	10 Oct.	10 Oct.	11 Oct.	12 Oct.	12 Oct.	12 Oct.	12 Oct.	13 Oct.
Time	11.30	14.00	16.00	16.10	12.00	12.00	14.15	14.30	16.05	10.15
Solar altitude	31°	27°	12°	10°	32°	32°	26°	24°	11°	28°
Total or indirect	T	T	T	I	T	T	T	I	I	T
Cloudiness	h	6	3	3	h	5	3	3	2	h
Type of clouds Height of clouds		stcu 800	stcu+ci	stcu+ci	cuni	cu 800	cu 1000	cu 1000	ast	
Horizon	hazy	hazy	hazy	hazy	hazy	hazy	hazy	hazy	hazy	hazy
Remarks					some rain bell glass					occ. rain bell glass
Wavelength										
6800	405	255	293	74	305	725	435	232	85	191
6600	405	280	225	73	276	705	405	206	77	160
6400	505	320	202	71	300	695	370	207	80	145
6200	620	310	196	72	315	580	375	232	81	176
6000	680	232	164	70	320	540	395	235	79	166
5800	525	255	168	73	325	465	385	255	88	168
5600	415	350	181	94	340	705	410	290	99	170
5400	395	296	187	98	350	460	410	295	102	156
5200	365 (160)	263	176	98	320	540	390	292	102	121
5000	350	269	192	108	360	460 (91)	405 (78)	310 (121)	111	93
4900	300	269	167	105	335	355	365	310	109	79
4800	203	266	155	108	360	340	390	320	113	85
4700	205	259	147	100	370 (130)	305	370	295	102	89
4600	300	251 (93)	148	102	350	320	360	300	107	66
4500	280	216	136	98	355	300	305	260	96	68
Class	?	C	B	A	A	?	A	A	A	B

Observation No.	181	182	183	184	185	186	187	188	189	190
Date	13Oct. 1932	14Oct.	14Oct.	14Oct.	17Oct.	17Oct.	17Oct.	17Oct.	17Oct.	18Oct.
Time	16.00	10.10	12.00	14.00	10.00	12.00	12.10	14.00	16.00	10.00
Solar altitude	12°	27°	31°	26°	24°	29°	29°	24°	10°	24°
Total or indirect	T	T	T	T	T	T	I	I	T	T
Cloudiness	10	10	10	10	9	8	8	4	4	10
Type of clouds Height of clouds	stcu 600	st 300	ni 300	st 500	stcu	stcu	stcu	stcu 1000	cuni 800	st 400
Horizon	cl.	v.hazy	v.hazy	hazy	hazy	hazy	hazy	m.cl.	m.cl.	m.cl.
Remarks		h. rain bell glass	h. rain bell glass	l. rain bell glass	bell glass	bell glass	bell glass		bell glass	
Wavelength										
6800	58	56	—	160	275	295	238	166	59	220
6600	56	50	33	154	250	222	239	128	78	172
6400	57	44	34	130	252	215	284	128	126	151
6200	55	45	33	120	256	218	237	134	77	143
6000	53	50	44	110	300	233	241	149	54	136
5800	52	59	47	93	320	252	244	168	89	136
5600	57	34	57	98	375	259	276	178	73	149
5400	55	38	58	118	395	269	310	220	54	164
5200	55	38	59	129	420	271	355	237	52	166
5000	52	37	59	124	465	320	435	252	55	177
4900	55	38	62	126	575 (137)	325	530	271	59	187
4800	55	36	59	102	445	350	485 (133)	380	58	214
4700	54	33	55	109	375	350 (117)	425	375	59	203
4600	45	36	59	131	360	365	440	272	65	199
4500	46	34	55	144	235	370	440	248	72	178
Class	A	C	B	B	B	A	C	C	?	A

Observation No.	191	192	193	194	195	196	197	198	199	200
Date	18Oct.	18Oct.	18Oct.	19Oct.	19Oct	19Oct.	19Oct.	19Oct.	19Oct.	20Oct.
Time	12.00	14.00	16.00	10.15	12.00	12.15	14.10	14.20	16.05	10.00
Solar altitude	29°	24°	10°	24°	29°	28°	22°	21°	9°	23°
Total or indirect	T	T	T	I	T	I	T	I	I	T
Cloudiness	10	8	7	5	4	7	3	3	2	h
Type of clouds Height of clouds	st 400	st 700	st+ni 700		cu	cu 1000	cu 1500	cu 1500	stcu 2000	
Horizon	m.cl.	m.cl.	m.cl.	hazý	cl.	cl.	cl.	cl.	m.cl.	m.hazy
Remarks	l. rain bell glass	l. rain bell glass	showery bell glass						sun dis appears behind hut	
Wavelength										
6800	160	252	37	185	810	360	705	207	106	106
6600	139	215	34	172	815	370	655	179	92	88
6400	109	222	36	171	780	360	720	171	90	77
6200	110	179	47	187	760	415	680	182	93	77
6000	102	146	61	186	765	375	690	183	90	65
5800	102	117	66	206	790	375	715	204	101	95
5600	109	108	80	237	840	410	740	227	109	122
5400	98	118	87	234	910	415	700	235	111	126
5200	93	127	89	266	865	355	705	244	118	141
5000	93	134	98	310	950 (134)	335	715 (112)	265	124	118
4900	102	119	83	296	960	310 (111)	300	261	124	99
4800	106	119	102	310	955	320	645	275	127	95
4700	94	133	101	310 (60)	845	297	450	300	124	113
4600	91	128	103	320	855	293	258	300	119	97
4500	101	118	99	296	755	235	215	295	119	87
Class	A	B	A	A	A	B	?	A	B	?

Observation No.	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
Date	20Oct. 1932	20Oct.	20Oct.	21Oct.	21Oct.	21Oct.	21Oct.	24Oct.	24Oct.	25Oct.	25Oct.	25Oct.	25Oct.	25Oct.	26Oct.	26Oct.	26Oct.	26Oct.	27Oct.	27Oct.
Time	12.15	14.00	16.00	10.10	12.00	14.00	16.10	11.45	14.00	10.00	10.15	12.00	14.00	15.55	10.10	12.15	14.00	16.00	12.05	14.00
Solar altitude	28°	23°	9°	24°	27°	23°	8°	27°	21°	21°	22°	27°	21°	9°	22°	26°	20°	8°	26°	20°
Total or indirect	T	T	T	T	T	I	T	T	T	T	I	I	I	I	T	T	T	T	I	T
Cloudiness	10	10	10	10	10	7	8	9	9	10	10	8	8	8	10	10	9	10	6	5
Type of clouds Height of clouds	st 400	st 300	st 200	st 200	stcu 300	stcu 200	stcu	stcu 800	stcu 800	st	st	stcu 1000	stcu 1000	ci+acu	stcu 400	st 800	st 800	stcu 800	cu 1500	cu+cist 2000
Horizon		v.hazy	v.hazy	v.hazy	v.hazy	m.cl.	m.cl.	m.hazy	m.hazy	hazy	hazy	hazy	m.hazy	m.hazy	v.hazy	hazy	m.cl	m.hazy	cl.	
Remarks	bell glass		drizzle bell glass	drizzle bell glass	bell glass			occ.sun							rain bell glass	rain bell glass		bell glass		
Wavelength																				
6800	172	132	23,5	160	132	293	126	540	77	605	136	227	292	69	151	74	51	—	292	380
6600	156	118	20,0	116	116	320	97	555	58	555	145	345	283	61	143	58	53	5,0	245	330
6400	145	111	22,0	114	142	292	84	485	57	540	160	345	280	52	109	55	42	3,4	249	355
6200	244	129	22,5	141	237	345	83	570	66	595	196	345	283	54	109	54	44	3,8	242	335
6000	264	136	22,0	126	286	274	61	645	63	605	226	325	284	53	102	44	44	3,8	241	297
5800	287	145	23,5	141	227	286	70	555	62	620	300	310	292	55	126	39	49	3,8	268	305
5600	355	166	32	158	241	360	94	510	74	640	360	280	305	62	140 (126)	80	58	4,2	277	295
5400	305	166	32	166	204	370	84	510	71	670	395	218	305	64	—	140	61	5,0	280	355
5200	257	161	29	151	196	335	99	475	69	650	380	202	300	64	—	128	61	4,8	260	435
5000	252	166	20,5	130	212	370	102	485 (185)	68	690 (118)	445 (176)	235	305	68	—	158	68	5,1	269	405
4900	207 (152)	155	21,0	136	186	405	103	425	67	650	480	260	286	66	—	130	67	6,0	248	300
4800	166	162	19,5	150	150	390	108	415	62	700	480	242	305	66	—	143	78	5,9	249	330
4700	162	178	16,0	148	207	386	95	380	74	640	450	245	310	66	—	161	80	5,0	211	285
4600	178	168	13,5	153	110	435	91	375	66	615	405	220	300	64	—	218	90	6,9	213	320
4500	169	208	15,5	209	132	—	88	335	55	640	375	—	229	63	—	244	87	5,9	227	256
Class	B	B	C	C	C	B	B	B	B	A	A	?	A	C		C	B	B	B	C

Observation No.	221	222*)	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
Date	27Oct. 1932	27Oct.	28Oct.	28Oct.	28Oct.	28Oct.	15Nov.	16Nov.	16Nov.	17Nov.	17Nov.	17Nov.	18Nov.	18Nov.	18Nov.	18Nov.	18Nov.	21Nov.	21Nov.	21Nov.
Time	14.05	15.55	10.00	12.15	13.55	16.00	14.00	12.05	15.02	12.10	14.00	15.05	10.05	12.10	14.00	14.10	15.00	12.00	14.00	14.20
Solar altitude	20°	9°	20°	26°	19°	8°	17°	21°	10°	21°	16°	9°	17°	21°	17°	16°	10°	21°	16°	14°
Total or indirect	I	T	T	T	T	T	T	T	T	T	T	T	T	T	T	I	I	T	T	I
Cloudiness	5	9	10	10	10	10	8	10	10	10	10	10	10	10	2	2	2	10	10	10
Type of clouds Height of clouds	cu+cist 2000	ast	st 600	st 600	stcu 800	stcu 300	st 1000	st 1000	st 1000	st 500	st 500	st 500	st 300	st 500	st 1000	st 1000	st 1000	st 200	st+stcu 200	stcu 300
Horizon		m.cl.	m hazy	m.hazy	hazy	hazy	v.hazy	m.hazy	m.hazy	v.hazy	v.hazy	v.hazy	v.hazy	v.hazy	v.hazy	v.hazy	v.hazy	inv.	v.hazy	hazy
Remarks		*) viz.p.8				l. rain bell glass												bell glass		
Wavelength																				
6800	221	33	276	110	110	28	96	103	45	92	31	—	52	100	200	131	96	94	—	—
6600	210	20,2	265	112	93	23,0	89	91	41	71	30	13,0	53	96	177	159	86	95	27	10
6400	210	17,8	249	109	88	19,8	85	100	38	61	30	13,2	54	100	171	162	86	101	29	12,0
6200	214	17,0	260	108	84	19,2	83	102	39	61	32	12,5	56	95	162	156	80	98	33	19,1
6000	210	16,0	250	110	74	17,1	88	102	36	63	31	14,0	58	100	191	160	84	87	33	22,6
5800	214	16,0	250	110	68	16,3	90	106	40	71	33	14,0	62	105	204	170	90	95	35	36
5600	226	18,0	252	112	68	18,0	93	108	41	75	34	14,9	66	104	180	176	92	95	36	33
5400	244	20,1	245	116	61	19,4	102	116	46	78	36	15,2	70	120	210	189	100	103	35	40
5200	252	20,9	237	111	62	20,0	97	111	45	80	37	16,3	66	116	210	201	106	88	33	45
5000	250	23,0	235	100	66	20,0	105	118	47	82	39	18,0	69	119	210	210	106	83	33	49
4900	231	22,0	219	92	70	19,8	100	121	46	77	43	17,0	71	120	228	210	106	74	31	47
4800	245	20,8	202	82	77	20,8	100	122	50	79	43	18,5	76	121	218	204	106	70	29	51
4700	237	20,9	196	88	79	20,2	102	121	52	75	44	19,0	78	123	220	197	103	77	25	50
4600	242	19,7	190	90	83	19,0	106	140	56	—	45	18,3	76	127	196	206	100	80	22	51
4500	233	20,2	176	83	80	21,3	102	130	50	—	44	14,9	74	121	196	185	100	71	—	46
Class	A	C	A	A	A	B	B	A	A	C	A	A	A	A	B	A	A	C	A	B

Observation No.	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
Date	21Nov. 1932	22Nov.	22Nov.	22Nov.	22Nov.	22Nov.	22Nov.	22Nov.	23Nov.	23Nov.	23Nov.	23Nov.	24Nov.	24Nov.	25Nov.	25Nov.	28Nov.	28Nov.	28Nov.	28Nov.
Time	10.00	10.00	10.25	12.00	12.20	14.05	14.15	15.05	10.00	12.10	14.00	14.55	10.00	12.00	14.05	14.50	11.55	12.10	14.00	14.10
Solar altitude	16°	16°	17°	21°	20°	16°	14°	10°	16°	21°	16°	10°	16°	20°	15°	10°	20°	20°	15°	13°
Total or indirect	T	T	I	T	I	T	I	T	T	T	T	T	T	T	T	T	T	I	T	I
Cloudiness	10	1	1	1	1	3	5	7	7	4	5	7	9	3	6	4	8	8	8	8
Type of clouds Height of clouds	st 200	ci	ci	ci	ci	ast	ast	ast	stcu 300	stcu 700	stcu 700	stcu 700	cu	stcu 1500	stcu 1500	ast	stcu 1000	stcu 1000	stcu 1000	stcu 1000
Horizon	v.hazy	hazy	hazy	m.hazy	m.hazy	m.cl.	m.cl.	m.cl.	m.cl.	cl.	cl.	sl.hazy	m.cl.	m.cl.	cl.	sl.hazy	m.cl.	m cl.	m.cl.	m.cl.
Remarks	bell glass								bell glass											
Wavelength																				
6800	83	262	90	280	88	215	146	50	203	231	73	63	76	148	99	—	362	127	196	133
6600	95	281	100	315	149	210	130	55	196	230	69	54	84	119	95	66	355	137	219	115
6400	99	275	108	289	147	192	135	48	194	218	69	51	86	107	96	66	360	130	179	109
6200	99	287	114	293	144	191	128	48	204	252	69	48	86	111	91	60	356	131	170	109
6000	108	300	129	345	161	189	141	45	210	235	76	39	87	121	90	57	351	149	159	109
5800	128	315	145	370	176	209	147	50	223	261	90	43	102	129	98	66	375	151	149	119
5600	123	300	152	355	188	203	147	51	219	224	98	43	111	120	98	64	400	160	153	123
5400	145	343 (127)	166	365	203	217	166	56	228	252	117	43	123	128	108	72	419	180	173	140
5200	157	333	190	325	220	231	177	58	252	253	130	46	138	124	110	77	431	210	178	135
5000	152	343	203	370	232	230	182	58	254	255	148	50	141	123	119	81	428	210	157	153
4900	146	329	208	375	235	235	178	60	252	253	161	53	154	144	120	82	432	214	169	161
4800	155	313	206	350	232	222	175	60	266	250	160	63	138	142	125	86	405	222	176	161
4700	143	324	192	355	232	218	173	62	254	260	165	63	135	157	122	89	396	221	149	165
4600	139	316	198	355	246	216	173	61	282	263	175	62	132	190	128	88	390	230	162	164
4500	120	259	175	350	241	198	164	64	251	246	166	63	121	235	117	92	—	—	153	167
Class	A	A	A	B	B	A	A	A	A	A	A	?	A	?	A	A	A	A	B	A

Observation No.	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
Date	28Nov. 1932	29Nov.	29Nov.	29Nov	29Nov.	29Nov	29Nov.	29Nov.	29Nov.	30Nov.	30Nov.	30Nov.	30Nov.	30Nov.	1Dec.	1Dec.	1Dec.	1Dec.	1Dec.	1Dec.
Time	15.25	10.00	10.30	12.10	12.20	13.50	14.00	15.00	15.05	10.00	12.00	12.10	14.00	14.50	10.00	10.10	12.05	13.55	14.05	15.10
Solar altitude	8°	15°	16°	20°	20°	15°	14°	8°	7°	14°	19°	19°	14°	10°	14°	15°	19°	15°	14°	7°
Total or indirect	I	T	I	T	I	T	I	T	I	T	T	I	T	T	T	I	T	T	I	I
Cloudiness	3	1	1	1	1	1	1	2	3	fog	4	4	8	8	3	3	4	1	1	7
Type of clouds Height of clouds	stcu 1500	ci	ci	ast	ast	ast	ast	st 1000	st 1000		ast	ast	st 2000	st 2000	cu 1500	cu 1500	stcu 1500	st	st	st 600
Horizon	m.cl.	foggy	foggy	m.cl.	m.cl.	v.hazy	v.hazy	v.hazy	v.hazy	inv.	m.hazy	m.hazy	hazy	hazy	hazy	hazy	cl.	cl.	cl.	m.cl.
Remarks																				
Wavelength																				
6800	35	262	111	359	108	200	99	81	66	219	360	197	150	73	370	173	435	206	75	—
6600	25	291	107	333	96	177	80	68	53	242	370	191	122	69	380	207	460	216	74	30
6400	21,6	281	113	343	97	192	91	68	50	259	370	188	118	64	370	207	450	203	83	29
6200	25	310	111	317	99	178	86	64	50	269	410	202	114	56	375	211	455	190	84	31
6000	23,6	312	120	355	114	172	92	64	49	244	420	212	120	59	360	221	465	197	90	30
5800	25	315	136	392	129	194	103	66	52	244	430	228	129	60	375	237	470	203	101	32
5600	27	317	141	392	134	201	114	72	52	247	410	218	124	67	370	249	480	201	108	37
5400	32	342	159	415	155	225	129	78	58	370	445	230	132	69	380	255	480	219	128	43
5200	33	361	187	420	172	229	138	81	65	330	460	250	137	72	400	288	525	237	137	41
5000	35	346	201	414	188	230	150	86	68	300	435	265	141	74	415	298	490	240	143	40
4900	36	328	214	410	193	230	154	88	71	281	430	253	143	80	380	280	455	231	158	40
4800	37	322	212	398	200	221	153	90	71	260	400	253	147	87	350	258	345	228	157	44
4700	35	345	219	400	210	218	156	90	64	241	380	236	140	79	350	272	410	218	161	44
4600	39	330	250	410	221	220	161	87	79	301	365	243	148	80	350	260	340	210	163	44
4500	—	290	246	370	213	200	151	80	65	231	340	243	127	76	340	256	—	185	162	47
Class	A	A	A	A	A	A	A	A	B	?	A	A	A	A	A	A	B	A	A	B

Observation No.	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
Date	2Dec. 1932	2Dec.	2Dec.	2Dec.	6Dec.	6Dec.	6Dec.	7Dec.	7Dec.	7Dec.	8Dec.	8Dec.	8Dec.	8Dec.	9Dec.	9Dec.	9Dec.	9Dec.	9Dec.	11Dec.
Time	12.05	12.20	14.00	15.00	12.00	14.00	15.00	12.10	14.00	15.10	10.00	12.00	14.00	14.05	10.10	10.15	12.15	14.05	15.05	10.00
Solar altitude	19°	18°	14°	7°	18°	13°	7°	18°	13°	6°	12°	18°	13°	11°	12°	13°	17°	12°	6°	12°
Total or indirect	T	I	T	T	T	T	T	T	T	T	T	T	T	I	T	I	I	I	I	T
Cloudiness	2	2	7	9	fog	fog	fog	8	10	8	9	9	2	2	5	5	4	3	1	4
Type of clouds Height of clouds	ast	ast	ast	ast				cu 600	stcu 800	stcu 500	cu 1500	stcu 1500	cu 1500	cu 1500	cu 800	cu 800	stcu 800	cu 600	st 1000	stcu 1000
Horizon	hazy	hazy	hazy	v.hazy				m.cl.	hazy	hazy	cl.	m.cl.	v.cl.	v.cl.	m.cl.	m.cl.	cl.	cl.	cl.	hazy
Remarks																				
Wavelength																				
6800	291	124	129	—	173	59	—	355?	36	—	112	166	207	85	283	81	193	103	—	254
6600	295	119	139	35	137	65	16,2	172	31	18,3	93	151	194	69	295	85	194	88	49	250
6400	279	119	137	26	131	69	21,6	173	33	20,3	101	160	190	78	302	91	201	82	50	254
6200	276	131	121	24	131-	71	18,1	178	36	19,3	95	158	180	79	290	96	177	79	44	259
6000	288	143	129	24	139	62	19,9	192	36	16,0	100	167	187	88	300	103	183	80	44	250
5800	305	158	133	25	149	64	23,1	240	37	16,8	105	171	176	101	310	116	212	98	49	269
5600	291	160	137	25	160	72	27	251	46	18,3	110	173	201	106	300	135	218	104	50	268
5400	315	180	147	29	174	84	28	302	47	21,7	128	187	222	119	315	145	237	115	60	280
5200	320	197	159	30	192	84	30	330	50	23,3	117	191	232	133	310	165	266	129	65	257
5000	330	210	162	33	191	88	33	330	52	25	143	197	211	140	330	173	278	139	65	235 (83)
4900	330	219	155	32	205	89	33	305	47	25	146	193	219	146	330	174	277	142	67	235
4800	320	217	156	34	202	96	35	290	48	26	145	198	219	146	320	182	256	133	66	196
4700	310	216	152	33	191	91	39	271	42	28	148	201	210	143	300	182	271	142	69	221
4600	320	218	147	35	190	105	45	256	36	27	139	197	214	143	310	183	277	147	72	196
4500	310	206	149	30	160	71	43	232	33	—	136	183	210	148	280	166	219	133	63	170
Class	A	A	A	A	A	B	B	A	A	B	B	A	A	A	A	B	B	B	B	A

Observation No.	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
Date	11 Dec. 1932	11 Dec.	11 Dec.	11 Dec.	11 Dec.	12 Dec.	12 Dec.	13 Dec.	13 Dec.	13 Dec.	13 Dec.	14 Dec.	14 Dec.	14 Dec.	14 Dec.	15 Dec.	15 Dec.	18 Dec.	18 Dec.	18 Dec.
Time	10.15	12.20	12.30	14.05	15.15	9.30	9.45	10.00	12.05	14.20	15.10	10.10	12.10	14.00	15.00	10.00	14.00	12.00	12.20	14.00
Solar altitude	13°	17°	17°	11°	4°	10°	11°	11°	16°	9°	4°	13°	16°	12°	7°	12°	12°	15°	15°	10°
Total or indirect	I	T	I	T	T	T	I	T	T	T	T	T	T	T	T	T	T	T	I	I
Cloudiness	4	4	4	8	8	10	10	9	10	10	10	10	10	10	10	10	10	2	2	7
Type of clouds Height of clouds	stcu 1000	ast	ast	st 2500	stcu 1500	stcu	stcu	stcu	st 1000	st 100	st 50	st 100	st 100	st 100	st 100	st 50-20	st 50	cist	cist	cist
Horizon	hazy	hazy	hazy	v.hazy	v.hazy	v.hazy	v.hazy	hazy	v.hazy	inv.	inv.	v.hazy	v.hazy	v.hazy	v.hazy	inv.	—	m.hazy	m.hazy	m.hazy
Remarks																	drizzle bell glass			
Wavelength																				
6800	149	280	158	113	—	292	161	59	173	—	—	25	81	—	—	80	—	277	110	133
6600	144	301	151	97	33	287	158	56	156	27	10,3	32	65	29	12,0	59	24,0	282	139	117
6400	151	292	151	104	27	228	157	57	167	27	7,8	43	61	23,5	10,2	50	27	271	136	118
6200	151	305	144	95	28	226	151	56	147	27	6,0	40	63	26	7,7	49	27	272	136	112
6000	155	310	144	104	26	230	157	67	149	20,3	6,3	40	63	27	8,9	49	22,2	278	151	121
5800	168	320	149	110	36	228	166	73	160	19,6	5,9	40	60	26	8,5	50	27	300	161	131
5600	169	320	138	112	28	230	171	72	157	19,0	6,5	46	61	26	11,0	46	26	288	171	133
5400	183	345	142	125	33	248	187	83	171	19,7	6,8	51	60	30	10,6	48	28	300	190	147
5200	196	355	151	124	34	258	192	84	190	20,3	7,4	50	66	30	12,0	38	32	320	209	148
5000	198	345	159	129	38	252	210	91	205	21,2	6,8	52	70	31	13,4	38	35	320	211	156
4900	215	330	161	140	36	250	200	94	215	21,5	7,6	53	70	31	12,7	—	33	325	222	153
4800	191	325 (109)	166	139	36	237	196	101	220	21,0	7,4	51	63	30	14,7	—	33	300	220	153
4700	204	315	167	140	38	226	190	109	212	25	8,3	50	60	31	14,7	—	35	305	218	157
4600	197	330	167	149	49	224	192	117	213	27	—	60	64	34	—	—	—	320	241	137
4500	203	297	158	138	34	202	181	109	185	26	—	—	60	35	—	—	—	310	224	139
Class	A	A	A	A	A	A	A	A	A	?	A	B	B	B	A	?	B	A	A	A

Observation No.	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
Date	18 Dec. 1932	19 Dec.	19 Dec.	19 Dec.	19 Dec.	19 Dec.	20 Dec.	20 Dec.	20 Dec.	20 Dec.	16 Jan. 1933	16 Jan.	16 Jan.	16 Jan.	18 Jan.	19 Jan.	19 Jan.	20 Jan.	20 Jan.	20 Jan.
Time	15.00	12.05	12.15	14.05	14.15	15.00	11.00	12.15	14.00	15.00	12.00	12.20	14.00	14.20	12.00	14.00	15.00	10.20	12.00	14.00
Solar altitude	5°	15°	10°	9°	5°	14°	15°	10°	4°	4°	18°	18°	13°	12°	19°	14°	9°	16°	20°	15°
Total or indirect	I	T	I	T	I	T	T	I	I	I	T	I	T	I	I?	?	?	T	T	T
Cloudiness	3	1	1	2	2	2	10	8	6	3	0	3	9	10	10	10	10	10	10	10
Type of clouds Height of clouds	ast	cicu	cicu	ast	ast	ast	stcu 1500	stcu 1500	stcu 1500	stcu 1500		ci	stcu 1500	st	st	st 300	st 300	st 300	stcu 300	st 500
Horizon	m.hazy	m.hazy	m.hazy	m.cl.	m.cl.	m.cl.	m.cl.	hazy	v.hazy	v.hazy	hazy	hazy	v.hazy	hazy	hazy	v.hazy	inv.	inv.		
Remarks																				
Wavelength																				
6800	45	277	150	162	94	65	153	122	113	78	320	174	103	62	186	43	20,0	62	76	49
6600	39	290	139	177	72	76	111	99	109	59	330	179	93	47	174	39	15,7	44	74	54
6400	41	269	137	162	80	65	131	94	119	59	325	196	98	47	169	40	13,8	45	68	45
6200	38	279	133	153	78	61	129	98	120	56	310	178	93	78	175	40	15,1	46	72	47
6000	39	306	152	152	89	61	121	95	137	59	315	171	96	52	191	39	15,6	46	87	44
5800	45	307	170	166	99	62	128	110	141	63	325	185	101	61	190	41	16,7	52	84	51
5600	46	302	176	160	95	64	122	110	142	67	330	193	107	64	184	44	18,0	62	83	53
5400	48	321	191	182	113	71	133	120	151	72	365	220	117	70	181	46	20,0	67	93	54
5200	51	348	212	191	121	74	131	130	169	75	395	231	117	80	194	50	22,5	67	94	56
5000	52	360	220	187	129	78	139	139	171	79	380	246	123	60	193	52	22,8	70	101	55
4900	55	352	229	189	134	78	138	141	171	79	370	231	123	64	198	52	23,5	68	105	48
4800	56	326	224	188	133	76	136	139	161	74	365	218	118	66	200	53	23,1	70	105	45
4700	58	330	226	182	132	76	134	148	154	80	—	200	120	80	210	54	24,1	83	103	46
4600	58	328	239	172	150	76	130	147	153	86	—	230	131	80	190	57	25	80	103	34
4500	51	310	219	178	138	70	118	141	142	83	—	228	112	80	162	50	25	81	89	31
Class	A	A	A	A	B	B	B	B	A	B	A	B	A	C	A	A	A	B	B	B

Observation No.	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
Date	20 Jan. 1933	23 Jan.	23 Jan.	23 Jan.	23 Jan.	24 Jan.	24 Jan.	24 Jan.	24 Jan.	25 Jan.	25 Jan.	25 Jan.	25 Jan.	26 Jan.	26 Jan.	26 Jan.	26 Jan.	31 Jan.	31 Jan.	2 Febr.
Time	15.00	10.00	12.00	14.00	15.10	9.45	12.10	14.00	15.10	10.10	10.20	12.10	12.20	10.15	10.30	12.15	12.30	12.10	12.20	12.15
Solar altitude	9°	15°	20°	15°	8°	14°	20°	16°	9°	15°	16°	20°	20°	16°	18°	20°	20°	21°	21°	21°
Total or indirect	T	?	T	I	?	T	T	T	T	T	I	T	I	T	I	T	I	T	I	I
Cloudiness	10	10	10	10	10	9-10	8	5	7	0	0	0	0	7	7	0	0	3	3	3
Type of clouds Height of clouds	st 500	st 500	st 500	st 500	st 500	st 800	stcu 1500	stcu 1500	stcu 1500					cu 1500	cu 1500			cist	cist	cu 300
Horizon						m.cl.	cl.	m.cl.	cl.	sl.hazy	sl.hazy	sl.hazy	sl.hazy	hazy	hazy	hazy	hazy	m.cl.	m.cl.	cl.
Remarks		snow bell glass	snow	snow	snow	snow				some snow on ground	some snow on ground	some snow on ground	some snow on ground							
Wavelength																				
6800	22,5	106	193	158	59	218	320	181	120	368	112	435	110	122	11.0	410	153	470	280	249
6600	24,0	101	174	123	41	198	325	163	111	407	116	430	105	134	11,2	410	150	445	252	240
6400	20,3	98	177	117	40	170	281	155	110	392	118	445	112	162	17,0	410	162	435	232	219
6200	20,9	98	175	113	39	177	272	151	100	407	123	475	116	152	18,1	410	153	460	252	215
6000	20,2	110	187	123	36	182	275	172	96	425	137	490	142	167	11,7	430	175	450	269	202
5800	20,0	106	195	131	39	195	285	225	100	675	150	510	150	168	12,1	445	180	475	271	222
5600	20,0	118	197	140	48	199	273	227	106	650	166	535	166	172	14,9	440	193	490	268	234
5400	21,3	127	210	145	50	237	290	222	117	615	171	550	190	168	27	465	218	470	310	257
5200	23,0	131	220	150	51	256	330	230	120	715	192	580	210	167	25	465	241	460	330	284
5000	21,8	142	230	149	54	255	360	252	131	(138) 532	232	560	240	191	30	450	252	460	350	215?
4900	21,7	127	235	146	76	279	355	247	131	610	233	(101) 550	248	210	29	390	257	(79) 480	345	300
4800	23,5	126	230	157	77	276	350	222	130	570	210	540	250	191	39	415	260	480	340	285
4700	23,1	134	221	164	83	265	330	222	131	610	239	530	258	226	40	(78) 395	253	480	350	295
4600	23,1	136	177	164	83	287	370	236	140	585	270	555	270	222	41	375	260	470	355	330
4500	—	128	203	140	90	280	360	227	130	520	275	480	270	203	37	365	250	435	—	315
Class	A	A	A	A	?	A	A	A	A	C	A	A	A	B	C?	A	A	A	B	A

Observation No.	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380
Date	9Fbr. 1933	10Fbr.	10Fbr.	10Fbr.	10Fbr.	14Fbr.	14Fbr.	15Fbr.	15Fbr.	16Fbr.	16Fbr.	16Fbr.	16Fbr.	16Fbr.	17Fbr.	17Fbr.	17Fbr.	17Fbr.	17Fbr.	20Fbr.
Time	12.15	10.00	12.05	14.00	15.05	14.00	16.05	14.00	16.00	10.00	14.00	14.20	15.45	15.55	10.00	12.00	12.10	14.05	16.00	14.00
Solar altitude	24°	20°	25°	20°	13°	21°	8°	21°	8°	21°	21°	20°	11°	9°	22°	28°	28°	22°	9°	23°
Total or indirect	T	T	T	T	T	?	I	I	I	T	T	I	T	I	I	T	I	T	T	I
Cloudiness	10	10	10	10	10	5	4	6	2	8	0	0	0	0	3	4	4	4	7	2
Type of clouds Height of clouds	stcu 600	stcu 300	stcu 300	stcu 600	st 1000	stcu 800	stcu 1500	stcu 800	cu 1500	cu					st 600	stcu 600	stcu 600	stcu 600	cu 600	cu 1500
Horizon	m.cl.	hazy	hazy	cl.	cl.	cl.	m.cl.	v.cl.	cl.	hazy	cl.	cl.	cl.	cl.	v.hazy	cl.	cl.	cl.	cl.	v.cl.
Remarks																			some rain bell glass	
Wavelength																				
6800	400	85	315	101	34	249	173	272	124	645	560	143	280	110	380	795	360	590	300	266
6600	380	74	325	89	34	260	159	261	105	715	515	134	263	95	370	800	360	630	305	280
6400	350	72	320	101	33	240	143	251	103	740	515	141	246	98	360	800	320	620	290	240
6200	355	80	340	102	37	270	136	271	111	740	560	144	262	106	385	850	310	685	288	269
6000	330	83	340	104	32	270	140	250	115	735	570	163	256	112	385	935	310	685	277	275
5800	330	86	350	114	40	285	132	280	115	725	620	185	254	119	390	950	310	760	264	305
5600	320	86	340	122	47	305	141	335	135	770	635	196	270	142	420	990	288	800	272	340
5400	330	88	350	123	50	335	147	315	146	775	630	220	281	155	435	935	320	775	280	345
5200	310	84	370	120	55	340	148	330	152	820	665	247	295	169	450	960 (350)	305	805	320	405
5000	250	81	370	132	66	355	160	335	171	850 (144)	645 (108)	272	313	192	450 (152)	975	320	805 (300)	290	390
4900	212	76	325	132	65	340	150	320	167	490	560	280	293	188	510	910	320	690	335	380
4800	209	72	260	128	69	340	144	320	169	405	585	268	262	184	510	875	340	—	276	380
4700	192	67	222	122	62	340 (59)	142	310	168	370	560	270	260	179	510	870	355	—	385	380
4600	197	69	191	122	53	340	140	325	163	410	575	265	252	195	525	880	345	—	390	370
4500	167	60	134	101	57	304	133	320	151	420	500	280	253	191	445	720	330	—	224	—
Class	B	B	?	A	B	A	A	A	A	?	A	A	A	A	A	A	A	A	B	A

Observation No.	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
Date	20Fbr. 1933	21Fbr.	21Fbr.	21Fbr.	21Fbr.	22Fbr.	22Fbr.	22Fbr.	22Fbr.	22Fbr.	24Fbr.	24Fbr.	24Fbr.	24Fbr.	27Fbr.	27Fbr.	27Fbr.	28Fbr.	28Fbr.	28Fbr.
Time	16.00	10.00	12.00	14.00	16.00	10.00	10.15	12.10	14.00	16.00	12.10	14.10	14.20	16.00	10.00	14.00	16.00	12.00	14.15	16.00
Solar altitude	10°	23°	29°	23°	10°	23°	24°	29°	23°	10°	30°	24°	23°	11°	25°	25°	11°	30°	24°	11°
Total or indirect	I	?	I	I	I	T	I	T	I	I	I	T	I	T	T	T	T	T	T	I
Cloudiness	8	10	9	6	6	0	0	8	8	4	8	3	3	2	10	9	9	6	7	9
Type of clouds Height of clouds	stcu 1000	st 200	st 600	stcu 700	stcu 700			stcu 300	stcu 300	stcu 1500	stcu 1500	stcu 1500	stcu 1500	acu	st 1000	ast 2500	ast	cu 1000	stcu 1500	ast
Horizon	v.cl.	inv.	inv.	m.hazy	m.hazy	cl.	cl.	v.hazy	v.hazy	hazy	m.cl.	cl.	cl.	m.cl.	m.cl.	m.cl.	m.cl.	m.cl.	m.cl.	hazy
Remarks		fresh snow	snow			snow on ground	snow on ground													
Wavelength																				
6800	186	400	430	280	211	585	186	470	330	149	230	590	211	103	245	370	56	425	241	211
6600	189	440	430	280	202	585	163	500	340	139	257	615	212	90	290	370	61	430	256	203
6400	169	390	450	305	179	590	179	480	340	121	249	560	211	87	325	370	57	430	241	196
6200	170	385	515	340	180	610	205	525	340	128	269	575	222	86	335	390	61	440	257	195
6000	168	360	530	345	182	610	210	500	350	125	281	595	219	88	345	395	56	420	239	194
5800	173	345	610	350	192	605	215	555	370	132	301	615	255	96	370	390	58	440	247	195
5600	177	395	630	370	199	645	224	595	400	140	247	630	274	100	360	420	54	445	260	197
5400	187	440	620	380	210	670	264	580	400	151	339	650	300	117	385	420	60	450	261	208
5200	197	500	660	410	218	690	279	600	440	161	378	700	320	134	410	450	58	495	297	212
5000	198	480	645 (143)	400 (171)	230	645 (142)	295	575 (227)	455	169	328	—	350	143	425	425	59	500 (234)	300	207
4900	190	500	600	445	210	585	281	545	420	157	635	—	345	139	415	440	61	530	279	196
4800	178	460	630	445	218	605	280	530	390	168	242	—	350	137	380	380 (132)	62	500	261	194
4700	163	480	625	380	210	605	278	495	390	161	247	—	350	143	410	430	60	500	269	191
4600	173	—	610	485	209	595	265	490	375	159	266	—	370	150	—	375	60	520	299	196
4500	149	—	500	465	190	530	263	505	350	149	275	—	340	141	—	330	58	410	287	174
Class	A	?	B	B	A	A	A	A	A	A	?	?	A	A	A	A	A	A	A	A

Observation No.	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420
Date	1Mch 1933	1Mch	1Mch	1Mch	1Mch	1Mch	2Mch	2Mch	2Mch	3Mch	3Mch	6Mch	6Mch	6Mch	6Mch	7Mch	7Mch	7Mch	7Mch	8Mch
Time	10.00	12.00	12.10	14.00	14.10	16.00	10.10	12.00	14.00	—	16.15	10.00	12.00	14.00	16.00	12.00	14.00	16.00	16.10	10.10
Solar altitude	25°	31°	31°	25°	25°	11°	27°	31°	26°	—	10°	28°	32°	28°	13°	33°	28°	13°	10°	29°
Total or indirect	T	T	I	T	I	I	I	I	I	T	T	I	T	T	T	I	T	T	I	T
Cloudiness	10	1	1	1	1	6	7	9	7	8	9	5	8	10	10	6	4	2	2	2
Type of clouds Height of clouds	stcu 1000	acu	acu	ast	ast	ast	stcu 400	stcu 800	cu 800	stcu 600	stcu 600	stcu 2500	stcu 1500	st 800	stcu 800	cu 1200	cu 800	cu 1500	cu 1500	cu 1000
Horizon	hazy	m.cl.	m.cl.	m.cl.	m.cl.	m.hazy	hazy	m.cl.	m.cl.	m.cl.	m.cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	hazy
Remarks				measured w. reducer																
Wavelength																				
6800	370	675	269	580	221	180	430	455	390	370	125	207	400	249	92	545	460	420	153	315
6600	305	685	276	590	243	174	465	455	420	365	111	222	395	252	80	530	455	420	159	375
6400	300	675	281	600	237	162	480	445	390	325	100	220	420	237	72	490	430	390	141	365
6200	292	735	310	620	259	151	445	485	410	335	95	256	425	240	68	520	510	410	153	400
6000	280	695	320	650	271	164	495	500	410	305	90	289	440	300	63	505	530	385	155	405
5800	280	805	340	650	282	154	560	530	430	335	87	310	470	325	68	550	550	410	168	450
5600	288	790	360	670	305	181	650	525	460	330	96	335	480	315	76	595	530	385	189	460
5400	287	780	380	695	340	187	720	535	465	310	102	365	520	305	78	610	550	440	202	520
5200	310	805	435	670	360	194	605	540	490	335	98	410 (136)	530	340	76	620	560	470	227	550
5000	305 (101)	805 (295)	420 (165)	675	380	221	570	505	460	345	102	415	515 (201)	340	81	620 (234)	560	465 (156)	252	465
4900	265	790	420	645	370	214	520	500 (170)	440	350	88	435	450	340	75	615	550 (177)	435	247	470
4800	283	720	410	510	365	209	445	500	445	335	94	430	480	325	76	590	510	415	240	465 (153)
4700	272	700	400	600	380	208	520	495	430	320	93	495	460	325 (103)	79	575	465	405	246	550
4600	325	670	400	600	390	218	—	500	430	305	92	465	445	340	80	605	410	415	260	605
4500	260	625	355	540	360	198	—	455	—	276	91	435	420	325	64	485	440	370	249	545
Class	B	A	A	A	A	A	?	A	A	A	A	A	A	B	?	A	B	A	A	B

Observation No.	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
Date	8Mch 1933	8Mch	8Mch	8Mch	8Mch	9Mch	9Mch	9Mch	9Mch	10Mch	10Mch	10Mch	10Mch	10Mch	10Mch	10Mch	10Mch	13Mch	13Mch	13Mch
Time	12.00	14.00	14.10	16.10	16.25	10.00	12.00	14.00	16.05	10.00	10.15	11.50	12.10	14.00	14.20	16.05	16.15	10.00	10.20	12.15
Solar altitude	33°	29°	27°	12°	10°	30°	35°	29°	12°	30°	31°	34°	34°	30°	28°	14°	12°	30°	31°	36°
Total or indirect	I	T	I	T	I	I	I	I	I	I	T	I	T	I	T	I	T	T	I	I
Cloudiness	3	1	1	1	1	9	9	9	9	3	3	1	1	1	1	1	1	0	0	0
Type of clouds Height of clouds	cu 1500	cu 2000	cu 2000	cu 2000	cu 2000	st 600	stcu 800	stcu 1000	stcu 2000	ast	ast	ast	ast	ast	ast	ast	ast			
Horizon	hazy	m.cl.	m.cl.	m.cl.	m.cl.	hazy	hazy	hazy	hazy	v.hazy	v.hazy	m.hazy	m.hazy	m.cl.	m.cl.	m.hazy	m.hazy	hazy	hazy	hazy
Remarks																				
Wavelength																				
6800	435	675	248	310	113	250	370	390	249	276	735	209	775	179	650	185	254	790	182	204
6600	425	705	237	305	114	257	385	400	227	300	760	222	810	163	675	159	249	875	236	243
6400	420	655	235	275	116	239	390	415	237	285	750	218	850	187	680	164	235	825	212	254
6200	455	775	242	285	122	250	410	450	216	310	800	232	920	196	735	170	271	870	265	265
6000	460	760	241	281	126	241	430	420	204	330	805	239	910	204	715	169	212	895	260	281
5800	485	830	265	280	138	271	470	460	211	340	865	271	975	263	750	182	238	965	267	305
5600	525	770	247	298	123	289	530	440	199	370	845	296	1000	242	790	190	234	980	291	320
5400	560	800	299	305	163	315	600	440	208	370	820	291	980	272	785	209	240	890	335	350
5200	610	780	345	310	172	325	570	450 (151)	209	390	840	330	950	296	775	211	241	975 (171)	360	380
5000	580 (196)	745 (282)	350	315	190	355	560 (202)	470	221 (68)	405	850 (151)	380	950 (169)	330 (117)	770 (141)	230	243	990	370	405
4900	555	730	355	275	177	375	555	450	225	385	735	365	930	320	700	214	224	930	360 (132)	380
4800	535	725	345 (128)	282	178	410 (157)	500	455	218	385	790	350	905	345	670	210	220	930	405	380 (138)
4700	530	700	345	257	188	390	510	470	215	390	780	390 (131)	910	360	710	197	219	940	390	390
4600	480	620	395	262	181	415	485	480	202	400	840	410	900	355	710	219	210	930	400	375
4500	415	505	385	242	158	365	460	480	166	—	795	410	790	365	595	200	166	950	415	310
Class	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A	A

Observation No.	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
Date	13Mch 1933	13Mch	13Mch	13Mch	13Mch	14Mch	14Mch	14Mch	14Mch	15Mch	15Mch	15Mch	15Mch	16Mch	16Mch	16Mch	17Mch	17Mch	17Mch	20Mch
Time	12.30	14.00	14.10	16.00	16.20	12.00	12.10	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	13.55	10.00	14.00	16.00	12.10
Solar altitude	35°	30°	29°	15°	11°	36°	35°	30°	15°	30°	36°	30°	16°	31°	37°	31°	31°	31°	17°	39°
Total or indirect	T	T	I	T	I	T	I	I	T	T	T	T	I	T	T	T	T	T	T	T
Cloudiness	0	0	0	0	0	1	1	5	9	10	9	10	8	10	10	10	10	10	10	9
Type of clouds Height of clouds						st 1500	st 1500	st 800	st 1500	stcu 600	stcu 600	stcu 400	stcu 600	stcu 500	stcu 1000	stcu 1000	stcu 1000	stcu 1000	stcu 800	stcu 1000
Horizon	hazy	cl.	cl.	cl.	cl.	hazy	hazy	hazy	hazy	hazy	hazy	v.hazy	v.hazy	v.hazy	m.cl.	cl.	cl.	m.cl.	m.cl.	m.cl.
Remarks																		l. rain bell glass	rain bell glass	
Wavelength																				
6800	830	645	156	420	161	590	355	360	161	129	430	495	219	390	310	139	160	155	34	610
6600	865	760	163	410	151	635	390	370	163	133	440	480	212	380	390	109	174	145	31	590
6400	865	780	173	395	157	620	385	370	155	156	420	480	207	370	440	103	246	156	25	560
6200	920	790	188	400	153	645	405	390	167	177	535	500	220	405	440	129	290	156	31	620
6000	930	810	200	385	162	645	380	390	162	187	595	480	210	380	390	131	216	148	26	620
5800	965	840	220	410	172	665	410	420	170	176	705	500	200	450	425	142	211	177	22,9	660
5600	1020	910	237	405	182	680	430	435	181	197	740	485	195	490	340	149	193	204	28	930
5400	945	865	273	400	204	680	445	455	187	234	820	485	188	530	400	172	210	226	35	860
5200	985	865	300	415	210	690	455	455	207	204	810	520	194	520	390	210	250	241	33	1010
	(182)																			
5000	930	900	315	410	231	670	455	460	216	231	740	500	207	380	320	213	350	280	31	—
		(159)	(125)			(122)	(169)	(157)	(74)	(100)	(252)			(176)						
4900	870	860	305	390	229	620	435	425	219	185	700	480	197	258	296	220	310	275	29	—
												(151)			(117)					
4800	825	765	315	375	235	595	425	460	236	185	705	510	194	310	241	243	291	278	34	—
4700	745	780	340	360	229	575	425	445	233	197	720	515	191	330	216	248	330	265	35	—
4600	730	715	330	370	248	615	405	435	257	216	810	520	185	310	182	243	—	264	41	—
4500	730	715	276	—	219	465	375	365	300	212	675	415	167	232	177	196	165	246	34	—
Class	A	A	A	A	A	A	A	A	A	B	B	A	B	?	B	B	?	A	C	?

Observation No.	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480
Date	20Mch 1933	23Mch	23Mch	23Mch	23Mch	23Mch	23Mch	23Mch	24Mch	24Mch	28Mch	28Mch	28Mch	29Mch	29Mch	29Mch	29Mch	29Mch	29Mch	29Mch
Time	14.00	10.05	10.30	11.55	12.10	14.05	16.00	16.20	10.00	10.40	10.00	10.25	12.00	10.00	10.20	12.05	14.00	14.20	16.00	16.30
Solar altitude	33°	34°	36°	40°	40°	34°	20°	15°	34°	36°	35°	38°	41°	36°	37°	42°	36°	33°	20°	15°
Total or indirect	T	I	T	I	T	T	I	T	T	I	I	T	T	I	T	I	T	I	T	I
Cloudiness	9	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Type of clouds Height of clouds	stcu 1000	ci	ci	ci	ci	ci	ci	ci	cist	cist	st 2500	st 2500	st 2500							
Horizon	m.cl.	v.cl.	v.cl.	v.cl.	v.cl.	v.cl.	v.cl.	v.cl.	v.cl.	v.cl.	cl.	cl.	cl.	m.cl.	m.cl.	cl.	cl.	cl.	cl.	cl.
Remarks																				
Wavelength																				
6800	495	167	900	111	940	830	96	600	900	161	157	905	935	146	905	123	725	118	500	110
6600	495	161	930	137	960	850	116	585	930	179	167	945	965	161	965	128	675	132	475	137
6400	500	181	940	141	980	840	117	600	910	155	179	940	990	179	930	132	705	147	455	132
6200	505	182	1020	149	1110	885	112	635	920	166	199	1020	1020	175	1080	149	770	151	485	151
6000	555	191	1040	167	1100	865	122	660	1040	191	211	1060	1090	197	975	168	785	168	505	155
5800	550	215	1090	200	1140	940	151	790	1100	206	221	1140	1030	220	1130	180	860	186	475	173
5600	460	233	1120	199	1195	980	158	780	1005	210	243	1160	—	320	1130	201	830	206	495	184
5400	460	250	1100	202	900	910	182	730	1070	248	264	1100	—	355	1100	230	820	218	505	201
5200	510	277	1180 (194)	250	820	980	192	775	1020 (187)	269	296	1140 (194)	—	282	1160 (210)	223	880 (147)	218	520	212
5000	495 (163)	300	1205	288	540 (192)	920 (169)	234	590	1100	299	310	1120	—	325 (117)	1100	226 (72)	845	226	505	237
4900	490	296	1095	298	540	845	220	—	1110	299	320 (122)	1135	—	325	1010	205	775	231	475	217
4800	—	300	1110	240	525	870	222	—	1035	325	335	1110	—	325	930	226	770	242	450 (143)	226
4700	—	305	1170	309	535	830	220	—	1000	315	330	1110	—	370	910	242	770	241	460	238
4600	—	320	1160	330	430	820	244	—	900	330	385	1115	—	390	840	248	735	248	472	252
4500	—	—	1020	243	350	660	230	—	835	290	385	900	—	370	840	216	645	232	—	242
Class	B	A	A	C	?	A	A	B	A	A	A	A		A	A	B	A	A	A	A

Observation No.	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
Date	30Mch 1933	30Mch	30Mch	30Mch	31Mch	31Mch	31Mch	31Mch	3Apr.	3Apr.	3Apr.	3Apr.	4Apr.	4Apr.	4Apr.	4Apr.	5Apr.	5Apr.	5Apr.	5Apr.
Time	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.05	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00
Solar altitude	36°	42°	36°	21°	36°	42°	36°	21°	38°	43°	38°	21°	38°	44°	38°	23°	38°	44°	38°	23°
Total or indirect	T	I	T	T	I	I	I	I	T	T	T	T	T	T	T	T	T	T	I	T
Cloudiness	10	10	10	10	7	6	8	4	10	10	10	10-7	10	10	10	10	10	10	7	10
Type of clouds Height of clouds	st 100	stcu 600	stcu 600	stcu 800	cu 500	cu 1000	cu 1000	cu 1500	stcu 500	stcu 500	stcu 800	stcu 1500	stcu 300	st 300	st 600	st 600	st 300	st 500	stcu 600	st 400
Horizon	hazy	v.hazy	v.hazy	v.hazy	hazy	m.cl.	cl.	cl.	v.hazy	v.hazy	cl.	cl.	v.hazy	v.hazy	hazy	hazy	v.hazy	v.hazy	hazy	hazy
Remarks						measured w. reducer										bell glass		bell glass		
Wavelength																				
6800	212	193	110	158	520	430	330	197	234	390	269	280	143	186	470	208	200	196	475	182
6600	239	189	11C	161	425	400	325	236	191	360	271	237	171	172	445	218	194	185	450	169
6400	193	182	113	158	400	415	281	242	197	400	281	249	167	170	450	232	190	181	420	167
6200	163	200	110	168	350	420	320	266	200	460	320	251	162	180	465	235	185	174	435	165
6000	160	194	109	169	345	455	325	256	160	495	325	250	167	177	455	225	175	167	440	166
5800	185	217	109	180	495	505	340	246	170	505	360	271	170	197	450	244	178	189	455	174
5600	199	220	102	197	515	525	340	260	181	575	370	265	160	206	515	224	195	196	460	181
5400	228	272	106	213	505	560	355	256	217	615	380	268	163	207	530	212	210	207	490	188
5200	210	252	106	217	540	570	350	270	231	615	385	250	181	216	530	—	210	217	525	192
5000	210	262	100	230	490	590 (215)	340	283	261	635 (220)	385	284	207	240	560 (196)	230	210	231	520 (189)	210
4900	193	241	90	230	480	560	410	283	250 (77)	605	355	283	163	230	570	178	194 (69)	233	485	194
4800	163	220	94	213	525	595	410	280	250	575	360	325	130	237	570	181	189	242	520	188
4700	179	212	94	216	550	570	445 (172)	283	250	550	375	380	167	242	590	173	236	241	505	181
4600	188	199	96	206	720	585	415	287	298	550	400	375	174	257	560	202	270	263	485	173
4500	200	187	84	190	820	495	390	290	311	525	—	—	227	232	550	202	214	242	475	164
Class	?	A	A	A	?	A	B	A	B	A	A	B	C	A	A	B	B	A	A	A

Observation No.	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520
Date	6Apr. 1933	6Apr.	6Apr.	6Apr.	10Apr.	10Apr.	10Apr.	11Apr.	11Apr.	11Apr.	11Apr.	11Apr.	12Apr.	12Apr.	12Apr.	13Apr.	13Apr.	24Apr.	26Apr.	26Apr.
Time	10.00	10.20	12.00	12.20	10.00	12.00	14.00	10.00	10.20	12.00	13.30	16.05	10.10	12.00	16.20	10.00	10.25	10.00	10.00	12.00
Solar altitude	39°	40°	44°	44°	40°	46°	40°	40°	42°	47°	43°	23°	42°	47°	21°	40°	41°	44°	44°	52°
Total or indirect	I	T	I	T	T	T	T	I	T	I	I	I	I	I	T	I	T	T	T	T
Cloudiness	4	4	4	3	10	10	10	4	4	6	9	4	7	7	10	4	4	3	10	9
Type of clouds Height of clouds	stcu 1000	stcu 1000	cu 1000	cu 1000	st 300	st 300	stcu 600	cist	cist	cist	ast	ast	acu	acu	ast	cu 800	cu 800	ast	st 300	stcu 800
Horizon	hazy	hazy	cl.	cl.	hazy	v hazy	v.hazy	hazy	hazy	hazy	hazy	v.hazy	v.hazy	v.hazy	hazy	v.cl.	v.cl.	m.hazy	v.hazy	hazy
Remarks																				bell glass
Wavelength																				
6800	420	905	297	905	219	330	500	310	740	480	500	266	565	445	237	259	955	985	250	405
6600	420	780	300	880	198	310	590	310	805	445	505	271	560	420	200	237	1050	950	252	360
6400	400	955	305	955	179	350	600	335	850	490	545	274	565	435	221	218	1040	945	254	425
6200	435	1010	355	1000	200	430	620	365	915	535	600	292	600	515	212	227	1130	1010	265	555
6000	425	1060	355	1040	219	530	535	360	805	525	580	281	580	480	204	238	1130	1030	275	520
5800	485	1110	410	1120	249	630	560	400	730	630	615	291	645	550	220	300	1200	1130	300	545
5600	490	1160	430	1180	298	680	485	415	740	700	605	282	635	585	220	330	1210	1130	325	565
5400	505	1100	490	1110	315	620	465	450	785	700	575	320	605	590	220	340	1210	1120	315	575
5200	550	1160 (212)	490	1180 (210)	330	625	375	520	785	735	575	320	595	630	214	350	1260 (215)	1130 (210)	280	565
5000	575 (203)	1150	510	1180	385	590 (200)	330	555 (197)	740	735 (274)	525	315	570 (191)	620 (220)	229	370	1275	1190	252	—
4900	530	1100	485 (176)	1115	355 (114)	590	360	510	780 (160)	695	525 (174)	315	570	585	210	370 (136)	1220	1080	229	672 (193)
4800	530	1020	470	1080	360	590	420 (159)	530	895	650	550	300	515	555	215	375	1215	1080	201	805
4700	500	1050	480	1080	350	590	450	545	895	635	545	320	510	555	212	405	1215	1100	236	905
4600	520	1080	495	1120	330	660	465	570	910	645	525	320	525	560	207	415	1240	1080	276	910
4500	560	865	475	1010	330	540	440	540	910	635	510	320	515	480	200	380	1045	1080	280	905
Class	A	A	A	A	A	B	?	A	?	A	A	A	A	A	A	B	A	A	?	?

Observation No.	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540
Date	26Apr. 1933	26Apr.	26Apr.	27Apr.	27Apr.	27Apr.	27Apr.	27Apr.	28Apr.	28Apr.	28Apr.	28Apr.	1May	1May	2May	2May	2May	2May	2May	3May
Time	14.00	16.00	16.15	10.00	10.15	12.00	14.00	16.00	10.00	1200	14.00	16.00	10.00	12.00	10.00	12.00	14.00	14.07	16.00	10.00
Souar altitude	46°	28°	26°	46°	47°	52°	46°	29°	45°	51°	45°	29°	46°	53°	47°	54°	47°	46°	30°	47°
Total or indirect	T	I	T	T	I	I	I	T	I	I	I	I	I	I	I	I	T	I	I	T
Cloudiness	5	3	3	1	1	6	6	9	9	9	9	10	10	5	8	1	2	2	7	3
Type of clouds Height of clouds	cu 2000	cu 2000	cu 2000	cu 2000	cu 2000	stcu 1500	stcu 2000	st 2500	stcu 800	stcu 800	stcu 1500	st 2000	200	cu 800	cu 600	cu 1000	cist	cist	cist	ast
Horizon	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	m.hazy	m.hazy	cl.	m.cl.	v.hazy	hazy	hazy	m.cl.	cl.	cl.	m.cl.	m.cl.
Remarks																				
Wavelength																				
6800	242	410	660	975	238	320	315	231	435	365	530	280	580	410	640	315	720	310	310	890
6600	300	360	650	1010	220	390	360	218	470	370	535	288	540	440	650	340	680	315	290	780
6400	435	370	660	1090	232	415	310	228	370	335	580	275	680	445	620	320	680	310	300	700
6200	—	420	680	1150	246	460	340	227	365	365	600	270	680	510	670	380	710	340	325	770
6000	280	400	680	1110	192	445	350	221	385	360	600	270	650	540	560	380	870	370	320	890
5800	310	425	740	1200	280	470	390	230	460	390	620	280	730	550	570	405	970	425	355	1410
5600	320	445	770	1180	300	445	405	227	515	410	660	288	770	630	605	455	1050	450	375	1540
5400	355	480	760	1170	335	480	425	230	520	440	680	300	740	630	620	465	1210	500	400	1430 (550)
5200	355	505	755	1280 (212)	350	500	440	236	540	475	700	310	620	660	640	530	1090 (189)	500	405	1480
5000	385	490	780 (284)	1340	380	590 (222)	450	248	540	505	725 (260)	310	700 (243)	660 (249)	655	545	1100	500	420	1280
4900	370	500 (182)	750	1130	268 (129)	585	460	236	565 (243)	510 (177)	680	320	685	—	630 (230)	545 (172)	1040	485 (168)	415	860
4800	360	475	690	1350	392	600	450 (212)	239	595	550	670	300	600	640	605	550	1060	530	440	870
4700	370	460	655	1340	440	585	490	244	580	510	640	300	615	560	550	605	920	505	470 (150)	900
4600	370	445	660	1450	445	615	515	212	285	500	670	315	685	635	655	560	940	565	475	820
4500	—	415	610	1140	470	560	—	208	625	570	640	310	540	580	580	575	825	495	470	690
Class	C	A	A	B	B	B	A	A	B	A	A	A	B	A	B	A	A	A	A	?

Observation No.	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560
Date	3May 1933	3May	3May	3May	3May	4May	4May	4May	5May	5May	5May	5May	5May	8May	8May	8May	8May	9May	9May	9May
Time	12.00	12.10	14.00	14.10	16.00	10.00	14.00	16.00	10.00	10.15	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00
Solar altitude	54°	54°	47°	45°	30°	47°	47°	30°	48°	49°	55°	48°	30°	48°	56°	48°	31°	48°	56°	48°
Total or indirect	I	T	T	I	I	I	I	I	I	T	I	I	I	I	T	T	T	T	T	T
Cloudiness	5	5	6	6	9	10	8	4	5	5	6	8	7	10	10	10	10	10	10	10
Type of clouds	ast	ast	acu	acu	ast	stcu	stcu	cu	cist	cist	cu	stcu	ast	st	stcu	stcu	stcu	stcu	stcu	stcu
Height of clouds						800	800	1500			1500	1500		200	300	400	400	400	500	800
Horizon	m.cl.	m.cl.	cl.	cl.	cl.	hazy	hazy	m.cl.	hazy	hazy	cl.	cl.	cl.	v.hazy	hazy	m.cl.	m.cl.	v.hazy	hazy	cl.
Remarks														rain bell glass	bell glass			rain bell glass	rain bell glass	
Wavelength																				
6800	330	975	925	365	380	360	465	234	500	890	530	350	390	212	175	209	173	98	85	237
6600	310	965	930	340	335	355	450	250	465	820	495	320	400	143	154	180	118	138	72	200
6400	330	990	975	365	315	345	480	242	495	895	520	370	415	112	172	172	123	124	88	187
6200	370	1110	1030	420	330	350	500	290	520	975	560	340	465	92	187	183	116	98	86	178
6000	360	1060	1020	430	315	350	475	335	515	1000	575	315	455	79	181	187	108	94	84	173
5800	400	1180	1120	480	340	400	560	380	615	1020	625	335	515	88	199	235	118	95	94	192
5600	425	1190	1080	475	335	430	550	425	595	970	645	360	525	93	203	330	118	94	103	224
5400	445	1070	1010	500	330	460	560	470	665	1000	660	360	545	93	228	385	137	98	113	270
5200	460	1180 (198)	1170 (190)	530	325	485	575	490	650	1120	690	370	535	90	272	440	127	185	118	248
5000	480	1150	1180	530	320	455 (153)	565	510	605	1100 (210)	695 (262)	375	540	84	248	490	138	246	124	217
4900	670 (238)	1120	1110	515	350	385	615	480 (160)	635	1025	640	365	520	75	230	415	150	257	132	200
4800	—	1150	1130	505 (184)	285	385	580 (220)	460	600 (238)	1090	655	355 (155)	505 (190)	—	220	335	170	245	142	201
4700	500	1110	1120	480	281	350	600	430	605	1095	635	405	500	—	170	320	183	355 (142)	166	143
4600	530	1130	1090	530	268	340	590	480	600	1050	690	410	515	—	162	350	214	460	182	176
4500	515	1060	940	505	248	243	560	450	545	1000	630	390	530	—	210	320	196	415	158	110
Class	A	A	A	A	B	A	A	A	A	A	A	B	A	?	B	?	B	?	A	B

Observation No.	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580
Date	9May 1933	10May	10May	10May	10May	11May	11May	11May	12May	12May	15May	15May	15May	15May	16May	16May	16May	16May	16May	17May
Time	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	10.00	14.00	9.00	11.00	13.00	15.00	9.00	11.00	13.00	13.10	15.00	10.00
Solar altitude	31°	49°	56°	49°	31°	49°	56°	49°	49°	49°	41°	56°	56°	41°	41°	56°	56°	54°	41°	49°
Total or indirect	T	I	T	T	T	I	I	I	I	I	T	I	I	I	T	I	I	T	I	I
Cloudiness	6	10	10	10	10	9	7	8	7	9	10	10	9	6	9	7	6	6	7	10
Type of clouds Height of clouds	cu 1500	cu 900	cu 500	cu 500	cu 300	stcu 600	cu 1500	cu 800	stcu 1500	stcu 1200	stcu 800	stcu 800	stcu 800	cu 800	stcu 1200	stcu 1000	stcu 1500	stcu 1000	stcu 1500	stcu 2000
Horizon	cl.	m.cl.	m.cl.	cl.	cl.	m.cl.	cl.	cl.	cl.	m.cl.	m.cl.	m.cl.	cl.	cl.	m.cl.	cl.	cl.	cl.	cl.	m.cl.
Remarks		l. rain bell glass	l. rain bell glass	l. rain bell glass	l. rain bell glass	l. rain bell glass	bell glass			bell glass	rain bell glass	rain bell glass								bell glass
Wavelength																				
6800	241	275	425	215	153	405	—	340	600	450	560	550	625	400	410	415	505	1160	455	715
6600	246	230	335	187	112	455	185	315	535	500	520	540	635	435	410	430	520	1130	445	630
6400	254	207	320	206	101	470	209	305	560	695	500	535	620	460	425	450	530	1080	460	620
6200	262	216	273	244	101	505	190	320	620	670	560	570	580	460	560	480	565	1130	485	670
6000	300	230	255	281	121	520	166	325	705	680	605	555	565	490	560	490	580	1120	505	655
5800	310	260	249	340	151	580	200	340	755	710	670	570	610	510	660	560	630	1210	510	730
5600	320	297	220	325	165	620	206	345	740	725	460	585	640	515	705	600	640	1170	540	775
5400	340	400	189	380	194	700	225	365	820	740	485	590	665	540	750	610	645	1220 (230)	545	780
5200	355	535	192	410	223	700	230	325	820	720	485	535	620	565	765	655	655	1140	565	830
5000	380	620	249	465	232	520	252	335	710 (253)	720 (232)	520	730 (246)	600 (228)	600 (198)	785 (314)	630 (224)	645 (273)	1130	525	845 (258)
4900	370	650	250	485 (118)	201	690 (183)	245	330	785	680	490	770	685	540	580	595	575	940	515 (188)	880
4800	365	595 (148)	360	520	199	720	264	320 (98)	700	440	575 (122)	730	590	375	465	610	570	970	510	850
4700	360	580	485 (138)	525	211	710	280	340	685	345	505	600	520	310	—	625	540	1050	540	825
4600	380	510	485	590	219	740	232	290	—	330	555	570	585	280	—	620	570	990	565	870
4500	—	395	420	620	184	710	202	240	—	297	380	510	475	300	—	535	465	865	475	850
Class	A	A	?	A	B	A	B	A	A	?	B	B	B	?	?	A	A	B	A	A

Observation No.	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600
Date	17May 1933	17May	17May	18May	19May	19May	19May	19May	19May	19May	22May	22May	22May	22May	22May	22May	22May	22May	23May	23May
Time	12.00	14.00	15.30	8.30	8.45	10.00	10.20	12.00	12.20	14.10	8.45	9.00	10.10	10.30	12.15	12.30	14.20	14.35	8.40	8.50
Solar altitude	58°	50°	37°	35°	36°	49°	51°	57°	56°	48°	40°	42°	51°	52°	57°	57°	47°	46°	39°	40°
Total or indirect	I	I	I	I	I	I	T	I	T	T	I	T	I	T	I	T	I	T	T	I
Cloudiness	10	10	9	4	1	3	4	5	5	4	0	0	0	0	1	1	2	2	1	1
Type of clouds Height of clouds	st 1500	stcu 1500	st	cu 800	cu 1000	cu 1000	cu 1000	cu 1500	cu 1500	cu 2000					acu	acu	stcu	stcu	cist	cist
Horizon	m.cl.	cl.	cl.	cl.	m.cl.	m.cl.	m.cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.
Remarks	bell glass		l. rain bell glass																	
Wavelength																				
6800	295	345	370	330	310	475	1220	480	1130	350	212	1075	186	985	241	1010	300	865	1080	167
6600	290	380	390	320	330	440	1270	470	1180	290	217	1050	198	1110	207	975	290	800	1120	182
6400	325	360	435	290	320	455	1320	520	1180	310	226	1080	209	1130	227	995	310	850	1105	179
6200	350	420	470	310	350	520	1400	525	1280	310	258	1120	230	1240	259	1095	340	950	1200	182
6000	330	460	555	320	370	520	1400	560	1270	340	278	1120	244	1190	271	1120	350	965	1230	213
5800	380	435	555	345	410	590	1500	630	1290	355	306	1230	266	1295	300	1190	390	1060	1310	230
5600	400	485	540	395	410	640	1470	620	590	370	307	1280	288	1310	315	1210	410	1070	1310	247
5400	445	515	630	465	455	660	1440 (264)	660	580	385	370	1240 (232)	335	1270	355	1130	445	1070	1280 (244)	281
5200	435	495	680	500	490	710	1430	670	1350 (203)	410	395	1175	350	1270 (209)	370	1180 (202)	465	1090 (190)	1260	292
5000	460	505	735 (208)	535	520	695 (119)	1550	680	1520	440	420	1220	380	1500?	415	1190	460	1105	1340	330
4900	435	500 (182)	750	535 (227)	520 (206)	680	1460	615 (237)	1420	415	415	1215	375	1235	400	1130	460 (84)	1090	1230	310
4800	440 (141)	530	710	535	510	640	1410	605	1420	420 (153)	430 (166)	1185	380 (143)	1260	410 (163)	1120	490	1060	1240	330
4700	460	505	685	530	540	680	1340	565	1290	445	415	1175	410	1285	400	1090	515	1105	1280	340 (143)
4600	460	480	720	560	580	820	1380	605	1440	485	475	1235	445	1385	420	1180	590	930	1370	335
4500	445	505	690	515	535	805	—	535	1330	490	475	1085	445	1340	380	1130	570	860	1300	310
Class	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Observation No.	601	602	603	604	605	606	607	608	609	610
Date	23May 1933	23May	23May	23May	23May	23May	24May	24May	24May	24May
Time	10.10	10.30	12.15	12.30	14.10	14.20	8.45	10.00	12.20	14.00
Solar altitude	52°	53°	59°	58°	49°	49°	41°	51°	59°	50°
Total or indirect	I	T	I	T	I	T	I	T	T	I
Cloudiness	0	0	0	0	1	1	10	10	9	7
Type of clouds Height of clouds					cist	cist	cist	st 1000	stcu	ast
Horizon	cl.	cl.	cl.	cl.	cl.	cl.	m.cl.	m.cl.	m.cl.	cl.
Remarks								rain bell glass		
Wavelength										
6800	167	1080	143	1000	129	815	410	265	530	555
6600	141	1060	122	1000	123	875	350	254	500	550
6400	164	1090	143	1040	135	930	350	254	500	600
6200	176	1180	149	1110	134	935	380	253	520	625
6000	187	1205	162	1130	149	960	350	247	515	635
5800	209	1305	188	1250	176	1030	380	256	580	690
5600	222	1315	201	1250	189	1070	370	264	610	760
5400	257	1250 (237)	212	1205	218	1000	380	265	625	745
5200	281	1230	236	1270 (217)	229	1080	380	248	680	755
5000	310	1270	274	1380	274	1160 (206)	380	251	635	745 (290)
4900	310	1200	286	1355	273	1060	365	242	650 (233)	690
4800	320	1235	288	1235	280	1080	340	217	630	710
4700	330 (116)	1180	325 (113)	1275	295	1080	335	221	615	675
4600	400	1230	450	1300	300	1120	335 (136)	233	620	670
4500	390	1150	420	1195	310	1200	325	194	645	610
Class	A	A	A	A	A	A	A	A	A	A

Observation No.	611	612	613	614	615	616	617	618	619	620
Date	24May	26May	26May	26May	29May	29May	29May	29May	29May	29May
Time	15.35	8.35	10.10	12.10	8.45	10.10	10.30	12.20	12.40	14.10
Solar altitude	39°	39°	51°	59°	40°	52°	54°	59°	58°	49°
Total or indirect	I	I	T	I	I	I	T	I	T	I
Cloudiness	4	5	8	8	3	1	1	2	2	3
Type of clouds Height of clouds	acu	cu 800	cu 1000	cu 1000	stcu 1000	stcu 1000	stcu 1000	cu 2000	cu 2000	cist
Horizon	cl.	cl.	m.cl.	m.cl.	m.cl.	cl.	cl.	cl.	cl.	cl.
Remarks										
Wavelength										
6800	292	580	360	665	540	365	1160	325	920	325
6600	310	550	350	650	565	380	1060	330	895	330
6400	320	555	390	665	580	400	1090	340	945	335
6200	340	590	420	725	630	475	1200	380	1040	380
6000	345	570	390	715	615	510	1205	405	1070	410
5800	390	645	420	840	665	590	1295	445	1160	440
5600	405	660	400	865	665	585	1290	470	1170	470
5400	440	675	385	705	665	600	1260 (235)	515	1295	520
5200	465	695	370	620	715	615	1240	535	1160	530
5000	485	685 (250)	390	620 (213)	740 (305)	610	1235	565	1200 (186)	565 (213)
4900	480	665	590 (233)	615	700	605 (229)	1105	575 (209)	1160	560
4800	470 (161)	645	635	660	655	610	1185	565	1170	560
4700	525	610	725	610	680	575	1105	570	1180	570
4600	510	580	—	655	680	600	1105	595	1100	580
4500	500	510	—	640	610	600	1050	540	1080	520
Class	A	A	?	?	A	A	A	A	A	A

Observation No.	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640
Date	29May 1933	29May	30May	30May	30May	30May	31May	31May	31May	31May	31May	1June	1June	1June	1June	1June	1June	2June	2June	2June
Time	14.30	15.35	8.30	10.00	14.00	15.30	8.40	8.45	10.05	12.00	14.00	9.35	10.00	12.05	12.25	14.05	15.30	8.30	8.40	10.00
Solar altitude	48°	39°	37°	51°	51°	39°	39°	41°	52°	60°	52°	40°	51°	61°	60°	51°	40°	40°	41°	51°
Total or indirect	T	I	I	I	T	T	T	I	I	I	I	T	T	I	T	I	I	T	I	I
Cloudiness	3	3	5	7	7	8	7	7	6	7	5	7	9	9	5	7	5	0	0	1
Type of clouds Height of clouds	cist	cist	cu 800	cu	cu	cu 900	cu	cu	cu 1000	cu	cu 1500	cu 1000	stcu 1500	stcu 1500	stcu 2000	stcu 2000	cu 800			cist
Horizon	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.	m.hazy	m.hazy
Remarks																		measured w. reducer		
Wavelength																				
6800	830	300	380	325	280	405	480	490	400	590	350	410	450	560	1070	515	230	1320	245	240
6600	860	330	385	340	290	410	435	480	415	600	360	410	410	590	1210	460	236	1380	240	251
6400	860	330	415	355	320	425	445	480	455	600	360	405	410	640	1310	465	249	1360	258	268
6200	915	380	460	425	360	470	420	485	520	670	390	430	445	700	1410	515	300	1355	281	297
6000	915	380	465	450	380	465	465	500	525	685	400	430	460	740	1370	595	315	1420	293	315
5800	975	415	510	520	410	510	510	555	615	735	430	465	515	790	1490	540	365	1500	340	330
5600	1020	460	495	540	415	540	545	580	695	800	445	465	515	825	1400	525	380	1430	365	360
5400	1170	480	535	530	420	570	570	580 (110)	705	780	470	480 (95)	575	785	1410 (171)	530	425	1470	291	410
5200	1020 (171)	500	565	530	410	610	620	545	745	825	465	470	585	760	1260	520	460	1470	425	430
5000	1090	515	580 (209)	560	420	—	—	645	790 (283)	830 (280)	455	470	605 (218)	775 (255)	1410	510	485	1480 (258)	450	460
4900	1060	525 (196)	580	625 (233)	420	—	—	645	740	805	445	485	610	730	1540	485 (161)	500 (96)	1450	440	465
4800	1060	520	610	570	430 (160)	—	—	670	670	780	390 (131)	520	590	730	1720	535	495	1420	440 (97)	435 (169)
4700	970	485	625	550	455	—	—	740	650	735	395	525	565	690	1560	520	495	1415	485	445
4600	900	515	670	545	520	—	—	645	665	775	415	510	590	715	1570	540	485	1540	445	460
4500	800	520	625	570	480	—	—	625	585	750	435	470	560	720	1160	485	485	1320	445	415
Class	A	A	A	A	A	?	?	A	A	A	A	A	A	A	?	B	A	A	A	A

Observation No.	641	642	643	644	645	646	647	648	649	650
Date	2June 1933	2June	2June	7June	7June	7June	7June	7June	8June	8June
Time	10.20	14.15	14.30	8.35	10.15	10.35	14.00	14.15	8.35	8.55
Solar altitude	53°	50°	48°	41°	54°	56°	53°	51°	41°	43°
Total or indirect	T	I	T	I	I	T	I	T	I	T
Cloudiness	1	1	1	0	0	0	4	4	0	0
Type of clouds Height of clouds	cist	acu	acu				cu 1000	cu 1000		
Horizon	m.hazy	m.cl.	m.cl.	cl.	cl.	cl.	cl.	cl.	cl.	cl.
Remarks										
Wavelength										
6800	1170	211	855	280	276	1030	310	935	215	1110
6600	1110	216	865	281	267	1030	320	950	216	1110
6400	1130	247	920	281	285	1110	325	980	215	1120
6200	1210	256	1000	325	325	1190	370	1060	235	1210
6000	1210	271	955	330	320	1200	370	1045	235	1220
5800	1300	300	1070	350	370	1300	415	1120	267	1330
5600	1320	330	1070	410	405	1330	450	1140	289	1380
5400	1300 (251)	365	1000	440	440	1330	500	1110	320	1400 (254)
5200	1300	385	1170 (189)	480	480	1380 (253)	510	1190 (210)	340	1415
5000	1320	410	1170	490	505	1420	520	1210	380	1500
4900	1220	405	1140	520 (190)	490 (192)	1340	535	1110	380	1420
4800	1250	405 (144)	1120	530	505	1340	530	1090	370 (148)	1360
4700	1240	430	1180	530	490	1330	510	1085	395	1260
4600	1220	480	1130	520	475	1320	520	1170	425	1270
4500	1090	450	1120	510	465	1160	550	850	380	1170
Class	A	A	A	A	A	A	A	B	A	A

Observation No.	651	652	653	654	655	656	657	658	659	660
Date	8June	8June	8June	8June	8June	9June	9June	9June	9June	9June
Time	10.15	10.30	14.05	14.20	15.35	8.35	10.07	12.15	14.07	14.30
Solar altitude	54°	56°	52°	50°	40°	41°	52°	62°	52°	50°
Total or indirect	I	T	I	T	T	T	I	I	T	I
Cloudiness	1	2	1	1	1	9	7	9	2	4
Type of clouds Height of clouds	cu 1500	cu 1500	cist	cist	cu 500	st 1500	ast	ast	cu 1500	ast
Horizon	cl.	cl.	cl.	cl.	cl.	cl.	cl	cl.	cl.	cl.
Remarks										
Wavelength										
6800	181	1170	161	865	745	420	560	570	845	249
6600	141	1140	130	865	760	385	505	585	890	263
6400	170	1190	137	930	770	385	565	580	920	289
6200	198	1290	162	1010	810	425	690	635	1020	330
6000	197	1220	160	980	820	390	695	610	1020	330
5800	224	1400	190	1100	895	430	775	725	1090	385
5600	251	1370	237	1130	930	420	775	770	1100	405
5400	279	1230 (230)	240	1170	910	440	725	770	1120	440
5200	305	1230	250	1210 (190)	940 (167)	435	760	735	1120 (390)	460
5000	330	1225	298	1280	970	430	725 (288)	725 (290)	1180	480
4900	330	1170	281	1150	955	415	685	680	1090	500 (181)
4800	350 (137)	1190	295	1150	890	410 (140)	670	700	1065 (183)	525
4700	365	1220	295	1200	850	450	735	730	1055	540
4600	435	1110	310	1250	880	450	725	680	1100	550
4500	370	1100	340	1080	790	420	665	700	1055	475
Class	A	A	A	A	A	A	A	A	A	

Observation No.	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680
Date	9June 1933	12June	12June	12June	13June	13June	13June	13June	13June	14June	14June	14June	15June	15June	15June	15June	15June	15June	16June	16June
Time	1530	10.00	12.25	14.00	8.45	10.07	12.15	14.10	15.30	10.10	14.07	14.20	8.35	10.05	10.30	14.05	14.20	15.30	10.00	10.10
Solar altitude	40°	53°	60°	53°	42°	55°	60°	52°	41°	53°	52°	50°	40°	54°	56°	53°	50°	41°	54°	55°
Total or indirect	I	T	T	T	I	I	I	I	I	I	I	T	I	I	T	T	I	I	T	I
Cloudiness	4	10	10	10	10	6	5	2	1	5	4	4	4	4	4	1	1	1	2	2
Type of clouds Height of clouds	cu 2500	cu 200	cu 200	cu 300	acu	cu 1500	cu 1500	cu 1500	cu 2000	acu	acu	acu	cu 2000	cu 1500	cu 1500	cu 2000	cu 2000	cu 2000	cu 2000	cu 2000
Horizon	cl.	v.hazy	v.hazy	hazy	m.cl.	hazy	cl.	m.cl.	cl.	m.cl.	cl.	cl.	m.cl.	m.cl.	m.cl.	cl.	cl.	cl.	cl.	cl.
Remarks		rain bell glass	rain bell glass	rain bell glass											rapidly changing					
Wavelength																				
6800	350	183	183	280	525	440	370	310	212	525	290	1090	380	345	985 / 1290	925	141	173	1110	290
6600	360	134	140	310	525	490	350	310	182	500	280	1030	350	335	460 / 1360	920	150	153	1140	290
6400	360	156	168	420	450	515	350	310	193	500	300	1120	350	330	470	990	148	148	1170	320
6200	390	157	179	515	495	525	410	310	230	510	330	1190	400	370	580 / 1600	1080	153	172	1270	345
6000	400	147	145	485	525	590	430	325	234	480	330	1140	415	380	1460	1040	169	184	1210	340
5800	430	151	155	445	570	645	510	350	273	535	380	1260	505	450	1580	1200	193	210	1300	385
5600	445	168	169	360	490	630	510	370	280	550	400	1290	560	485	1580	1170	208	231	1370	405
5400	470	209	180	335	500	665	505	395	315	565	420	1290 (241)	555	520	1580 (280)	1140	241	260	1250	430
5200	465	207	180	305	620	680	510	430	340	585	445	1230	625 (125)	525	1370	1180 (201)	260	281	—	440
5000	450	230	166	315	620 (210)	670 (260)	510	450	375	600 (227)	470	1270	680	560 (106)	635	1180	290	305	—	445
4900	450	230	164	310	735	650	520 (192)	440 (156)	355	565	480 (184)	1140	700	550	875	1130	295	305	—	470 (90)
4800	390 (131)	219	173	335	650	620	540	460	370 (146)	585	490	1090	660	580	730 / 1250	1150	296	310	—	415
4700	395	210	154	360	830	655	540	470	340	585	460	1050	665	610	870 / 1240	1120	305 (123)	315 (113)	—	520
4600	415	245	166	385	780	595	575	485	405	640	515	1010	690	675	1060	1070	300	375	—	560
4500	435	223	142	370	—	—	570	420	335	530	495	940	600	655	925	980	300	340	—	525
Class	B	B	B	?	B?	A	?	A	B	A	A	A	A	A	?	A	A	B		B

Observation No.	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700
Date	16June 1933	16June	16June	19June	19June	20June	20June	21June	21June	21June	23June	23June	23June	26June	26June	26June	27June	27June	27June	28June
Time	12.00	13.50	14.10	10.07	15.07	10.00	12.10	10.00	14.00	14.15	10.00	12.00	14.10	10.00	12.00	14.00	10.00	12.15	14.00	10.00
Solar altitude	62°	55°	53°	54°	44°	54°	62°	55°	54°	53°	55°	62°	54°	54°	62°	54°	53°	61°	53°	53°
Total or indirect	I	T	I	T	T	I	T	I	I	T	T	T	T	T	T	T	T	T	I	T
Cloudiness	8	4	4	9	10	10-6	9	7	5	5	10	10	10	10	10	10	7	10	9	10
Type of clouds Height of clouds	cu 2000	cu 2000	cu 2000	cu 200	cu 500	cu 300	cu 600	cu 800	cu 1000	cu 1000	st 500	st 1500	st 1500	stcu 1000	stcu 1000	stcu 600	cu 800	cu 1000	cu 800	stcu 600
Horizon	cl.	cl.	cl.	cl.	hazy	hazy	hazy	cl.	cl.	cl.	hazy	m.cl.	cl.	hazy	hazy	hazy	hazy	m.cl.	m.cl.	hazy
Remarks				occ.rain bell glass	l. rain bell glass		occ.rain bell glass	occ.rain bell glass					measured w. reducer				occ.rain bell glass			rain bell glass
Wavelength																				
6800	520	1020	262	430	385	173	258	660	410	360	445	665	435	500	460	470	580	725	635	286
6600	470	985	260	345	395	108	252	575	385	395	465	675	405	530	440	420	455	845	600	310
6400	485	1010	278	262	435	85	252	580	375	460	465	670	425	520	370	450	465	820	585	320
6200	520	1150	298	360	480	113	278	600	410	520	530	720	420	570	310	475	510	860	660	350
6000	525	1120	310	395	470	175	267	515	410	530	495	680	430	565	241	465	505	835	630	350
5800	595	1230	350	430	520	236	305	445	450	560	560	750	455	600	251	485	565	940	700	410
5600	600	1210	370	285	545	300	325	410	475	580	590	720	450	585	221	480	580	860	710	410
5400	635	1220	410	207	570	355	370	385	510	545	565	745	440	525	233	500	530	830	690	410
5200	645	1260 (220)	445	202	550	370	380	340	555	505	575	765	440	485	260	495	560	820	680	390
5000	690 (126)	1295	480	200	585	410	410	405	580	465	560	790 (280)	460 (127)	425	350	470	540	840 (310)	600 (213)	385
4900	710	1190	465 (86)	176	550 (158)	420	405	385	535 (290)	450 (161)	515 (177)	760	395	405	440	430	485 (181)	765	560	360
4800	805	1205	475	155	505	400 (147)	460	420 (143)	550	510	490	740	420	395 (131)	500 (187)	330	540	675	600	360 (96)
4700	685	1135	485	154	500	390	445 (192)	445	540	500	500	740	410	390	530	340 (129)	510	620	635	365
4600	725	1080	540	166	490	410	445	440	570	535	505	770	430	420	565	355	600	610	705	370
4500	665	1060	485	225	440	385	470	460	510	525	475	705	390	385	510	340	485	650	680	350
Class	B	A	A	?	A	A	A	?	A	?	A	A	A	A	?	B	B	B	C	A

Observation No.	701	702	703	704	705	706
Date	1July 1933	3July	3July	4July	6July	6July
Time	10.00	10.30	12.00	10.00	8.20	8.40
Solar altitude	53°	53°	60°	52°	39°	40°
Total or indirect	T	I	I	T	I	T
Cloudiness	1	1-2	7	10	4	4
Type of clouds	cist	cist	cist	stcu	cu	cu
Height of clouds				1000	1500	1500
Horizon	cl.	cl.	cl.	cl.	hazy	hazy
Remarks						
Wavelength						
6800	1080	137	410	465	510	1010
6600	1190	132	410	495	490	—
6400	1200	136	400	520	480	1190
6200	1210	149	450	520	510	—
6000	1250	161	430	480	530	1310
5800	1310	185	475	465	540	—
5600	1400	195	525	440	650	1390
5400	1310 (240)	225	545	425	610	—
5200	1400	232	545	405	655	1370 (227)
5000	1220	275	560	380	620 (228)	—
4900	1160	290	550 (201)	350	575	1440
4800	1110	284	545	380 (137)	610	—
4700	1190	300 (114)	530	390	565	1260
4600	1200	340	530	440	565	—
4500	980	320	495	490	540	1150
Class	A	A	A	B	A	A

CHAPTER III.

Systematic treatment of the measurements.

§ 1. The illumination $Id\lambda$ at a certain moment is a function of the wavelength and our measuring has supplied a number of values for this function.

If during the interval necessary for each set of measurements, given in Chapter II, the intensity had remained constant, the curve drawn through the 15 points obtained in a I, λ diagram would indeed represent the instantaneous illumination as a function of the wavelength. We had to investigate to what extent a definite condition of the atmosphere and a definite position of the sun correspond to a characteristic curve. In order to ascertain this, the various curves obtained were divided into groups, and we tried to find analytical functions of which the graphs would represent, to a sufficient approximation, the measured curves.

The coefficients entering into those expressions will then serve as parameters, so that it should be possible to describe each curve by a number of parameters. This way of proceeding is justified when the number of parameters required in this connection is small and the number of curves to be compared sufficiently great. For the groups of observations referring to "cloudless sky" to "$^3/_{10}$ covered sky" we succeeded indeed in finding for each altitude of the sun, a set of parameters, determining a curve. The mutual differences between the other observations are, however, so great that the required number of parameters would become too large with respect to the number of observations carried out, for the results obtained in this way to be reliable. On this account we considered for the second group of observations the values of the illumination for each wavelength separately. This means that we have to deal with 15 groups of measured quantities. The quantities of each group were arranged statistically independently of each of the other groups.

§ 2. In the above it was assumed that the results of Chapter II represent true values of the illumination at a definite moment. This is, however, not the case. One of the causes of the deviations from these true values are the unavoidable errors of measuring, already discussed in Chapter I. The chief cause, however, is the time it takes to obtain one complete set of measurements; this interval varies between 5 and 15 minutes and in the meantime the illumination is by no means constant. Fluctuations may be due to changes in the sun's altitude, to atmospheric conditions, or to alterations in the measuring apparatus.

The solar altitude can indeed change appreciably in the course of 10 minutes, especially when the sun is low, in which position the influence of any change in its altitude is at the same time the strongest.

Atmospheric conditions can change very considerably within a short interval in the case of a clear as well as of a clouded sky. We mention here, for example, the changes arising from the gradual clouding, from the increasing thickness of the cloud layer, from the passing of a cloud over the sun or near it, etc.

Changes in the measuring apparatus are, for example, any damaging or spoiling of the white surface (by raindrops or by touching it) the moistening or drying of the bellglass during the measuring, the blurring of the glass parts of the instruments, further, changes in the effect of the reducers, either by touching them, or by accidental displacements etc. As for the pyrometerlamp, this may be considered as constant during a short interval of time. Indeed, when a new standardizing shows a satisfactory agreement with the previous one, we may take it for granted, that no changes of any importance have occurred.

When the observed values of the illumination were plotted against the wavelength they turned out, in general, not to lie on a smooth curve and moreover, the deviations from a curve, drawn so as to fit the points as well as possible, proved greater than one had a right to expect, considering the precision of the apparatus used.

In order to progress under these conditions, the material was divided into 4 classes, according to the amount of the differences between the ordinates representing actually observed values and the corresponding ones of the averaging curve. Those observations where all (or nearly all) of the differences were less than 10 % were classified under *A* — those with deviations from 10 % to 20 % under *B* and those with deviations from 20 % to 30 % under *C*. The remaining observations, which were not reliable were judged unsuitable for a graphical representation.

Now we assume the averaging curve to represent the actual instantaneous illumination as a function of the wavelength. Whether this assumption be true or not, depends on the speed of the changes mentioned above. These changes can be described chiefly as slow, moderately rapid, and rapid changes.

Slow changes are, for example, the gradual clouding over of the sky, the increasing thickness of the cloud layer, the dissolving of a haze, or the change in the solar altitude. Their characteristic feature is, that during the measuring, a gradual change makes itself felt, continuing in one direction only for at least half the time of a measurement. The description of the conditions is, therefore, often only right for part of the observations. The graphs referring to them belong mostly to class *A*, a few of them to class *B*.

Rapid changes are often more or less periodical in character; their period is only a small fraction of the time of a measurement. Among these are, for example, changes with fragmentary clouding and strong wind, with a bright sky, etc. These changes are at times very considerable and it may happen even that the illumination shifts rapidly from one extreme value to the other and back again, without any really intermediate state. When a cloud passes right over the sun, for example, the illumination will be at one moment chiefly indirect and the next moment chiefly direct. Strictly speaking, two curves should be drawn in such cases, each referring to its own momentary condition. Observations under these circumstances show sudden and strong fluctuations, of which observ. N$^{o.}$ 675 is a typical example. Generally speaking, it was hardly possible to obtain definite results from such cases. The curves found for them belong either to class *C* or are of no use at all. Other changes exist in fluctuations about an intermediate stage. The curves obtained represent then approximately the illumination belonging to that phase. The fluctuations themselves are in these cases usually slighter. This type of curve is to be found in all classes.

Moderately rapid changes; these are mostly periodical, but the period amounts now to more than half the measuring interval. These changes take place, for example, in the case of slowly drifting clouds. The curves found from observation under these conditions deviate so strongly from the more usual types, that one can ascribe only a small reliability to them.

For those groups, however, which allow of a parametric representation of their curves, one may assume that the fluctuations will cancel out, so that the final result represents indeed the instantaneous illumination. Figs. 2 and 3 show the number of observations belonging to the classes *A, B* and *C* as a function of the degree of covering. Fig. 2 refers to the total — fig. 3 to the indirect illumination. From the high percentage of curves in class *A* for the lower degrees of cloudiness, we gather that the measured curves are a satisfactory representation of the momentary state of affairs; considerable changes are evidently few in number. With an increasing degree of covering, however, the percentages of the curves belonging to the classes *B* or *C* increase also, while, at the same time, the curves of class *A* become less reliable as representations of instantaneous lighting.

§ 3. *Classification of the observations.* The following analysis refers to the Nos. 181 to 706. For these observations the details of the atmospheric condition were ascertained and put down in a uniform way, which was not the case for the numbers 1 to 180. The available material is divided into two principal groups: I. *total illumination*, II. *indirect illumination*. Each of these groups is subdivided, according to the *degree of covering* into 11 subgroups, 0, 1, ... 9, 10. In each of these subgroups the type of clouds is distinguished and within these groups the *solar altitude* is taken to be the only variable. After the determination for each group of a set of characteristic values, we tried to represent the differences between the actual and these characteristic values as systematic deviations, due to the influence of such factors as the height of the clouds, the degree of visibility

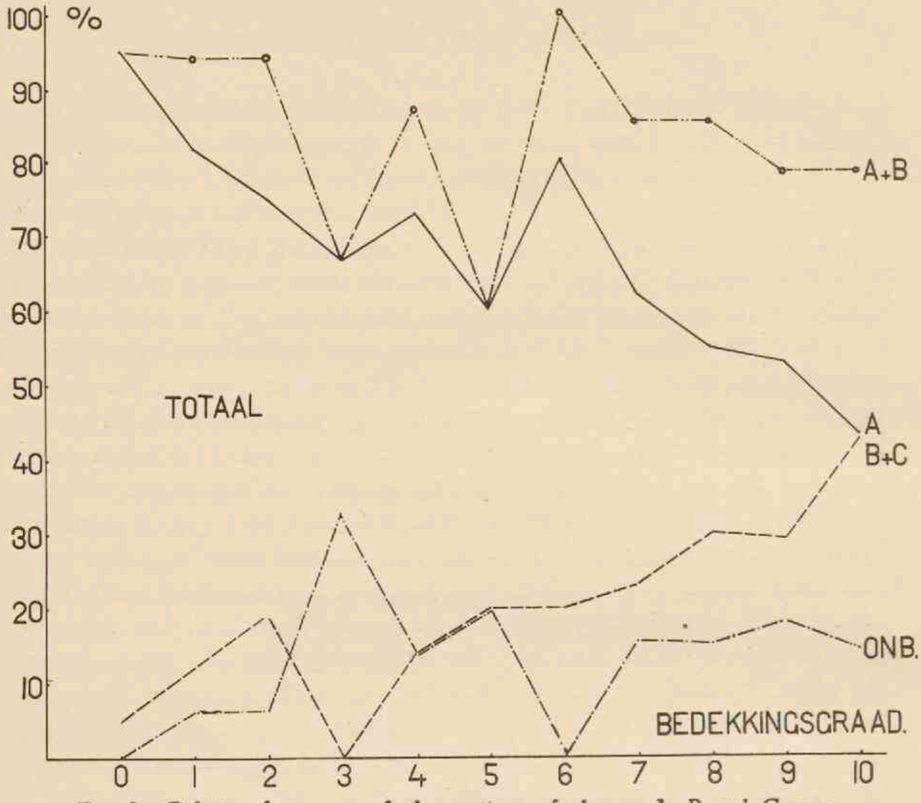

Fig. 2. Relative frequency of observations of classes *A*, *B* and *C* as a function of the degree of covering (Total illumination). (onb. = ?)

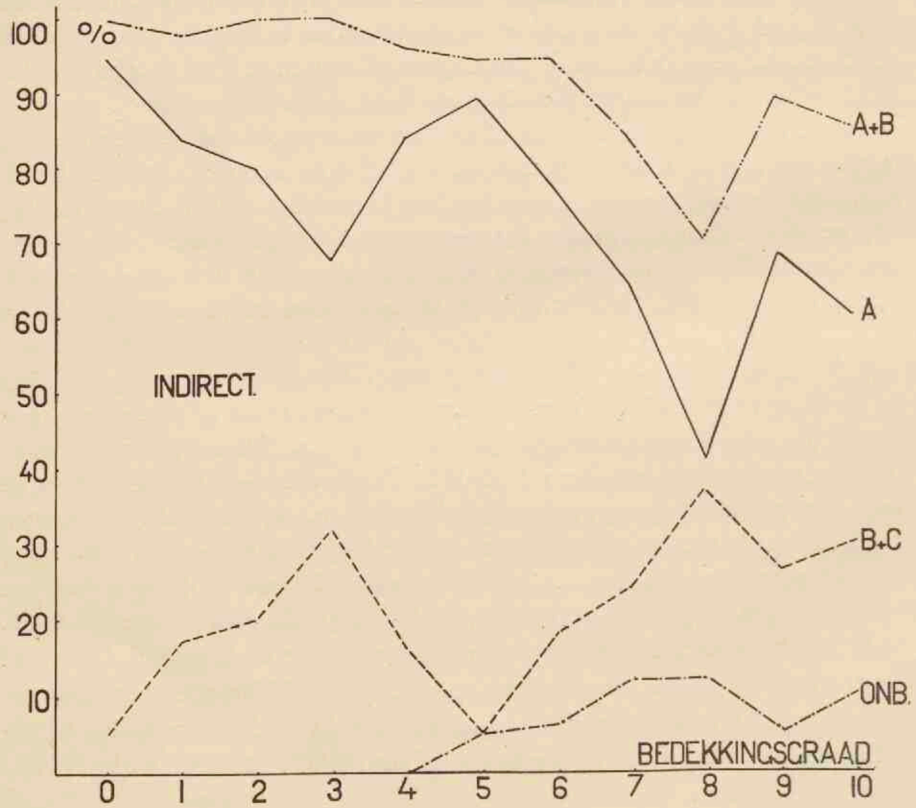

Fig. 3. Relative frequency of observations of classes *A*, *B* and *C* as a function of the degree of covering (Indirect illumination). (onb. = ?)

of the horizon, the time of the day (forenoon or afternoon), the season of the year (spring-autumn) etc. In most cases without success, however, the dispersion of the points proving much more considerable than any assumed systematic deviations from the characteristic quantities. For the numbers 194 and 533, the type of clouds was not filled in, we put down *cu* and *stcu* respectively, judging from the type in the observations before and after these on the same day. We shall show in the following how our results were obtained for the various separate groups.

Principal Group I. Total illumination.

Degree of covering 0. Numbers of observations available 21, from which 20 belong to class *A* and the remaining one to class *C*. The curve of the latter (N⁰. 350) showed a shape differing from the normal one; since we were unable to trace this deviation, the observation was rejected. In N⁰. 331 the values for I from $\lambda = 4900$ to $\lambda = 4500$ are missing. The 20 curves are represented analytically by the following equation of the third degree containing 4 parameters

$$I = \alpha + \gamma \left\{ \frac{(x-\beta)^3}{3} - (x-\beta)\,\delta^2 \right\} \quad . \; . \; . \; . \; . \; . \; . \quad (1)$$

Here x is written for $\lambda/_{100}$; the differences between the values from this formula and those on the averaging curve originally drawn, amount in the majority of cases to less than 5 %.

Equation (1) is chosen in such a way that the coefficients can be readily determined from the curve. I possesses namely a maximum for $x_m = \beta - \delta$; then $I_m = \alpha + \frac{2}{3}\gamma\delta^3$; further for $x_{min} = \beta + \delta$ I possesses a minimum, $I_{min} = \alpha - \frac{2}{3}\gamma\delta^3$ and at x_b I has finally a point of flexion where $I_b = \alpha$. After the determination of the coefficients from these relations the approximation was checked for $x = 45$, and if necessary for $x = 68$.

We must now find out how the sets of values for α, β, γ, and δ, found in this way from the various curves, are related to each other by their dependence on the solar altitude φ. If one considers α, β, γ and δ each separately as a function of φ, considerable deviations from the best interpolated curve are apt to appear. In order, therefore, to ensure the connection between the various curves, we proceeded as follows.

Let some given specimen of (1) be represented by the set α_0, β_0, γ_0 and δ_0. We now put the question which values the other parameters must have to give the best representation of this curve when we give one of them, e.g. γ the value $\gamma_0 + d\gamma$. We consider that the best representation which we obtain when we assume that $\int_{x_2}^{x_1} (dI)^2\,dx$ must be a minimum. Here x_1

and x_2 denote the extreme values of x of the region considered, i.e. in our case $x_1 = 68$ and $x_2 = 45$. We obtain from (1):

$$dI = \frac{\partial I}{\partial \alpha} d\alpha + \frac{\partial I}{\partial \beta} d\beta + \frac{\partial I}{\partial \gamma} d\gamma + \frac{\partial I}{\partial \delta} d\delta$$

For a given value of $d\gamma$ we find in this way the best values of $d\alpha$, $d\beta$ and $d\delta$. If we imagine γ to undergo a finite change, then α, β and δ must suffer at the same time changes, which can be found by treating the equations obtained from the minimum condition (in which $d\gamma$ is the independent variable and $d\alpha$, $d\beta$ and $d\delta$ the dependent variables) as differential equations in α, β, γ and δ. This way of proceeding leads for $x_1 = 68$ and $x_2 = 45$ to the equations

$$\alpha - \gamma\left(\tfrac{1}{3}\beta^3 - \beta\delta^2 - 58626\right) = c_0 \quad \text{(2a)}$$

$$\gamma\left(\beta^2 - \delta^2 - 3166\right) = c_1 \quad \text{(2b)}$$

$$\gamma\left(56^1/_2 - \beta\right) = c_2 \quad \text{(2c)}$$

The values α_0, β_0, γ_0 and δ_0 must also satisfy these equations. The constants c_0, c_1 and c_2 are determined by the condition that on substitution of $\alpha = \alpha_0$, $\beta = \beta_0$, $\gamma = \gamma_0$ and $\delta = \delta_0$ the equations (2) shall become identities. If now a given curve is described by the coefficients α_0, β_0, γ_0 and δ_0 one can find the best values for three among them, with the aid of the equations (2), if to the remaining one a certain value is given, differing from its original value.

To begin with, we plot the value obtained for α, β, γ and δ respectively against φ. Let us suppose, now, that we can draw in one of these graphs a curve in which several of the points fit fairly well, but that there are a few points among them, which do not fit in the curve. We can then shift these points until they come to lie on the curve. The points of the other graphs, corresponding to these points, will then suffer displacements satisfying (2). If now, after all these displacements have been effected, the dispersion has become less, the new points give an indication where to draw the curve, which owing to the original spreading could not be drawn with certainty. The curves, found in this way are mutually dependent; the displacements must, however, be found by trial.

In our case β and δ show the least dispersion. If we represent x_m as a function of φ, we obtain a number of points through which an average curve can be drawn. Since now $\beta - \delta = x_m$ this furnishes a check as to whether we are on the right track with certain displacements. In fig. 4*a*, 4*b*, 4*c* and 4*d*, α, β and x_m, γ and δ are plotted against φ. In fig. 5 [1]) I is plotted against λ for $\varphi = 20°$, 40° and 50°, where I is computed with the aid of the parameters obtained from fig. 4*a*, 4*b*, 4*c* and 4*d*.

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[1]) Page 61.

Much the same result is obtained in a partially different way, which requires less computing, but does not so easily admit of a clear insight to what is taking place. In the

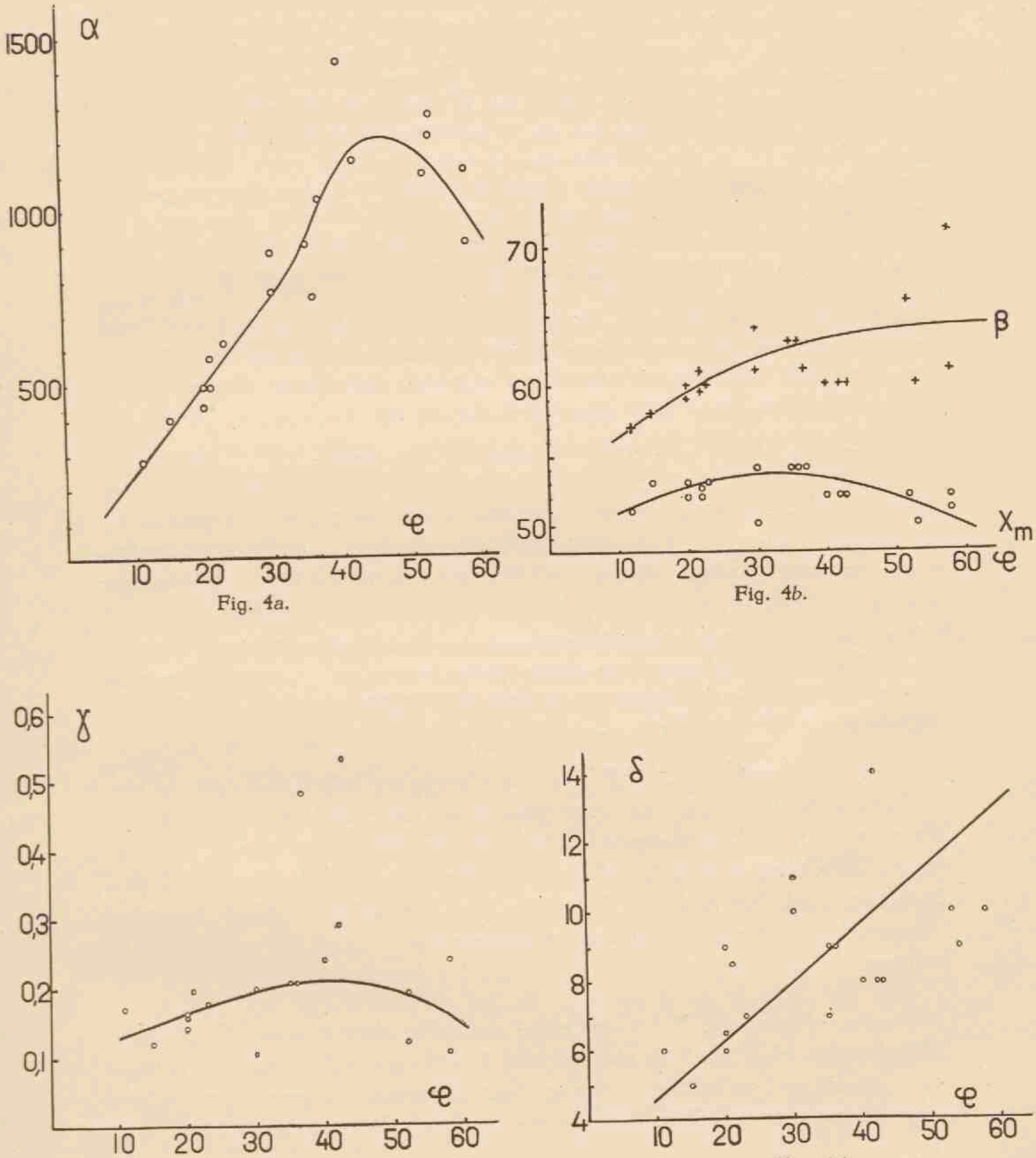

Fig. 4a.

Fig. 4b.

Fig. 4c.

Fig. 4d.

Fig. 4. α, β, γ, δ, x_m as functions of the solar altitude (degree of covering 0).

region considered, all curves for I show a maximum I_m each at its own wavelength λ_m. Now a curve is completely determined when we know $i = \frac{I}{I_m} \cdot 100$ for each value of λ, and the value of I_m. We plot i against φ and choose from the curves so obtained those, that have their maximum at the same wavelength λ_m. We determine next the values which i as a function of φ, takes for $\lambda = 6600$, 6000, 5000 and 4500 Å and compute further the average value of i for each value of φ, at the wavelengths just mentioned. From the data, thus obtained, we construct an average curve i, λ. We do the same for all groups for which λ_m has one and the same value. In this way we shall find for each separate group one average curve if i turns out to be independent of φ, but more than one if this is not the case. These curves can be analytically represented in the same way as above, so that the parameters can be determined as functions of φ, from which the final curve i, λ is then obtained. Besides, we determine I_m as a function of φ. The method, just described, is simpler if there is a sufficient number of curves available having their maximum at the same wavelength λ_m because then the dispersion in the graphs of the parameters as functions of φ is not considerable.

In our present case (cloudless sky) the curves could be divided according to the value of φ in three groups, namely $\varphi < 30$; $30 \leq \varphi \leq 40$; $\varphi > 40$. For the first group $\lambda_m = 5200$ Å (one curve with $\lambda_m = 5300$ was included); for the second group $\lambda_m = 5400$ and 5600 Å. These were taken together. Finally for the third group $\lambda_m = 5200$ Å again (one curve with $\lambda_m = 5000$ was included). The position of the centre of gravity in the λ_m, φ diagram was for the three groups such, that we get:

$\varphi < 30$; $\varphi = 18$; $\lambda_m = 5200$; $i(6600) = 87$; $i(6000) = 90$; $i(5000) = 97$; $i(4500) = 83$; 8 points.

$30 \leq \varphi \leq 40$; $\varphi = 36$; $\lambda_m = 5400$; $i(6600) = 83$; $i(6000) = 93$; $i(5000) = 96$; $i(4500) = 96$; 5 points.

$\varphi > 40$; $\varphi = 51$; $\lambda_m = 5200$; $i(6600) = 80$; $i(6000) = 90$; $i(5000) = 100$; $i(4500) = 92$; 7 points.

From these data and those already mentioned above, we obtained the dotted curves of fig. 5. The agreement between the results of this method and those of the complete parametric treatment is satisfactory; the greatest deviation amounts to 4 %, namely at the extreme wavelength $\lambda = 6800$ Å.

Degree of covering 1. All types of clouds are taken together, on the understanding, that, if the type proves to have any influence on the illumination, it will be determined from the systematic deviations. Number of available observations 31; of these 26 belong to class A, 4 to class B and 1 was rejected. Fig. 5 shows the curves for a few solar altitudes; they were computed with the aid of the same parameters α, β, γ and δ. Any systematic influence of the type of clouds could not be detected.

Degree of covering 2. Number of available observations 16; of these 12 belong to class A, 3 to class B and 1 was rejected. Two observations were considered to belong to the indirect illumination observations, where they fit in quite well. Fig. 5 shows the result of the computation.

Degree of covering 3. Number of available observations 12; of these 8 belong to class A, the remaining 4 were rejected. In this case the observations are too few in number to admit of a positive statement.

For degrees of covering higher than 2, the treatment explained above applies no longer, owing to the large differences occurring in the results of the measuring. An efficient statistical treatment would require an enormous number of observations which, however, is not available. In the following we confined ourselves to the comparison between the illuminations per unit of wavelength (denoted by I) at each of the 15 measured wavelengths [1]). We take it that I is a function of the degree of covering, the solar altitude and occasionally the type of clouds. For a definite degree of covering the data are arranged in groups according to the solar altitude, namely groups for which $\varphi = 0 — 5$; $5 — 10$; ....; $50 — 55$; $55 — 63$, respectively. For each of these groups we compute the logarithmical mean $\log \bar{I} = \frac{1}{n} (\log I_1 + \log I_2 + \ldots\ldots + \log I_n)$ for each of the 15 wavelengths for which the measurements were obtained. Each group furnishes therefore 15 values for $\log \bar{I}$. The logarithmical mean was chosen because for that quantity the number of positive and of negative deviations turn out to be nearly equal, while the average absolute value of the deviations is practically independent of the solar altitude. The quantity $\log \bar{I}$ is now considered to be a function of λ that for a sufficient number of observations can be represented by a smooth curve, made to fit as well as possible the 15 points of the observed values. These points are not independent of each other, since the 15 values, obtained one after the other, belong to atmospherical conditions and positions of the sun, that are either the same or closely connected. The curve obtained in this way does not give a representation of the instantaneous illumination occurring on an average but only gives the value of the illumination, occurring on an average at each wavelength separately, without taking into due account the values occurring at the same time at the other wavelengths.

We shall denote $\log \bar{I}$ for a certain wavelength by adding the wavelength in brackets. In the following we give the set of values of $\log \bar{I}$ (5600) found for $\varphi = 10°$; $20°$; $30°$; $40°$; $50°$ and $60°$ and we give further the amounts by which $\log \bar{I}$ (4500), $\log \bar{I}$ (5000), $\log \bar{I}$ (6000) and $\log \bar{I}$ (6800) are found to surpass, for $\varphi = 50°$, $30°$ and $15°$, the corresponding values of $\log \bar{I}$ (5600). The percentages added in brackets refer to the value of $\bar{I}$ in regards $\bar{I}$(5600).

We proceed now to give the results obtained in this way for the various degrees of covering.

Degree of covering 3. The curves representing $\log \bar{I}$ as a function of λ are more or less irregular. $\log \bar{I}$ has been determined as a function of φ for $\lambda = 4500$, 5000, 6000 and 6800 Å. Through the point thus found curves have been drawn, from which mean curves $\log \bar{I}$ (5600) have been constructed for a number of values of φ.

We find for $\log \bar{I}$ (5600) resp. 2.36; 2.69; 2.87; 2.95; 2.99; 3.01.

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1) The division into the classes *A, B, C* etc. has no influence on this procedure.

Deviations:

	$\varphi=50°$	$\varphi=30°$	$\varphi=15°$
$\lambda=4500$	—0,11 (—22 %);	—0,08 (—17 %);	—0,16 (—31 %)
$\lambda=5000$	0,00 (0 %);	0,00 (0 %);	0,00 (0 %)
$\lambda=6000$	—0,02 (— 5 %);	—0,02 (— 5 %);	—0,04 (— 9 %)
$\lambda=6800$	—0,06 (—13 %);	—0,04 (— 9 %);	—0,04 (— 9 %)

The average value of $|\log I - \log \bar{I}|$ computed for all groups of φ together amounts to 0.10 at $\lambda=4500$ Å and, nearly linearly increases to 0.13 at $\lambda=6800$ Å.

Degrees of covering 4 and 5. In order to obtain a greater number of observations in one group, these two degrees of covering are considered together. Any definite systematic deviation cannot be stated. Number of available observations 21 for degree 4 and 10 for degree 5. The graph $\log \bar{I}$ (5600) $= f$ (φ) was computed in the same way as for degree of covering 3.

We found $\log \bar{I}$ (5600) $=$ 2.03; 2.56; 2.84; 2.97; 3.03; 3.06.

Deviations:

	$\varphi=50°$	$\varphi=30°$	$\varphi=15°$
$\lambda=4500$	—0,06 (—13 %);	—0,07 (—15 %);	—0,02 (— 5 %)
$\lambda=5000$	+0,02 (5 %);	0,00 (0 %);	+0,04 (10 %)
$\lambda=6000$	—0,01 (— 2 %);	—0,02 (— 5 %);	—0,03 (— 7 %)
$\lambda=6800$	—0,11 (—22 %);	—0,17 (—33 %);	—0,05 (—11 %)

The average value of $|\log I - \log \bar{I}|$ is 0.10 at $\lambda = 4500$ Å increases to 0.16 from $\lambda=4500$ to $\lambda=5500$ Å and decreases again to 0.15 from $\lambda = 5500$ to $\lambda = 6800$ Å. No systematic deviation could be stated in connection with the type of clouds.

Degrees of covering 6 and 7. Number of available observations 18, of which 5 belonged to degree 6 and 13 to degree 7. The small number of observations is due to the rapid changes in the lighting conditions which make it difficult to measure the total illumination. These changes are of frequent occurrence when, as is here the case, the sky is partly covered.

We found $\log \bar{I}$(5600) $=$ 1.86; 2.39; 2.68; 2.80; 2.88; 2.90.

Deviations:

	$\varphi=50°$	$\varphi=30°$	$\varphi=15°$
$\lambda=4500$	0,00 (0 %);	0,00 (0 %);	+0.04 (10 %)
$\lambda=5000$	+0,02 (5 %);	+0,01 (2 %);	+0,04 (10 %)
$\lambda=6000$	—0,03 (—7 %);	—0,02 (— 5 %);	—0,03 (— 7 %)
$\lambda=6800$	—0,04 (—9 %);	—0,07 (—15 %);	—0,12 (—24 %)

The average value of $|\log I - \log \bar{I}|$ is 0.13 at $\lambda=4500$ Å and increases to 0.16 at $\lambda=6800$ Å.

Degree of covering 8. Number of available observations 19. The maximum of $\log \bar{I} = f(\lambda)$ shifts towards the shorter wavelengths with decreasing altitude of the sun.

We found: $\log \bar{I}$ (5600) = 1.80; 2.35; 2.64; 2.70; 2.70; 2.69.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	—0,02 (— 5 %);	—0,06 (—13 %);	+0,04 (10 %)
$\lambda = 5000$	+0,02 (5 %);	+0,01 (2 %);	+0,04 (10 %)
$\lambda = 6000$	—0,03 (— 7 %);	—0,02 (— 5 %);	—0,03 (— 7 %)
$\lambda = 6800$	—0,08 (—17 %);	—0,06 (—13 %);	—0,02 (— 5 %)

The average value of $|\log I - \log \bar{I}|$ is 0.14 at $\lambda = 4500$ Å, it increases to 0.19 from $\lambda = 4500$ Å to $\lambda = 5600$ Å, whereupon it decreases gradually to 0.13 from $\lambda = 5600$ Å to $\lambda = 6800$ Å.

Degree of covering 9. Number of available observations 27. The curves for $\log \bar{I} = f(\lambda)$ show a slightly different shape for the various solar altitudes.

We found: $\log \bar{I}$ (5600) = 1.65; 2.24; 2.59; 2.69; 2.72; 2.73.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,06 (15 %);	—0,09 (—19 %);	+0,10 (27 %)
$\lambda = 5000$	+0,03 (7 %);	—0,01 (— 2 %);	+0,09 (25 %)
$\lambda = 6000$	—0,03 (— 7 %);	—0,01 (— 2 %);	—0,04 (— 9 %)
$\lambda = 6800$	—0,08 (—17 %);	+0,01 (2 %);	—0,01 (— 2 %)

The average value of $|\log I - \log \bar{I}|$ is 0.10 at $\lambda = 4500$ Å, it increases to 0.13 from $\lambda = 4500$ Å to $\lambda = 5000$ Å and decreases again to 0.11 from $\lambda = 5000$ Å to $\lambda = 6800$ Å.

Among the observations 5 belong to the stratus type of clouds, 14 to stratocumulus and 4 to cumulus. In order to form an opinion about any possible influence of the type of clouds on the illumination the average values of $|\log I - \log \bar{I}|$ were also computed for each type separately, $\bar{I}$ still denoting the logarithmic mean over all the curves. The deviations found for stratus at $\lambda = 4500$, 5000, 5600, 6800 Å were +0.10; 0.00; —0.10; —0.15 respectively. For stratocumulus at the same wavelengths: +0.01; +0.06; +0.08; +0.06; and for cumulus +0.04; +0.06; +0.13; +0.11.

Though we cannot ascribe a high precision to these numbers (the values of $\log \bar{I}$ were determined from groups, in which the types of clouds occurred in different proportions) we can, for stratus clouds, gather from them that there is a tendency to contain more than the average amount of blue, and for cumulus clouds, that, generally speaking, they transmit more than the average amount of energy.

Degree of covering 10. Number of available observations 102, of these 55 belong to the *stratus* type, 37 to *stcu*, 9 to *cu* and 1 to *ast*.

We found: $\log \bar{I}(5600) = 1.45$; 2.00; 2.27; 2.37; 2.46; 2.53.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,02 (5 %);	+0,06 (15 %);	+0,12 (32 %)
$\lambda = 5000$	+0,02 (5 %);	+0,01 (3 %);	+0,08 (20 %)
$\lambda = 6000$	—0,02 (—5 %);	—0,02 (— 5 %);	—0,03 (— 7 %)
$\lambda = 6800$	—0,04 (—9 %);	—0,03 (— 7 %);	+0,14 (38 %)

The average value of $|\log I - \log \bar{I}|$ is 0.15 at $\lambda = 4500$ Å, increases to 0.175 from $\lambda = 4500$ Å to $\lambda = 5800$ Å, remains constant from $\lambda = 5800$ Å to $\lambda = 6600$ Å, and decreases to 0.165 from $\lambda = 6600$ Å to $\lambda = 6800$ Å.

As the number of observations is fairly large, we are able to determine the frequency of the different values of $\log I - \log \bar{I}$. In connection with the remarks on page 62 we take together the values considered here with those measured as indirect. We form groups of values of $\log I - \log \bar{I}$, which lie between —0.7 and —0.5, —0.5 and —0.3, etc. We state that the distribution of the deviations is practically not dependent on the solar altitude. In this way we find for 3 values of λ the following table (frequency in %):

Deviations between:

	— 0,7 and — 0,5 ; 0,20 and 0,32;	— 0,5 and — 0,3 ; 0,32 and 0,50;	— 0,3 and — 0,1 ; 0,50 and 0,79;	— 0,1 and + 0,1 ; 0,79 and 1,26;	+ 0,1 and + 0,3 ; 1,26 and 2,00;	+ 0,3 and + 0,5 ; 2,00 and 3,16;	+ 0,5 and + 0,7 3,16 and 5,00 [1]
$\lambda = 4500$	3	7	21	41	20	5	3
$\lambda = 5600$	2	9	25	30	24	8	2
$\lambda = 6800$	1	5	26	34	24	9	1

The frequency curve is markedly broader at $\lambda = 5600$ and 6800 than at $\lambda = 4500$.

The data can further be divided into groups according to the wavelength λ_m, at which I is a maximum. We formed the following three groups: I. $\lambda_m \leq 4800$ Å; II. 4800 Å $< \lambda_m \leq 5800$ Å; III. 5800 Å $< \lambda_m$. For each of these groups $\log \bar{I}$ was computed in the same way as it was computed for all observations together. Group III contains only observations for which φ has values between 20° and 40°. They agree more or less with the observations of group II for $\lambda = 6800$ Å and $\lambda = 6000$ Å, while at $\lambda =$

[1]) These numbers are the factors by which the mean value has to be multiplied corresponding to the logarithmical deviations.

5000 Å and $\lambda = 4500$ Å their values are somewhat less. The mean value of $\log I$ at 4500 Å appears to be nearly the same for the three groups. The other mean values are higher for the groups II and III. We give here the values of $\log \bar{I}$ (5600) (for the usual values of φ) for all observations together, for group I and for group II and III together:

All observations	: 1.45; 2.00; 2.27; 2.37; 2.46; 2.53.
Group I	: 1.40; 1.94; 2.18; 2.30; 2.33; 2.34.
Group II and III	: 1.50; 2.15; 2.39; 2.51; 2.58; 2.61.

We gather from these values that the curve for all observations together lies, for the lower values of φ, close to the curve of group I, whereas for the higher values, it shifts towards the curve of groups II and III. According as the layer of clouds transmits more light, λ_m moves towards the centre of the wavelength region considered. On dark days λ_m lies in the neighbourhood of $\lambda = 4500$ Å or shorter wavelengths. Generally speaking, the thickness of the layer of clouds diminishes with increasing solar altitude.

There remains to be investigated whether the division of the observations according to the value of λ_m runs parallel to the division according to the type of clouds, *st, stcu* and *cu*. The 88 curves which were available for this purpose (the curves belonging to the classes *A, B* and *C*) were distributed as follows:

	total number	group I.	group II.	group III.
st	49	25	19	5
stcu	31	11	15	5
cu	8	2	5	1

We note a certain preference for group I in the case of *stratus* clouds and for group II in the case of *stcu* and *cu*. If now we inquire for all types of clouds, belonging to the degree of covering 10, into the deviations from the mean, it appears that this deviation has for *st* a very small negative value, for *stcu* a somewhat higher positive value and for *cu* a still greater negative value. For all types, however, the individual deviations are much greater, while positive as well as negative deviations are everywhere of frequent occurrence. From the above we draw the conclusion that the division according to the type of clouds has no marked features in common with the division according to λ_m.

Principal Group II. Indirect illumination.

Degree of covering 0. Number of available observations 22; of these 21 belong to class *A*, 1 to class *B*. From $\lambda = 6800$ Å down to $\lambda = 5000$ Å a satisfactory approximation of the curves is furnished by $I = a\lambda^{-2}$. From $\lambda = 5000$ Å down to $\lambda = 4500$ Å the representation is less satisfactory for those observations, for which $\lambda_m > 4500$ Å. Let us first consider those curves for which the highest value of I coincides with the extreme wavelength $\lambda = 4500$ Å. We can then construct from the values of a computed for each observation, a graph a, φ. We find from this curve for $\varphi = 10°$, 20°, 30°, 40°, 50°, 60° for a the values $4\frac{1}{2}$, $6\frac{1}{2}$, $8\frac{1}{2}$, $9\frac{1}{2}$, 9, 8×10^9 respectively. (For I in Watt/Å cm^2 we get: 65; 90; 120; 130; 125; 110.) The number of observations with $\lambda_m = 4500$ Å was 12, for 2 $\lambda_m = 4600$ Å, for 5 $\lambda_m = 4700$ Å, for 1 $\lambda_m = 4900$ Å and for 2 $\lambda_m = 5000$ Å. For these observations a value for a could also be computed, but the value of I for $\lambda = 4500$ Å was then less satisfactorily represented. For λ_m at 5000, 4800, 4600 Å the deviations from the values following from $I = a\lambda^{-2}$ amount to about —30 %; —20 % and —10 %. The values found for a were, but for a few exceptions, higher than the corresponding ones at $\lambda_m = 4500$ Å.

On inspecting the values of $\log I$ at $\lambda = 4500$, 5000, 6000 and 6800 Å we find that as functions of φ they show an increasing dispersion with increasing λ_m and φ. The curves $\log I = f(\lambda)$ found in this way (containing φ as a parameter) enable one to compute a term $\log a$, connected with I by the relation $\log I = \log a - 2 \log \lambda$. The quantities, thus found, agree with those, determined according to the previous method, which we shall, therefore, consider to be the average curves.

Degree of covering 1. Number of available observations 36. We consider $\log I$ as a function of φ for $\lambda = 4500$, 5000, 6000 and 6600 Å. The observations are here devided into two groups; one for which $\lambda_m = 4500$ Å and 4600 Å and the other for which it has higher values. In this second group λ_m varies between 4700 Å and 5200 Å.

From the four curves $\log I = f_i(\varphi)$ for $\lambda = 4500$, 5000, 6000 and 6600 Å (group I) we construct the graph $\log I = f(\lambda)$ containing φ as a parameter. We can determine the quantities n and a in such a way that for each separate solar altitude the expression $\log I + n \log \lambda = \log a$ remains approximately constant. (For each φ, $\log a$ possesses a different value). We find, here again, $n = 2$, while a becomes for $\varphi = 10°$, 20°, 30°, 40°, 50° equal to $2\frac{1}{2}$, 5, $7\frac{1}{2}$, 8, $7\frac{1}{2} \times 10^9$. (For I in Watt/Å cm^2 we get 35; 70; 105; 110; 105.) Thus showing a behaviour similar to that sub degree 0. Only, the corresponding values of a are here somewhat lower.

The four curves $\log I = f_j(\varphi)$ of group II yield for $\log I$ at $\lambda = 4500$, 5000, 6000 and 6600 Å values which differ from the corresponding values of the first group, by the constant amounts 0.06; 0.14; 0.20; 0.25 respectively. The values of I of the second group are, therefore, obtained from those of the first by multiplying with the factors 1.15; 1.4; 1.6; 1.8 respectively. Of the observations, 27 belonged to group I, and 9 to group II. The mean curve would therefore be represented by multiplying $I = a\lambda^{-2}$ of group I with 1.03; 1.08; 1.13; 1.22 for $\lambda = 4500$, 5000, 6000, 6600 Å.

Degree of covering 2. Number of available observations 15. Henceforth we shall treat the observations in the same way as from degree 3 onward in the case of total illumination. (The values for $\log \bar{I}$ (5600) refer again to $\varphi = 10°$; $20°$; $30°$; $40°$; $50°$; $60°$.)

We found: $\log \bar{I}$ (5600) = 2.06; 2.34; 2.54; 2.60; 2.64; 2.64.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,09;	+0,07;	+0,10
$\lambda = 5000$	+0,07;	+0,07;	+0,10
$\lambda = 6000$	—0,05;	—0,07;	—0,07
$\lambda = 6800$	—0,12;	—0,15;	—0,14

The average value of $|\log I - \log \bar{I}|$ is 0.06 for all wavelengths.

Degree of covering 3. Number of available observations 19.

We found $\log \bar{I}$ (5600) 1.86; 2.40; 2.63; 2.72; 2.75; —.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,05;	+0,01;	+0,07
$\lambda = 5000$	+0,06;	+0,05;	+0,07
$\lambda = 6000$	—0,06;	—0,05;	—0,05
$\lambda = 6800$	—0,15;	—0,11;	—0,02

The average value of $|\log I - \log \bar{I}|$ is 0.06 at $\lambda = 4500$ Å; it increases to 0.09 from $\lambda = 4500$ Å to $\lambda = 6000$ Å and remains thenceforth constant to $\lambda = 6800$ Å.

Degree of covering 4 and 5. Number of available observations 44; of which 26 belong to degree 4 and 18 to degree 5.

We found $\log \bar{I}$ (5600) = 2.08; 2.33; 2.55; 2.67; 2.69; 2.70.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,04;	+0,04;	+0,04
$\lambda = 5000$	+0,05;	+0,06;	+0,07
$\lambda = 6000$	—0,08;	—0,08;	—0,04
$\lambda = 6800$	—0,13;	—0,09;	—0,02

The average value of $|\log I - \log \bar{I}|$ is 0.05 at $\lambda = 4500$ Å and increases gradually to 0.08 from $\lambda = 4500$ Å to $\lambda = 6800$ Å. The number of observations is here sufficiently high to allow of a division. We collect in this case the curves with $\lambda_m \leq 4800$ Å in group I and the remaining ones with $\lambda_m > 4800$ Å in group II. At $\lambda = 4500$ Å the values of $\log \bar{I}$ of group II appear to be slightly lower than those of group I for equal values of φ. At $\lambda = 5000$, 6000 and 6800 Å the values of both groups are nearly equal for values of φ up to 30°. For higher values of φ, $\log \bar{I}$ of group II becomes greater than that of group I, namely for $\varphi = 50°$ to the amounts 0.08; 0.12; 0.10 respectively. Here again, we note that λ_m shifts towards the longer wavelengths according as the total energy radiated by the sky increases. The same phenomenon could be observed only still more pronounced sub degree of covering 1.

Degree of covering 6 and 7. Number of available observations 42. One of them (N⁰. 355) showed such a tremendous deviation that it was rejected.

We found $\log \bar{I}\,(5600) = 2.02;\ 2.46;\ 2.65;\ 2.73;\ 2.75;\ 2.75.$

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	—0,05;	—0,01;	+0,07
$\lambda = 5000$	+0,02;	+0,02;	+0,04
$\lambda = 6000$	—0,04;	—0,04;	—0,04
$\lambda = 6800$	—0,09;	—0,09;	—0,09

The average value of $|\log I - \log \bar{I}|$ is nearly the same at all wavelengths, namely 0.07.

Degree of covering 8. Number of available observations 17.

We found $\log \bar{I}\,(5600) = 2.00;\ 2.36;\ 2.51;\ 2.60;\ 2.63;\ 2.70.$

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,01;	+0,01;	+0,01
$\lambda = 5000$	+0,02;	+0,05;	+0,06
$\lambda = 6000$	—0,02;	—0,02;	—0,04
$\lambda = 6800$	—0,08;	—0,07;	0,00

The average value of $|\log I - \log \bar{I}|$ is 0.07 at $\lambda = 4500$ Å, increases to 0.10 from $\lambda = 4500$ Å to $\lambda = 5000$ Å and remains constant from $\lambda = 5000$ Å to $\lambda = 6800$ Å.

Degree of covering 9. Number of available observations 19.

We found $\log \bar{I}(5600) =$ ——; 2.5; 2.68; 2.75; 2.78; 2.78.

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	0,00;	—0,06;	—0,08
$\lambda = 5000$	0,00;	0,00;	0,00
$\lambda = 6000$	—0,03;	—0,04;	—0,04
$\lambda = 6800$	—0,10;	—0,09;	0,00

The average value of $|\log I - \log \bar{I}|$ is 0.08 at $\lambda = 4500$ Å decreases to 0.05 from $\lambda = 4500$ Å to $\lambda = 5000$ Å and remains constant from there up to $\lambda = 6800$ Å.

Degree of covering 10. Number of available observations 20.

We found $\log \bar{I}\,(5600) = 1.65;\ 2.35;\ 2.53;\ 2.58;\ 2.60;\ 2.60.$

Deviations:

	$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
$\lambda = 4500$	+0,02;	—0,03;	+0,04
$\lambda = 5000$	+0,05;	+0,04;	+0,06
$\lambda = 6000$	—0,04;	—0,05;	—0,06
$\lambda = 6800$	—0,05;	—0,02;	+0,04

The average value of $|\log I - \log \bar{I}|$ is 0.2 over the whole region of the spectrum.

Survey of the observations 181—706. The variables, that essentially determine the illumination are the solar altitude and the degree of covering. We did not succeed in discovering any characteristic influences of the other data (type of clouds etc.).

Considering the total and the indirect illuminations at $\lambda = 5600$ and at different degrees of cloudiness we see that for degrees 9 and 10 the indirect illumination is greater than the total. At degree 8 this is the case for $\varphi < 25$. At $\varphi > 25$ the mean total illumination is the higher. It appears that the total illuminations in that region, is as high as the indirect on an average. At degrees 6 and 7 we have the same thing. In this case the majority of observations are indirect. There are a few high total values now. At degrees 4 and 5 the total illumination as a rule is higher than the indirect, a number of total values, however, being of the same magnitude as the indirect. At degree 3 this is an exception and for degrees 0 to 2 it practically never happens. For the degrees 0—5 the mean total illumination is considerably higher than the mean indirect illumination.

At the observations of the group indirect the light that came out of the direction of the sun has been screened. This could only be done when the

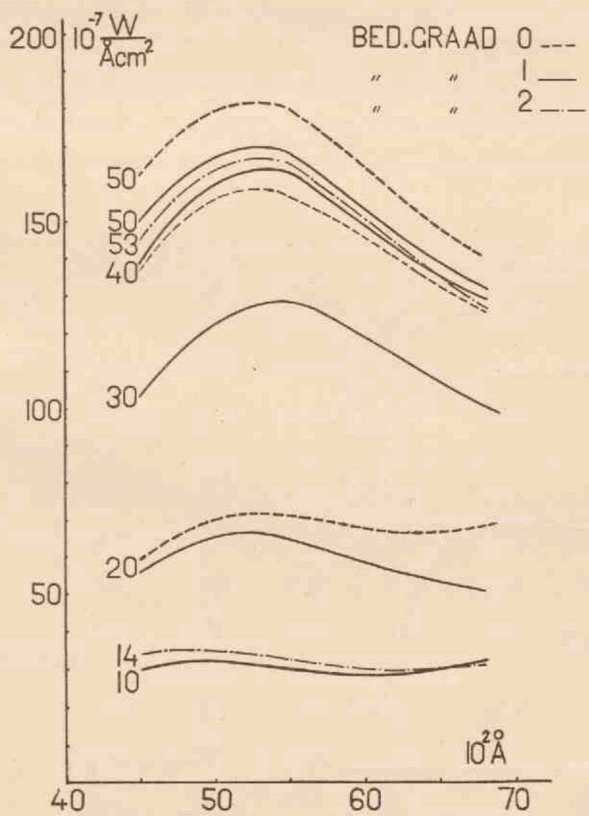

Fig. 5. Total illumination as a function of the wavelength for different solar altitudes at the degrees of covering 0, 1 and 2.

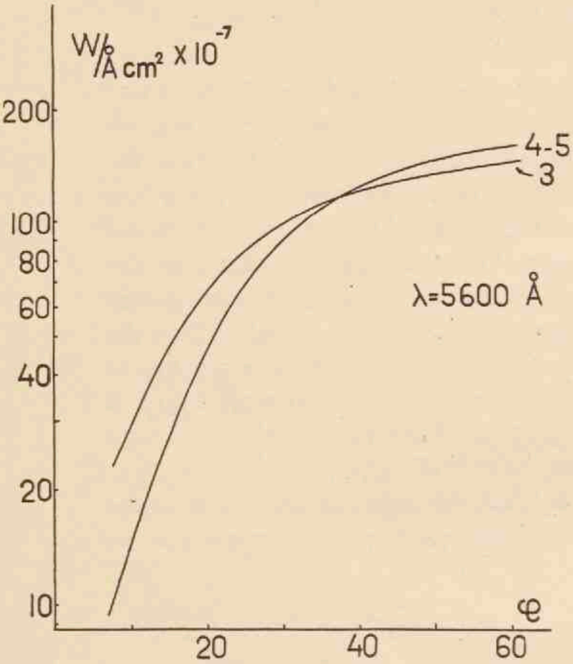

Fig. 6. Total illumination as a function of the solar altitude at $\lambda = 5600$ Å at different degrees of covering.

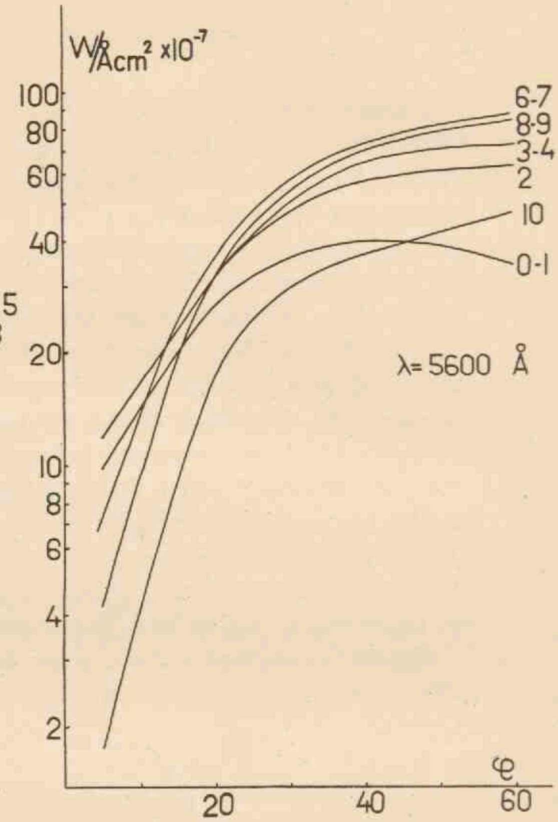

Fig. 7. Sky-illumination as a function of the solar altitude at $\lambda = 5600$ Å at different degrees of covering.

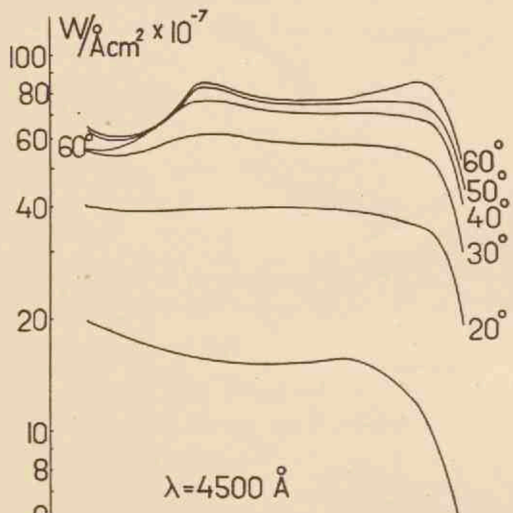

Fig. 7A. Sky-illumination as a function of the degree of covering at $\lambda = 4500$ Å at different solar altitudes.

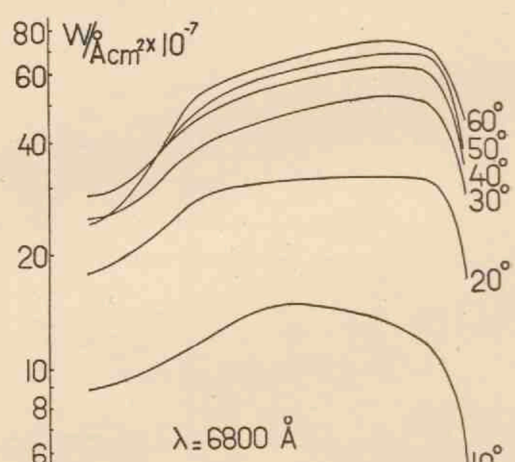

Fig. 7B. Sky-illumination as a function of the degree of covering at $\lambda = 6800$ Å at different solar altitudes.

position of the sun was visible. So at the degrees 9 and 10 those observations where the cover of clouds was thinnest and in consequence the illumination largest have been put in the group indirect. In all cases, total as well as indirect, the illumination is practically caused by scattered light only. When the sun appears for small intervals every now and then as a consequence of the rapid and important changes of the light it is not well possible to measure the total illumination at degrees 6 to 8. Most measurements at these degrees are indirect, small solar altitudes excepted ($\varphi < 25$) where the disturbances are less extensive. Some of the few total observations for higher solar altitudes are markedly higher than the mean value of the corresponding indirect illumination others are of the same order of magnitude. Here too the illumination by scattered light is most important. For the degrees 6—10 we shall not distinguish between total and indirect illumination but bring both in one group: sky-illumination. In constructing a graph of the sky-illumination we exclude the two large values of degree 6 at $\varphi \backsim 50°$. For solar altitudes below 25° it has no sense to distinguish between total and indirect here. For degrees of covering $\leqq 5$ the solar altitude below which total and indirect illumination are practically the same decreases. At degrees 2—5 we may take as a limit $\varphi = 10$. At degrees 0 and 1 it is necessary to distinguish between them down to $\varphi = 5$.

In this way we have constructed the graphs 6 and 7. Fig. 6 gives the

Sky-illumination.

Degree of covering:		0	1	3	5	7	9	10
$\varphi = 15°$	$\lambda = 4500$	+ 0,19	+ 0,14	+ 0,07	+ 0,04	+ 0,04	+ 0,04	+ 0,05
	$\lambda = 5000$	+ 0,10	+ 0,09	+ 0,07	+ 0,06	+ 0,06	+ 0,06	+ 0,06
	$\lambda = 6000$	— 0,05	— 0,05	— 0,05	— 0,05	— 0,05	— 0,05	— 0,05
	$\lambda = 6800$	— 0,18	— 0,13	— 0,05	— 0,02	0,00	+ 0,02	+ 0,04
$\varphi = 30°$	$\lambda = 4500$	+ 0,19	+ 0,14	+ 0,06	+ 0,02	0,00	0,00	0,00
	$\lambda = 5000$	+ 0,10	+ 0,09	+ 0,06	+ 0,04	+ 0,03	+ 0,03	+ 0,03
	$\lambda = 6000$	— 0,05	— 0,06	— 0,07	— 0,06	— 0,06	— 0,04	— 0,04
	$\lambda = 6800$	— 0,17	— 0,16	— 0,12	— 0,09	— 0,06	— 0,03	— 0,02
$\varphi = 50°$	$\lambda = 4500$	+ 0,19	+ 0,14	+ 0,06	0,00	— 0,03	— 0,01	+ 0,02
	$\lambda = 5000$	+ 0,10	+ 0,09	+ 0,06	+ 0,03	+ 0,01	+ 0,01	+ 0,01
	$\lambda = 6000$	— 0,05	— 0,06	— 0,07	— 0,07	— 0,05	— 0,03	— 0,02
	$\lambda = 6800$	— 0,17	— 0,16	— 0,15	— 0,11	— 0,08	— 0,06	— 0,05

Total illumination (in W/Åcm²).

Degree of covering		0 [1]	1 [1]	3	5
Solar altitude $\varphi = 10^\circ$	$\lambda = 4500$ Å	30×10^{-7}	30×10^{-7}	24×10^{-7}	15×10^{-7}
	5000	36	33	34	16
	5600	35	30	33	15
	6000	33	28	32	14
	6800	41	33	29	13
$\varphi = 20^\circ$	$\lambda = 4500$ Å	58	56	54	46
	5000	71	65	69	54
	5600	71	63	68	50
	6000	68	59	64	48
	6800	67	52	60	42
$\varphi = 30^\circ$	$\lambda = 4500$ Å	105	105	85	81
	5000	115	120	102	93
	5600	115	120	102	93
	6000	110	115	98	89
	6800	95	100	89	76
$\varphi = 40^\circ$	$\lambda = 4500$ Å	140	140	110	110
	5000	155	160	130	130
	5600	155	160	130	130
	6000	150	150	125	125
	6800	130	130	110	110
$\varphi = 50^\circ$	$\lambda = 4500$ Å	160	150	120	125
	5000	180	170	145	150
	5600	180	170	145	145
	6000	165	155	140	140
	6800	140	130	130	125
$\varphi = 60^\circ$	$\lambda = 4500$ Å	155	155	125	130
	5000	165	165	150	160
	5600	155	165	150	150
	6000	150	155	145	145
	6800	130	130	135	130

[1]) Obtained by parameter-method.

Sky-illumination (in W/Åcm²)

Degree of covering		0 [1]	1 [1]	3	5	7	9	10
Solar altitude $\varphi = 10°$	$\lambda = 4500$	20×10^{-7}	18×10^{-7}	16×10^{-7}	15×10^{-7}	16×10^{-7}	11×10^{-7}	4.9×10^{-7}
	5000	16	16	17	16	15.5	11	4.6
	5600	13	13	14	14	14	9.5	4 1
	6000	12	11	12	12	12.5	8.5	3.8
	6800	8.9	9.6	13	15	14	11	5.6
$\varphi = 20°$	$\lambda = 4500$	42	37	41	38	39	36	20
	5000	34	33	42	40	38	34	19
	5600	27	27	35	35	36	32	18
	6000	24	24	30	31	32	29	16
	6800	18	20	29	31	32	32	18
$\varphi = 30°$	$\lambda = 4500$	58	51	63	58	59	55	30
	5000	47	46	63	60	65	59	33
	5600	37	37	55	55	59	55	30
	6000	33	32	47	48	52	49	27
	6800	25	26	41	43	52	52	29
$\varphi = 40°$	$\lambda = 4500$	66	59	78	71	71	70	38
	5000	54	53	78	74	75	71	38
	5600	43	43	68	68	73	70	37
	6000	38	37	58	59	65	65	35
	6800	29	30	50	53	62	62	35
$\varphi = 50°$	$\lambda = 4500$	65	58	83	76	76	75	45
	5000	53	51	83	80	84	80	44
	5600	42	42	72	73	82	78	43
	6000	37	36	62	63	73	73	40
	6800	28	29	54	56	68	68	38
$\varphi = 60°$	$\lambda = 4500$	56 [2]	50 [2]	85	78	78	86	54
	5000	46	45	85	81	88	88	49
	5600	36	36	74	74	88	84	47
	6000	32	32	63	65	78	78	46
	6800	24	26	55	58	73	73	42

[1] Obtained by parameter-method.

[2] There is good reason for suspecting these values to be too low.

total illumination for degrees 3—5, fig. 7 gives the sky-illumination as a function of φ for different degrees of cloudiness at $\lambda = 5600$.

The intensities of other wavelengths generally have different values. For some wavelengths the deviations from the values at $\lambda = 5600$ have been collected in the tables on page 63 and in the following:

Total illumination:

Solar altitude φ	15°		30°		50°	
Degree of covering	3	5	3	5	3	5
$\lambda = 4500$	—0,12	—0,02	—0,08	—0,06	—0,08	—0,06
$\lambda = 5000$	+0,01	+0,04	0,00	0,00	0,00	+0,02
$\lambda = 6000$	—0,02	—0,02	—0,02	—0,02	—0,02	—0,02
$\lambda = 6800$	—0,05	—0,07	—0,06	—0,09	—0,05	—0,07

The logarithmical differences correspond to the following percentages of the mean value:

−0.20 = −37 %	−0,10 = −21 %	0,02 = 5 %	0,12 = 33 %
−0,18 = −34 %	−0,08 = −17 %	0,04 = 10 %	0,14 = 38 %
−0,16 = −31 %	−0,06 = −13 %	0,06 = 15 %	0,16 = 45 %
−0,14 = −28 %	−0,04 = − 9 %	0,08 = 20 %	0,18 = 52 %
−0,12 = −24 %	−0,02 = − 5 %	0,10 = 27 %	0,20 = 59 %

From these tables and from the graphs of fig. 5, 6 and 7 we find the tables on pages 64 and 65.

The value of $|\log I - \log \bar{I}|$ of the sky-illumination is about 0.06 and 0.08 at $\lambda = 4500$ and $\lambda = 6800$ respectively, at degree 3. At degree 8 its value becomes larger and at degree 10 it is about 0.15 and 0.17 at the wavelengths mentioned.

Finally we wish to know the intensity of the light that reaches us from the direction of the sun. The difference between total and indirect illumination at a certain instant is the direct illumination which may be considered equal to the illumination by the non-scattered and non-absorbed part of the light of the sun, if there is no cloud between the white measuring surface and the sun. For the computation of the direct illumination we can use those pairs of observations of which we may assume that they indicate the values of the illumination at the same moment. This condition is satisfied the more easily as the degrees of covering are smaller and the solar altitude greater. We take as solar altitude of the direct illumination found in this way that of the total illumination as it changes more than the indirect. The results are better surveyable if we consider the energy that falls per second on a unit surface perpendicular to the sunrays. We have to multiply the differences found by cosec φ. This procedure leads to the following tables:

Degree of covering 0

Solar altitude	10°	20°	30°	40°	50°	60° 1)
$\lambda = 4500$	38	73	106	128	139	139 $\times 10^{-7}$ W/Åcm^2.
$\lambda = 5000$	78	115	145	164	178	167
$\lambda = 5600$	98	139	167	178	182	180
$\lambda = 6000$	118	146	163	171	171	167
$\lambda = 6800$	115	139	164	156	150	139

Degree of covering 1

$\lambda = 4500$	14	49	79	111	125	125
$\lambda = 5000$	28	53	132	188	167	139
$\lambda = 5600$	42	98	153	208	167	153
$\lambda = 6000$	42	105	167	195	188	153
$\lambda = 6800$	42	84	153	174	146	125

Degree of covering 2—6

$\lambda = 4500$	28	49	63	72	79	84
$\lambda = 5000$	42	77	105	118	128	125
$\lambda = 5600$	56	98	125	139	146	139
$\lambda = 6000$	56	84	111	125	125	125
$\lambda = 6800$	56	84	111	111	111	111

The solar intensity generally decreases with an increasing degree of cloudiness. Between $\varphi = 30$ and $\varphi = 50$ the intensities at degree 1 practically all reach very high values. The same phenomenon takes place for degree o and the other degrees considered, only less markedly.

A cause of these facts may be:

a. that all measurements under consideration have been made in a certain interval of time where exceptional atmospheric conditions occurred. 7 of the 9 observations were made in March, 1 in April and 1 in May (highest value obtained). At the solar altitudes between $\varphi = 30$ and $\varphi = 50$ only one other measurement was made. This one gave an extremely small value ($\varphi = 36$);

b. that all measurements have been made in a certain interval of time where the standardizing of the pyrometer was not correct. In this case also other observations in the same time-interval should be extremely high. This is, however, not the case.

The above computations are based on data from the observations N°. 181—706. We shall now pass on to the treatment of the nos. 1—180, which can be done in a similar way. Since, however, the degrees of covering are not always given, we divide the observations in three groups — those obtained with heavily clouded, half clouded sky and with bright sun, the last group including those with faint sunshine. (In the following the values of log $\bar{I}(5600)$ refer to $\varphi = 10°$, 20°, 30°, 40° and 50°.)

1) The values at 60° are uncertain.

Total illumination.

Heavy clouds. Number of available observations 42. If we determine $\log \bar{I}(5600)$ as a function of λ, considerable fluctuations appear to exist. The approximate values on the average curve are $\log \bar{I}(5600) = 1.75$; 2.15; 2.32; 2.42; 2.45.

Deviations:		$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
	$\lambda = 4500$	+0,02;	+0,02;	—0,06
	$\lambda = 5000$	+0,01;	0,00;	—0,03
	$\lambda = 6000$	—0,05;	—0,04;	—0,03
	$\lambda = 6800$	—0,04;	—0,01;	+0,08

For the higher values of φ, this agrees approximately with the observations sub degrees of covering 9 and 10. For $\varphi = 15°$ the agreement is less satisfactory. The curve $\log \bar{I}(5600) = f(\varphi)$ nearly coincides with the one sub degree of covering 10 in fig. 6.

Semi-clouded sky. Number of available observations 18. The curves for $\varphi > 35°$ are smooth, the others show considerable fluctuations.

We found $\log \bar{I}(5600) =$ —; 2.34; 2.68; 3,00; 3.10.

Deviations:		$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
	$\lambda = 4500$	—0,09;	—0,03;	+0,06
	$\lambda = 5000$	+0,02;	+0,02;	+0,03
	$\lambda = 6000$	—0,06;	—0,05;	—0,05
	$\lambda = 6800$	—0,06;	—0,05;	—0,05

These values correspond approximately to those found sub degrees of covering 4 to 8; for the smaller φ's the agreement is closer for the higher degrees of covering and vice versa.

The same is true for the values of $\log \bar{I}$; for $\varphi = 50°$, it is higher than the corresponding previous measurements (lower, however, than the value found there for bright sun), while for $\varphi = 30°$ the curve shows a closer resemblance to those sub degree of covering 6 to 8.

Bright sunshine. Number of available observations 41, two extra observations for faint sunshine.

The curve $\log \bar{I}(5600) = f(\varphi)$ is easily drawn, as the positions of the various points are particularly favourable.

We found $\bar{I}(5600) = 2.00$; 2.64; 2.86; 2.95; 2.97.

Deviations:		$\varphi = 50°$	$\varphi = 30°$	$\varphi = 15°$
	$\lambda = 4500$	+0,01;	—0,05;	—0,03
	$\lambda = 5000$	0,00;	+0,03;	+0,04
	$\lambda = 6000$	—0,05;	—0,04;	—0,03
	$\lambda = 6800$	—0,05;	—0,03;	+0,07

These values do not agree with a definite degree of covering though to a certain extent the general behaviour can still be traced in them. Log $\bar{I}$ behaves more or less as sub degrees of covering 3, 4 and 5.

Owing to the less detailed grouping the dispersion in the observations Nos. 1 to 180 is greater than in the Nos. 181—706, discussed above.

Indirect illumination.

Heavy clouds. Number of available observations 17. The values of φ belonging to these observations varied between 25° and 50°.

We find for $\varphi = 30°$, 40°, 50° log $\bar{I}$ (5600) = 2.59; 2.68; 2.73.

And the deviations at the other wavelengths for $\varphi = 50°$ and 30° are:

	$\varphi = 50°$	$\varphi = 30°$
$\lambda = 4500$	+0,03;	+0,03
$\lambda = 5000$	+0,06;	+0,01
$\lambda = 6000$	—0,10;	—0,04
$\lambda = 6800$	—0,10;	—0,04

As regards log $\bar{I}$ as a function of φ this agrees very satisfactorily with that of the group under the degrees of covering 3—9. The deviations from the other wavelengths are also of the same order of magnitude.

Semi-clouded sky. Number of available observations 20. We find for $\varphi = 20°$, 30°, 40° and 50°, log $\bar{I}$ (5600) = 2.43; 2.58; 2.62; 2.64.

All these values lie in the same region. There is no convincing agreement with any of the curves of fig. 7. At the other wavelengths for $\varphi = 50°$ and 30° the deviations are:

	$\varphi = 50°$	$\varphi = 30°$
$\lambda = 4500$	+0,10;	+0,01
$\lambda = 5000$	+0,05;	+0,01
$\lambda = 6000$	—0,05;	—0,05
$\lambda = 6800$	—0,07;	—0,03

These observations show some agreement with those of degrees of covering 2—5.

Bright sunshine. Number of available observations 39, and 2 for faint sunshine. We find for $\varphi = 10°$; 20°; 30°; 40° and 50° log $\bar{I}$ (5600) = (2.00); 2.33; 2.47; 2.52; 2.54. The deviations at the other wavelengths appear to be practically independent of φ. We find for them: +0.05; +0.05; —0.09; —0.14 respectively.

These observations evidently correspond to degree of covering 0 to 2 of the observations N°. 181—706. The agreement is very convincing.

CHAPTER IV.

Statistics of the Lux numbers.

One can compute from the observations the amount of energy producing the horizontal illumination. We shall express this amount in *Lux* units. According to the definition of this unit the Lux number is found by first multiplying the power expressed in Watt per m^2 and per Å of the light of a certain wavelength incident on a horizontal surface, by the relative luminosity factor of the eye for that wavelength, by then integrating this product with respect to the wavelength and by finally dividing the integral by the mechanical equivalent of light (= 0.00164 W/IPC). The integral itself represents the number of light-Watt's. The lux number refers therefore to 1 m^2, whereas we measured the energy, incident on 1 cm^2 while it was, moreover, expressed in relative units, one unit equalling 1.39×10^{-8} W/Å.cm^2. We computed an approximate value for the integral by dividing the wavelength region from $\lambda = 6900$ Å to $\lambda = 4500$ Å into strips of 200 Å, and by treating the luminosity factor of the eye over the full width of a strip as a constant equal to the value at its centre. By this procedure the integral changes into a sum and we find for the Lux number

$$L = \frac{10^4}{0{,}00164} \int_0^\infty 1{,}39 \times 10^{-8} . r . o . d\lambda = \frac{1{,}39 \times 10}{1{,}64} \int_0^\infty r . o . d\lambda = 17{,}0 \; \Sigma \; r_\lambda \, o_\lambda .$$

Here r_λ denotes the number of relative units and o_λ the relative luminosity factor of the eye belonging to the strip in question.

We can make up the statistics of the Lux numbers as a function of the degree of covering and the solar altitude. The result is given in the tables on page 71. The values of $\overline{L}$ (in thousands of lux) are obtained by determining the logarithmical mean value of L for regions of solar altitudes covering 5°. The values refer to the illumination of the observations 181—706. The number of observations from which the mean was obtained, are added in brackets.

From the these tables it appears that for the indirect illumination L is equal to or larger than the total illumination at higher degrees of covering. We introduce the sky-illumination in the same way as has been done on page 63. For the values of L at degrees of covering $\geqq 7$ we don't distinguish between total and indirect. We find the curves of fig. 8 for the total and of fig. 9 for the sky-illumination. The dotted curves in fig. 8 represent the total illumination for the observations 1—180. This material was divided into three groups: bright sunshine, semi-clouded sky and

TOTAL ILLUMINATION

Degree of Cloudiness	φ between 0—5	5—10	10—15	15—20	20—25	25—30	30—35	35—40	40—45	45—50	50—55	55—63
0	—	—	25 (1)	34 (2)	49(5)	—	81(2)	85(3)	120(3)	—	115(2)	115(2)
1	—	—	22 (3)	31 (5)	29(2)	66(3)	76(5)	100(3)	81(1)	98(3)	110(5)	105(1)
2	—	6,3(2)	18 (4)	23 (3)	—	43(1)	—	—	—	93(2)	100(1)	110(2)
3	—	—	26 (2)	11 (1)	52(2)	66(1)	74(1)	—	100(2)	100(2)	—	—
4	—	6,2(1)	12 (2)	36 (3)	39(2)	68(3)	—	—	98(4)	34(1)	110(3)	110(1)
5	—	—	27 (1)	13 (2)	31(1)	—	—	30(1)	—	91(1)	71(2)	110(2)
6	—	—	9,3(1)	—	—	—	35(3)	—	—	98(1)	105(1)	—
7	—	7,9(4)	9,3(2)	18 (2)	—	38(1)	—	42(1)	—	—	43(1)	—
8	—	3,4(3)	10 (4)	14 (2)	30(4)	33(3)	44(1)	—	—	—	38(1)	—
9	—	2,0(2)	9,3(3)	14 (3)	10(3)	33(2)	43(1)	65(1)	40(3)	—	49(2)	41(2)
10	0,24(1)	1,5(8)	4,9(9)	5,8(11)	15(19)	18(11)	20(9)	28(7)	33(8)	43(4)	30(10)	36(6)

INDIRECT ILLUMINATION

Degree of Cloudiness	φ between 0—5	5—10	10—15	15—20	20—25	25—30	30—35	35—40	40—45	45—50	50—55	55—63
0	—	20 (1)	16 (1)	16(2)	17(4)	22(1)	22(2)	27(2)	28(5)	—	24(2)	26(2)
1	—	4,9(1)	13 (4)	15(3)	14(3)	25(3)	25(3)	29(4)	22(4)	22(2)	28(8)	30(1)
2	—	10 (3)	11 (3)	16(3)	30(1)	—	—	—	—	41(2)	34(1)	50(2)
3	—	4,3(4)	9,6(1)	20(2)	25(5)	41(1)	39(2)	—	49(2)	49(2)	—	—
4	6,0(1)	13 (1)	15 (2)	17(3)	22(3)	28(1)	37(1)	39(5)	40(4)	—	38(5)	—
5	—	—	12 (1)	14(1)	49(3)	31(1)	39(1)	53(2)	35(1)	54(1)	45(5)	50(2)
6	—	—	16 (3)	—	30(2)	24(1)	53(1)	—	45(2)	45(2)	50(2)	56(3)
7	—	3,3(1)	12 (1)	18(1)	30(1)	43(3)	40(2)	43(2)	51(3)	59(2)	54(5)	41(4)
8	—	5,5(1)	12 (3)	18(1)	25(3)	25(2)	28(1)	31(1)	—	41(4)	26(1)	60(2)
9	—	—	19 (2)	—	—	54(1)	35(4)	49(2)	52(1)	55(4)	48(2)	63(3)
10	—	1,7(1)	6,8(5)	17(1)	28(1)	26(1)	—	—	38(4)	31(5)	—	44(2)

heavy clouds. For $\varphi > 35°$ the curve "semi-clouded sky" proves to furnish higher L-values than the curve "bright sun". For the rest they agree with

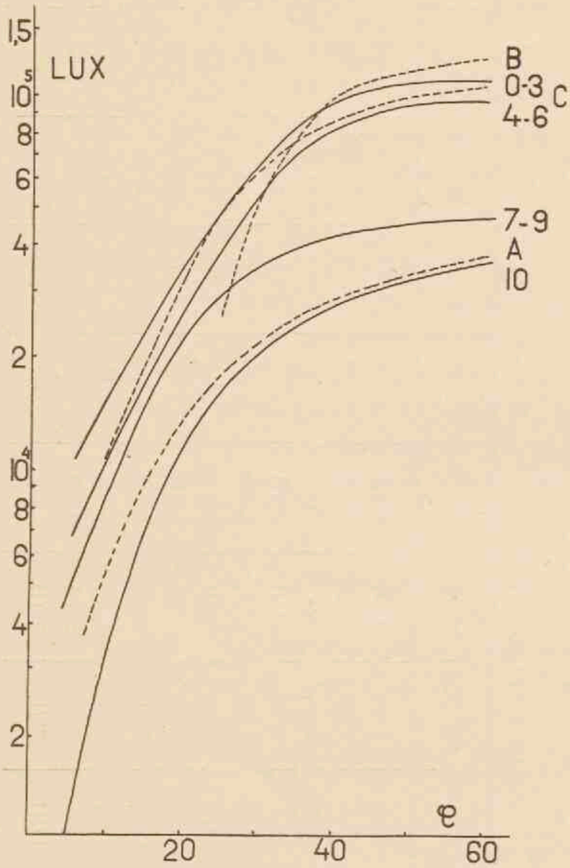

Fig. 8. Total illumination as a function of the solar altitude at different degrees of covering.

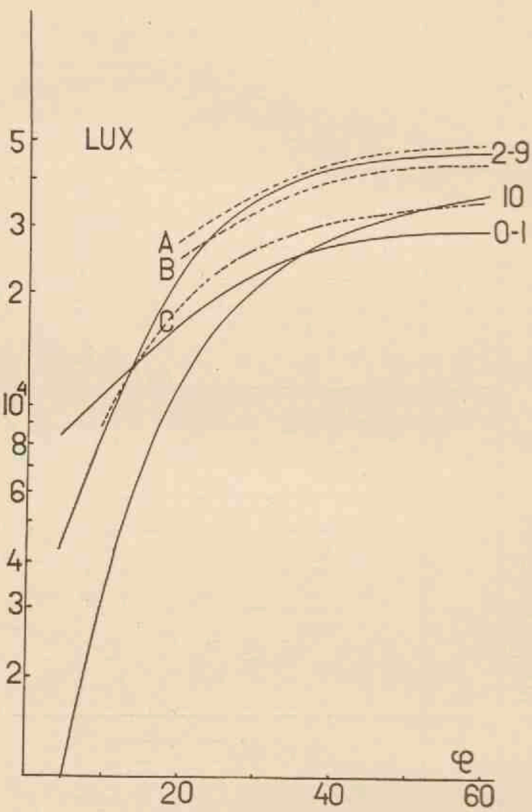

Fig. 9. Sky-illumination as a function of the solar altitude at different degrees of covering.

the curves for degree of covering 0—3 and 4—6. The curve "heavy clouds" lies between the curves for degree of covering 7—9 and 10.

The dotted curves of fig. 9 represent the indirect illumination for the observations 1—180. The curve "heavy clouds" coincides more or less with the one of degree of covering 5—9, the curve "slight clouds" follows the curve of degree of covering 2—4, while "bright sunshine" lies between the curves of the degrees of covering 0—1 and 2—4 [1]).

Finally, we have computed the probability of a certain value of L to occur at a certain moment. Since our measurements cover only about a year's time, our material alone was insufficient to construct statistics of the Lux number at a definite hour of a definite day. We have, therefore, determined these statistics with the aid of data furnished by the Royal

[1]) In figs. 8 and 9 A = heavily clouded; B = semi-clouded; C = bright sun.

Dutch Met. Inst. at De Bilt, concerning the cloudiness at 8, 10, 12, 14 and 18.30 o'clock (Amst. T. = Gr. M. T. + ∽ 20 min.). These were, among other things, registered daily for nearly 5 years at De Bilt (October 1930—July 1935). The frequency of the degrees of cloudiness 0, 1, 2—3, 4—6, 7—8, 9, 10 and of a group where the clouds were invisible (by fog, darkness or otherwise) at the hours mentioned in the various months is given in the table on page 74.

The mean value of the Lux number as a function of the solar altitude can be read out of the graphs of fig. 8 and 9 for different degrees of cloudiness. It proved suitable to take together the degrees of cloudiness in four groups for the total illumination: 0—3, 4—6, 7—9, 10 and in four groups for the sky-illumination: 0—1, 2—6, 7—9, 10. In order to compute the frequency of the deviations from the mean value we take together the observations at the solar altitudes $\varphi = 0 \rightarrow 5$; $5 \rightarrow 10$; etc. and consider the value of the lux number $\bar{L}$ (in fig. 8 and 9) in the middle of an altitude region as the mean value of the whole region. We put the deviations themselves into groups. Those values of L where $|\log L - \log \bar{L}| \leqq 0.10$ belong to one group. Other groups are formed to those values of L for which $0.10 < \log L - \log \bar{L} \leqq 0.30$ etc. As most curves are much steeper for $\varphi < 25°$ as for $\varphi > 25°$ we may expect that the deviations are greater in the former case. This happens to be the case, for we find:

Total illumination

Deviations:	+ 0,5 to + 0,3	+ 0,3 to + 0,1	0,1 to — 0,1	— 0,1 to — 0,3	— 0,3 to — 0,5	— 0,5 to — 0,7
Degree of covering						
0—3 ($\varphi > 25°$)		2	96	2		
($\varphi < 25°$)		25	50	25		
4—6 (φ all values)	7	20	46	20	7	
Sky-illumination						
0—1 (φ all values)		20	60	20		
2—6 ($\varphi > 25°$)		10	80	10		
2—6 ($\varphi < 25°$)		28	60	10	2	
7—9 ($\varphi > 25°$)		20	60	20		
7—9 ($\varphi < 25°$)	5	20	44	20	8	3
10 (φ all values)	9	26	30	26	6	3

When the frequency of degree of cloudiness b_i is f_1 (b_i) and the frequency of the illumination v_j at the degree b_i is $f_2(b_i, v_j)$, the frequency of the illumination v_j is $\sum_i f_1(b_i) \cdot f_2(b_i, v_j)$.

In our table the frequency of v_j is the percentage of the total number of lux numbers considered that is expected to occur between the given limits. In computing the mean value of L in a certain month at a certain hour we took the solar altitude at that hour at the middle of the month.

Frequency of degree of covering.

	8 h.								10 h.							
Degree of covering	0	1	2-3	4-6	7-8	9	10	inv.	0	1	2-3	4-6	7.8	9	10	inv.
January	3	11	4	8	7	11	48	8	9	7	1	8	5	15	41	14
February	2	11	10	7	7	17	39	7	4	12	8	13	9	14	36	4
March	13	16	12	15	6	15	19	4	16	17	10	15	9	17	14	2
April	4	6	7	8	15	24	35	1	3	7	5	17	17	23	28	0
May	6	8	7	16	20	15	26	2	4	10	6	17	20	18	24	1
June	7	9	8	12	13	23	28	0	1	14	9	13	18	20	25	0
July	3	12	7	12	22	22	22	0	3	14	10	19	8	27	19	0
August	6	12	9	14	21	19	18	1	4	14	7	22	10	23	20	0
September	11	9	16	11	13	17	19	4	8	12	12	21	12	15	18	2
October	3	8	10	10	14	26	27	2	3	8	8	17	17	21	25	1
November	2	5	13	7	6	20	43	4	3	7	8	12	10	16	39	5
December	2	11	6	14	2	6	51	8	6	9	4	10	6	18	39	8

	12 h.								14 h.							
January	7	12	3	7	10	15	40	6	8	5	7	8	8	16	41	7
February	2	10	10	11	12	23	29	3	2	11	10	16	8	19	33	1
March	12	18	8	12	19	19	12	0	15	15	7	12	15	20	16	0
April	2	3	7	23	17	23	25	0	3	4	5	17	24	23	24	0
May	2	10	9	19	13	20	27	0	1	11	11	15	20	19	23	0
June	1	11	10	17	20	20	21	0	1	11	11	19	18	24	16	0
July	4	5	11	17	19	20	24	0	3	7	4	23	20	20	23	0
August	2	8	6	27	23	20	14	0	2	11	11	20	22	20	14	0
September	4	12	5	31	13	15	20	0	4	14	6	32	10	20	14	0
October	1	9	8	11	18	21	31	1	1	7	11	20	16	20	24	1
November	2	2	8	15	8	24	37	4	1	4	7	13	12	25	35	3
December	5	11	6	6	7	23	36	6	5	7	8	7	12	12	43	6

	18½ h.									18½ h.							
Degree of covering	0	1	2-3	4-6	7-8	9	10	inv.	Degree of covering	0	1	2-3	4-6	7-8	9	10	inv.
Jan.	20	4	10	3	5	6	44	8	July	3	11	12	20	13	20	21	0
Febr.	6	14	15	5	4	12	41	3	August	4	19	11	22	19	17	8	0
March	10	22	16	9	12	8	23	0	Sept.	3	21	17	12	12	17	17	1
April	3	9	13	16	11	21	27	0	Oct.	3	13	20	13	10	11	29	1
May	5	12	15	22	11	18	17	0	Nov.	14	7	9	11	6	9	41	3
June	7	14	14	18	16	16	15	0	Dec.	20	4	6	5	4	5	47	9

The following tables give the results of this computation for the total- and the sky-illumination resp.

Month	Time	Probability (in $^0/_0$) of the occurrence of an illumination by sky + sun between:																Logarithmical mean
		85—135 lux	135—215 lux	215—340 lux	340—540 lux	540—850 lux	850—1350 lux	1350—2150 lux	2150—3400 lux	3400—5400 lux	5400—8500 lux	8500—13500 lux	13500—21500 lux	21500—34000 lux	34000—54000 lux	54000—85000 lux	85000—135000 lux	
January	8	2	3	14	16	15	5	7	13	10	10	5						1150 lux
	10						1	3	13	16	19	19	17	10	2			7900 „
	12								1	5	13	19	27	20	12	3		16000 „
	14						1	3	13	16	18	19	17	10	3			8100 „
February	8				1	4	10	14	13	9	17	17	12	3				4400 „
	10								1	2	12	14	17	24	22	8		21000 „
	12									1	2	8	14	27	30	15	3	31000 „
	14								1	2	11	13	17	27	21	8		21000 „
March	8							1	1	7	9	14	22	39	6	1		16000 „
	10										1	4	5	11	22	55	2	48000 „
	12											1	3	12	28	15	41	60000 „
	14									1	1	4	5	13	26	47	3	45000 „
April	8									1	2	9	19	36	21	10	2	27000 „
	10										1	2	7	17	34	18	21	46000 „
	12										1	2	6	16	32	16	27	49000 „
	14										1	2	6	17	37	17	20	46000 „
	18½		1	2	7	11	10	9	17	20	16	7						2300 „
May	8										1	4	7	15	31	37	5	43000 „
	10											1	4	15	32	17	31	55000 „
	12											1	4	14	29	18	34	56000 „
	14											1	4	14	31	17	33	56000 „
	18½						1	7	7	11	18	24	22	10				8500 „
June	8										1	2	7	17	33	25	15	46000 „
	10											1	4	14	31	17	33	56000 „
	12											1	3	14	31	17	34	56000 „
	14											1	3	13	31	17	35	58000 „
	18½							1	6	7	11	20	31	20	3	1		12500 „
July	8										1	1	6	16	36	25	15	47000 „
	10											1	3	12	28	17	39	60000 „
	12											1	4	15	32	17	31	55000 „
	14											1	4	15	32	18	30	54000 „
	18½					1	1	7	9	11	15	25	20	10	1			8100 „
August	8									1	1	5	14	30	15	31	3	35000 „
	10										1	1	6	13	27	15	37	55000 „
	12											1	2	13	32	18	34	58000 „
	14											1	4	13	31	15	36	58000 „
	18½				1	2	5	5	9	20	25	23	10					5500 „
September	8								1	2	8	11	17	25	26	10		23000 „
	10										1	1	5	13	26	47	7	49000 „
	12										1	1	5	13	26	18	36	55000 „
	14											1	4	13	30	40	12	51000 „
October	8					1	2	9	12	13	16	23	17	7				6800 „
	10									1	5	9	16	28	32	9		26000 „
	12									1	2	8	10	18	31	30		35000 „
	14									1	4	9	16	27	33	10		27500 „
November	8			1	3	5	17	15	11	23	18	7						2700 „
	10							1	2	13	15	18	23	20	8			12500 „
	12								1	2	13	15	18	23	23	5		20000 „
	14							1	2	12	14	19	26	20	6			12500 „
December	10					1	2	8	14	17	17	19	16	6				6300 „
	12							1	4	13	16	22	21	16	7			11500 „
	14					1	2	8	15	17	17	18	16	6				6300 „

Month	Time	Probability (in $^0/_0$) of the occurrence of a sky-illumination between:																Logarith-mical mean
		85—135 lux	135—215 lux	215—340 lux	340—540 lux	540—850 lux	850—1350 lux	1350—2150 lux	2150—3400 lux	3400—5400 lux	5400—8500 lux	8500—13500 lux	13500—21500 lux	21500—34000 lux	34000—54000 lux	54000—85000 lux	85000—135000 lux	
January	8	2	3	14	15	15	5	7	16	10	10	3						1150 lux
	10						1	3	13	15	22	32	14					6900 „
	12								1	5	13	23	41	15	2			13500 „
	14						1	3	13	15	21	32	14	1				7100 „
February	8					3	11	15	13	10	26	18	4					3800 „
	10								1	2	11	17	27	29	12	1		17500 „
	12									1	2	10	21	34	27	5		25000 „
	14								1	2	11	15	24	33	13	1		18000 „
March	8							1	1	7	11	24	39	16	16	1		13000 „
	10										1	7	18	25	41	8		30000 „
	12											1	9	32	48	10		35000 „
	14									1	1	7	17	25	40	9		30000 „
April	8									1	2	11	26	47	12	1		22000 „
	10										1	2	9	25	50	13		36000 „
	12										1	2	8	21	55	13		36000 „
	14										1	1	8	23	53	14		37000 „
	$18^1/_2$		1	2	7	11	10	11	32	17	7	2						1950 „
May	8										1	6	13	22	47	11		33000 „
	10											1	7	25	52	14	1	38000 „
	12											1	7	24	52	14	2	38000 „
	14											1	6	24	54	14	1	38000 „
	$18^1/_2$					1	1	7	8	14	38	26	5					6000 „
June	8										1	2	10	27	48	12		35000 „
	10											1	7	26	51	14	1	38000 „
	12											1	6	24	54	14	1	38000 „
	14											1	5	23	56	14	1	39000 „
	$18^1/_2$							1	6	8	17	47	20	1				9100 „
July	8										1	1	9	26	50	13		35000 „
	10											1	6	26	53	13	1	38000 „
	12											1	6	24	54	14	1	38000 „
	14											1	6	23	54	15	1	39000 „
	$18^1/_2$					1	1	7	9	12	25	33	11	1				6800 „
August	8									1	1	7	23	54	14			23500 „
	10										1	1	9	26	52	11		35500 „
	12											1	4	22	58	15		39000 „
	14											1	6	24	56	13		38000 „
	$18^1/_2$				1	2	5	6	11	37	25	11	2					4300 „
September	8								1	2	8	16	37	27	8	1		17500 „
	10										1	1	9	26	52	11		35000 „
	12										1	1	8	25	54	11		36000 „
	14										1	1	7	25	55	11		36000 „
October	8					1	2	10	13	15	18	30	10	1				5900 „
	10									1	5	12	24	40	16	2		22000 „
	12									1	2	9	13	22	42	11		30000 „
	14									1	4	11	23	42	17	2		22000 „
November	8			1	3	5	17	15	11	29	16	3						2600 „
	10							1	2	13	16	22	31	14	1			11000 „
	12								1	2	13	16	22	31	14	1		18000 „
	14							1	2	12	14	20	32	17	2			12000 „
December	10					1	2	8	14	16	23	26	9	1				5800 „
	12							1	4	13	17	31	25	8	1			10500 „
	14					1	2	8	15	17	23	24	9	1				5600 „

The means for the various months obtained from our own material have been compared in the following table with the values derived from the two probability-tables of pages 75 and 76, which are added in brackets. All values have been given in thousands of Lux. The results calculated in this way are in good accordance with those from our probability method.

Time	9 *)	10	12	14	15 *)	16 *)
Total illumination						
in Aug. 1932	89(45)	91 (55)	110(58)	68 (58)	—	40 (35)
Sept.	32(35)	42 (49)	39(55)	50 (51)	40 (40)	18 (25)
Oct.	—	16 (26)	24(35)	19 (27^{5})	—	6,3(7)
Nov.	—	16 (12^{5})	17(20)	9,8(12^{5})	4,2(8)	—
Dec.	—	11^{5}(6,3)	18(11^{5})	6,8(6,3)	2,0(—)	—
Jan. 1933	—	16 (7,9)	27(16)	9,6(8,1)	4,3(4)	—
Febr.	—	32 (21)	44(31)	34 (21)	4,1(15)	13 (5)
March	—	49 (48)	62(60)	41 (45)	—	19 (15)
April	—	44 (46)	42(49)	37 (46)	—	25 (27)
May	78(50)	65 (55)	51(56)	52 (56)	—	17 (45)
June	56(50)	54 (56)	44(56)	69 (58)	—	62 (45)
Sky-illumination						
in Aug. 1932	34(30)	38 (35,5)	43(39)	36 (38)	—	28 (25)
Sept.	29(25)	34 (35)	29(36)	26 (36)	21 (25)	20 (20)
Oct.	—	25 (22)	32(30)	23 (22)	—	7,1 (6)
Nov.	—	16 (11)	16(18)	9,8(12)	4,8(7)	—
Dec.	—	16 (5,8)	16(10^{5})	7,6(5,6)	4,1(—)	—
Jan. 1933	—	5,1(6,9)	19(13^{5})	6,6(7,1)	1,7(4)	—
Febr.	—	31 (17^{5})	31(25)	28 (18)	—	15 (4)
March	—	29 (30)	32(35)	29 (30)	—	17 (13)
April	—	38 (36)	46(36)	48 (37)	—	31 (22
May	40(36)	43 (38)	41(38)	42 (38)	47 (36)	39 (33)
June	38(37)	36 (38)	55(38)	35 (39)	—	30 (35)

*) The data in brackets at 9, 15 and 16 o'clock are obtained by intra- or extrapolation.

The result of this investigation can be summarised as follows. The illumination is variable with respect to the intensities themselves at the various wavelengths separately, as well as with respect to the ratios between these intensities. In their general features these changes are determined by the solar altitude and the degree of covering. For given values of these two factors the intensities deviate on both sides of a certain mean value. These deviations increase with increasing cloudiness. Expressed in percentages of the mean value they are nearly equal for each degree of covering over the whole region of the solar altitudes, that concerns us.

Total illumination. When there is no, or only a slight cloudiness, the illumination is with rather high precision determined by the solar altitude. In this case the absolute values as well as the mutual ratios of the intensities at various wavelengths show only small deviations from their mean values. The maximum intensity occurs in the region from $\lambda = 5000$ Å to $\lambda = 5600$ Å. With increasing cloudiness the fluctuations in the intensities become more and more pronounced as is also the case with the fluctuations in their mutual ratios, to such an extent even that we can no longer speak very well of a definite characteristic illumination belonging to definite values of the solar altitude and the degree of covering. We assign, therefore, the mean value of the intensity of a certain number of wavelengths without paying attention to any correlation between these intensities.

In general, the fluctuations are somewhat smaller for the shorter than for the longer wavelengths, while, as regards the division of the observations in groups according to the wavelength of the maximum value of *I*, those observations that possess the smaller intensities relatively to the mean intensity show a certain preference for that group, for which λ_m is small ($\lambda_m = 4500$ to 4800 Å).

For greater solar altitudes and complete covering, λ_m shifts towards values somewhere between 5000 Å and 5800 Å; for smaller altitudes, more towards 4500 Å to 4800 Å; in the latter case the intensities of the red wavelengths are relatively strong.

Indirect illumination. Here the behaviour of the fluctuations with respect to the mean value is chiefly the same as in the case of total illumination; they increase also with increasing cloudiness. They are, however, smaller (except for total covering) than the corresponding fluctuations of total illumination.

When there is a cloudless- or very slightly clouded sky, the fluctuations round a certain mean value are relatively small as are also the fluctuations of their mutual ratios. These ratios are fairly constant and practically independent of the solar altitude. For higher values ($> 40°$) of the latter the intensity of all wavelengths shows a tendency to decrease. When the degree of covering exceeds 2/10 we must confine ourselves again to the determination of a mean value for each wavelength separately. With increasing cloudiness, the indirect illumination increases until the sky is almost completely covered; with a completely clouded sky the illumination is again smaller. For high degrees of covering, the indirect illumination approaches the total illumination, and for complete covering it becomes in many cases identical with the latter. With low positions of the sun, and a clouded sky, the intensities in the red part of the spectrum become relatively stronger. The maximum of the intensities moves towards the shorter wavelengths as the intensities over the whole range of the spectrum decrease. The fluctuations of the intensities in the red part of the spectrum are somewhat greater than those in the blue-violet part, particularly when the sky is half-covered.

The observations, discussed above, cover only a short period. Yet, in our opininon, the conclusion is justified that the above summary (pages 64, 65, 67, 75, 76 and figs. 5—9) of the final results can be used to advantage as information for our country, concerning daylight-illumination, for architectural computations. It would be very profitable to carry out similar observations for longer periods at a stretch; apart from their bearing on technical and architectural problems, they would certainly be of value for meteorology itself as well.

CHAPTER V.

Application of the obtained results to the scattering of light in the atmosphere.

The atmosphere influences the illumination chiefly by the processes of scattering and absorption. Both phenomena depend on the nature and the number of the particles that build up the atmosphere. From our material we shall derive a few data concerning some quantities that are of interest in this connection.

Scattering and absorption with a clear sky. In the preceding chapters we distinguished between total- and indirect illumination. Subtraction of the latter from the former gives the direct illumination. With a clear sky this difference consists chiefly of the non-scattered and non-absorbed part of the energy entering the atmosphere in the direction of the observed surface. It contains, besides, a small amount of light, which after having been scattered a few times, strikes the surface in the direction from the sun. We determined the direct illumination from pairs of observations, one immediately after the other, and referring to the total- and indirect illumination respectively. As the screen, which served to intercept the direct radiation of the sun, cuts off also the radiation from the immediate vicinity of the sun, [the brightness of that side of the screen which is turned to the white surface is only a small fraction of that of the screened part of the sky] the values found by the contrivance are somewhat higher than the true values of the non-disturbed energy. The error so introduced, can, however, never assume an appreciable value since the brightness of the sun is a great many times the brightness of the sky. According to KING[1], for example, the fraction $\frac{\text{tot. energy sky}}{\text{tot. energy sun}}$ is 125×10^{-8} for equal solid angles and for zenith position of the sun. Though for small solar altitudes this amount will be much higher, we may safely neglect the error in question. It will be convenient to introduce in our computations the energy, flowing per second across the unit of area, at right angles to the light path. This energy is found by multiplying the difference between the total- and the indirect illumination by cosec φ (φ solar altitude).

Let $I(\lambda)\, d\lambda$ be the part of the flow of energy between λ and $\lambda + d\lambda$ and $I_0(\lambda)\, d\lambda$ the corresponding energy entering the atmosphere.

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[1]) L. V. KING, Phil. Transact. Roy. Soc. London, A. 212, 415, 1913.

We have then:

$$I(\lambda) = I_0(\lambda)\, e^{-\int (s+\varkappa)\, dl} \quad \ldots \ldots \ldots \ (1)$$

Here s and $\varkappa$ denote the coefficients of scattering and absorption respectively. Generally speaking $\int (s+\varkappa)\, dl$ will be a function of λ. On the assumption, that the dimensions of the particles scattering the light in the medium are small, compared with the wavelength of the light travelling through it, RAYLEIGH derived the following expression for s:

$$s = \frac{32\,\pi^3 (\mu - 1)^2}{3\,\lambda^4\, n}$$

μ denotes the refractive index of the medium, λ the wavelength in cm and n the number of particles per cm^3; s refers then to a length of the lightpath equal to 1 cm. μ is a function of λ. For air of normal composition $\frac{\mu-1}{\varrho}$ has a constant value for each wavelength, ϱ representing the density of the air. For the wavelength $\lambda = 6800$ Å, the value of $\frac{\mu-1}{\varrho}$ is 0.2246 and for $\lambda = 4500$ Å it is 0.2281. We shall take it to have the value 0.226 throughout our range of wavelengths. We have, further, for air of 0° C and 760 mm Hg. pressure $\varrho = 0.001293$ g/cm^3. According to RUTHERFORD and GEIGER, the number of molecules per cm^3 in air under these conditions is $n = 2.72 \,.\, 10^{19}$. If λ is expressed in Å, RAYLEIGH's formula gives with these values $s = 8.03 \times 10^{10} \frac{\varrho}{\lambda^4} (cm^{-1})$. The integral $\int_0^\infty s\, dl$ is proportional to $\int_0^\infty \varrho\, dl$ where $l = 0$ and $l = \infty$ refer to the observed surface and the sun respectively. This integral is a function of the solar altitude. For $\varphi > 30°$, it is approximately proportional to $\frac{1}{\sin \varphi}$. For $\varphi < 30°$ the curvature of the earth's surface makes itself felt. BEMPORAD gives for the ratio between this integral and the corresponding one along the vertical the following values. The values of cosec φ are added for comparison.

TABLE I. [1])

Solar altitude φ	90°	70°	50°	30°	20°	15°	10°	5°	2°
Cosec φ	1,000	1,064	1,305	2,000	2,924	3,864	5,76	11,47	28,7
$f(\varphi)$ (BEMPORAD)	1,000	—	—	1,995	2,904	—	5,60	10,39	19,8

Let us assume that ϱ along the vertical can be represented by $\varrho = \varrho_0\, e^{-bh}$,

[1]) These data are taken from N. SHAW. Manual of Meteorology Vol. III (1930).

where $b = 0.118 \times 10^{-5}$ cm^{-1} (which answers approximately the behaviour of ϱ in the lower layers of the air), we shall have then $\int_0^\infty \varrho\, dl = \frac{\varrho_0}{b} = \frac{\varrho_0}{0{,}118 \times 10^{-5}}$. ϱ_0 is the density at sealevel. On substituting for ϱ_0 the value 0.001293 g/cm^3, we find finally $\int_0^\infty s dl = \frac{8{,}8 \times 10^{13}}{\lambda^4} f(\varphi)$.

As for $\varkappa$ its value is fairly low with a cloudless sky. $\varkappa$ will also be dependent on the wavelength. Water and water-vapour, for example, present in the atmosphere will absorb a certain amount of energy. Ozon has a region of absorption between $\lambda = 5300$ Å and 5900 Å [1]).

Apart from the actual gas molecules other particles are to be found in the atmosphere. In a cloud, for example, particles occur having diameters of about 10 μ. Particles of dust occur with dimensions 0.3 μ to 1.7 μ (measured with the dustcounter of OWEN). Further, there are clusters of molecules measuring up to 0.2 μ. PERNTNER estimates the particles of volcanic dust at 1.85 μ. A few years after serious volcanic eruptions there are still fairly large quantities of these particles pervading the atmosphere. Particles larger than 10 μ behave like reflecting bodies. The scattering is then no longer selective. The limit between selective and non-selective scattering of the visible light lies somewhere between 10 μ and 0.5 μ. For very small particles the scattering is proportional to λ^{-4}, for larger ones to λ^0. Moderately small particles will therefore presumably give rise to scattering, proportional to a power of λ between 0 and —4 [2]).

In order to be able to determine the weakening of the sunlight on its way through the atmosphere, we must know I_0 (λ). MULDERS [3]) gives the energy radiated by 1 cm^2 of the sun's surface per second and per unit of solid angle, expressed in erg's for $d\lambda = 1$ cm. The mean distance of the earth from the sun is $A = 15 \times 10^7$ km. and the radius of the sun $R = 6.955 \times 10^5$ km [4]). For mean distance of the sun I_0 (λ) expressed in W/cm^2 Å becomes $\bar{I}_0 (\lambda) = \pi \frac{R^2}{A^2} \cdot 10^{-15} = 6.77 \times 10^{-20}$ *the number of Mulders units.* Expressed in our relative units (see Chapter II) $\bar{I}_0$ (λ) is 4.87×10^{-12} *Mulders units.* We obtain then in relative units the following values:

TABLE II.

λ:	4500	4600	4700	4800	4900	5000	5200	5400	5600	5800	6000	6200	6400	6600	6800
$\bar{I}_0 (\lambda)$:	1950	1940	1900	1960	1780	1840	1705	1720	1690	1655	1570	1495	1460	1360	1300

[1]) Handbuch der Astrophysik, Bd. IV, p. 31 (1929).

[2]) See also SHAW, Man. of Meteor. According to some authors the exponent of λ may vary from 1 to —4.

[3]) MULDERS, Diss. Utrecht, p. 67 (1934).

[4]) Handbuch der Astrophysik IV, p. 60.

For our computations we assume further, that we can write

$$I_0(\lambda) = \bar{I}_0(\lambda)\left(1 + \frac{4.5}{135}\cos\frac{t}{T}\,2\pi\right)$$

where $\bar{I}_0(\lambda)$ is given in table II t denotes the time, elapsed since the earth passed the perihelium (2 Jan.), T is the interval of one year. The numbers 135 and 4.5 are the mean value of the solar constant (in $kW/(10\ m)^2$) and the maximum deviation from that value respectively. From our material we derived in 18 cases the direct illumination and plotted $\log I_0(\lambda)$ — $\log I(\lambda)$ against $\left(\frac{6800}{\lambda}\right)^4$. If only RAYLEIGH-scattering occurred, the points so obtained would lie on straight lines through the origin, and the slope of these lines would be a measure for s. In 12 cases (group I) it proved indeed feasible to construct such a straight line. In 5 other cases (group II) the points in the region from $\lambda = 4500$ Å to $\lambda = 5000$ Å fitted fairly well

TABLE III.

	Group I	Group II	Potsdam 100 m	Washington 10 m	Mt. Wilson 1780 m	Mt. Whitney 4420 m
7000	—	—	—	0,176	0,060	0,045
6800	0,078	0,176	0,127	—	—	—
6600	0,093	0,201	0,138	—	—	—
6400	0,134	0,225	0,150	—	—	—
6200	0,116	0,213	0,162	—	—	—
6000	0,147	0,235	0,174	0,274	0,117	0,068
5800	0,146	0,240	0,186	—	—	—
5600	0,154	0,257	0,200	—	—	—
5500	—	—	—	0,302	0,132	0,087
5400	0,210	0,282	0,213	—	—	—
5200	0,205	0,266	0,229	—	—	—
5000	0,234	0,338	0,247	0,350	0,153	0,105
4900	0,272	0,393	—	—	—	—
4800	0,372	0,441	0,269	—	—	—
4700	0,372	0,435	—	0,399	0,190	0,128
4600	0,405	0,461	0,301	—	—	—
4500	0,438	0,542	—	0,446	0,223	0,161

in a straight line through the origin — for longer wavelengths, however, $\log I_0(\lambda)$ — $\log I(\lambda)$ proved greater than the ordinates of the corresponding points on the straight line. In one case, finally, the deviations were such, that we rejected it. KING [1]) finds from values obtained in the observatories of Washington and Potsdam, that the lines show a sudden deflection at $\lambda = 6100$. No trace of this appeared in our results. Besides, he found from the material of Washington, Potsdam, Mt. Wilson and Mt. Whitney each time a small constant factor. Our method is not accurate enough, either to conform or to contradict its existence. According to KING this factor must be due to absorption, but cannot cause a considerably deviation. There appeared, though, to occur a systematic deviation in the region $\lambda = 5200$ to $\lambda = 5000$. In that part of the spectrum the scattering was evidently less than in the neighbouring parts. It may be, that the radiation of the sun is stronger there than we assumed it to be, or it is perhaps due to an error of measuring, or, again, it may be connected with the ozon-absorption in the region next to it. For a comparison between the values of $\int (s + \varkappa) dl$, found from our material and those obtained from observations at Potsdam, Washington, Mt. Wilson and Mt. Witney all values are reduced to zenith position of the sun by dividing them by the corresponding values of $f(\varphi)$. We give here the average values of groups I and II separately and uncorrected. (Table III.)

The values of group II agree more or less with those of Washington. For $\lambda > 5000$ Å the values of group I are somewhat lower than those of Potsdam. Group II appears to yield for all wavelengths higher values than group I. The scattering particles of the former group are evidently larger than of the latter; to group II belongs, therefore, the greater coefficient of scattering, especially towards the longer wavelengths. Presumably the absorption increases also towards the red. The results of group I can be approximately represented by $s = 0.084 \times \left(\frac{6800}{\lambda}\right)^4 \cdot f(\varphi) = \frac{18 \times 10^{13}}{\lambda^4} f(\varphi)$. This amounts to more than twice the theoretical value. On examining the ratio between the measured and the theoretical value it appears generally speaking, to have higher values in summer than in

TABLE IV.

φ	11	15	20	20	20	21	23	30	30	36	35	37	42	43	52	53	58	58
month	II	III	III	I	I	II	II	III	III	III	III	III	V	VI	V	V	V	VI
ratio	1,6	1,9	2,0	1,7*)	3,0*)	1,7	2,0*)	2,0	1,6	2,5*)	3,1	1,6**)	1,9	1,2	2,2	2,4	2,9	3,3*)

*) group II, inclination determined for $\lambda < 5200$,
**) deviating shape.

winter. Those values that are higher in winter belong mostly to group II. The results of the computation are given in table IV.

[1]) KING, l.c. p. 425.

The brightness of the sky is a consequence of scattering. According to RAYLEIGH's theory, the light, incident on a scattering particle, is not distributed equally over all directions, not even when the particle is a sphere. In reality the particles are not spherical. Owing to their chance orientation, however, an element of volume of a scattering medium will behave in the same way for any angle of incidence. KING [1]), to whom we owe a detailed discussion of the problem of the scattering in the atmosphere, does not introduce this complication but assumes that each particle scatters the incident energy evenly over all directions. He derives an integral equation and gives an approximate solution of it. In order to solve the equation, the coefficient of scattering in each point of the space considered, further the intensity and direction of the incident radiation and the optical properties of the boundary surfaces must be known. For simplicity, KING substitutes for the atmosphere a place layer of air between the (flat) earth and universal space, out of which parallel radiation enters the layer. The earth is assumed to be perfectly absorbing. He proves then, that the condition at the surface of the earth does not depend on the density distribution of the atmosphere, provided the latter is a function of the height only. If we wish to take into account the curvature of the earth, this holds no longer. The solution of the integral-equation becomes the least complicated if one assumes the atmosphere to be a flat layer of constant density. Without entering into the details of this solution we can account more or less for a few of the phenomena we have met with. We imagine a space in which scattering takes place and fix our attention on dv one of its elements of volume. Let the coefficient of scattering be s. In a direction at an angle θ with that of the incident radiation of intensity E the energy scattered by dv within an elementary solid angle $d\omega$ is given by $E \, . \, dv \, . \, s \, . \, \mu(\theta) \, . \, d\omega$; $\mu(\theta)$ is a function of θ only. $\int \mu(\theta) \, d\omega$ over all directions from dv is equal to 1. The state in dv will lie between the following extremes; the energy reaching dv arrives a) from one direction and b) evenly from all directions. In case a) the amount of scattered energy leaving the element in the direction θ relatively to the direction of incidence, is $E \, . \, s \, . \, \mu(\theta) \, . \, d\omega \, dv$. If $I(\lambda)$ denotes the intensity at the wavelength λ, then the amount of energy between λ and $\lambda + d\lambda$ will be $I(\lambda) \, . \, s \, . \, \mu(\theta) \, . \, d\omega \, . \, dv \, . \, d\lambda$ which is proportional to s. In case b) if the energy entering dv from the solid angle $d\omega$ is $I_1(\lambda) \, d\lambda \, d\omega$ (the total amount entering dv is consequently $4\pi I_1 \, d\lambda$), the energy leaving dv within the solid angle $d\omega'$ will be $I_1 \, d\omega'$ and the total amount leaving the element will be again $4\pi I_1 \, d\lambda$. This means that the energy radiated in some given direction is independent of s, or, in other words that s has no influence on the distribution of the light.

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1) KING, l.c.; SPIJKERBOER, diss. Utrecht (1917).

Let us suppose that, according as the element dv lies further in the interior of the scattering space, the state in the element will resemble more closely state b). In the deeper layers, therefore, the coefficient of scattering is supposed to have less influence on the distribution of the light. What is to be understood by "deep" in this connection, depends on s and the actual localisation of the element considered. For example, for light of a wavelength λ_1 for which s is large, there may exist at one and the same spot a state, that is very much like state b) whereas for light of a wavelength λ_2 for which s is small, a state may prevail much more like state a). If we consider a second spot, further away from the boundary, its state as far as wavelength λ_1 is concerned will be practically the same, but, as regards wavelength λ_2, it will differ widely from the state in the first spot in that it is now much more like state b). Let us fix the boundaries at the planes $x = o$ and $x = t$, it then appears from the integral equation that for an element in a layer at the distribution of the light will be a function of st and sx. If, therefore, t is chosen sufficiently large and if our supposition concerning the gradual approach to state b) in the interior is true, the distribution of the light of wavelength λ_1 in the layer at $\frac{a}{s_1}$ will be the same as of the light of wavelength λ_2 in the layer at $\frac{a}{s_2}$. If in the neighbourhood of $x = t/2$ the state b) prevails for all wavelengths, the spectral energy distribution in that neighbourhood will be the same as in the incident light. We have already seen that with a clear sky the energy distribution over the range from $\lambda = 6800$ Å to $\lambda = 5000$ Å was approximately proportional to λ^{-2}. For shorter wavelengths, the intensities fall frequently below the values corresponding to this distribution. The variations from deep-blue to pale-blue are certainly, for the greater part, connected with variations of the coefficient of scattering. Though in the deeper layers where state b) prevails the coefficient of scattering does not influence the distribution of the light, it does, nevertheless influence the total absorption. For, that light for which s is largest, will travel over the longest distance in the medium, so that the product of absorption coefficient and lightpath can have widely different values for different values of s and thus for different wavelengths.

Scattering and absorption in clouds. In clouds scattering takes place also. The scattering particles are in this case larger than those, to which RAYLEIGH's formula applies, and the scattering is in the majority of cases only slightly — or not at all selective. The sun, seen through a thin cloud is white, whereas seen through a sooty fog it is red. Besides, the scattering is much more pronounced than in a cloudless atmosphere. The fact that inside a cloud the light is white, is not necessarily an indication of non-selective scattering. Next to scattering absorption takes place also. The coefficient of absorption of water increases with increasing wavelength.

This may be the explanation of the fact, that with a heavily clouded sky the maximum of radiation lies at $\lambda = 4500$ Å (see Chapter III). Here again we meet with the mutual influence of scattering- and absorption-phenomena, which may give rise to great fluctuations in the spectral distribution of the daylight, as well as to large differences in its intensity.

Influence of the earth's surface. The reflection of light at the surface of the earth is also of some moment for the lighting. This is very strikingly illustrated by snow and ice, by which a great part of the incident radiation suffers diffuse reflection. Owing to the capricious character, however, of these phenomena, it is hardly possible to include them in a numerical treatment. Besides, our material is unsufficient to deduce from it the data necessary for their adequate discussion.

STELLINGEN

I.

De beschouwingen van SHAW over het donkere uiterlijk van sommige wolken geven geen geheel juiste voorstelling van de invloeden, die hierbij van belang zijn.

SIR NAPIER SHAW, Manual of Meteorology, Vol. III (1930), page 93.

II.

De wijze van behandeling van de foutenwet van Gauss volgens COOLIDGE verdient geen aanbeveling.

J. L. COOLIDGE, An introduction to mathematical probability (1925).

III.

Er bestaan zoowel Barkhausen-Kurz trillingen, waarbij de veldvervorming door de ruimtelading essentieel is, als andere waarbij dat niet het geval is.

IV.

De meeste auteurs betrekken ten onrechte het axiale electrische veld in de onmiddellijke nabijheid van de gloeidraad bij aanwezigheid van een cylindrische anode, die de gloeidraad omsluit, niet in hun beschouwingen over electronenemissie.

V.

De breedte van de lichtvlek in photographisch registreerende apparaten is voor de opstelling van KAISER kleiner dan deze aangeeft.

H. KAISER, Theorie der photographischen Registrierung, Z. f. Techn. Phys. 16, 303, 1935.

VI.

Er zijn aanwijzingen, dat de vloedgolf, die dubbelstercomponenten op elkaar veroorzaken, niet gericht is volgens de verbindingslijn der middelpunten.

VII.

De door MOUTON geconstateerde afname van de gezichtsscherpte met de afstand van de test, wordt niet verklaard, doordat de gezichtsscherpte ongelijk is voor verschillende deelen van het netvlies.

MOUTON, Recherches sur les propriétés physiques et les effets physiologiques d'une lumière colorée, pag. 57 (1935).

VIII.

Het is twijfelachtig of het ideaal van een wegdek van volkomen gelijkmatige helderheid bij wegverlichting dient te worden nagestreefd.