

## NOTES ON GLOBAL RADIATION IN AUSTRALIA

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Since 1953 a network of six stations recording global (sun plus sky on horizontal surface) radiation by Robitzsch bimetallic actinographs has been in operation in Australia. Table 1 gives the monthly means ( $\text{cal cm}^{-2} \text{ day}^{-1}$ ) and the annual sum ( $\text{Kcal cm}^{-2}$ ).

Comparing the global radiation during the first and the second half-year one finds at all stations a marked prevalence of radiation during the second half. But it must be considered that compared with the times between the solstices the second half year has more days of strong radiation (23 - 31 December), the first half more days with weak radiation (23 - 30 June). If one corrects for this difference one finds (Table 2) that at most stations the global radiation in the half years of equal extraterrestrial solar radiation becomes practically identical. Only the tropical stations Darwin and Garbutt retain a prevalence of the second half year during which the cloudiness is markedly smaller.

To establish the conditions of global radiation in more detail, Tables 3(a) - 3(f) have been calculated; they contain the mean numbers of days with global radiations of varying amounts per month and per year. As the monthly distributions are based upon less than 100 observations, the tenths are without significance. Very dull days with less than  $50 \text{ cal/cm}^2$  occurred at all stations except Darwin; but with the exception of Box Hill in winter they are very rare. At four stations daily radiation values exceeding  $800 \text{ cal/cm}^2$  have been observed; the exceptions are Williamtown and Darwin. At the latter station the maximum global radiation has not exceeded  $700 \text{ cal/cm}^2$ , an indication of the relatively small intensities at equatorial and low latitude tropical stations. The mean maximum and minimum values are given in greater detail in Table 4.

TABLE 1

Mean Global Radiation

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
Darwin 12.4S, 130.8E	480	470	510	425	460	430	455	515	560	565	550	526	183
Garbutt 19.2S, 146.8E	510	480	490	455	395	370	400	455	560	525	665	660	182
Alice Springs 23.8S, 133.9E	670	655	580	445	380	330	350	440	565	585	660	655	192
Guildford 31.9S, 116.0E	665	625	530	370	265	230	230	340	440	545	670	735	168
Williamtown 32.8S, 151.8E	550	450	460	330	260	210	235	300	400	490	570	590	148
Box Hill 37.8S, 145.1E	610	485	425	280	175	140	165	225	330	435	525	600	133

TABLE 2

Percentage of Global Radiation in first half-year

	Darwin	Garbutt	Alice Springs	Guildford	Williamtown	Box Hill
Jan.-June	47	47	45	48	49	46
23.XII-22.VI	47	47	50	50	49	49

Table 3  
 Frequencies of Daily Amounts of Global Radiation  
 (a) - Darwin

1953-55	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0-50													
51-100			0.4	0.8							0.3		1.1
101-150	2.2	0.4	0.4										3.0
151-200	0.4			0.4							0.4		1.2
201-250	1.3	1.3	0.4	1.6	0.3					0.4	0.4	1.0	6.7
251-300	2.2	1.3		0.8	0.4	0.4	0.3		0.3		0.7	1.1	7.5
301-350	1.3	0.9	0.8	2.3	0.3	1.4	1.4				0.7	1.4	10.5
351-400	1.3	1.8		3.1	3.1	2.7	1.7			1.0	0.7	1.7	17.1
401-450	3.0	4.4	2.0	<del>7.4</del>	7.3	12.2	4.8	2.0	1.0	1.3	1.4	1.4	48.2
451-500	2.2	<u>5.7</u>	7.7	5.1	<u>12.6</u>	<u>13.2</u>	<u>21.6</u>	6.4	1.0	2.0	4.6	2.5	<u>84.6</u>
501-550	<u>5.6</u>	2.2	<u>8.9</u>	<u>7.4</u>	7.0		1.4	<u>16.9</u>	8.8	7.8	3.9	3.5	73.4
551-600	3.4	4.4	5.7	1.2				5.7	<u>12.1</u>	7.4	6.4	4.2	50.5
601-650	4.4	4.4	4.8						6.8	<u>8.1</u>	<u>6.7</u>	<u>8.4</u>	43.6
651-700	3.9	1.3								3.0	4.6	5.2	18.0

Table 3 (contd.)

## Frequencies of Daily Amounts of Global Radiation

(b) - Garbutt

1953-55	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0-50	0.4	0.4											0.8
51-100	0.4	1.1		0.4	0.4								2.3
101-150	0.4	1.1	0.8	0.7	0.4	0.5		0.4					4.3
151-200		1.1	0.4	0.7	1.1	0.5	0.3	0.7		0.4			5.2
201-250	1.1	1.1	1.2	1.5	1.1	2.1				0.4	0.4		8.9
251-300	1.1	1.1	1.6	1.5	1.4	2.1	2.1	0.7		0.4			12.0
301-350	1.8	0.7	2.0	1.5	2.5	3.1	2.8	1.1					15.5
351-400	2.9	1.9	1.6	1.1	3.9	4.6	5.5	0.7	1.7		0.8		24.7
401-450	3.3	1.1	1.2	3.0	<u>10.2</u>	<u>17.0</u>	<u>18.6</u>	6.1	1.0	0.4	0.4	1.0	<u>63.3</u>
451-500	2.2	2.6	3.3	3.7	<u>10.2</u>		1.7	<u>11.1</u>	1.4	0.4	0.4	0.7	37.7
501-550	2.5	3.0	4.9	<u>8.9</u>				10.4	3.4	2.2	1.1	0.7	37.1
551-600	2.9	3.0	<u>7.0</u>	6.7				<u>15.0</u>	<u>15.0</u>	3.4	0.8	3.0	<u>41.8</u>
601-650	<u>5.4</u>	<u>6.4</u>	6.1	0.4				7.5	7.5	7.8	3.8	3.7	41.1
651-700	3.3	1.9	0.8						<u>13.8</u>	<u>13.8</u>	9.9	<u>10.8</u>	40.5
701-750	2.9	1.1							1.5	<u>11.8</u>	<u>10.4</u>		27.7
751-800	0.7									0.4	0.7		1.8
801-850											0.4		0.4

x June 1955 not recorded

Table 3 (contd.)

Frequencies of Daily Amounts of Global Radiation

(c) - Alice Springs

	1953-55	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0-50							0.3							0.3
51-100				0.7			1.0	0.3						2.0
101-150		0.3		0.3	0.7	0.3	1.0	0.3				0.3		3.3
151-200	0.3	0.3		1.1	0.3	2.3	1.0	0.3		0.3				6.0
201-250		0.3		1.1	1.7	1.3	1.8	0.3	0.3	1.0				7.8
251-300	0.3		0.3	0.3	0.3	1.0	3.1	1.3	1.0				1.0	8.4
301-350			0.3	0.3	1.4	2.3	4.1	1.0	0.3		0.7	0.7	0.3	11.2
351-400			1.1	2.8	9.1	18.2	12.1	2.1			0.7	0.7	0.7	47.2
401-450	0.7		0.3	3.2	13.9	0.7	11.4	7.0	0.3	0.3	1.4	0.3		39.2
451-500	1.0	0.3	1.4	7.7	2.0			16.3	1.8	1.8	1.8	1.0	0.7	34.0
501-550	0.7	1.1	3.6	9.5				3.1	5.7	2.4	2.4	1.7	1.3	29.2
551-600	1.3	2.5	8.0	2.1					14.3	2.4	2.4	3.4	3.1	37.3
601-650	5.8	2.5	11.2						6.7	2.1	2.1	3.4	3.8	42.5
651-700	5.8	13.0	4.7						0.8	8.3	8.3	3.8	4.1	40.4
701-750	9.2	5.4								2.8	2.8	9.0	8.9	35.2
751-800	5.8	2.2										5.2	5.8	18.9
801-850	0.3											0.7	1.0	2.0

Table 3 (contd.)

## Frequencies of Daily Amounts of Global Radiation

(d) - Guildford

	1953-55	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0-50						x	x	$\bar{x}$						0.5
51-100						0.5	1.8	0.5	0.3					3.1
101-150			0.7	0.3	0.4	3.2	1.8	0.5	1.0	0.3				8.2
151-200		0.3	0.7	0.3	1.1	2.5	4.3	8.1	1.4	0.3				19.0
201-250		0.3		0.3	1.9	4.3	4.9	<u>10.0</u>	4.8		0.3			26.8
251-300			0.3		2.6	7.5	15.9	9.1	5.2	2.0			0.3	<u>42.9</u>
301-350		0.3	0.3	0.3	5.0	7.0	1.2	2.9	<u>8.3</u>	1.6	0.7			27.3
351-400		0.3	1.3		4.0	5.4			5.9	6.0	1.0	0.7		24.6
401-450		0.7	0.3	1.4	7.7				4.2	3.0	2.8	0.3	1.0	21.4
451-500		0.7	0.3	4.9	6.6				<u>8.6</u>	<u>8.6</u>	4.9	1.0	0.3	27.3
501-550		1.0	1.0	<u>8.4</u>	0.4				6.9	<u>6.9</u>	<u>6.3</u>	2.0	0.3	26.3
551-600		4.1	1.7	8.0					1.3	4.2	4.2	2.3	1.4	23.0
601-650		2.0	4.7	5.9						5.9	5.9	4.0	0.3	22.8
651-700		3.1	<u>2.0</u>	1.0						4.9	4.9	5.3	3.0	26.3
701-750		<u>10.2</u>	7.3								<u>8.7</u>	<u>8.7</u>	3.0	29.2
751-800		7.8	0.3								5.7	<u>15.9</u>	<u>29.7</u>	
801-850												5.4	5.4	5.4

x May June 1953 not recorded.  $\bar{x}$  July 1953 8 days only.

Table 3 (contd.)

Frequencies of Daily Amounts of Global Radiation

(e) - Williamtown

1953-55	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0-50					0.3	0.3	0.3						0.6
51-100		0.7		1.3	0.7	2.4	2.0	0.5			0.5		8.1
101-150	0.8	2.1	0.7	2.1	2.4	4.9	5.4	1.5	1.0	0.5	0.5		21.9
151-200	1.6	2.4	1.1	0.4	2.1	5.6	2.0	4.1	2.5	0.5	0.5	0.5	23.3
201-250	1.2	1.0	0.4	3.4	5.5	5.3	3.7	4.1	1.0	1.0	1.0	1.5	29.1
251-300	0.8	1.0	0.7	3.4	<del>2.7</del> 11.8	<del>10.9</del>	2.0	2.0	1.5	1.5	1.0	0.5	<del>14.8</del>
301-350	0.8	1.4	1.1	5.1	9.3	6.8	6.8	6.6	3.0	1.0			35.1
351-400	2.3	1.7	3.3	<del>7.2</del>	1.0			<del>2.2</del> 0.5	0.5	3.0	1.6	0.5	30.3
401-450	0.8	1.0	4.0	3.8				3.1	6.5	2.0	1.0	0.5	22.7
451-500	3.1	3.8	5.8	3.0				<del>12.0</del>	2.5	2.5	1.6	2.6	<del>34.4</del>
501-550	1.9	1.0	6.2	0.4				2.0	5.6	5.6	1.0	3.1	21.2
551-600	3.1	<del>4.1</del> 7.3							<del>6.1</del>	<del>6.1</del>	2.1	4.1	26.8
601-650	1.9	2.4	0.4						5.1	5.1	3.6	2.6	16.0
651-700	<del>6.2</del> 3.8								2.0	2.0	5.2	5.1	22.3
701-750	5.9	1.4							<del>2.4</del> 6.6	<del>2.4</del> 6.6			23.3
751-800	1.2	0.3									1.0	3.6	6.1
801-850													

x Aug. to Dec. 1955 not recorded

Table 3 (contd.)

## Frequencies of Daily Amounts of Global Radiation

(f) - Box Hill

1953-55	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0-50				0.3	1.3	2.4	1.0	1.0					6.0
51-100				1.0	2.3	4.1	3.1	2.0	1.0		0.3		13.8
101-150	0.3	0.3	1.3	1.3	7.0	<u>10.1</u>	<u>9.2</u>	2.3	2.0	1.3	0.7	0.7	36.5
151-200	0.7	1.3	1.0	3.7	7.3	9.1	8.9	5.7	1.7	0.7	1.3		<u>41.4</u>
201-250	0.7	1.3	1.3	5.3	<u>9.0</u>	4.7	6.5	5.7	3.1	2.3	0.7	0.3	40.9
251-300		0.7	2.0	4.0	3.7		2.0	<u>9.3</u>	<u>4.8</u>	2.0	0.7		29.2
301-350		1.3	1.7	5.7	0.3		0.3	4.0	4.1	1.3	1.3	1.3	21.3
351-400	0.7	2.3	1.7	<u>6.3</u>				1.0	3.7	<u>5.0</u>	1.0	2.0	23.7
401-450	1.7	2.0	<u>7.3</u>	1.3					3.4	3.3	0.7	2.0	21.7
451-500	1.7	3.7	5.7	1.0					3.4	4.0	4.3	1.3	25.1
501-550	3.7	4.0	5.0						2.7	3.7	<u>5.0</u>	3.7	27.8
551-600	3.0	<u>4.7</u>	3.3						4.7	4.7	3.0	3.0	21.7
601-650	4.7	4.0	0.7						1.7	1.7	3.3	1.7	16.1
651-700	4.3	1.7							1.0	1.0	3.0	3.0	13.0
701-750	<u>5.3</u>	0.7							0.3	0.3	3.7	<u>5.7</u>	15.7
751-800	3.7										1.0	5.3	10.0
801-850	0.7											1.0	1.7



The maxima which refer to clear or mainly clear days, have a smooth seasonal trend with highest values in midsummer; the minima have a more irregular distribution as they are based upon only two to three years and depend upon the occurrence of days with continuous thick cloud cover which are rare. The lowest minima occur in midwinter, with the exception of Darwin and Garbutt where they occur during the rainy summer season. The absolute maxima, highest at Garbutt, Guildford and Box Hill, reach 825-830 cal/cm<sup>2</sup>.

The greatest frequency of daily radiation is, according to Table 3, found at most places and times near the upper end of the scale for that month. This shows the prevalence of days without clouds or with thin clouds over most of Australia. It is interesting that this applies to Darwin during the rainy season too. The only exception, apart from a slight indication at Guildford in July at the height of the rainy season, is at Box Hill in winter and spring where overcast days are frequent and where even with a smaller degree of cloudiness the screening effect of clouds upon the lower sun becomes important. In the annual means the frequency has two maxima, with the exception of Darwin where the annual variation is small. The duplication is caused by the frequency of clear days in summer and winter when their values change little, whilst in the transitional seasons clear days have a bigger variation of global radiation.

The differences of the radiation climate of the different places is shown in the distribution of the quartiles of the radiation distribution. Table 5 gives the values for the limits of the quartiles and the limits of the first and fourth quartiles as percentages of the median value.

It can be expected that a close relation exists between the monthly global radiation and the cloudiness of the month. This is fully corroborated by the correlation between the deviations of the monthly mean global radiation and the deviations of the monthly mean cloudiness of the different months in the three-year period from the average values for these three years as shown in Table 6.

TABLE 5

Quartiles of the Annual Frequencies of the Global Radiation

	Darwin	Garbutt	Alice Springs	Guildford	Williamtown	Box Hill						
1st quartile	430	90%	390	80%	380	75%	260	60%	235	66%	160	52%
median	480		490		510		430		355		310	
4th quartile	555	116%	610	125%	640	126%	630	147%	535	151%	510	164%

TABLE 6

Coefficients of Correlation (r) between Monthly Global Radiation and Cloudiness and their Ratios to their Probable Errors (f)

	Darwin	Garbutt	Alice Springs	Guildford	Williamtown	Box Hill					
r	r/f	r	r/f	r	r/f	r	r/f				
-0.56	7	-0.50	6	-0.54	7	-0.83	22	-0.84	23	-0.56	7