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MONTHLY MEAN SOLAR RADIATION STATISTICS FOR AUSTRALIA

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Abstract—Tables of monthly mean solar radiation parameters are computed from detailed cloud cover information. The parameters include direct and global daily total energy inputs to horizontal, inclined and "sun-tracking" surfaces. Comparison with measured global radiation at 12 stations reveals virtually no systematic error in the computation scheme, and an error of 2MJ m^{-2} day^{-1} in the worst case month of any station.

INTRODUCTION

This paper reports theoretically computed data on the monthly average values of solar radiation available at 43 sites over the Australian continent. The data are an extension of earlier work described in a C.S.I.R.O. report which dealt with seasonal averages [1] and are computed from detailed cloud observations using empirical mean reflectances for the clouds at different levels. Specifically, the data consist of tables of (1) global radiation on a horizontal surface, (2) diffuse radiation on a horizontal surface, (3) direct beam radiation on a surface perpendicular to the beam, (4) global radiation on a surface perpendicular to the beam, (5) global radiation on a north-facing flat plate inclined at the latitude angle and (6) the direct beam component of global radiation on a north-facing flat plate inclined at the latitude angle. The description of the calculations in the next section follows closely that given in the original report.

BASIS OF CALCULATIONS

The solar constant or the mean solar irradiance on a surface normal to the beam just outside the earth's atmosphere is 1353 W/m^2 [2]. On its path down through the atmosphere this radiant energy is reduced considerably by scattering and absorption and is altered in character such that the radiant energy at the ground consists of two components—the energy I in the direct beam of the sun, and the energy D of the diffuse radiation scattered to the ground from other parts of the sky. The direct component has obvious directional properties, while the diffuse component is (for most engineering applications) effectively isotropic. Thus the total flux density on a horizontal flat plate (the global radiation G) is given by

$$G(\theta) = I(\theta) \cos \theta + D(\theta) \qquad (1)$$

where θ is the zenith angle of the sun.

The flux density on a flat plate which is not horizontal is given by a similar expression with θ replaced by the angle β between the direction of the sun and the normal to the plate. In this case, however, corrections must be made to account for the plate receiving radiation reflected from a certain fraction of the ground and only a complementary fraction of the sky.

Direct beam fluxes

In clear skies both I and D are primarily functions of solar zenith angle θ. Although the fluxes are affected by water vapour, regional albedo and atmospheric aerosols, variation due to these factors is relatively small (5–10 per cent). Water vapour absorption by the whole atmosphere is fairly constant (at about 15–20 per cent) because of saturation of the absorption bands [3]; the regional surface albedo over most of Australia is not highly variable except with θ itself [4], and in any event has a minimal effect on downcoming radiation [5]; and except on occasions of extensive bush fires and sand storms, the atmospheric turbidity (a measure of direct radiation reduction by aerosol pollution) in Australia is of the order of the global background—that is, the direct beam reduction by aerosols is only a few per cent.

Thus a single empirical curve relating direct radiation and solar zenith angle was used in the present work. That is

$$I(\theta) = 950\{1 - \exp[-0.075(\tfrac{1}{2}\pi - \theta)]\} \qquad (2)$$

where I is in W m^{-2}. Thus if the sun were vertically overhead I would be 950 W m^{-2}.

Calculation of the direct beam energy over a day is simply a matter of calculating θ as a function of time, integrating $I(\theta)$ over the day, and reducing the integrated value by the observed fractional cloud cover ϕ since the presence of cloud in the solar beam normally reduces I to zero. Mathematically, the appropriate formula used here for the mean daily input of direct energy $\bar{I}$ is

$$\bar{I} = (1 - \phi) \sum_{T_1}^{T_2} I(\theta) \qquad (3)$$

Table 1. Total global radiation on a horizontal surface (MJ m^{-2} d^{-1})

LOCATION	J	F	M	A	M	J	J	A	S	O	N	D	AVE
1.1	18.8	18.8	19.2	19.6	17.4	16.5	17.0	18.3	21.2	21.6	22.8	20.9	19.3
1.2	20.4	19.8	20.1	22.1	19.4	19.6	20.0	22.2	23.5	23.7	23.5	21.4	21.3
1.3	21.1	20.4	19.9	18.9	16.1	15.5	15.9	18.5	21.8	22.8	23.7	22.1	19.7
1.4	22.8	22.3	20.8	19.7	16.3	15.8	16.7	18.5	22.4	23.6	24.9	23.9	20.6
1.5	22.9	21.8	20.0	18.3	15.2	14.9	15.5	17.5	21.7	23.1	24.9	23.4	19.9
1.6	23.8	22.9	20.7	18.9	15.6	14.5	15.5	17.2	21.6	23.3	24.9	24.1	20.3
1.7	24.7	23.5	20.9	19.2	15.8	14.4	15.4	17.5	21.8	23.4	25.3	24.5	20.5
2.1	22.5	21.7	21.6	21.5	18.6	17.2	18.9	21.2	23.9	25.4	26.1	24.7	21.9
2.2	22.8	23.7	21.0	21.3	18.1	17.4	17.2	20.6	23.2	23.8	24.9	23.6	21.5
2.3	21.3	20.5	20.5	21.5	18.2	18.1	18.6	21.6	23.1	24.0	23.7	22.0	21.1
2.4	24.8	22.9	22.3	20.5	17.5	16.1	17.8	19.9	23.5	25.8	27.5	27.0	22.1
2.5	26.3	23.7	23.5	19.0	16.7	15.7	17.4	19.2	23.2	25.9	27.8	27.4	22.2
2.6	26.4	25.4	22.9	18.1	16.2	14.2	15.6	18.3	22.4	25.0	26.6	27.7	21.6
2.7	25.8	23.8	21.7	17.1	15.0	13.1	14.5	17.2	21.7	24.3	25.7	26.7	20.6
2.8	25.9	23.3	21.9	19.3	15.4	14.1	15.8	18.1	22.1	24.1	25.8	25.1	20.9
2.9	26.3	23.8	22.4	20.4	16.3	14.9	16.2	18.8	22.5	24.3	26.1	26.4	21.5
2.10	24.7	23.3	22.0	21.5	17.7	16.9	17.6	20.3	23.4	25.5	26.7	25-2	22.1
2.11	25.6	23.9	23.0	20.4	16.3	15.1	16.0	18.4	22.8	24.9	27.8	25.8	21.7
2.12	25.8	24.6	21.7	19.4	15.0	13.6	14.8	17.2	21.5	24.0	26.4	25.6	20.8
2.13	26.8	25.1	22.8	19.3	14.5	13.0	14.5	17.0	21.4	23.6	25.8	26.7	18.7
2.14	25.9	25.1	20.9	17.5	12.9	11.4	12.3	14.6	19.2	22.4	25.8	26.4	19.5
3.1	26.5	25.1	22.4	16.6	14.4	12.1	13.3	15.7	20.1	23.4	25.3	27.3	20.2
3.2	27.3	25.3	21.0	15.1	12.7	10.2	11.2	14.0	17.9	22.1	24.7	26.9	19.0
3.3	27.3	24.5	21.4	15.8	13.3	11.3	12.4	15.1	19.5	23.0	25.6	27.0	19.7
3.4	25.9	23.3	20.5	16.6	13.0	11.2	12.3	14.9	19.5	22.3	25.4	25.2	19.2
3.5	26.2	23.9	20.0	16.0	12.0	10.4	11.2	14.0	19.5	21.7	24.0	25.0	18.5
3.6	26.7	25.1	21.6	17.3	12.7	11.1	12.1	14.9	19.0	22.9	25.5	27.0	19.7
3.7	26.3	23.7	19.4	14.6	10.8	9.5	9.6	12.5	16.1	20.8	23.6	25.1	17.7
3.8	26.9	25.1	20.9	16.1	11.5	10.0	10.6	13.4	17.3	21.8	25.1	26.9	18.8
3.9	26.4	24.9	19.9	15.5	10.9	9.4	9.6	12.1	16.6	20.8	24.4	26.3	18.1
3.10	25.1	23.0	19.2	15.1	11.1	9.6	10.2	12.5	16.7	20.0	23.5	25.0	17.6
3.11	22.3	21.2	18.5	15.5	12.0	10.0	11.3	13.3	17.1	19.4	22.6	22.9	17.2
3.12	23.7	21.9	19.0	16.1	12.5	10.6	11.7	14.0	17.9	20.1	23.6	24.0	17.9
3.13	25.1	23.7	20.4	17.1	12.6	11.0	12.2	14.1	18.5	21.8	25.2	25.7	19.0
3.14	23.4	22.1	19.7	16.8	13.2	11.6	12.9	14.8	19.3	21.2	24.4	23.6	18.6
3.15	23.6	22.4	19.7	17.6	14.1	12.7	13.6	16.0	20.3	21.7	25.0	23.8	19.2
4.1	24.0	20.7	17.1	12.8	10.3	9.0	9.5	11.7	14.9	18.6	21.0	23.4	16.1
4.2	24.3	21.3	17.3	12.8	9.3	8.2	8.4	11.1	14.4	18.7	20.9	23.0	15.8
4.3	26.9	24.4	19.8	14.7	10.3	9.0	b.2	12.3	16.0	21.1	23.7	26.4	17.8
4.4	24.0	21.3	17.6	13.3	9.5	8.2	8.6	11.1	14.5	18.6	21.4	23.1	15.9
4.5	24.2	21.6	17.4	13.0	9.5	8.1	8.7	11.1	14.9	18.5	21.9	23.1	16.0
4.6	24.9	22.0	17.3	12.4	8.7	7.2	7.6	10.3	14.4	19.7	22.6	24.4	16.0
4.7	23.5	20.4	16.1	11.6	8.1	6.9	7.5	10.0	13.7	18.7	21.0	22.8	15.0

T_1 and T_2 are the times of sunrise and sunset. The time step was 15 min in the present calculations. θ is given by

$$\sin\left(\tfrac{1}{2}\pi - \theta\right) = \sin S \sin \Phi + \cos S \cos \Phi \cos T_0, \quad (3a)$$

where Φ = the location latitude;
S = the solar declination for the time of year;
and T_0 = the hour angle.

In the present work the solar zenith angle calculations and integrations such as that of eqn (3) have been performed for the 15th of each month. However, the cloud cover ϕ is a true monthly average so that the tables of direct energy input are, in all cases, those of monthly means. The units in the tables are of total daily input in megajoules per square meter per day.

Equation (3) was used to calculate $\bar{I}$ (Table 3). In order to calculate its component $\bar{I}_1$ on a north-facing flat plate inclined at the latitude angle (Table 6), one must take into account the angle between the solar beam and the normal to the plate as follows:

$$\bar{I} = (1 - \phi) \sum_{T_1}^{T_2} I(\theta) \cos \beta \quad (4)$$

Table 2. Diffuse radiation on a horizontal surface (MJ m^{-2} d^{-1})

LOCATION	J	F	M	A	M	J	J	A	S	O	N	D	AVE
1.1	12.4	12.7	12.3	10.5	8.8	7.7	7.8	8.6	8.8	10.2	10.2	12.5	10.2
1.2	13.0	12.2	11.0	5.8	6.0	4.0	4.1	3.8	5.8	7.4	8.6	12.1	7.8
1.3	11.0	10.7	9.3	7.2	6.4	5.3	5.7	5.3	5.8	6.9	7.5	9.7	7.6
1.4	9.7	8.7	7.6	5.5	5.3	4.0	3.7	4.3	4.5	5.9	6.8	8.4	6.2
1.5	10.0	9.2	8.3	6.2	5.8	4.1	4.1	4.7	4.8	6.3	7.0	9.3	6.7
1.6	8.9	8.1	7.3	4.8	4.7	3.8	3.2	4.2	4.0	6.0	7.0	8.8	5.9
1.7	7.9	7.1	6.8	4.4	4.3	3.6	3.3	4.0	3.7	5.8	6.4	8.2	5.5
2.1	10.6	10.9	7.9	4.3	3.8	3.4	2.6	2.5	3.2	4.3	4.9	7.4	5.5
2.2	10.4	10.0	8.8	4.2	4.1	3.1	3.4	3.1	4.0	5.9	6.1	9.7	6.1
2.3	12.8	12.3	9.8	4.7	5.2	3.3	3.8	2.9	5.0	6.7	8.7	11.9	7.3
2.4	8.1	9.5	7.1	5.2	3.8	3.2	2.2	2.8	2.9	3.6	3.7	5.8	4.8
2.5	6.3	8.0	5.2	6.4	4.2	3.4	2.3	3.2	3.0	3.7	3.6	5.8	4.6
2.6	6.1	5.5	4.8	6.1	3.9	3.5	2.6	2.8	2.8	4.2	5.3	5.3	4.4
2.7	7.0	6.8	5.7	6.3	4.4	3.8	2.9	3.2	3.0	4.8	6.6	6.7	5.1
2.8	6.9	7.5	5.5	4.5	4.3	3.4	2.1	2.8	2.8	5.0	6.3	8.1	4.9
2.9	6.1	6.7	5.5	3.6	4.0	3.4	2.4	2.7	2.8	4.8	5.3	6.0	4.4
2.10	7.9	7.9	6.6	3.2	3.7	2.7	2.4	2.4	3.0	4.4	4.9	7.5	4.7
2.11	7.4	7.7	5.3	3.8	4.4	3.6	2.8	3.2	2.9	4.8	4.2	7.3	4.8
2.12	7.1	6.6	6.0	3.6	4.1	3.6	2.8	3.3	3.3	5.3	5.8	8.1	5.1
2.13	6.1	5.9	4.5	3.6	4.3	3.6	2.6	3.2	3.0	5.6	6.5	7.0	4.7
2.14	8.1	5.8	5.7	4.1	4.3	3.8	3.3	4.4	4.4	7.1	7.1	8.8	5.6
3.1	6.5	5.4	4.4	6.1	3.9	3.8	3.3	4.0	4.1	5.5	7.1	6.5	5.0
3.2	6.1	5.0	5.2	6.1	4.2	4.3	4.0	4.5	5.4	6.5	7.6	7.1	5.5
3.3	6.0	5.9	5.1	6.0	4.1	4.1	3.6	4.0	4.2	5.8	7.5	7.4	5.3
3.4	7.4	7.4	6.2	5.6	4.6	4.2	3.7	4.3	4.2	6.8	7.6	9.1	5.9
3.5	7.3	6.3	5.9	5.2	4.6	4.0	3.7	4.3	5.4	7.1	8.6	9.4	6.0
3.6	7.1	5.7	4.9	4.2	4.6	4.0	3.5	3.9	4.4	6.3	7.6	7.8	5.3
3.7	7.4	6.6	5.9	5.3	4.7	3.9	4.3	4.8	6.1	7.3	8.6	9.5	6.2
3.8	6.9	5.2	9.7	4.2	4.2	3.5	3.5	4.0	5.3	6.7	7.4	7.8	5.3
3.9	8.0	6.3	5.9	4.5	4.3	3.6	4.1	4.8	5.7	7.8	8.6	8.9	6.0
3.10	8.6	7.2	6.3	4.6	4.1	3.4	3.4	4.4	5.5	7.9	8.6	9.1	6.1
3.11	10.5	8.6	7.1	4.7	4.1	3.8	3.3	4.4	5.8	8.8	9.2	10.9	6.8
3.12	9.4	8.2	6.9	4.6	4.0	3.6	3.2	4.1	5.3	8.4	8.6	9.9	6.4
3.13	8.3	6.8	5.8	4.0	4.2	3.7	3.4	4.5	4.9	7.0	6.9	8.5	5.7
3.14	9.4	8.3	6.7	4.5	4.2	3.5	3.0	4.1	4.5	7.6	7.5	10.2	6.1
3.15	9.1	8.3	7.4	4.8	4.4	3.8	3.5	4.1	4.2	7.3	7.1	9.6	6.1
4.1	9.6	9.6	8.7	7.3	5.3	4.6	4.6	5.6	7.8	9.7	11.8	11.5	8.0
4.2	9.5	8.8	7.4	6.0	4.8	3.8	4.3	5.1	7.0	9.0	11.1	11.5	7.4
4.3	6.5	5.6	5.1	4.4	4.3	3.5	4.0	4.4	6.1	6.7	8.3	7.8	5.6
4.4	9.9	8.4	6.9	5.4	4.5	3.8	4.1	5.0	6.8	9.0	10.5	10.9	7.1
4.5	9.5	8.3	7.0	5.6	4.4	3.5	3.7	4.7	6.3	9.0	10.3	11.0	6.9
4.6	8.7	7.5	6.5	4.9	3.6	3.0	3.2	4.1	5.7	7.3	9.2	10.1	6.3
4.7	10.0	8.8	7.3	5.3	3.9	2.8	3.0	4.2	6.3	8.0	10.5	11.6	6.8

where β is the angle between the beam and the normal to the plate and is given by

$$\beta = \theta \pm \cos^{-1}\{[(\sin T_0)^2 + (\cos T_0)^2(\cos \Phi)^2]^{1/2}\} \quad (5)$$

For the southern hemisphere the positive sign is appropriate for latitude angles greater than the declination and vice versa.

Global and hemispheric fluxes

The calculation of global flux is more difficult, since one must take into account not only the fraction of cloud cover but also the contribution of the clouds to the diffuse flux. In cloudy skies D may be the dominant (or only) radiant energy flux.

The global flux at the surface at a particular time (i.e. at a particular θ) may be expressed as

$$G(\theta) \cong I_0\left(1 - \sum_i a_i\phi_i\right)\{1 - k - k_1(1-\phi)\} \cos\theta. \quad (6)$$

Here I_0 is the solar constant, k is the absorption due to atmospheric water vapour (assumed to be constant at 0.18) and k_1 is the albedo of the atmosphere in the fraction of clear sky $(1-\phi)$. The a_i are the albedos of the clouds

Table 3. Direct beam radiation (MJ m^{-2} d^{-1})

LOCATION	J	F	M	A	M	J	J	A	S	O	N	D	AVE
1.1	8.7	8.1	9.3	11.8	12.7	13.6	14.0	14.0	17.0	15.2	16.9	11.5	12.8
1.2	10.0	10.3	12.4	23.1	20.1	24.3	24.5	26.9	24.4	21.9	20.1	12.6	19.2
1.3	13.7	13.0	14.5	17.1	15.0	16.4	16.4	19.9	22.5	21.5	21.8	16.7	15.7
1.4	17.6	18.3	18.3	20.9	17.6	19.7	21.3	21.7	25.7	24.1	24.4	20.8	20.9
1.5	17.4	17.1	16.3	18.2	15.3	18.5	19.1	20.1	24.4	22.9	24.1	18.9	19.4
1.6	20.0	20.2	18.9	21.5	18.2	18.7	21.1	20.8	25.8	23.8	24.1	20.5	21.1
1.7	22.6	22.2	20.0	22.6	19.2	18.9	20.8	21.6	26.5	24.2	25.5	21.9	22.2
2.1	16.0	14.6	18.9	25.2	23.3	22.5	26.2	28.3	29.3	28.6	28.4	23.3	23.7
2.2	16.7	18.5	16.9	25.2	22.1	23.6	23.5	26.8	27.2	24.3	25.2	18.7	22.4
2.3	11.4	11.0	14.7	24.5	20.3	24.0	23.6	28.0	25.4	23.5	20.2	13.7	20.0
2.4	22.5	18.1	21.3	22.5	22.2	21.9	25.8	26.7	29.7	30.4	32.0	28.5	25.1
2.5	26.9	21.3	25.6	19.0	20.4	21.0	25.3	25.3	29.1	30.4	32.6	29.2	25.5
2.6	27.3	27.1	25.8	18.6	20.8	19.1	22.7	25.1	29.1	28.8	28.8	30.2	25.3
2.7	25.4	23.3	23.1	17.0	18.3	17.0	20.7	23.1	28.1	27.2	26.0	26.9	23.8
2.8	25.7	21.7	23.6	23.1	18.9	19.2	24.1	25.0	28.8	26.5	26.4	22.9	23.8
2.9	27.3	23.3	24.0	25.8	20.6	20.2	23.8	25.8	28.8	26.9	28.1	27.5	25.2
2.10	22.7	20.9	21.5	27.4	22.6	24.1	25.3	27.8	29.2	28.8	29.4	24.0	25.3
2.11	24.6	21.9	25.1	25.3	19.8	20.0	22.7	24.4	29.2	27.8	31.8	24.9	24.8
2.12	25.3	24.7	22.7	24.8	18.9	18.3	21.4	22.9	27.3	26.1	28.1	23.5	23.7
2.13	28.1	26.4	26.5	24.9	17.7	17.3	21.4	22.9	27.8	25.3	26.2	26.7	24.3
2.14	24.4	27.1	22.7	22.1	15.8	14.8	17.1	17.8	23.2	22.1	25.7	23.8	21.4
3.1	27.2	27.3	26.2	16.8	18.6	15.4	18.3	19.6	24.4	25.4	24.9	28.1	22.7
3.2	28.8	28.4	23.6	15.0	15.6	11.3	13.7	16.5	19.5	22.5	23.5	26.9	20.4
3.3	29.0	25.8	24.0	16.1	16.8	13.9	16.5	19.0	23.7	24.6	24.8	26.6	21.7
3.4	25.3	22.2	21.1	18.0	15.1	13.6	16.3	18.3	23.7	22.2	24.4	21.9	20.2
3.5	25.9	24.7	21.1	18.1	13.9	12.6	14.6	17.2	19.1	21.0	21.3	21.2	19.2
3.6	26.7	27.1	24.9	21.6	14.9	14.0	16.3	19.3	22.8	23.9	24.6	26.1	21.9
3.7	26.1	24.3	20.5	15.9	11.7	11.4	10.7	13.9	16.1	19.7	20.8	21.5	17.7
3.8	27.5	28.2	24.7	20.3	14.1	13.3	14.1	17.0	19.2	22.2	24.6	26.3	21.0
3.9	25.4	26.0	21.6	19.1	12.8	12.2	11.1	13.4	17.8	19.2	22.1	24.0	18.7
3.10	22.9	22.5	19.9	18.2	13.6	13.0	13.8	14.9	18.1	17.8	20.9	21.9	18.1
3.11	16.1	17.8	17.2	18.2	15.1	12.5	15.6	16.0	18.1	15.4	18.6	16.5	16.4
3.12	19.6	19.3	18.2	19.3	15.8	13.8	16.4	17.6	19.9	16.9	20.6	19.2	18.1
3.13	23.0	23.7	21.6	21.6	15.6	14.1	16.8	16.8	21.2	21.3	25.2	23.5	20.4
3.14	19.0	19.3	19.3	20.0	16.4	15.6	18.7	18.5	22.8	19.4	23.2	18.2	19.2
3.15	19.7	19.4	17.8	20.3	17.0	16.4	18.3	19.8	24.2	20.2	24.4	19.1	19.7
4.1	19.9	15.7	12.8	9.3	9.6	9.0	9.8	11.1	11.4	13.0	12.9	16.3	12.6
4.2	20.7	18.0	15.5	12.0	9.1	9.5	8.7	11.2	12.2	14.6	13.9	15.9	13.4
4.3	28.3	26.9	22.9	17.9	12.0	11.7	10.7	14.6	16.3	21.4	21.6	25.8	20.3
4.4	19.6	18.8	16.8	13.9	10.0	9.4	9.6	11.5	12.7	14.5	15.4	17.0	14.1
4.5	20.5	19.4	16.4	13.3	10.3	10.1	10.5	12.2	14.4	14.4	16.5	16.8	14.6
4.6	23.1	21.4	17.5	14.0	10.8	9.7	10.0	12.4	15.1	19.0	19.5	20.1	16.1
4.7	19.4	17.4	14.5	11.9	9.3	9.7	10.1	11.7	12.9	16.6	15.3	15.9	13.9

plus the atmosphere above them at each of the levels i, and the ϕ_i are the fractional amounts of cloud at each of the levels i which are visible from above when cloud overlap is taken into account.

Table 9. Total global on a sun tracking flat plate (MJ m^{-2} d^{-1})

Cloud level	Cloud Type	Albedo a_i
1	Cirrus	0.35
2	Altocumulus-altostratus	0.55
3	Low cloud 2	0.60
4	Low cloud 1	0.50

The major difficulty in calculating G is to assign accurate mean values to the a_i. The values in Table 9 are estimates based on experience with radiometric measurements from high altitude balloons (see, e.g. [6]) among other sources. Their accuracy does not justify including a dependence on solar angle. In any event, very little is known about the dependence of cloud albedo on θ. A value of k_1 was chosen appropriate to the mean solar zenith angle of the 15th of each month. Greater precision is not justified in view of the possible inaccuracies in the values of the a_i. Note also that no additional absorption of solar energy by clouds is included, since the absorption bands of water vapour and of liquid overlap to a very

Table 4. Total global on a sun tracking flat plate (MJ m^{-2} d^{-1})

LOCATION	J	F	M	A	M	J	J	A	S	O	N	D	AVE
1.1	19.9	19.8	20.5	22.3	20.6	20.5	21.1	21.9	25.3	24.9	26.6	22.8	22.2
1.2	21.8	21.5	22.5	29.1	26.1	28.8	29.1	31.3	30.5	29.2	28.4	23.7	26.8
1.3	23.9	23.0	23.1	23.9	21.0	21.6	21.8	25.2	28.4	28.4	29.2	25.9	24.6
1.4	26.9	26.7	25.7	26.6	22.8	24.0	25.4	26.4	30.7	30.2	31.3	29.0	27.1
1.5	26.9	25.8	24.2	24.2	20.7	22.7	23.4	24.9	29.6	29.4	31.2	27.9	25.9
1.6	28.7	28.1	26.0	26.5	22.9	22.6	24.7	25.3	30.4	30.0	31.3	29.1	27.1
1.7	30.4	29.4	26.7	27.4	23.7	22.9	24.5	25.9	30.9	30.3	32.1	30.0	27.8
2.1	26.0	24.7	26.5	30.0	27.6	26.4	29.7	21.8	33.4	33.5	33.8	30.8	29.5
2.2	26.6	28.0	25.1	30.0	26.6	27.3	27.5	30.6	31.9	30.5	31.5	28.0	28.6
2.3	23.2	22.3	23.8	29.6	25.5	27.9	27.9	31.8	30.9	30.3	28.6	24.6	27.2
2.4	30.5	27.2	28.3	27.9	26.4	25.6	29.0	30.3	33.5	34.8	36.5	34.7	29.6
2.5	33.5	29.1	31.2	25.2	24.9	24.8	28.5	29.1	33.1	34.9	36.9	35.3	30.5
2.6	33.7	33.0	31.0	24.5	24.9	22.8	26.0	28.7	32.8	33.6	34.6	36.0	30.1
2.7	32.6	30.2	28.9	22.9	22.7	20.9	24.1	26.9	32.0	32.5	32.8	33.8	28.4
2.8	32.7	29.1	29.3	27.9	23.3	22.8	27.0	28.5	32.5	32.0	33.0	30.9	29.1
2.9	33.6	30.0	29.8	30.0	24.9	23.9	26.9	29.3	32.6	32.2	33.8	33.8	30.1
2.10	30.5	28.6	28.1	31.4	26.8	27.4	28.5	31.3	33.2	33.8	34.7	31.4	30.5
2.11	32.0	29.6	30.7	29.7	24.3	23.9	26.1	28.2	33.1	33.1	36.7	32.2	30.0
2.12	32.5	31.4	28.8	29.0	23.1	22.0	24.7	26.8	31.4	31.9	34.2	31.6	29.0
2.13	34.5	32.6	31.6	29.1	22.0	21.0	24.6	26.6	31.7	31.2	33.0	33.9	29.3
2.14	32.4	33.2	28.5	26.5	20.0	18.4	20.6	22.2	27.9	29.0	33.0	32.5	27.0
3.1	33.9	33.1	31.2	22.6	22.6	19.2	21.8	23.9	29.0	31.2	32.0	34.9	28.0
3.2	35.3	33.9	29.0	20.6	19.6	15.2	17.5	20.9	24.9	28.9	31.1	34.2	25.9
3.3	35.4	32.1	29.5	21.7	20.8	17.7	20.2	23.2	28.4	30.7	32.4	34.2	27.2
3.4	32.8	29.5	27.3	23.4	19.5	17.5	19.9	22.7	28.3	29.0	32.0	30.8	26.1
3.5	33.3	31.2	27.1	23.1	18.1	16.3	18.2	21.5	24.5	28.0	29.7	30.3	25.1
3.6	34.0	33.2	30.2	26.2	19.3	17.7	19.8	23.4	27.6	30.3	32.2	33.9	27.3
3.7	33.5	31.0	26.4	20.9	15.9	15.0	14.5	18.3	21.9	26.8	29.1	30.6	23.7
3.8	34.6	33.9	29.9	24.7	18.1	16.6	17.5	21.0	24.5	28.8	32.0	34.1	26.3
3.9	33.5	32.5	27.5	23.6	16.7	15.5	14.8	17.8	23.3	26.6	30.4	32.7	24.6
3.10	31.3	29.6	26.0	22.8	17.4	16.1	17.1	19.1	23.5	25.3	29.1	30.7	24.0
3.11	25.9	26.0	23.9	22.9	19.0	16.0	19.0	20.3	23.7	23.5	27.3	26.7	22.9
3.12	28.6	27.2	24.8	24.0	19.7	17.3	19.8	21.7	25.2	24.7	29.0	28.7	24.2
3.13	31.1	30.6	27.5	26.0	19.6	17.7	20.3	21.1	26.3	28.2	32.2	31.8	25.2
3.14	28.0	27.2	25.8	24.7	20.5	19.1	21.9	22.7	27.7	26.6	30.7	27.9	25.2
3.15	28.4	27.4	24.9	25.3	21.3	20.2	22.0	24.1	29.0	27.3	31.5	28.4	23.2
4.1	29.0	24.6	20.6	15.5	14.1	12.9	13.7	16.0	18.3	21.7	23.6	26.9	19.7
4.2	29.7	26.3	22.3	17.3	13.2	12.8	12.3	15.7	18.5	22.7	24.0	26.5	20.1
4.3	35.1	32.9	28.2	22.3	15.8	14.9	14.3	18.8	22.0	28.0	29.7	33.6	24.6
4.4	29.0	26.7	23.3	18.9	14.0	12.7	13.1	15.9	18.9	22.6	25.1	27.1	20.6
4.5	29.6	27.3	22.9	18.4	14.2	13.2	13.8	16.4	20.2	22.5	26.0	27.0	20.9
4.6	31.5	28.7	23.6	18.5	14.1	12.3	12.8	10.2	20.3	26.0	28.1	29.7	21.8
4.7	28.7	25.5	21.0	16.6	12.6	12.2	12.9	15.5	18.5	24.0	24.8	26.5	19.9

large extent and the difference would amount to no more than 3 per cent[1].

The mean daily total of global energy $\bar{G}$ (Table 1) was obtained by summation over θ for the centre day of the month. That is

$$\bar{G} = \sum_{T_1}^{T_2} G(\theta). \tag{7}$$

Having obtained $G(\theta)$ by calculation from eqn (6), and $I(\theta)$ from eqn (2), it is possible to calculate from eqn (1) the diffuse radiation $D(\theta)$ which is specifically required in order to calculate the fluxes on an inclined plane. Such a plane receives only a certain fraction of radiation from the sky ($\approx\cos^2 \frac{1}{2}\epsilon$ of the diffuse radiation for instance, where ϵ is the angle of inclination of the plane) but this reduced flux is augmented by radiation reflected by the ground, i.e. by $(1-\cos^2 \frac{1}{2}\epsilon)A\ G(\theta)$ where A is the surface albedo. In the present work A has been assumed to be 0.2 and the surface to be a nonspecular reflector. The cases of interest here are that of a flat plate which sun tracks such that it is always normal to the beam (Table 4), and that of a flat

Table 5. Total global radiation on a north facing flat plate inclined at latitude angle (MJ m^{-2} d^{-1})

LOCATION	J	F	M	A	M	J	J	A	S	O	N	D	AVE
1.1	17.8	18.0	19.4	19.9	17.8	17.0	17.5	18.7	21.5	21.8	21.0	19.0	19.2
1.2	19.2	18.6	20.5	23.0	20.3	20.8	21.3	23.4	24.3	24.2	21.2	19.8	21.4
1.3	19.1	20.9	20.6	20.1	17.3	16.9	17.3	20.0	23.1	23.7	20.6	19.6	19.9
1.4	19.9	23.1	22.0	21.5	18.2	18.1	19.1	20.6	24.4	24.9	25.9	20.4	21.5
1.5	19.8	22.7	21.2	20.2	17.1	17.4	18.0	19.8	23.9	24.5	26.0	20.0	20.9
1.6	24.6	24.1	22.3	21.4	18.2	17.3	18.7	20.0	24.3	25.0	26.1	24.9	22.2
1.7	25.6	24.8	22.7	21.9	18.6	17.3	18.5	20.4	24.6	25.1	26.6	25.4	22.6
2.1	20.1	22.2	22.6	23.4	20.7	19.4	21.3	23.6	25.8	26.7	21.8	21.1	22.4
2.2	20.2	24.5	22.0	23.4	20.2	19.9	20.3	23.0	25.1	25.0	25.8	20.6	22.5
2.3	19.6	20.9	21.3	23.2	19.8	20.2	20.6	23.7	24.6	25.0	20.7	20.0	21.6
2.4	21.0	23.8	23.8	22.4	20.1	18.9	20.9	22.8	26.0	27.6	28.9	22.4	23.2
2.5	21.5	24.8	25.4	21.0	19.3	18.5	20.7	22.2	25.8	27.8	29.2	22.2	23.2
2.6	27.6	27.1	25.3	20.5	19.4	17.4	19.3	21.9	25.7	27.2	28.1	29.1	24.1
2.7	27.1	25.5	24.1	19.5	18.2	16.3	18.3	20.9	25.3	26.6	27.2	27.9	23.1
2.8	27.1	24.8	24.3	22.5	18.4	17.4	19.9	21.9	25.6	26.2	27.2	26.1	23.5
2.9	27.5	25.1	24.5	23.5	19.3	18.0	19.8	22.3	25.5	26.2	22.2	27.6	23.5
2.10	20.8	24.3	23.5	24.2	20.4	19.9	20.7	23.3	25.8	27.2	23.1	21.1	22.9
2.11	26.7	25.1	25.2	23.4	19.1	18.1	19.4	21.7	25.9	26.9	25.2	26.8	23.6
2.12	27.1	26.3	24.1	23.0	18.3	17.0	18.6	20.9	24.9	26.3	28.0	26.7	23.4
2.13	28.3	27.0	25.8	23.1	17.7	16.4	18.5	20.8	25.1	25.9	20.9	28.0	23.1
2.14	27.4	27.5	20.0	21.6	16.4	14.9	16.3	18.3	23.0	24.9	20.6	27.7	21.6
3.1	28.0	27.2	25.4	19.3	17.9	15.3	17.0	19.2	23.5	25.9	26.9	28.7	22.9
3.2	29.0	27.8	24.2	17.9	16.1	12.8	14.3	17.3	21.1	24.6	26.4	28.4	21.7
3.3	29.0	26.7	24.5	18.7	16.9	14.4	16.0	18.8	23.2	25.7	27.3	28.5	22.5
3.4	27.4	25.2	23.2	19.8	16.2	14.3	15.9	18.5	23.2	24.7	27.0	26.4	21.8
3.5	27.9	26.2	23.0	19.5	15.2	13.5	14.8	17.7	20.8	24.1	25.6	26.2	21.2
3.6	28.3	27.5	25.0	21.4	16.1	14.4	15.8	18.9	22.7	25.5	27.2	28.4	22.6
3.7	28.1	26.1	22.6	18.0	13.7	12.6	12.4	15.7	19.1	23.3	25.3	26.5	20.3
3.8	28.8	27.9	24.8	20.4	15.1	13.6	14.3	17.4	20.8	24.6	27.1	28.6	22.0
3.9	28.2	27.2	23.4	19.2	14.3	12.8	12.6	15.3	20.1	23.4	26.2	27.9	20.9
3.10	26.7	25.3	22.4	19.7	14.6	13.2	14.0	16.1	20.2	22.4	25.2	26.4	20.5
3.11	23.3	23.0	21.0	19.2	15.7	13.2	15.2	17.0	20.3	21.3	24.1	23.9	19.8
3.12	25.0	23.7	21.6	19.9	16.1	14.0	15.7	17.8	21.3	22.0	25.1	25.1	20.6
3.13	26.5	25.8	23.3	21.1	16.1	14.3	16.0	17.5	22.0	24.2	27.0	27.0	21.7
3.14	24.5	23.7	22.2	20.3	16.7	15.1	17.0	18.5	22.8	23.2	26.0	24.5	21.2
3.15	24.7	23.8	21.7	20.7	17.2	15.9	17.1	19.4	23.5	23.5	26.4	24.7	21.6
4.1	25.4	22.3	19.1	14.7	12.7	11.4	12.1	14.3	17.0	20.2	22.1	24.3	18.0
4.2	25.9	23.3	20.0	15.6	11.9	11.1	11.0	14.0	17.0	20.8	22.2	24.1	18.1
4.3	29.0	27.3	23.7	18.8	13.6	12.4	12.3	16.0	19.3	24.0	25.6	28.2	20.9
4.4	25.5	23.5	20.6	16.6	12.4	11.0	11.5	14.1	17.2	20.7	22.8	24.3	18.4
4.5	25.8	23.9	20.4	16.3	12.5	11.3	11.9	14.4	18.1	20.7	23.4	24.3	18.6
4.6	27.0	24.8	20.8	16.2	12.2	10.5	11.0	14.1	18.0	22.8	24.7	26.0	19.0
4.7	25.3	22.8	19.1	15.0	11.2	10.4	11.0	13.7	16.9	21.5	22.7	24.1	17.8

plate facing north but tilted at the latitude angle (Table 5). The formula for the instantaneous flux density $F(\theta)$ received by the suntracking plate is

$$F(\theta) = I(\theta) + D(\theta)\cos^2 \tfrac{1}{2}\epsilon + G(\theta) A (1 - \cos^2 \tfrac{1}{2}\epsilon). \tag{8}$$

The angle ϵ is equal to θ in this situation and the daily input was calculated by a summation similar to that for $\bar{G}$ in eqn (7). The formula for the instantaneous flux density $F_1(\theta)$ received by the north-facing flat plate is

$$F_1(\theta) = I(\theta)\cos\beta + D(\theta)\cos^2(\tfrac{1}{2}\Phi) + G(\theta) A [1 \cos^2(\tfrac{1}{2}\Phi)] \tag{9}$$

where again the total daily input was calculated by summation.

Cloud data

The present calculations use the cloud amounts at various levels recorded (generally) every 3 hr at the 43 mainland meteorological observing stations shown in Fig. 1. The stations have been numbered on the figure in four

Table 6. Direct beam radiation component on a north facing flat plate inclined at latitude angle (MJ m^{-2} d^{-1})

LOCATION	J	F	M	A	M	J	J	A	S	O	N	D	AVE
1.1	5.5	5.2	7.0	9.4	9.0	9.3	9.7	10.1	12.7	11.5	10.8	7.1	8.9
1.2	6.2	6.5	9.5	17.2	14.4	16.8	17.2	19.6	18.5	16.8	12.5	7.7	13.6
1.3	8.2	10.1	11.2	12.9	10.9	11.6	11.7	14.7	17.3	16.7	13.1	9.9	12.4
1.4	10.2	14.4	14.4	16.0	12.9	14.1	15.4	16.3	19.9	19.0	1-.1	12.0	15.3
1.5	9.8	13.5	12.9	14.0	11.3	13.3	13.9	15.1	19.1	18.2	19.0	10.7	14.2
1.6	15.8	16.1	15.0	16.6	13.5	13.5	15.4	15.8	20.3	19.0	19.1	16.1	16.4
1.7	17.8	17.6	15.9	17.5	14.3	13.7	15.2	16.4	20.9	19.3	20.2	17.2	17.2
2.1	9.5	11.4	14.7	19.1	16.9	16.0	18.7	21.0	22.6	22.4	16.8	13.7	16.9
2.2	9.8	14.5	13.2	19.2	16.1	16.8	16.9	20.0	21.1	19.1	19.7	10.9	16.4
2.3	6.8	8.6	11.4	18.5	14.6	16.9	16.8	20.8	19.5	18.3	12.1	8.1	15.1
2.4	12.9	14.3	16.7	17.3	16.3	15.7	18.7	20.0	23.1	24.0	25.1	16.3	18.4
2.5	15.2	16.8	20.2	14.6	15.1	15.1	18.3	19.0	22.8	24.1	25.6	16.4	18.6
2.6	21.5	21.6	20.5	14.5	15.5	13.9	16.7	19.1	22.9	23.0	22.8	23.8	19.7
2.7	20.1	18.6	18.4	13.2	13.8	12.5	15.3	17.7	22.2	21.8	20.6	21.2	18.0
2.8	20.2	17.3	18.8	18.0	14.1	14.0	17.8	19.1	22.8	21.2	21.0	18.0	18.5
2.9	21.5	18.5	19.1	19.9	15.3	14.6	17.4	19.6	22.6	21.4	22.2	21.6	19.5
2.10	13.0	16.5	16.9	21.0	16.6	17.2	18.3	20.9	22.8	22.7	23.1	13.7	18.6
2.11	19.3	17.4	19.9	19.6	14.7	14.5	16.6	18.5	23.0	22.1	25.2	19.5	19.2
2.12	20.0	19.7	18.2	19.3	14.2	13.4	15.8	17.6	21.7	21.0	22.3	18.5	18.5
2.13	22.2	21.1	21.3	19.5	13.4	12.8	15.9	17.6	22.1	20.3	20.9	21.1	19.0
2.14	19.3	21.8	18.3	17.5	12.1	11.1	12.9	13.9	18.6	17.8	20.6	18.9	16.9
3.1	21.5	21.9	21.0	13.2	14.1	11.4	13.7	15.2	19.4	20.4	19.8	22.2	17.8
3.2	22.9	22.8	19.0	11.8	11.9	8.5	10.3	12.8	15.7	18.1	18.8	21.3	16.2
3.3	23.0	20.8	19.4	12.7	12.8	10.4	12.4	14.8	19.0	19.9	19.8	21.0	17.2
3.4	20.1	17.9	17.0	14.2	11.5	10.2	12.2	14.2	18.9	17.9	19.5	17.3	15.9
3.5	20.6	19.9	17.1	14.4	10.7	9.5	11.1	13.5	15.3	17.0	17.1	16.8	15.3
3.6	21.2	21.8	20.1	17.1	11.4	10.5	12.3	15.1	18.3	19.3	1917	20.6	17.3
3.7	20.7	19.6	16.7	12.7	9.0	8.7	8.2	10.9	13.0	15.9	16.6	17.0	14.1
3.8	21.9	22.7	20.1	16.2	10.9	10.1	10.8	13.4	15.5	18.0	19.7	20.8	16.7
3.9	20.2	21.0	17.6	15.3	9.9	9.3	8.5	10.5	14.4	15.6	17.7	19.0	16.5
3.10	18.2	18.1	16.1	14.5	10.5	9.9	10.6	11.8	14.7	14.4	16.6	17.3	14.4
3.11	12.8	14.3	13.9	14.5	11.6	9.4	11.9	12.6	14.6	12.4	14.9	13.0	13.0
3.12	15.6	15.6	14.7	15.3	12.1	10.4	12.5	13.7	16.0	13.6	16.5	15.2	14.3
3.13	18.2	19.0	17.5	17.1	11.9	10.6	12.7	13.1	17.0	17.2	20.1	18.6	16.1
3.14	15.1	15.5	15.6	15.8	12.5	11.7	14.0	14.4	18.3	15.6	18.5	14.4	15.1
3.15	15.6	15.5	14.3	15.9	12.8	12.1	13.6	15.3	19.3	16.2	19.4	15.1	15.4
4.1	15.8	12.7	10.4	7.4	7.4	6.8	7.5	8.7	9.2	10.5	10.3	12.9	10.0
4.2	16.4	14.5	12.6	9.6	7.2	7.3	6.7	8.9	9.9	11.9	11.1	12.6	10.7
4.3	22.5	21.7	18.6	14.3	9.3	9.0	8.3	11.6	13.2	17.3	17.3	20.4	15.3
4.4	15.6	15.1	13.7	11.2	7.8	7.2	7.4	9.1	10.3	11.7	12.3	13.5	11.2
4.5	16.3	15.7	13.4	10.7	8.1	7.8	8.2	9.7	11.7	11.7	13.2	13.3	11.7
4.6	18.3	17.2	14.3	11.3	8.6	7.6	7.9	10.0	12.3	15.5	15.6	15.9	12.9
4.7	15.3	14.0	11.8	9.7	7.4	7.6	8.0	9.4	10.6	13.5	12.2	12.5	11.0

groups corresponding roughly to four climate zones. The observers record their estimates of the actual amount of cloud at each of four levels in the atmosphere as well as the total cloud cover. The information is available from the Bureau of Meteorology, and for the present purpose all data for 1965–69 inclusive were used and monthly means were extracted for each station. In order to calculate the ϕ_i required in eqn (6), a simple overlapping geometrical exercise leads to the formula

$$\phi_i = \phi_{Ti}\left(1 - \sum_{j=1}^{i-1} \phi_j\right), \tag{10}$$

where ϕ_{Ti} is the recorded total cloud amount at level i. There are objections to this procedure, but it is a good check that, averaged over a few days, the quantity $\sum_{1}^{4} \phi_i$ is generally very close to the average total cloud amount actually recorded by the observers.

It is of course true that an individual cloud report (of amount in eighths) may be quite inaccurate. However, the time and spatial averaging used in the present calculations involve so many observations that the essentially random error is reduced well below the possible error in the a_i.

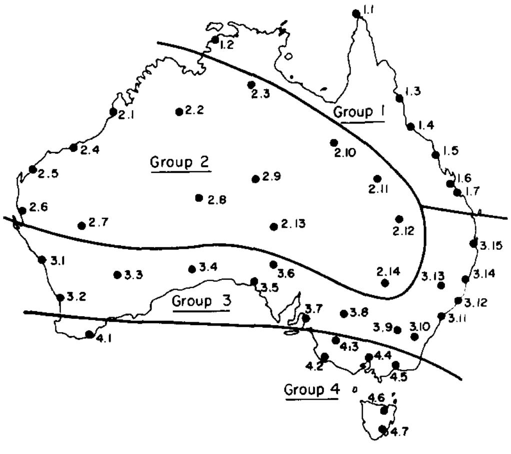

Fig. 1. Location of weather stations.

Comparison with observation

The Bureau of Meteorology's global radiation data are the only extensively available measurements in Australia. Table 7 compares the computed and observed monthly averages of global radiation for 12 widely dispersed sites about the continent. The difference between calculation and observation is never more than ±10 per cent except for the winter readings for Hobart where the daily total of incoming energy is only about 10 MJ m^{-2} day^{-1} because of its high latitude. The absolute difference for any month and any situation is rarely greater than 2 MJ m^{-2} day^{-1}. Furthermore the error is fairly random, so that the mean monthly difference for the 12 months reduces to 5 per cent or less for the worst stations and to about 1 per cent when all 12 stations are considered. Such accuracy of prediction is quite remarkable bearing in mind the crude nature of the observations on which the prediction is based.

Table 7. Comparison of predicted and measured global radiation input in (MJ m^{-2} d^{-1}) for 12 Australian stations for each month. The yearly means of the monthly differences (between prediction and measurement) for each station are quoted as a percentage beneath the station name

Horizontal		J	F	M	A	M	J	J	A	S	O	N	D	Av.Yr
Adelaide	Measured	24.97	22.61	18.05	13.33	9.95	7.93	8.94	11.81	16.87	19.57	23.28	25.14	16.87
+ 4.5%	Predicted	26.3	23.7	19.4	14.6	10.8	9.5	9.6	12.5	16.1	20.8	23.6	25.1	17.66
Alice Springs	Measured	26.73	25.44	23.85	19.31	15.67	14.76	16.01	19.87	22.94	25.10	26.23	26.35	21.79
- 1.2%	Predicted	26.2	23.8	22.4	20.4	16.3	14.9	16.2	18.8	22.5	24.3	26.1	26.4	21.53
Brisbane	Measured	25.33	23.06	20.22	15.88	12.47	11.53	12.47	15.12	18.71	22.11	24.76	25.14	18.90
+ 1.6%	Predicted	23.6	22.4	19.7	17.6	14.1	12.7	13.6	16.0	20.3	21.7	25.0	23.8	19.21
Canberra	Measured	25.89	23.28	18.51	14.42	11.02	8.63	9.54	12.72	17.83	21.12	24.87	26.69	17.85
- 1.5%	Predicted	25.1	23.0	19.2	15.1	11.1	9.6	10.2	12.5	16.7	20.0	23.5	25.0	17.58
Darwin	Measured	18.40	18.62	19.65	18.40	19.65	19.19	19.31	21.80	23.05	23.17	21.35	19.87	20.24
+ 5.0%	Predicted	20.4	19.8	20.1	22.1	19.4	19.6	20.0	22.2	23.5	23.7	23.5	21.4	21.31
Hobart	Measured	23.19	19.94	15.13	10.61	6.65	5.09	5.51	8.48	13.15	17.96	20.79	23.19	14.14
+ 5.9%	Predicted	23.5	20.4	16.1	11.6	8.1	6.9	7.5	10.0	13.7	18.7	21.0	22.8	15.03
Longreach	Measured	28.73	24.07	22.83	19.99	15.78	15.10	16.35	18.51	22.83	26.12	28.84	27.03	22.17
- 2.3%	Predicted	25.6	23.9	23.0	20.4	16.3	15.1	16.0	18.4	22.8	24.9	27.8	25.8	21.67
Melbourne	Measured	24.87	21.46	16.69	11.58	7.57	6.25	6.93	9.65	13.17	18.17	21.92	24.19	15.15
+ 4.9%	Predicted	24.0	21.3	17.6	13.3	9.5	8.2	8.6	11.1	14.5	18.6	21.4	23.1	15.93
Perth	Measured	27.25	25.21	20.67	14.88	10.56	9.43	10.33	13.63	17.60	22.48	26.57	28.84	18.91
+ 0.6%	Predicted	27.3	25.3	21.0	15.1	12.7	10.2	11.2	14.0	17.9	22.1	24.7	26.9	19.03
Port Hedland	Measured	27.59	24.76	25.21	19.99	15.10	16.47	17.72	21.01	23.62	26.80	28.73	29.30	23.02
- 4.1%	Predicted	24.8	22.9	22.3	20.2	17.5	16.1	17.8	19.9	23.5	25.8	27.5	27.0	22.11
Sydney	Measured	22.48	18.96	18.28	18.51	10.67	8.97	10.45	13.06	16.69	21.46	24.53	23.17	17.26
- 0.5%	Predicted	22.3	21.2	18.5	15.5	12.0	10.0	11.3	13.3	17.1	19.4	22.6	22.9	17.18
Townsville	Measured	21.69	20.55	20.10	18.62	16.13	15.78	16.35	19.42	23.73	23.73	25.66	25.44	20.60
+ 0.2%	Predicted	22.8	22.3	20.8	19.7	16.3	15.8	16.7	18.5	22.4	23.6	24.9	23.9	20.64

Table 8. Predicted monthly means (over 5 years) and actual measured monthly means of diffuse radiation at Melbourne for 7 successive years

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	
	9·9	8·4	6·9	5·4	4·5	3·8	4·1	5·0	6·8	9·0	10·5	10·9	PREDICTED
1967	7·85	5·87	4·68	4·21	4·50	2·77	3·35	4·75	4·82	7·02	7·27	7·99	MEASURED
1968	7·56	5·18	6·05	4·86	3·74	3·2	3·10	4·61	5·69	7·20	8·60	8·64	
1969	8·28	7·02	5·26	4·21	4·21	3·24	3·20	5·00	5·94	8·78	9·94	9·86	
1970	9·47	6·95	5·83	4·46	3·92	3·20	4·25	5·44	7·92	8·53	8·71	8·71	
1971	7·78	7·52	6·08	3·71	3·71	2·84	3·56	4·46	7·16	8·75	9·11	8·64	
1972	9·22	6·91	5·51	4·18	3·20	3·35	3·42	4·32	6·98	7·34	7·50	6·84	
1973	9·45	7·99	5·51	4·00	3·82	3·24	3·42	4·03	6·12	8·71	8·06	9·04	

Presumably the U-shaped distribution of cloud cover (i.e. a higher proportion of occasions of zero or eight eighths cloud cover than of some intermediate value) works towards ensuring a good answer.

The only station in Australia where long-term records of the global, diffuse and direct components of solar radiation are simultaneously available is at Aspendale, Victoria. Comparison of the monthly averages with prediction again show a fairly random error of the order of 2 MJ m^{-2} day^{-1} in each component.

The extent of the annual variability of the monthly average diffuse radiation (the most variable quantity on a percentage basis) can be gauged from Table 8, where the predicted monthly means are compared with the actual measured values over eight successive years in Melbourne. The extremes range ± 1 MJ m^{-2} day^{-1} from the mean. The annual variability of global radiation is roughly ± 10 per cent.

In summary it appears that, for time scales of a month or more, the accuracy of radiation prediction from normal meteorological cloud observations is of the same order as the accuracy of actual measurement. This last is recognized as no better than ± 5 per cent. On this basis it is difficult to justify very large-scale radiation monitoring networks unless the interest is definitely in radiation variations on a time-scale shorter than a month.

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APPENDIX. METEOROLOGICAL WEATHER STATIONS

1.1 Thursday Is.
1.2 Darwin
1.3 Cairns
1.4 Townsville
1.5 Mackay
1.6 Rockhampton
1.7 Gladston

2.1 Broome
2.2 Hall's Creek
2.3 Daly Waters
2.4 Port Hedland
2.5 Onslow
2.6 Carnarvon
2.7 Meekatharra
2.8 Giles
2.9 Alice Springs
2.10 Cloncurry
2.11 Longreach
2.12 Charleville
2.13 Oodnadatta
2.14 Cobar

3.1 Geraldton
3.2 Perth
3.3 Kalgoorlie
3.4 Forrest
3.5 Cedina
3.6 Woomera
3.7 Adelaide
3.8 Mildura
3.9 Wagga
3.10 Canberra
3.11 Sydney
3.12 Williamtown
3.13 Tamworth
3.14 Coff's Harbour
3.15 Brisbane

4.1 Albany
4.2 Mt Gambier
4.3 Nhill
4.4 Melbourne
4.5 Sale
4.6 Launcheston
4.7 Hobart

Resumen—A partir de una información detallada de la nubosidad se computaron tablas de parámetros de radiación media mensual. Los parámetros incluyen la incidencia de energía total diaria, tanto directa como global, en superficies horizontales, inclinadas y seguidoras del Sol. La comparación hecha con las mediciones de radiación global de 12 estaciones revelan virtualmente un error no sistemático de computación y en el peor de los casos de cualquier estación un error de 2MJ m^{-2} $día^{-1}$.

Résumé—Des tables de rayonnement solaire mensuel moyen ont été calculées à partir d'informations détaillées sur la couverture nuageuse. Les paramètres tiennent compte de l'énergie journalière directe et globale arrivant sur le plan horizontal, sur une surface de captation inclinée, ou sur une surface orientée vers le soleil. La comparison avec la mesure de la radiation globale pour 12 stations montre pratiquement l'absence d'erreur systématique dans le schéma de calcul, et une erreur de 2 MJ m^{-2} $jour^{-1}$ par moins dans le plus mauvais des cas pour chaque station.