



University of Denver

COLORADO SEMINARY

DENVER RESEARCH INSTITUTE UNIVERSITY PARK, DENVER, COLORADO 80210

7 January 1970

Dr. M. P. Thekaekara
National Aeronautics & Space Administration
Goddard Space Flight Center
Greenbelt, Md. 20771

Dear Dr. Thekaekara:

I am enclosing the sheet listing the various values of the solar constant with the weights assigned to the various determinations. I would like to take a little time to explain my reasons for the weights I assigned since it may help you in judging what weight to give my weights. I have rated the value of Drummond et al., at 8. The reason for not rating this value 10 is that the x-15 measurement was very short and really not of sufficient length to put much weight upon. The data obtained from aircraft altitude require corrections for a number of atmospheric effects including aerosol attenuation which our ascent data show to be definitely significant. Drummond makes no correction for aerosol and overcorrects for water vapor but ignores CO_2 , etc. In view of these questions concerning the corrections I think the weight placed on the determination has to be reduced. The GSFC - cone and Hy-Cal I assigned a weight of 4 partially because of the atmospheric correction but also because the instruments used in the measurement have not been as thoroughly studied as the conventional pyrheliometers and I am not certain of their calibrations. The GSFC Angstrom units I would weight at 8 and 7 again largely because of the uncertainty in atmospheric corrections. The JPL Mariner results I would weight at 0 because of the uncertainty of the scale used in the measurement. This would apply also to Willson's result. I don't think either value should carry any weight until the discrepancy between the values measured on the so-called cavity radiometer scale and those measured by the standard pyrheliometers have been resolved. All the other measurements have been based on the 1956 Pyrheliometer scale and I think it is not appropriate to include the results measured on a different scale. I would weight your result at 3 and the Ames result I would weight at 1 since I don't feel that any spectral measurement should be weighted as heavily as the total irradiance measurements. I would weight our results at 10. I am of course prejudiced but in addition I feel that the atmospheric corrections in our case are much more certain than from the aircraft and I also feel that our results reflect a very careful ground calibration and we have maintained this accuracy during flight. Kondratiev's results I would have to weight at zero because he keeps changing his value and it is very difficult to determine how carefully he calibrated his instrument, what he did during flight, etc.

Dr. M. P. Thekaekara
NASA, Goddard Space Flight Center

7 Jan. 1970

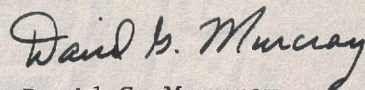
2.

I don't think the ground based observations and reviews should be considered at all since in most cases they have been normalized to some chosen value. I think the spectral results of these investigations should certainly be considered in considering the solar spectral irradiance but not in the total irradiance value.

I am not going to indicate any suggested changes in the spectral distribution through the visible region. Unfortunately the spectral irradiance changes rapidly with wavelength and hence the value depends very strongly on the resolution of the instrument used to make the measurements. This makes the comparison of experimental values obtained by different investigators very difficult and I think you are in a better position to weight your results in comparison with the others. I think the NASA 711 values should be corrected in accordance with Dr. Kostkowski's measurements.

I am enclosing a list of the various measurements which I have been able to find concerning the solar irradiance at the longer wavelengths. These values are given in terms of the temperature of the sun at these wavelengths. I do not have black body tables for these temperatures and wavelengths so I have not converted from black body temperature to solar irradiance since I assumed you might have suitable tables. If this is not the case, let me know and I will correct the values.

Yours sincerely,



David G. Murcray
Professor of Physics/
Sr. Research Physicist

dgm:hkw

Encl.

Value for same temperature
Computed by me.

IRRADIANCE AT EARTH DUE TO SUN

Brightness K	λ	Irradiance at Earth (watts/cm ² μ) ①	
5626 ± 100 M	4	8.828	8.89 × 10 ⁻⁴
5270 ± 150 M	5	3.566	3.42 × 10 ⁻⁴
5160 ± 40	8.63	4.433	4.51 × 10 ⁻⁵
5036 ± 30 506	11.1	1.636	1.64 × 10 ⁻⁵
5050 ± 80	12.02	1.206	1.23 × 10 ⁻⁵
4590 ± 110	20.	1.490	1.50 × 10 ⁻⁶
4370 ± 260	275.	4.270	4.29 × 10 ⁻¹¹
5550 ± 275 low	1000.	3.118	3.14 × 10 ⁻¹³

The Duncan Labs &
to Kenger / Needed

9.5 × 10 ⁻⁴	8.85
3.83 × 10 ⁻⁴	3.73 × 10 ⁻⁴
4.61 × 10 ⁻⁵	4.50 × 10 ⁻⁴
1.65 × 10 ⁻⁵	1.67 × 10 ⁻⁵
1.19 × 10 ⁻⁵	1.21 × 10 ⁻⁵
1.6 × 10 ⁻⁶	1.58 × 10 ⁻⁶

$$P = \frac{\sigma T^4 \times \pi r^2}{\pi \times A^2}$$
 where $r =$ radius of the solar disc = 6.960×10^{10} cm
 $A = AU = 1.497 \times 10^{13}$ cm
 $\sigma = 5.669 \times 10^{-12}$ W cm⁻² deg⁻⁴

T	P Wcm ⁻²
5626	.1245
5270	.0945
5160	.0869
5036	.0788
5050	.0797
4590	.0544
4370	.0447
5550	.1163
6000	.1588

① Computed by a grad. student. Interpolation
between adjacent temp. & λ on Planck's
Tables.



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15 January 1970

Dr. M. P. Thekaekara
NASA
Goddard Space Flight Center
Greenbelt, MD. 20771

Dear Dr. Thekaekara:

I am enclosing the page I forgot to include in my earlier letter. I am also including a sheet from an article by Skimabukuro and Stacey, *Astrophysical Journal*, Vol. 152, June 1968, which lists the published values for IR solar radiances. I have been almost totally unsuccessful in getting titles for the references. Our library does not have any of the referenced journals. The one I have found is Low, F. J. and Davidson, A. W., *Lunar Observations at a Wavelength of 1 Millimeter*, *Ap. J.* 143, 1278, and of course our paper "The Spectral Radiance of the Sun from 4μ to 5μ ", *Applied Optics*, Dec. 1964, 1373, F. H. Murcray, D. G. Murcray and W. J. Williams. I am sorry to be of so little help on these.

Yours sincerely,

David G. Murcray
Professor of Physics/
Sr. Research Physicist

dgm:hkw
Encl.

P.S. The 300μ result is included in a preprint by J. A. Eddy, P. J. Lena, R. M. MacQueen, "Far Infrared Measurements of the Solar Minimum Temperature".

11/4/54
MRS A 711

T	λ	λT	$c/\lambda T$	$e^{c/\lambda T}$	values H.P. 3/23	P_λ	$W/cm^2 \mu^{-1}$	↓
5626	4 μ	2.2504 $^{\circ}Kcm$.6390	1.89459	8.840	8.828×10^{-4}	8.89	9.5
5270	5	2.6350	.5457	1.72582	3.570	3.566×10^{-4}	3.42	3.83
5160	8.63	4.4531	.3229	1.38113	4.438	4.433×10^{-5}	4.51	
5036	11.1	5.5900	.2572	1.29330	1.638	1.636×10^{-5}	1.64	1.65
5050	12.02	6.0701	.2369	1.2673	1.1207	1.206×10^{-5}	1.23	1.20
4590	20	9.1800	.15664	1.16957	1.492	1.490×10^{-6}	1.50	1.6
4370	275	120.1750	.01197	1.01204	4.271×10^{-11}	4.270×10^{-11}	4.29	
5550	1000	555.0	.002590	1.00259	3.121×10^{-13}	3.118×10^{-13}	3.14	

$\pi = 3.1415926536$

Allen's value

r radius of the sun = 6.960×10^{10} cm 6.9598×10^{10}
 R distance of the earth from the sun = 1.497×10^{13} cm 1.495985×10^{13}
 $c_1 = 1.1909 \times 10^{-12}$ W cm² ster⁻¹ } Pivovonky to Nagel 1.19086×10^{-12}
 $c_2 = 1.4380$ cm^oK } 1.43879

$N_\lambda = \frac{2hc^2}{\lambda^5 (e^{c_2/\lambda T} - 1)}$ $\frac{c_1}{\lambda^5 (e^{c_2/\lambda T} - 1)}$ W cm⁻² per cm band per steradian

$P_\lambda = N_\lambda \frac{\pi r^2}{R^2}$ W cm⁻² per cm bandwidth at one astronomical unit.

Typical calculation $\lambda = 4 \mu$ $T = 5626^{\circ}K$ $\lambda T = 2.2504^{\circ}Kcm$
 $c_2/\lambda T = .6390$; $(e^{c_2/\lambda T} - 1) = 0.89459$

$P_\lambda = \frac{\pi r^2 c_1}{R^2 \lambda^5 (e^{c_2/\lambda T} - 1)} = \frac{3.1416 \times 6.96 \times 10^{20} \times 1.1909 \times 10^{-12}}{1.497^2 \times 10^{26} \times (4 \times 10^{-4})^5 \times 0.89459} = \frac{181.2 \times 10^2}{2052.9}$
 $= 8.828 \times 10^{-2}$ W cm⁻² cm⁻¹ = 8.828×10^{-2} W cm⁻² μ ⁻¹

$\frac{\pi r^2}{R^2} c_1 = 8.09747512 \times 10^{-17}$ $P_\lambda = \frac{\pi r^2}{R^2} c_1 \frac{1}{\lambda^5 (e^{c_2/\lambda T} - 1)}$

Power on

H P 9100A calculator

Program at hand

(Program 10 A)

$$T = 5.626 \times 10^3$$

Point at
Set Floating

$$\lambda = 4 \times 10^4$$

Press Clear

$$4.42 \times 10^{-81} \text{ W cm}^{-2} = .442 \text{ mW cm}^{-2}$$

Press Go To

between 4 & 4.5

134.38

Press 0

134.00

Press 0

 .38

Insert Card

press enter

press Go To

press 0

press 0

press Continue See 1.

enter T 5.626

press enter exp.

enter 3

press ↑

enter λ 4

press enter exp

4

—

Continue

$$8.839577 \times 10^0$$

Continue for another set of values

Table I Mercury

Proposed Values of the Solar Constant (mW cm^{-2})

Source	Value of the Solar Constant mW cm^{-2}	Estimated error $\pm \text{mW cm}^{-2}$	Relative weight to be given 0 to 10
High altitude measurements			
Eppley - JPL, NASA 711, X-15, Drummond <u>et al</u>	P_i 136.0	0.2	w_i 8
GSFC - NASA 711 - Cone	135.8	2.4	4
GSFC - NASA 711 - Hy-Cal	135.2	2.2	4
GSFC - NASA 711 - \AA - 6618	$\frac{\sum P_i w_i}{\sum w_i} = 134.96$ 134.3	2.6	8
GSFC - NASA 711 - \AA - 7635	134.9	4.0	7
GSFC - NASA 711 Average - Throckmora <u>et al</u> .	135.1	2.8	3
JPL Mariner - Plamondon	135.3	2.0	0
Ames NASA 711 - Carey 14 - Arvesen <u>et al</u> .	139.0	2.8	1
U of Denver - Balloon - Murray <u>et al</u> .	133.8	0.6	10
USSR U of Leningrad - Balloon - Kondratyev (Letter 4-15-69)	136.0		0
JPL - Balloon - Willson	139.0	0.6	0
Ground based measurements and Revisions of earlier values			
NRL - Mt Lemmon and Smithsonian - Johnson	139.5	2.8	0
AFCRL - Review - Gast	139.0		0
NBS - Mauna Loa - 3100-5300 \AA - Stein + Ellis	136.0	6.8	0
Germany - Jungfrau joch 3300-12500 \AA - Labs and Neckel	136.5	2.7	0
USSR U. of Moscow - Revision - Makarova and Kharitonov	141.8	3.5	0