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DETERMINATION OF DESIGN METEOROID MASS FOR A SPORADIC AND STREAM METEOROID ENVIRONMENT

by Donald J. Kessler and Robert L. Patterson

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SUMMARY

Meteor influx rates vary throughout the year, and, accordingly, the hazard to spacecraft changes. The total meteor activity can be represented as a fairly constant sporadic background with periods of increased activity associated with meteor streams. For a given probability of impact, the design meteoroid mass is a function of the meteoroid flux, the exposed area, and the time spent in the environment. A method is developed to compute the design mass for exposure to a specified meteoroid environment.

INTRODUCTION

Meteor activity during the course of a year varies considerably, with reasonably well defined, periodically recurring peaks. When the shower or stream meteors are separated from the total activity, the sporadic or background meteor activity is found to remain fairly constant. Thus, the sporadic activity can be presented as an annual average value. Individual stream activity is characterized by an increase to a maximum followed by a period of decay. When the periods of activity of a number of streams coincide, a curve of activity as a function of time becomes a complex curve. An example of the stream activity from October to December is illustrated in figure 1.

The probability of encountering the design meteoroid mass or size is a function of the meteoroid flux, the exposed area, and the time spent in the environment. For the assumed time-invariant sporadic flux, it is a simple matter to compute the design mass, but for the time-variable stream flux, the calculation becomes more complicated. This paper presents a generalized method for determining the design meteoroid mass.

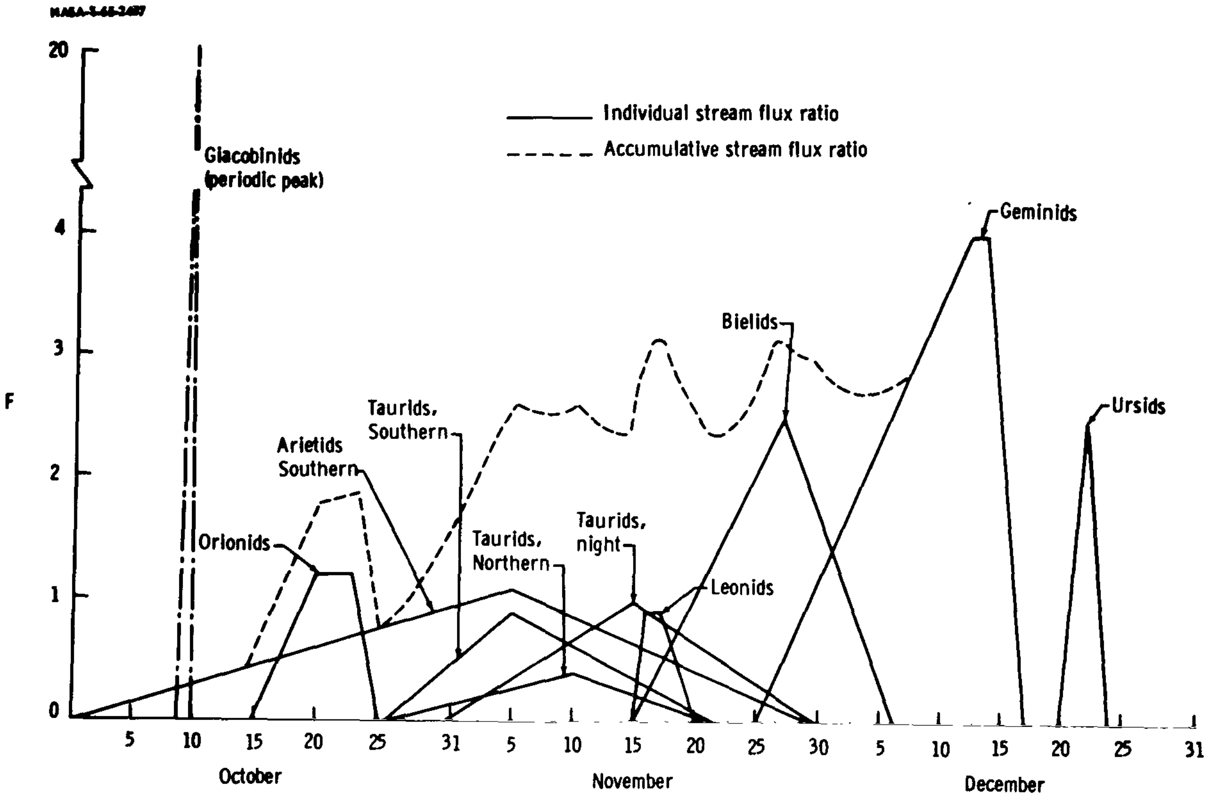


Figure 1. - Ratio of accumulative meteoroid stream flux to the sporadic meteoroid flux for masses $\geq 10^{-2}$ grams

SYMBOLS

A	exposed area, A_{total} (1 - planetary shielding factor), sq ft
F	stream-to-sporadic flux ratio
m	meteoroid mass, grams
N	cumulative flux, number/ft^2-day of masses $\geq$ m
n	number (for example, number of concurrent streams)
P_o	probability of not encountering a particle of mass $\geq$ m
t	time
V	average velocity of the meteoroid stream, km/sec
α	meteoroid flux-mass constant
τ	spacecraft exposure time, days

μ defined in equation (13)

Subscripts:

sp sporadic meteoroids

st meteoroid streams

σ streams and sporadics

Superscripts:

β, δ exponents of variables in flux-mass relation

THEORY

The probability P_o of not being hit by a particle of mass m, or larger, in time τ on an exposed area A is given in reference 1 as

$$P_o = e^{-NA\tau} \tag{1}$$

The meteoroid stream flux equation of reference 2 can be written in general form as

$$\log_{10} N = - \beta \log_{10} m - \delta \log_{10} V + \log_{10} \alpha + \log_{10} F$$

or as

$$N = m^{-\beta} V^{-\delta} \alpha F \tag{2}$$

Combining equations (1) and (2) and assuming the special case that F is a constant throughout the time interval τ

$$P_o = e^{-\left(m^{-\beta} V^{-\delta} \alpha F A \tau\right)} \tag{3}$$

In general, however, F is a function of time t, and equation (3) in logarithmic form becomes

$$\log_e P_o = - m^{-\beta} V^{-\delta} \alpha A \int_{t_1}^{t_2} F(t) dt \tag{4}$$

If t_1 is 0, the elapsed time $t_2 - t_1$, or τ as previously defined, is numerically equal to t_2. Solving for m^β and rewriting the limits of the integration

$$m^\beta = \frac{-V^{-\delta}\alpha A}{\log_e P_o} \int_0^\tau F(t)dt \tag{5}$$

To illustrate the effect on the design mass m of various time dependent flux distributions $F(t)$, consider

$$\frac{-V^{-\delta}\alpha A}{\log_e P_o} = k$$

then,

$$m^\beta = k \int_0^\tau F(t)dt \tag{5a}$$

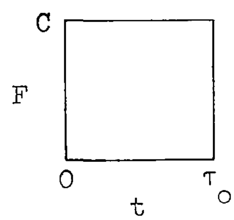
The following examples are idealized flux distributions for a period of stream activity τ_o.

The first case is for a constant flux C throughout the exposure time

$$F = C \qquad \left(0 \le t \le \tau_o\right)$$

$$m^\beta = k \int_0^{\tau_o} C\ dt$$

$$m^\beta = kC\left(\tau_o\right)$$



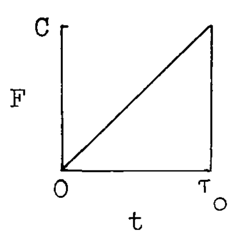
Case 1

For the second case of F varying linearly from 0 to C at $t = \tau_o$,

$$F = \frac{C}{\tau_o} t \qquad \left(0 \le t \le \tau_o\right)$$

$$m^\beta = k \int_0^{\tau_o} \frac{C}{\tau_o}\ t\ dt$$

$$m^\beta = kC\left(\frac{\tau_o}{2}\right)$$

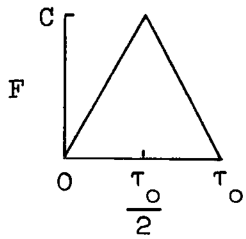


Case 2

In the third case, F increases linearly from 0 to C at $t = \frac{\tau_o}{2}$ and then decreases to 0 at $t = \tau_o$

$$F = \frac{2C}{\tau_o} t \qquad \left(0 \le t \le \frac{\tau_o}{2}\right)$$

$$F = 2C\left(1 - \frac{t}{\tau_o}\right) \qquad \left(\frac{\tau_o}{2} \le t \le \tau_o\right)$$



Case 3

$$m^\beta = k\int_0^{\frac{\tau_o}{2}} \frac{2Ct}{\tau_o}\, dt + k\int_{\frac{\tau_o}{2}}^{\tau_o} 2C\left(1 - \frac{t}{\tau_o}\right) dt$$

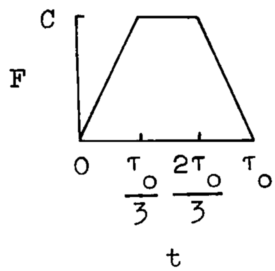
$$m^\beta = kC\left(\frac{\tau_o}{2}\right)$$

In the fourth case,

$$F = \frac{3Ct}{\tau_o} \qquad \left(0 \le t \le \frac{\tau_o}{3}\right)$$

$$F = C \qquad \left(\frac{\tau_o}{3} \le t \le \frac{2\tau_o}{3}\right)$$

$$F = 3C\left(1 - \frac{t}{\tau_o}\right) \qquad \left(\frac{2\tau_o}{3} \le t \le \tau_o\right)$$



Case 4

$$m^\beta = k\int_0^{\frac{\tau_o}{3}} \frac{3Ct}{\tau_o}\, dt + k\int_{\frac{\tau_o}{3}}^{\frac{2\tau_o}{3}} C\, dt + \int_{\frac{2\tau_o}{3}}^{\tau_o} 3C\left(1 - \frac{t}{\tau_o}\right) dt$$

$$m^\beta = kC\,\frac{2\tau_o}{3}$$

The preceding integrations are based on the assumption that the exposure includes the entire stream period τ_o. However, if the time of exposure τ is less than τ_o, the design mass could be expressed as a function of τ/τ_o. This has been done for each of the preceding cases, and the result is shown in figure 2, where a design mass of 1 is the value for case 1 and $\tau = \tau_o$. Thus, the relative severity of various types of idealized distributions has been established.

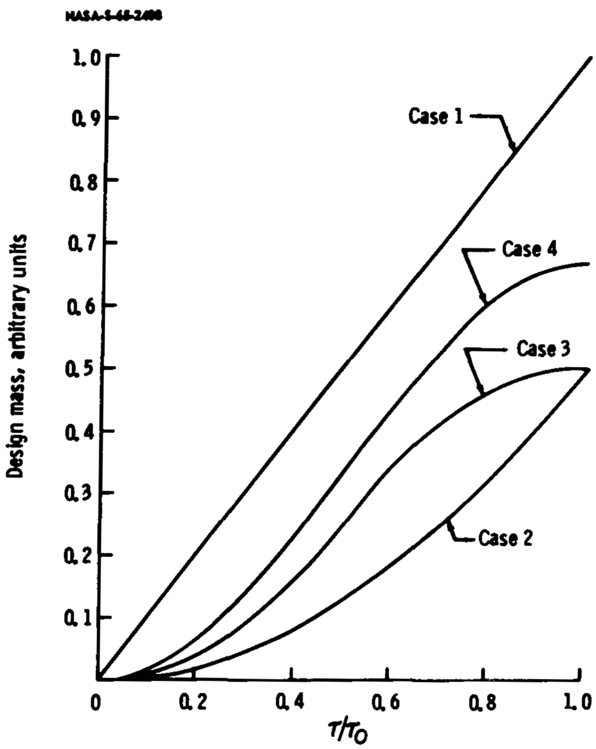


Figure 2. - Design mass as a function of τ/τ_o for various stream distributions

APPLICATION: STREAM METEOROIDS

The flux equation for stream meteoroids from reference 2 is

$$N = \frac{m^{-1.34} V^{-2.68} F}{2.92 \times 10^6} \tag{6}$$

Substituting equation (6) into equation (1)

$$m^{1.34} = \frac{-AV^{-2.68} F\tau}{2.92 \times 10^6 \log_e P_o} \tag{7}$$

When the stream to sporadic flux ratio is time dependent, equation (7) must be written as

$$m^{1.34} = \frac{-A\ V^{-2.68}}{2.92 \times 10^6 \log_e P_o} \int_{t_1}^{t_2} F(t)dt \tag{8}$$

From equation (8), the design mass may be determined for any stream as a function of time for a given A and P_o. However, several streams may be active at the same time, and it is desirable to determine the design mass for the exposure to all active streams. If n different streams are active simultaneously, the effect on the design mass in equation (8) would be a change in F(t) and V so that

$$m^{1.34} = \frac{-\ A}{2.92 \times 10^6 \log_e P_o} \left(V_1^{-2.68} \int_{t_1}^{t_2} F_1(t)dt + \ldots + V_n^{-2.68} \int_{t_1}^{t_2} F_n(t)dt \right) \tag{9}$$

Equation (9) can be simplified as follows:

$$m^{1.34} = m_1^{1.34} + \ldots + m_n^{1.34} \tag{10}$$

Consider next the design mass for a single stream as being summed over several time increments, that is

$$m^{1.34} = \frac{-A\ V^{-2.68}}{2.92 \times 10^6 \log_e P_o} \int_{t_1}^{t_2} F(t)dt + \int_{t_2}^{t_3} F(t)dt + \ldots + \int_{t_{n-1}}^{t_n} F(t)dt \tag{11}$$

or simply

$$\sum_{k=1}^{n} \left(m_{t_k, t_{k+1}}\right)^{1.34} = \left(m_{t_1, t_2}\right)^{1.34} + \left(m_{t_2, t_3}\right)^{1.34} + \ldots + \left(m_{t_n, t_{n+1}}\right)^{1.34} \tag{12}$$

This equation may be used to determine a design mass using the design masses for shorter time increments. For example, if $\left(m_{t_1, t_2}\right)^{1.34}$ is the design mass to the 1.34th power for staying in the environment from the first day to the beginning of the second day, and $\left(m_{t_2, t_3}\right)^{1.34}$ is the design mass for exposure from the second to the third day, then

$$m^{1.34} = \left(m_{t_1, t_2}\right)^{1.34} + \left(m_{t_2, t_3}\right)^{1.34}$$

is the design mass to the 1.34th power for exposure to 2 consecutive days.

Using the generalities expressed in equations (10) and (12), it is possible to construct a table where $m^{1.34}$ would be calculated for each day and each stream of reference 2. Then, in order to determine the design mass for several days, $m^{1.34}$ for each stream and each day's exposure could be added together and the 0.746th power taken of the sum. This is the basis for table I, with the parameter μ defined as follows:

$$m^{1.34} = \mu \left(\frac{-\ A}{\log_e P_o}\right) \tag{13}$$

The equation for computing the values of μ of table I is derived by solving equations (13) and (8) for μ.

$$\mu_{st} = \frac{\int_{t_1}^{t_2} F(t)dt}{2.92 \times 10^6 \ V^{2.68}} \tag{14}$$

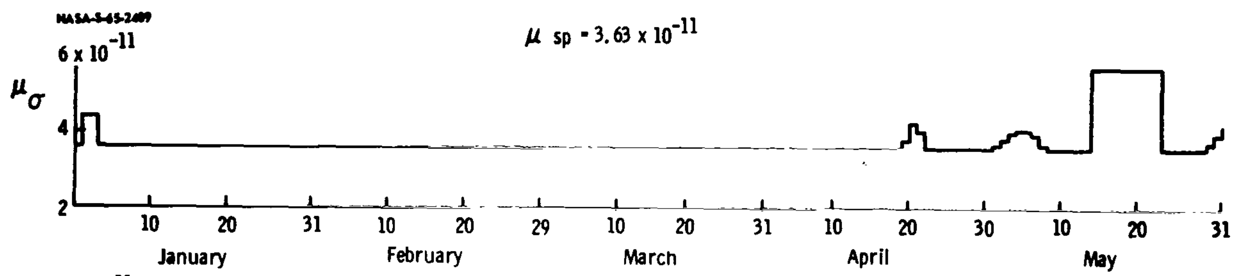
When n meteoroid streams and the sporadic meteoroid background are combined, the design mass is defined as follows:

$$m_\sigma = \left(\mu_\sigma \frac{-A}{\log_e P_o}\right)^{0.746} \tag{15}$$

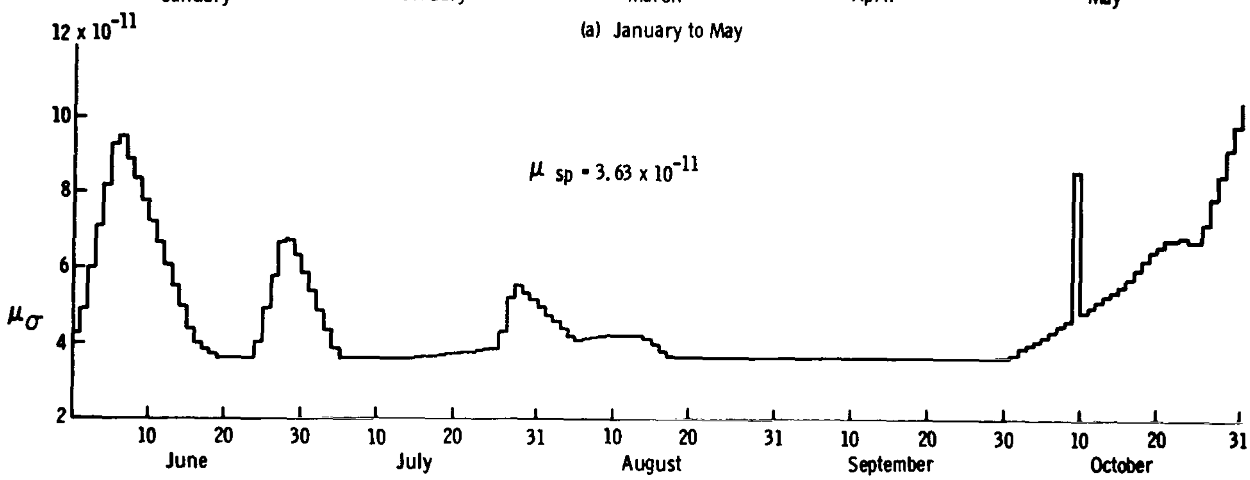
where

$$\mu_\sigma = \mu_{sp} + \sum \mu_{st}$$

Table I includes the values μ_{st} and $\sum \mu_{st}$ for the meteoroid streams throughout the year for an exposure time of 1 day, beginning on the date shown. The F values used from reference 2 are for masses $\geq 10^{-2}$ grams. Plots of μ_σ for any day of the year where $\mu_{sp} = 3.63 \times 10^{-11}$ are presented in figure 3.

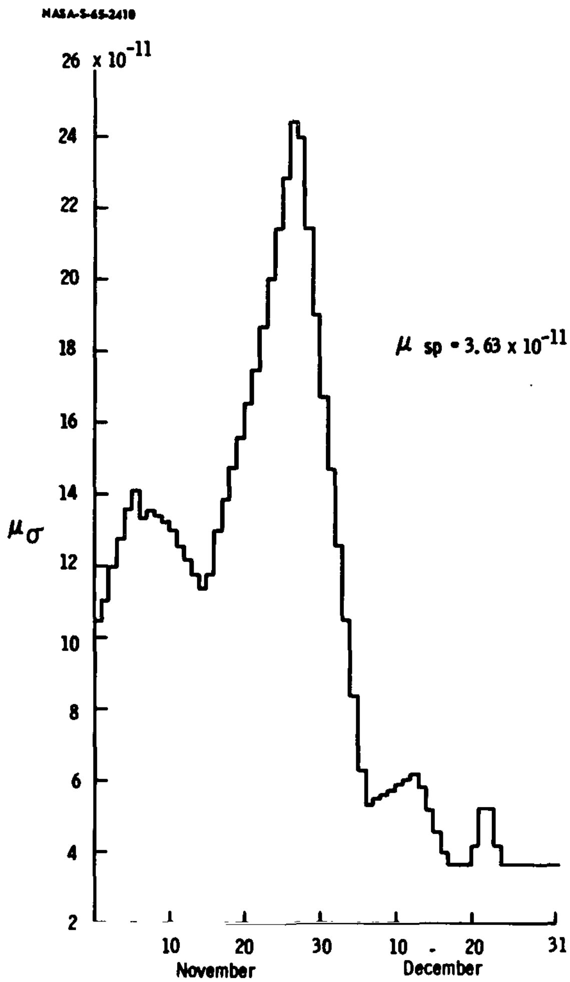


(a) January to May



(b) June to October

Figure 3. - Design mass area probability parameter



(c) November and December
Figure 3. - Concluded.

To illustrate the computations of the design mass, consider the period from November 25 to November 27 for an exposed spacecraft area of 500 sq ft and $P_o = 0.9999$. The factor μ_σ for the 3 days in question is, from figure 3(c),

$$\mu_\sigma = (22.8 + 24.4 + 23.9) \times 10^{-11}$$

$$= 71.1 \times 10^{-11}$$

and from equation (15)

$$m_\sigma = \left(71.1 \times 10^{-11} \frac{-A}{\log_e P_o}\right)^{0.746}$$

$$m_\sigma = 1.46 \times 10^{-2} \text{ gram}$$

A computer program, more flexible than the method presented in the text, has been prepared to compute the critical mass for various spacecraft exposures. This program permits the use of a monthly sporadic flux variation and the use of stream flux ratios other than those of reference 2.

CONCLUDING REMARKS

A time-variable meteoroid flux, consisting of a sporadic and stream environment, produces a correspondingly variable design mass for the same mission duration throughout the year. The relative severity of various types of idealized flux distributions has been illustrated, and a general method has been developed to compute the design mass. The method proposed is suitable for solution with a computer program, and as the meteoroid flux becomes better defined the program could be easily altered. A question of considerable importance is whether the stream flux distribution varies with the mass; if it does, the analysis may be applicable only within the size range of the flux observations.

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2. Burbank, Paige B.; Cour-Palais, Burton G.; and McAllum, William E.: A Meteoroid Environment for Near-Earth, Cislunar, and Near-Lunar Operations. NASA TN D-2747, 1965.

Manned Spacecraft Center
National Aeronautics and Space Administration
Houston, Texas, March 8, 1965

TABLE I.- METEOROID FLUX PARAMETER

Date of activity	Stream (a)	μ_{st}	$\Sigma\ \mu_{st}$
Jan. 2	(Quadrantids)		0.76×10^{-11}
Jan. 3			.76
Apr. 19	Lyrids		0.23×10^{-11}
Apr. 20			.64
Apr. 21			.45
May 1	η-Aquarids		0.08×10^{-11}
May 2			.25
May 3			.41
May 4			.49
May 5			.49
May 6			.37
May 7			.12
May 14	O-Cetids		2.15×10^{-11}
May 15			2.15
May 16			2.15
May 17			2.15
May 18			2.15
May 19			2.15
May 20			2.15
May 21			2.15
May 22			2.15
May 29	Arietids		0.12×10^{-11}
May 30			.37
May 31			.62

[a]Streams in parentheses do not have yearly activity.

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
June 1	Arietids	0.87×10^{-11}	
	ζ-Perseid	.41	1.29×10^{-11}
June 2	Arietids	1.12×10^{-11}	
	ζ-Perseid	1.24	2.36×10^{-11}
June 3	Arietids	1.37×10^{-11}	
	ζ-Perseids	2.06	3.43×10^{-11}
June 4	Arietids	1.62×10^{-11}	
	ζ-Perseids	2.89	4.51×10^{-11}
June 5	Arietids	1.87×10^{-11}	
	ζ-Perseids	3.72	5.59×10^{-11}
June 6	Arietids	1.92×10^{-11}	
	ζ-Perseids	3.92	5.84×10^{-11}
June 7	Arietids	1.77×10^{-11}	5.27×10^{-11}
	ζ-Perseids	3.50	5.27
June 8	Arietids	1.61×10^{-11}	
	ζ-Perseids	3.09	4.70×10^{-11}
June 9	Arietids	1.46×10^{-11}	
	ζ-Perseids	2.68	4.14×10^{-11}

TABLE I. - METEOROID FLUX PARAMETERS - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
June 10	Arietids	1.31×10^{-11}	
	ζ-Perseids	2.27	3.58×10^{-11}
June 11	Arietids	1.15×10^{-11}	
	ζ-Perseids	1.86	3.01×10^{-11}
June 12	Arietids	1.00×10^{-11}	
	ζ-Perseids	1.44	2.44×10^{-11}
June 13	Arietids	0.85×10^{-11}	
	ζ-Perseids	1.03	1.88×10^{-11}
June 14	Arietids	0.69×10^{-11}	
	ζ-Perseids	.62	1.31×10^{-11}
June 15	Arietids	0.54×10^{-11}	
	ζ-Perseids	.21	0.75×10^{-11}
June 16	Arietids		0.38×10^{-11}
June 17			.23
June 18			.08
June 24	β-Taurids		0.43×10^{-11}
June 25			1.29
June 26			2.15
June 27			3.01
June 28			3.19

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma\ \mu_{st}$
June 29	β-Taurids		2.70×10^{-11}
June 30			2.21
July 1			1.72
July 2			1.23
July 3			.74
July 4			.25
July 15	Perseids		0.01×10^{-11}
July 16			.03
July 17			.06
July 18			.08
July 19			.10
July 20			.12
July 21			.15
July 22			.17
July 23			.19
July 24			.21
July 25			.24
July 26	Perseids	0.26×10^{-11}	
	δ-Aquarids	.43	0.69×10^{-11}
July 27	Perseids	0.28×10^{-11}	
	δ-Aquarids	1.30	1.58×10^{-11}
July 28	Perseids	0.30×10^{-11}	
	δ-Aquarids	1.63	1.93×10^{-11}

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
July 29	Perseids δ-Aquarids	0.33×10^{-11} 1.41	1.74×10^{-11}
July 30	Perseids δ-Aquarids	0.35×10^{-11} 1.19	1.54×10^{-11}
July 31	Perseids δ-Aquarids	0.37×10^{-11} .98	1.35×10^{-11}
Aug. 1	Perseids δ-Aquarids	0.39×10^{-11} .76	1.15×10^{-11}
Aug. 2	Perseids δ-Aquarids	0.42×10^{-11} .54	0.96×10^{-11}
Aug. 3	Perseids δ-Aquarids	0.44×10^{-11} .33	0.77×10^{-11}
Aug. 4	Perseids δ-Aquarids	0.46×10^{-11} .11	0.57×10^{-11}
Aug. 5	Perseids		0.48×10^{-11}
Aug. 6			.50
Aug. 7			.53
Aug. 8			.55
Aug. 9			.57
Aug. 10			.58

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream (a)	μ_{st}	$\Sigma\ \mu_{st}$
Aug. 11	Perseids		0.58×10^{-11}
Aug. 12			.58
Aug. 13			.58
Aug. 14			.51
Aug. 15			.36
Aug. 16			.22
Aug. 17			.07
Oct. 1	Arietids, Southern		0.06×10^{-11}
Oct. 2			.19
Oct. 3			.32
Oct. 4			.45
Oct. 5			.58
Oct. 6			.71
Oct. 7			.86
Oct. 8			.97
Oct. 9	Arietids, Southern	1.10×10^{-11}	
	(Giacobinids)	3.84	4.94×10^{-11}
Oct. 10	Arietids, Southern		1.23×10^{-11}
Oct. 11			1.36
Oct. 12			1.49
Oct. 13			1.62
Oct. 14			1.75

[a]Streams in parentheses do not have yearly activity

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
Oct. 15	Arietids, Southern	1.88×10^{-11}	
	Orionids	.05	1.93×10^{-11}
Oct. 16	Arietids, Southern	2.01×10^{-11}	
	Orionids	.14	2.15×10^{-11}
Oct. 17	Arietids, Southern	2.12×10^{-11}	
	Orionids	.23	2.35×10^{-11}
Oct. 18	Arietids, Southern	2.27×10^{-11}	
	Orionids	.32	2.59×10^{-11}
Oct. 19	Arietids, Southern	2.40×10^{-11}	
	Orionids	.41	2.81×10^{-11}
Oct. 20	Arietids, Southern	2.53×10^{-11}	
	Orionids	.45	2.98×10^{-11}
Oct. 21	Arietids, Southern	2.66×10^{-11}	
	Orionids	.45	3.11×10^{-11}
Oct. 22	Arietids, Southern	2.79×10^{-11}	
	Orionids	.45	3.24×10^{-11}
Oct. 23	Arietids, Southern	2.92×10^{-11}	
	Orionids	.34	3.26×10^{-11}

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma\ \mu_{st}$
Oct. 24	Arietids, Southern	3.05×10^{-11}	
	Orionids	.11	3.16×10^{-11}
Oct. 25	Arietids, Southern	3.18×10^{-11}	3.18×10^{-11}
Oct. 26	Arietids, Southern	3.31×10^{-11}	
	Taurids, North	.05	
	Taurids, South	.20	3.56×10^{-11}
Oct. 27	Arietids, Southern	3.44×10^{-11}	
	Taurids, North	.16	
	Taurids, South	.61	4.11×10^{-11}
Oct. 28	Arietids, Southern	3.57×10^{-11}	
	Taurids, North	.28	
	Taurids, South	1.02	4.87×10^{-11}
Oct. 29	Arietids, Southern	3.70×10^{-11}	
	Taurids, North	.39	
	Taurids, South	1.43	5.52×10^{-11}
Oct. 30	Arietids, Southern	3.83×10^{-11}	
	Taurids, North	.50	
	Taurids, South	1.84	6.17×10^{-11}

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
Oct. 31	Arietids, Southern	3.96×10^{-11}	
	Taurids, North	.61	
	Taurids, South	2.25	6.82×10^{-11}
Nov. 1	Arietids, Southern	4.08×10^{-11}	
	Taurids, North	.72	
	Taurids, South	2.66	
	Taurids, Night	.08	7.54×10^{-11}
Nov. 2	Arietids, Southern	4.22×10^{-11}	
	Taurids, North	.83	
	Taurids, South	3.07	
	Taurids, Night	.23	8.35×10^{-11}
Nov. 3	Arietids, Southern	4.35×10^{-11}	
	Taurids, North	.94	
	Taurids, South	3.48	
	Taurids, Night	.38	9.15×10^{-11}
Nov. 4	Arietids, Southern	4.48×10^{-11}	
	Taurids, North	1.05	
	Taurids, South	3.88	
	Taurids, Night	.54	9.95×10^{-11}

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
Nov. 5	Arietids, Southern	4.45×10^{-11}	
	Taurids, North	1.16	
	Taurids, South	3.96	
	Taurids, Night	.69	10.26×10^{-11}
Nov. 6	Arietids, Southern	4.27×10^{-11}	
	Taurids, North	1.27	
	Taurids, South	3.72	
	Taurids, Night	.84	9.71×10^{-11}
Nov. 7	Arietids, Southern	4.08×10^{-11}	
	Taurids, North	1.38	
	Taurids, South	3.48	
	Taurids, Night	1.00	10.10×10^{-11}
Nov. 8	Arietids, Southern	3.90×10^{-11}	
	Taurids, North	1.49	
	Taurids, South	3.24	
	Taurids, Night	1.15	9.78×10^{-11}
Nov. 9	Arietids, Southern	3.72×10^{-11}	
	Taurids, North	1.60	
	Taurids, South	3.00	
	Taurids, Night	1.31	9.63×10^{-11}

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
Nov. 10	Arietids, Southern	3.54×10^{-11}	
	Taurids, North	1.58	
	Taurids, South	2.76	
	Taurids, Night	1.46	9.34×10^{-11}
Nov. 11	Arietids, Southern	3.36×10^{-11}	
	Taurids, North	1.45	
	Taurids, South	2.52	
	Taurids, Night	1.61	8.94×10^{-11}
Nov. 12	Arietids, Southern	3.18×10^{-11}	
	Taurids, North	1.31	
	Taurids, South	2.28	
	Taurids, Night	1.77	8.54×10^{-11}
Nov. 13	Arietids, Southern	3.00×10^{-11}	
	Taurids, North	1.17	
	Taurids, South	2.04	
	Taurids, Night	1.92	8.13×10^{-11}
Nov. 14	Arietids, Southern	2.82×10^{-11}	
	Taurids, North	1.03	
	Taurids, South	1.80	
	Taurids, Night	2.08	7.73×10^{-11}

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream (a)	μ_{st}	$\Sigma \mu_{st}$
Nov. 15	Arietids, Southern	2.63×10^{-11}	
	Taurids, North	.89	
	Taurids, South	1.56	
	Taurids, Night	2.08	
	(Leonids)	.16	
	(Bielids)	.84	8.16×10^{-11}
Nov. 16	Arietids, Southern	2.45×10^{-11}	
	Taurids, North	.76	
	Taurids, South	1.32	
	Taurids, Night	1.94	
	(Leonids)	.32	
	(Bielids)	2.52	9.31×10^{-11}
Nov. 17	Arietids, Southern	2.27×10^{-11}	
	Taurids, North	.62	
	Taurids, South	1.08	
	Taurids, Night	1.79	
	(Leonids)	.27	
	(Bielids)	4.21	10.24×10^{-11}
Nov. 18	Arietids, Southern	2.08×10^{-11}	
	Taurids, North	.48	
	Taurids, South	.84	
	Taurids, Night	1.65	
	(Leonids)	.16	
	(Bielids)	5.89	11.10×10^{-11}

[a]Streams in parentheses do not have yearly activity.

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream (a)	μ_{st}	$\Sigma \mu_{st}$
Nov. 19	Arietids, Southern	1.90×10^{-11}	
	Taurids, North	.34	
	Taurids, South	.60	
	Taurids, Night	1.50	
	(Leonids)	.05	
	(Bielids)	7.57	11.96×10^{-11}
Nov. 20	Arietids, Southern	1.72×10^{-11}	
	Taurids, North	.21	
	Taurids, South	.36	
	Taurids, Night	1.36	
	(Bielids)	9.26	12.91×10^{-11}
Nov. 21	Arietids, Southern	1.54×10^{-11}	
	Taurids, North	.07	
	Taurids, South	.12	
	Taurids, Night	1.22	
	(Bielids)	10.90	13.85×10^{-11}
Nov. 22	Arietids, Southern	1.36×10^{-11}	
	Taurids, Night	1.08	
	(Bielids)	12.60	15.04×10^{-11}
Nov. 23	Arietids, Southern	1.18×10^{-11}	
	Taurids, Night	.93	
	(Bielids)	14.30	16.41×10^{-11}

[a]Streams in parentheses do not have yearly activity

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream (a)	μ_{st}	$\Sigma \mu_{st}$
Nov. 24	Arietids, Southern Taurids, Night (Bielids)	1.00×10^{-11} .79 16.00	17.79×10^{-11}
Nov. 25	Arietids, Southern Taurids, Night (Bielids) Geminids	0.82×10^{-11} .64 17.70 .07	19.23×10^{-11}
Nov. 26	Arietids, Southern Taurids, Night (Bielids) Geminids	0.63×10^{-11} .50 19.40 .22	20.75×10^{-11}
Nov. 27	Arietids, Southern Taurids, Night (Bielids) Geminids	0.45×10^{-11} .36 19.10 .37	20.28×10^{-11}
Nov. 28	Arietids, Southern Taurids, Night (Bielids) Geminids	0.27×10^{-11} .21 16.80 .51	17.79×10^{-11}

[a]Streams in parentheses do not have yearly activity.

TABLE I.- METEOROID FLUX PARAMETER - Continued

Date of activity	Stream (a)	μ_{st}	$\Sigma \mu_{st}$
Nov. 29	Arietids, Southern	0.09×10^{-11}	
	Taurids, Night	.07	
	(Bielids)	14.60	
	Geminids	.66	15.42×10^{-11}
Nov. 30	(Bielids)	12.30×10^{-11}	
	Geminids	.81	13.11×10^{-11}
Dec. 1	(Bielids)	10.10×10^{-11}	
	Geminids	.96	11.06×10^{-11}
Dec. 2	(Bielids)	7.85×10^{-11}	
	Geminids	1.10	8.95×10^{-11}
Dec. 3	(Bielids)	5.61×10^{-11}	
	Geminids	1.25	6.86×10^{-11}
Dec. 4	(Bielids)	3.36×10^{-11}	
	Geminids	1.40	4.76×10^{-11}
Dec. 5	(Bielids)	1.12×10^{-11}	
	Geminids	1.54	2.66×10^{-11}

[a] Streams in parentheses do not have yearly activity.

TABLE I.- METEOROID FLUX PARAMETER - Concluded

Date of activity	Stream	μ_{st}	$\Sigma \mu_{st}$
Dec. 6	Geminids		1.69×10^{-11}
Dec. 7			1.84
Dec. 8			1.98
Dec. 9			2.13
Dec. 10			2.28
Dec. 11			2.42
Dec. 12			2.50
Dec. 13			2.19
Dec. 14			1.56
Dec. 15			.94
Dec. 16			.31
Dec. 20	Ursids		0.54×10^{-11}
Dec. 21			1.61
Dec. 22			1.61
Dec. 23			.54

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