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ASL-DUST: A TACTICAL BATTLEFIELD DUST CLOUD AND PROPAGATION CODE
VOLUME 2 - USER'S MANUAL

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CONTENTS

Accession For	
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Justification	
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or special
A	23

LIST OF FIGURES	5
TABLE	6
SECTION	
1 INTRODUCTION	7
2 THE COMPUTER ROUTINES	9
General Information	9
Coordinate System	9
Executive Routine	9
INPUT	11
PGROUP	11
CGROUP	12
CROSS	12
MIE	15
ANF	21
CUMNOR	21
INITG	22
TIMECO	23
TIMECG	23
PATH	24
DEPTH	24
ADDVEC	25
SUBVEC	26
MULVEC	26
DOTVEC	26
DSTVEC	26
3 INPUT	27
General Information	27
Description of the Input Cards	28
A Card	31
B Card	32
C Card	33
D Card	34
E Card	34
F Card	35

Contents (cont)

	G Card	37
	H Card	37
	I Card	37
	J Card	38
	K Card	39
	L Card	39
	M Card	40
SECTION		
4	SAMPLE PROBLEM	41
5	CODE LISTING	69
	Executive Routine	70
	INPUT	74
	PGROUP	83
	CGROUP	96
	CROSS	102
	MIE	110
	ANF	114
	CUMNDR	116
	INITG	117
	TIMECO	121
	TIMECG	124
	PATH	129
	DEPTH	137
	ADDVEC	143
	SUBVEL	144
	MULVEC	145
	DOTVEC	146
	DSTVEC	147
	REFERENCES	148

LIST OF FIGURES

1	Coordinate system	11
2	Input card parameters	29
3	Default values for input parameters	30
4	Input cards for sample problem	42
5	ASL-DUST output	43

TABLE

1	ASL-DUST computer routines	10
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SECTION 1 INTRODUCTION

A wide variety of electro-optical (E-O) sensors are employed in the modern tactical battlefield environment. Dust clouds are generated when tactical munitions detonate at or below the ground surface. These dust clouds can be a major source of degradation for the battlefield performance of the E-O sensors. References 1 and 2 present models which have been developed for the munitions dust clouds and the propagation of E-O signals through the clouds. ASL-DUST is the computer program for these dust cloud and propagation models.

This volume, the User's manual for ASL-DUST, discusses the computer subroutines and the input-output parameters, and provides a sample problem. A listing of the code is given in the appendix.

ASL-DUST is written in Fortran IV and is comprised of about 4,500 cards. There are many comment cards to aid the programmer in understanding the internal workings of each routine. Approximately 28K of storage is required. A typical case with one dust cloud, one sight path, and eight calculation times takes about a third of a second on a CDC 7600 computer.

The inputs to the code are the burst parameters, transmitter-receiver parameters, soil and carbon parameters including size distribution and index of refraction, meteorological conditions, size groups of particulates, and the calculation times. The code first calculates the Mie propagation parameters (extinction, absorption, scattering, and backscatter mass coefficients) for each size group, for each particulate material, and for each frequency. Then at each calculation time the code finds the dust cloud position and spatial

mass distribution. The code integrates the mass penetrated within each particulate size group along each sight path (the path between each transmitter-receiver pair). Applying the previously calculated Mie propagation parameters, the code then computes the transmission of each signal along its sight path.

SECTION 2

THE COMPUTER ROUTINES

GENERAL INFORMATION

ASL-DUST is organized into an executive (main) program and a set of subroutines. The modular organization of the code is designed for maximum user flexibility. The user who wishes to modify some model parameter can do so by modifying the appropriate subroutine or by simply substituting his own subroutine. Moreover, many of the routines are complete within themselves and can be lifted and used for other purposes. For instance, the Mie routines form a complete detailed Mie calculation code.

This section briefly describes each of the eighteen ASL-DUST routines. Table 1 summarizes their major functions. More information concerning the detailed logical organization of the routines may be obtained from the listings of the Fortran source programs presented in the appendix. The method of preparing the inputs for ASL-DUST is discussed in Section 3.

COORDINATE SYSTEM

A three-dimensional Cartesian coordinate system is used. The x and y axes are horizontal and the z axis is the vertical direction (see Figure 1). Azimuths in the horizontal plane are measured clockwise from the y axis.

EXECUTIVE ROUTINE

This routine controls the sequence of operations for ASL-DUST. The routine first sets the tape numbers for input-output and the default values for the input quantities. It then reads the input for the first problem by calling INPUT. Next, the Mie propagation

TABLE 1. ASL-DUST COMPUTER ROUTINES

Name of Routine	Function
Executive Routine	Control program. Determines sequence of operations.
INPUT	Reads and writes the input quantities.
PGROUP	Control program for calculating the Mie propagation coefficients for each size group, for each particulate material, and for each frequency.
CGROUP	Performs preliminary Mie propagation coefficient calculations; sets up input for CROSS.
CROSS	Integrates over the size group.
MIE	Provides Mie efficiencies and scattering pattern for a single uniform spherical particle.
ANF	Evaluates a complex function used in Mie.
CUMNOR	Computes the cumulative function of the normal random probability distribution.
INITG	Evaluates the initial ($t = 0+$) properties of the dust clouds.
TIMECO	Determines the location and dimensions of the ideal massless size group.
TIMECG	Determines the location and dimensions of a given size group in the dust clouds.
PATH	Integrates the dust cloud mass density along each sight path.
DEPTH	Computes optical depths along each sight path. Prints output results.
ADDVEC	Adds two three-vectors together.
SUBVEC	Subtracts two three-vectors.
MULVEC	Multiplies a three-vector by a scalar.
DOTVEC	Scalar (dot) product of two three-vectors.
DSTVEC	Computes the distance between end points of two three-vectors.

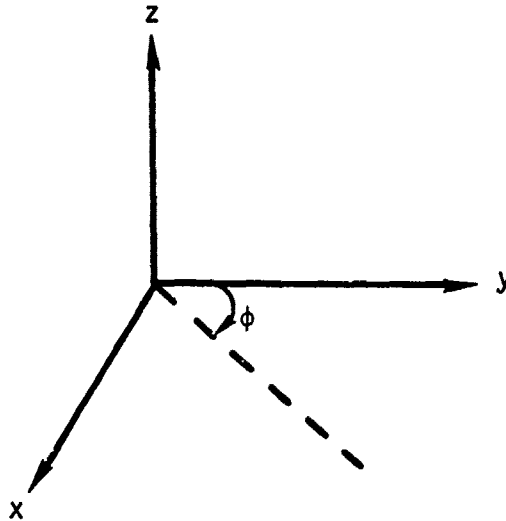


Figure 1. Coordinate system.

coefficients for each particulate material, size group, and frequency are calculated and stored by calling PGROUP. The initial ($t = 0+$) properties of the dust clouds from each burst are found by a call to INITG. Then for each calculation time and for each burst, the mass distribution of each size group is found by calls to TIMECO and TIMECG. For each sight path a call to PATH computes the group mass penetrated. A call to DEPTH then computes the optical depth along each sight path. After all calculations are complete the output is written out; the program then begins again by reading the input for the next problem.

INPUT

This routine reads the input quantities for each problem. After all input is read, the routine writes out the input data.

PGROUP

This is the control routine for calculation of the Mie propagation coefficients for each size group, each particulate material, and each frequency. The primary Mie parameters are the extinction, absorption, and scattering cross sections and mass coefficients averaged over a

size group. The routine first calculates the Mie propagation coefficients for each size group assuming that there is no mixing of particulates from other size groups. The size groups are ordered by size, beginning with the smallest. The coefficients for each group are calculated in turn until the extinction contribution of the present size group becomes negligible; the remaining larger size groups are not calculated and their coefficients are set equal to zero. This neglect of the insignificant size groups saves computing time. After all significant size groups are calculated, the routine then writes out the unmixed propagation coefficient results.

The routine then recomputes the mass fractions and propagation coefficients in each size group by assuming a mixture of particle sizes. The mixing model is given in the fractionization section of Reference 2. The routine then writes out the mixed propagation coefficient results.

CGROUP

This routine does some preliminary Mie propagation calculations for a given size group. It sets up the input to routine CROSS.

CROSS

This routine evaluates the size group mean Mie propagation coefficients by integrating over the particle size probability distribution. CROSS calls routine MIE to evaluate the coefficients at a particular integrand point.

A new variable step length algorithm has been developed for the integration over particle sizes. The algorithm accounts for the rate of change of integrand magnitude with step length and the contribution of the step to the total integral. A rapidly changing integrand requires smaller steps, while a portion of the integral that contributes little to the total can be calculated with larger steps. The algorithm is designed to produce maximum accuracy with minimum computational time.

The equations solved in the routines are the following. The mean cross section per particle is

$$\bar{\sigma} = \frac{\int_{a_1}^{a_2} \frac{\pi a^2}{4} Q(a) P(a) da}{\int_{a_1}^{a_2} P(a) da} \quad \text{cm}^2 \text{ per particle} \quad , \quad (1)$$

where

- $\bar{\sigma}$ = average cross section per particle for scattering, backscatter, absorption, or extinction (cm^2)
- a = particle diameter (cm)
- a_1 = minimum diameter of particle size group (cm)
- a_2 = maximum diameter of particle size group (cm)
- $Q(a)$ = Mie efficiency for scattering, backscatter, absorption, or extinction for a particle of diameter a
- $P(a)$ = size probability distribution (log normal, power law, or hybrid).

The normalized scattering pattern is

$$S_N(\theta) = \frac{1}{\bar{\sigma}_{\text{SCA}}} \int_{a_1}^{a_2} \frac{\pi a^2}{4} Q_{\text{SCA}}(a) P(a) S(\theta, a) da \quad , \quad (2)$$

where

- $\bar{\sigma}_{\text{SCA}}$ = average cross section per particle for scattering, given in Equation 1 (cm^2)
- $Q_{\text{SCA}}(a)$ = Mie efficiency for scattering
- $S(\theta, a)$ = normalized scattering pattern at scattering angle for a single particle of diameter a
- $S_N(\theta)$ = normalized scattering pattern for the size group.

The scattering patterns are normalized so that

$$\frac{1}{4\pi} \int_{4\pi} S(\theta) d\Omega = 1 \quad . \quad (3)$$

Hence an isotropic scattering pattern is identically equal to unity for all angles. The mass coefficient per gram of material in the size group is

$$\mu = N_T \bar{\sigma} \quad \text{cm}^2 \text{ g}^{-1} \quad , \quad (4)$$

where

μ = mass coefficient for scattering, backscatter, absorption, or extinction ($\text{cm}^2 \text{ g}^{-1}$)

N_T = total number of particles per gram of material in the size group (g^{-1}).

The integration strategy is the following:

$$I_T = \int_{a_1}^{a_2} I(a) da = \sum_{j=1}^n \int_{a_j}^{a_{j+1}} I(a) da \quad , \quad (5)$$

where

$I(a)$ = integrand of the integral of interest.

The interval from a_1 to a_2 is broken up into a number of subintervals. For each subinterval we assume that the integrand can be described by a power law,

$$I(a) = I(a_j) \left(\frac{a}{a_j} \right)^x \quad a_j \leq a \leq a_{j+1} \quad (6)$$

where

$$x = \frac{\ln \frac{I(a_{j+1})}{I(a_j)}}{\ln \frac{a_{j+1}}{a_j}} \quad . \quad (7)$$

Then the contribution to the total integral of this subinterval is

$$\Delta I_T = \int_{a_j}^{a_{j+1}} I(a) da \quad (8)$$

$$= \begin{cases} \frac{I(a_j)a_j}{x+1} \left[\left(\frac{a_{j+1}}{a_j} \right)^{x+1} - 1 \right] & x \neq -1 \\ I(a_j)a_j \ln \frac{a_{j+1}}{a_j} & x = -1 \end{cases} .$$

The contributions of the subintervals are calculated and summed until either

- (1) the diameter limits of the size group interval are reached, or
- (2) the integral converges to its final value (the remaining unsummed subintervals are negligible).

The step size is chosen as the e-folding distance for the integrand:

$$(\Delta a)_j = a_{j+1} - a_j = a_j \left[e^{\frac{1}{|x|}} - 1 \right] . \quad (9)$$

With this step size,

$$I(a_{j+1}) = I(a_j) e^{\pm 1} , \quad (10)$$

where the plus sign is for positive x and the negative sign is for negative x . In addition, for those cases where the integrand is decreasing so that the subinterval contributions are decreasing, the step size is increased. The increase is taken as the ratio of the previous contribution to the last contribution:

$$(\Delta a)_j = a_j \left[e^{\frac{1}{|x|}} - 1 \right] \frac{(\Delta I_T)_{j-1}}{(\Delta I_T)_{j-2}} \quad \text{if} \quad \frac{(\Delta I_T)_{j-1}}{(\Delta I_T)_{j-2}} > 1 . \quad (11)$$

MIE

This routine calculates the Mie efficiencies and scattering pattern for a given uniform spherical particle. This routine and its slave routine ANF were originally developed by the author for the WOE code, Reference 3. For completeness and reader convenience, the documentation is reproduced here.

We first present the formulas for the Mie solution (see any standard text for a derivation) and then the method used to solve the equations. Define the following quantities:

r = radius of the uniform sphere

λ = wavelength of the incident radiation

$\alpha = 2\pi r/\lambda$

= dimensionless size parameter

$m = m_R - im_I$

= complex index of refraction of the sphere (note that here we are using m instead of n , since by custom n is used as the order in the Mie formulas)

$Y = m\alpha$

σ_{SCA} = scattering cross section of the sphere

σ_{ABS} = absorption cross section of the sphere

$Q_{SCA} = \sigma_{SCA}/\pi r^2$

= scattering efficiency of the sphere

$Q_{ABS} = \sigma_{ABS}/\pi r^2$

= absorption efficiency of the sphere

$Q_{EXT} = Q_{ABS} + Q_{SCA}$

= extinction efficiency

$S(\theta)$ = scattering function. $S(\theta) d\Omega$ is the fraction of the incident unpolarized energy per unit area that is scattered into solid angle $d\Omega$, which is centered about the direction that makes an angle θ with the direction of the incident radiation (θ is the scattering angle).

The equations for the Mie solution are:

$$Q_{SCA} = \frac{2}{\alpha^2} \sum_{n=1}^{\infty} (2n+1) \left[|a_n|^2 + |b_n|^2 \right] \quad (12)$$

$$Q_{EXT} = \frac{2}{\alpha^2} \sum_{n=1}^{\infty} (2n+1) \operatorname{Re} (a_n + b_n) \quad (13)$$

(where Re signifies the real part of)

$$S(\theta) = \frac{1}{2} \left(\frac{\lambda}{\pi} \right)^2 \left\{ |S_1(\theta)|^2 + |S_2(\theta)|^2 \right\} \quad , \quad (14)$$

where

$$a_n = \frac{\alpha \Psi'_n(Y) \Psi_n(\alpha) - Y \Psi'_n(\alpha) \Psi_n(Y)}{\alpha \Psi'_n(Y) \xi_n(\alpha) - Y \xi_n(\alpha) \Psi_n(Y)} \quad (15)$$

$$b_n = \frac{Y \Psi'_n(Y) \Psi_n(\alpha) - \alpha \Psi'_n(\alpha) \Psi_n(Y)}{Y \Psi'_n(Y) \xi_n(\alpha) - \alpha \xi_n(\alpha) \Psi_n(Y)} \quad (16)$$

$$S_1(\theta) = \sum_{n=1}^{\infty} \frac{2n+1}{n(n+1)} \left\{ a_n \pi_n(\cos \theta) + b_n \tau_n(\cos \theta) \right\} \quad (17)$$

$$S_2(\theta) = \sum_{n=1}^{\infty} \frac{2n+1}{n(n+1)} \left\{ b_n \pi_n(\cos \theta) + a_n \tau_n(\cos \theta) \right\} \quad (18)$$

and

$$\Psi_n(z) = \left(\frac{\pi z}{2} \right)^{1/2} J_{n+1/2}(z) \quad (19)$$

$$\xi_n(z) = \left(\frac{\pi z}{2} \right)^{1/2} \left[J_{n+1/2}(z) + i(-1)^n J_{-n-1/2}(z) \right] \quad (20)$$

$$\pi_n(\cos \theta) = P'_n(\cos \theta) \quad (21)$$

$$\tau_n(\cos \theta) = \cos \theta \pi_n(\cos \theta) - \sin^2 \theta \frac{d}{d \cos \theta} \pi_n(\cos \theta) \quad . \quad (22)$$

The J's are spherical Bessel functions of complex argument and half-integer order. The P's are Legendre polynomials. Ψ and ξ are Riccati-Bessel functions, and π and τ are associated Legendre polynomials. Define an arbitrarily oriented plane containing the scattering sphere

and the incident radiation. Then for scattered radiation within the plane, the complex amplitude function $S_1(\theta)$ describes the scattering for an incident plane wave with vertical polarization (E perpendicular to the scattering plane); $S_2(\theta)$ is for horizontal polarization (E parallel to the scattering plane).

As might be expected from the complexity of the Mie equations, the numerical evaluation of Q_{SCA} , Q_{EXT} , and $S(\theta)$ for a given m and α is not, in general, a trivial task. The terms in the infinite series have to be evaluated and summed. The number of terms that have to be evaluated before the series converge depends primarily upon the size parameter α . Roughly, the number of Mie terms required is 1.5α ; for large particles and small wavelengths, several hundred terms are often required before convergence.

The evaluation of the various orders of ξ_n , π_n , and τ_n is straight forward. We can use the well known recurrence relations of Bessel functions and Legendre polynomials to obtain

$$\xi_n(\alpha) = \frac{2n-1}{\alpha} \xi_{n-1}(\alpha) - \xi_{n-2}(\alpha) \quad , \quad (23)$$

with initial values

$$\xi_0(\alpha) = \sin \alpha + i \cos \alpha \quad (24)$$

$$\xi_{-1}(\alpha) = \alpha - i \sin \alpha \quad (25)$$

$$\pi_n(\cos \theta) = \frac{2n-1}{n-1} \cos \theta \pi_{n-1}(\cos \theta) - \frac{n}{n-1} \pi_{n-2}(\cos \theta) \quad (26)$$

$$\begin{aligned} \tau_n(\cos \theta) = & \cos \theta \left[\pi_n(\cos \theta) - \pi_{n-2}(\cos \theta) \right] \\ & - (2n-1) \sin^2 \theta \pi_{n-1}(\cos \theta) + \tau_{n-2}(\cos \theta) \quad . \quad (27) \end{aligned}$$

The initial values are

$$\pi_0(\cos \theta) = 0 \quad (28)$$

$$\tau_0(\cos \theta) = 0 \quad (29)$$

$$\pi_1(\cos \theta) = 1 \quad (30)$$

$$\tau_1(\cos \theta) = \cos \theta \quad (31)$$

$$\pi_2(\cos \theta) = 3 \cos \theta \quad (32)$$

$$\tau_2(\cos \theta) = 3 \cos (2\theta) \quad (33)$$

With the initial values, we can use the forward recurrence relations to generate the required terms to any order. The forward recursion technique for these three functions is stable and accurate.

To complete our numerical evaluation, we define the complex function

$$A_n(Y) = \frac{\psi'(Y)}{\psi(Y)} \quad (34)$$

With this definition, the Mie formulas for a_n and b_n can be written

$$a_n = \frac{\left(\frac{A_n(Y)}{m} + \frac{n}{\alpha}\right) \operatorname{Re} \left\{ \xi_n(\alpha) \right\} - \operatorname{Re} \left\{ \xi_{n-1}(\alpha) \right\}}{\left(\frac{A_n(Y)}{m} + \frac{n}{\alpha}\right) \xi_n(\alpha) - \xi_{n-1}(\alpha)} \quad (35)$$

$$b_n = \frac{\left(m A_n(Y) + \frac{n}{\alpha}\right) \operatorname{Re} \left\{ \xi_n(\alpha) \right\} - \operatorname{Re} \left\{ \xi_{n-1}(\alpha) \right\}}{\left(m A_n(Y) + \frac{n}{\alpha}\right) \xi_n(\alpha) - \xi_{n-1}(\alpha)} \quad (36)$$

The primary difficulty in evaluating the Mie formulas lies in the evaluation of $A_n(Y)$. Using the properties of the Bessel functions, we can write $A_n(Y)$ as

$$A_n(Y) = -\frac{n}{Y} + \frac{J_{n-1/2}(Y)}{J_{n+1/2}(Y)} \quad (37)$$

Thus, if we can evaluate the Bessel functions, say by forward recursion, $A_n(Y)$ can be evaluated. Alternately, we can use the recurrence relations for the ratios of the Bessel functions and write the recursion equation for $A_n(Y)$ itself as

$$A_n(Y) = -\frac{n}{Y} + \left(\frac{n}{Y} - A_{n-1}(Y)\right)^{-1} \quad (38)$$

with initial condition

$$A_0(Y) = \frac{\cos Y}{\sin Y} \quad (39)$$

The forward recursion technique for the evaluation of $A_n(Y)$ is very susceptible to error in at least four cases (Reference 4):

- When the argument is small
- When the argument is large, requiring a large number of orders
- When the imaginary value is larger than the real value
- For certain anomalous values.

The use of forward recursions to generate the consecutive orders of Bessel functions is a classic example of unstable numerical methods.

Many other techniques have been devised to generate the required Bessel functions or ratios. Most techniques involve some type of backward recursion. The values of the Bessel functions or the ratios are evaluated at a high order, and the backward recursion relation is used to evaluate the lower orders. The backward recursion does not have the instability of the forward method. However, care must be taken to preserve accuracy; some techniques lose accuracy even when using double precision arithmetic. Recently Lentz (Reference 4) has developed an algorithm for evaluating the Bessel functions and ratios that eliminates the weaknesses of the earlier methods. Lentz's algorithm uses a new technique of evaluating continued fractions that starts at the beginning rather than the tail and has a built-in error check. Using the method, any $A_n(Y)$ can be generated completely

independently of all preceding values with high accuracy. Readers are referred to Lentz's article for details.

We use Lentz's method to generate $A_n(Y)$ for n of order $\approx 1.5\alpha$ and then use the backward recursion relationship,

$$A_{n-1}(Y) = \frac{n}{Y} - \left(\frac{n}{Y} + A_n(Y) \right)^{-1}, \quad (40)$$

to generate all lower orders. Using the forward recursion relations for the other functions, the a_n and b_n are calculated and infinite series summed until convergence. In almost all cases, convergence is reached before reaching the highest precomputed order of $A_n(Y)$. Otherwise Lentz's method is used to generate any additional needed terms.

Utilizing the Lentz algorithm, we have written a very compact computer routine that evaluates the exact Mie equations for Q_{SCA} , Q_{EXT} (and thus Q_{ABS}), and $S(\theta)$. The running time is quite reasonable for an exact calculation. For $\alpha = 1.2$, three orders are required for convergence, and the running time is 1 millisecond on a CDC 7600 computer. For $\alpha = 100$, 103 orders are required with a running time of 25 milliseconds.

ANF

ANF is a slave routine to MIE. ANF uses Lentz's method (Reference 4) to evaluate the complex function $A_n(Y)$ of Equation 37.

CUMNOR

This routine evaluates the following function:

$$\text{CUMNOR}(X) = \begin{cases} F(x) & x \leq 0 \\ 1 - F(x) & x \geq 0 \end{cases} \quad (41)$$

where

$$F(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x e^{-\frac{1}{2}t^2} dt \quad (42)$$

= cumulative probability of the standardized normal random probability distribution.

To numerically evaluate CUMNOR(X) we use the approximation formulas of Reference 5. For $|x|$ less than 5 we use the polynomial approximation formula 26.2.17, and for $|x| \geq 5$ we use the asymptotic approximation formula 26.2.24.

For $-5 < x < 5$,

$$\text{CUMNOR}(X) = 1 - \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \left[b_1 z + b_2 z^2 + b_3 z^3 + b_4 z^4 + b_5 z^5 \right] \quad (43)$$

where

$$z = \frac{1}{1 + p|x|}$$

$$p = 0.2316419$$

$$b_1 = 0.319581530$$

$$b_2 = -0.356563782$$

$$b_3 = 1.781477937$$

$$b_4 = -1.821255978$$

$$b_5 = 1.530274429$$

The error in this approximation is less than 7.5×10^{-8} . For $|x| \geq 5$,

$$\text{CUMNOR}(X) = \left[\frac{\sqrt{4 + x^2} - |x|}{2} \right] \frac{e^{-\frac{x^2}{2}}}{\sqrt{2\pi}} \quad (44)$$

At $|x| = 5$ the error in this approximation is less than 1.1×10^{-8} and decreases rapidly with increasing $|x|$.

INITG

The initial dust cloud is assumed to form instantaneously at burst time. This routine evaluates the following initial cloud parameters:

1. Total dust mass lofted in the main and base dust clouds.
2. Total carbon mass in the main and base dust clouds.
3. Initial radius of equivalent spherical cloud.
4. Initial radii of the main dust cloud in the artillery shell track direction, cross track direction, and vertical direction.
5. Initial radii of the main dust cloud in the wind track and cross track directions.
6. Main dust cloud rise rate constant.
7. Main dust cloud vertical diffusion constant.
8. Time delays before the wind begins moving the main and base clouds horizontally.
9. Mean wind velocities at the center of the initial cloud and at 10 meters altitude.

After evaluation the routine writes out most of the initial parameters.

TIMECO

The smallest particles in the main dust cloud rise with the ideal spherical cloud rise rate, transport with the wind velocity (after the initial time delay), and diffuse with the ideal cloud diffusion rate. The heavier particles will rise at a slower rate and eventually fall out of the cloud, will lag behind the smaller particles in horizontal wind transport, and will diffuse at a slower rate. At a given time t after burst, this routine evaluates the following parameters for the ideal zero mass particles in both the main and base dust clouds:

1. Centroid coordinates (location of the center of mass of the ideal cloud).
2. Radii in the wind track, cross track, and vertical directions.

TIMECG

This routine calculates the same parameters of centroid location and cloud radii at time t for the finite size particles in a given size group.

PATH

This routine evaluates the integral of the mass density (mass penetrated) along the sight path between a given transmitter-receiver pair due to each type of particulate material in a given size group at a given time. The quantity evaluated is

$$M_P = \int_0^{D_{TR}} \rho(D) dD \quad \text{g cm}^{-2} \quad , \quad (45)$$

where

D = distance along sight path from transmitter to receiver (cm)

D_{TR} = total distance from transmitter to receiver (cm)

$\rho(D)$ = mass density at distance D along sight path due to the given particulate material in the given size group (g cm^{-3}).

The integration strategy is to begin at the point of closest approach of the sight path to the size group centroid location and numerically integrate forward and backward. The numerical integration uses a Simpson's Rule approximation with a step size of 0.2 of the Gaussian standard deviation of the size group mass density. The integration is continued until the receiver or transmitter is reached or until the mass density becomes negligible. The integration is terminated when the distance from the integration point to the group centroid exceeds five standard deviations. At this point the mass density at the integration point is down at least a factor of $e^{-5^2/2} = 3.7 \times 10^{-6}$ from the density at the cloud centroid.

DEPTH

This routine evaluates the optical depths and transmission along a given sight path at a given time. It calculates the optical depth contribution due to each material in each size group and the sum of all contributions. The quantities evaluated are

$$(\tau_E)_i = (M_P)_i (\mu_E)_i \quad (46)$$

= extinction optical depth contribution due to the
particulates in size group i

$(M_p)_i$ = mass penetrated due to particulates in size group i
(g cm⁻²)

$(\mu_E)_i$ = mass extinction coefficient for particulates in size
group i (cm² g⁻¹)

$(\tau_s)_i = (M_p)_i (\mu_s)_i$ (47)
= scattering optical depth contribution

$(\tau_A)_i = (M_p)_i (\mu_A)_i$ (48)
= absorption optical depth contribution

$\tau_E = \sum_i (\tau_E)_i$ (49)
= total extinction optical depth due to all size groups

$\tau_s = \sum_i (\tau_s)_i$ (50)

$\tau_A = \sum_i (\tau_A)_i$ (51)

$T = e^{-\tau_E}$ (52)

= transmission (one way).

Routine DEPTH writes out the optical depth contribution results and the total optical depths and transmission. Because the detailed results of the individual optical depth contributions can result in a large amount of output, the printing of these detailed results can be suppressed by an input option.

ADDVEC

This routine and the following vector routines are extremely short and do simple vector operations. This routine adds two three-vectors together:

$$\vec{v} = \vec{v}_1 + \vec{v}_2 = (x_1 + x_2, y_1 + y_2, z_1 + z_2) \quad (53)$$

where

$\vec{v}_1 = (x_1, y_1, z_1)$ = first three-vector

$\vec{v}_2 = (x_2, y_2, z_2)$ = second three-vector.

SUBVEC

This routine subtracts two three-vectors:

$$\vec{v} = \vec{v}_1 - \vec{v}_2 = (x_1 - x_2, y_1 - y_2, z_1 - z_2) \quad . \quad (54)$$

MULVEC

This routine multiplies a three-vector by a scalar:

$$\vec{v} = s\vec{v}_1 = (sx_1, sx_2, sx_3) \quad , \quad (55)$$

where

s = scalar .

DOTVEC

This routine forms the scalar (dot) product of two three-vectors:

$$p = \vec{v}_1 \cdot \vec{v}_2 = x_1x_2 + y_1y_2 + z_1z_2 \quad . \quad (56)$$

DSTVEC

This routine evaluates the distance between the endpoints of two three-vectors:

$$D = |\vec{v}_1 - \vec{v}_2| = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \quad . \quad (57)$$

SECTION 3

INPUT

GENERAL INFORMATION

All input is read by the INPUT subroutine from a logical file unit which has been assigned the number 5. This can be readily changed to meet the requirements of a particular computer installation by changing the value of the variable ITAPE which appears at the beginning of the Executive Routine.

Input is prepared on standard IBM punched cards. Each input card contains a letter, from A to M, punched in column 1 to identify the information contained on that card. The INPUT routine reads the input a card at a time, interprets the identification letter, and assigns the data to the appropriate input variables. Card after card is read until a blank card (a card with no punch in column 1) is read. This signifies that all of the data for this problem have been presented and thus terminates the input sequence and initiates calculation. After all calculations have been completed and the output printed, the Executive Routine returns to the INPUT routine to read the data for the next problem. As many separate problems as desired may be stacked; the data cards for each problem end with a blank card to initiate calculation. Two blank cards in a row indicate the end of the problem sets.

A large number of inputs are required to completely specify a problem. There are 13 different input cards with up to 8 input items on a card. Except for the burst yield, default values are internally supplied for all input values not specified by the user. Before the input data for the first problem are read, the values for all input

variables (except burst yield) are set to the default values. Then the input cards for the first problem are read and all user-specified inputs are substituted for the default values. At the end of the first problem card set, a complete set of input data exists, either all user supplied or a combination of user and default inputs. For the second problem, the code begins with the first problem data set and only the inputs on the second problem data cards are changed from the first problem values. Hence only those cards with information different from the preceding problem need be included on succeeding problems. The only exception is that every problem set must have at least one A card, which contains the burst yield information. Thus a problem set may consist of all 13 different input cards or, at the minimum, consist of a single A card. There are up to 8 input values on a data card.

If any entry is left blank, the code automatically uses the default value for that entry. Hence, when a data card is used on succeeding problems, all entries on that card that are not default values must be supplied even though they may be the same as the preceding problem. If a card is not supplied, the code assumes the values are the same as the preceding case; if a card is supplied, the code assumes that all values on the card are respecified.

DESCRIPTION OF THE INPUT CARDS

Figure 2 shows the input card parameters, and Figure 3 shows the default values. Each input card is read under an A1, E9.0, 7E10.0 format. Thus the data are punched in floating point format in 10-column fields, with the exception that the first field occupies nine columns to make room for the card identification letter in column 1. Note that whole numbers may be punched as integers if the number is right justified within the appropriate field.

Ten bursts are allowed, so there can be up to 10 A and B cards. Similarly 10 transmitter-receiver pairs are allowed, so there can be up to 10 C and D cards. The order of the different cards is

I	10	20	30	40	50	60	70	80
A	W(1) (lb) Total TNT yield of 1st burst	f _H (1) Fraction in hydro yield of 1st burst	C _Y (1) Shape factor in track direction of 1st burst	C _P (1) Shape factor in cross track of 1st burst	C _Y (1) Shape factor in vertical direc- tion of 1st burst	X _B (1) (m) x-coordinate of 1st burst	Y _B (1) (m) y-coordinate of 1st burst	Z _B (1) (m) z-coordinate of ground surface at 1st burst
B	DGB(2) (m) Depth of burst	f _{CR} (1) Fraction of apparent crater mass lofted	S _{CR} (1) m ³ [lb TNT] ^{-1.111} Apparent crater volume scaling factor for 1st burst	α _{CR} (1) (deg) Azimuth of 1st shell track (CW from y-axis)				
C	ν(1) (MHz) Frequency of 1st transmit- ter receiver	λ(1) (μm) Wavelength of 1st transmitter- receiver	X _T (1) (m) x-coordinate of 1st transmitter	Y _T (1) (m) y-coordinate of 1st trans- mitter	Z _T (1) (m) z-coordinate of 1st trans- mitter	X _R (1) (m) x-coordinate of 1st receiv- er	Y _R (1) (m) y-coordinate of 1st re- ceiver	Z _R (1) (m) z-coordinate of 1st receiver
D	n _A (1) (REAL) Real part of index of ref- raction for mode A for 1st frequency	n _A (1) (IMAG) Imaginary part for mode A for 1st frequency	n _B (1) (REAL) Real part for mode B for 1st frequency	n _B (1) (IMAG) Imaginary part for mode B for 1st frequency	n _C (1) (REAL) Real part for carbon for 1st frequency	n _C (1) (IMAG) Imaginary part for carbon for 1st frequency		
E	ρ _G (gm cm ⁻³) Bulk density of soil	ρ _D (gm cm ⁻³) Density of dust grains	f _{W20} Moisture content fraction of soil mass that is water	ρ _C (gm cm ⁻³) Density of carbon particles	L _C Carbon yield frac- tion (carbon weight divided by total TNT weight)	R _{HAB} Ratio of mode A to mode B mass in lofted cloud	R _{BASE} Ratio of mass in base cloud to mass in main cloud	
F	d _{NA} (μm) LOG-normal mean diam- eter of mode A particles	S _A log-normal standard deviation parameter mode A particle	d _{minA} (μm) Power law minimum diameter parameter for mode A particles	d _{maxA} (μm) Power law maxi- mum diameter parameter for mode A particles	P _A Power law expo- nent for mode A particles			
G	d _{NB} (μm) LOG normal mean diameter of mode B particles	S _B	d _{minB} (μm)	d _{maxB} (μm)	P _B			
H	d _{NC} (μm) carbon parti- cles	S _C	d _{minC}	d _{maxC}	P _C			
I	P _{SP} Pasquill sta- bility factor 1-A, 2-B, 3-C, 4-D, 5-E, 6-F	f _{RC} entrainment factor for rising cloud	C _D Drag coeffi- cient for rising cloud	ρ _A (gm cm ⁻³) Air density at ground level	H _G (m) Elevation of ground level	T _G (°K) Air tempera- ture at ground level	T _L (°K m ⁻¹) Temperature lapse rate	H _I (m) Altitude of inversion layer above ground
J	V _M (m s ⁻¹) Mean wind velocity	A _{TV} (m) Altitude at which mean wind speed is mea- sured	P _{TV} power law expo- nent of verti- cal profile of mean wind- speed	α _V (DEG) Azimuth of wind velocity vector (mea- sured CW from y)				
K	D _G (1) (m) Maximum dia- meter of par- ticles in size group 1	D _G (2) (m) Maximum diameter in size group 2	D _G (3)	D _G (4)	D _G (5)	D _G (6)	D _G (7)	D _G (8)
L	t(2) (s) Time after burst of 1st calculation	t(3) (s) 2nd calculation time	t(3) (s) 3rd calcula- tion time	t(4)	t(5)	t(6)	t(7)	t(8)
M	P _{PRINT} Print control option 0=print details 1=print only summary							

Figure 2. Input card parameters.

	10	20	30	40	50	60	70	80
I								
A	Must be specified by user	0.5	1	1	1	0	0	0
B	0	0.25	0.03	0				
C	10^5	3	500	50	2	-500	50	2
D	1.66	0.016	1.66	0.016	2	1		
E	1.5	2.5	0.15	1.5	0.3	0.25	0.1	
F	!	2.2						
G	20	2	180	10^4	4			
H	0.5	2						
I	4	1	0.8	0	0	288	-9.8×10^{-3}	1000
J	3	10	0.1	0				
K	5	10	20	30	40	50	60	70
K	80	90	100	105	110	115	120	125
K	130	135	140	145	150	155	160	165
K	170	175	180	185	190	195	200	210
K	220	230	240	250	260	270	280	290
K	300	350	400	450	500	600	750	1000
K	5000	10,000						
L	2	4	6	8	10	12	14	16
L	18	20	22.5	25	27.5	30	32.5	35
L	37.5	40	45	50	55	60	70	80
L	100							
M	0							

Figure 3. Default values for input parameters.

immaterial, but the multiple cards within a given identification card must be in sequence. That is, if there are five A cards, then the five corresponding B cards must be in the same order. The first A card goes with the first B card; the second A card goes with the second B card, etc.

A Card

The A card contains the first part of the burst information. Up to 10 bursts are allowed, so there can be up to 10 A cards. For this version of the code all bursts are assumed to detonate simultaneously at time zero. The first entry is the total TNT yield, or equivalent TNT yield for a non-TNT device, in pounds. This is the one entry which must be specified by the user; no default value is provided. An A card without an entry for the yield will be ignored by the code.

The second entry is f_H , the fraction of the total yield which appears as hydrodynamic energy. f_H is used in the determination of the initial ideal spherical cloud radius,

$$R_I = 1.54 \left(W f_H \frac{\rho_0}{\rho} \right)^{1/3} \text{ m} \quad (58)$$

where

W = total munition yield (lb TNT)

ρ_0 = sea level air density (g cm^{-3})

ρ = air density at blast site (g cm^{-3}).

The third, fourth, and fifth entries are the shape factors for the real initial dust cloud. A static blast will generally produce an initial cloud that is roughly spherical ($C_T = C_p = C_v = 1$). But a live munition impacts the ground with a large velocity and can produce dust clouds that are elongated in the shell track direction. The radii of the initial real dust cloud in the shell track, cross track, and vertical directions are taken as the product of these shape factors and the ideal spherical cloud radius of Equation 58:

$$R_T = C_T R_I \quad m \quad (59a)$$

$$R_P = C_P R_I \quad (59b)$$

$$R_V = C_V R_I \quad . \quad (59c)$$

The sixth, seventh, and eighth entries are the coordinates of the ground surface at the burst. Note that the z coordinate is the coordinate of the ground surface and not that of the burst itself. A surface burst and a buried burst have the same z coordinate.

B Card

The B card contains the rest of the burst information. The first B card goes with the first A card, the second B card with the second A card, etc. If there are more A cards than B cards, the code automatically fills the missing B inputs with default values. If there are more B cards than A cards, the code simply ignores the excess B cards.

The first B entry is the depth of burst. This is the distance the munition center of mass is below the ground surface at detonation. A munition that detonates above the ground would have a negative value for depth of burst. Currently this variable is not used in the code. For some soils the apparent crater volume scaling factor is a smooth function of the depth of burst. For these soils the scaling factor could be internally calculated rather than being input.

The second entry is the fraction of the apparent crater mass that is lofted into the dust cloud. A crater is left in the soil after a munition explosion. The volume of this visible crater (that part below the original ground level) is the apparent crater volume. The apparent crater mass is the mass of the soil that was in the apparent crater volume. Part of the mass is lofted into the dust cloud, part is thrown out to the sides, and part is piled up on the crater rim.

The third entry is the apparent crater volume scaling factor. The volume of the apparent crater is calculated from the scaling relation,

$$V_A = S_{AC} W^{1.111} \text{ m}^3, \quad (60)$$

where

V_A = volume of apparent crater (m^3)
 S_{AC} = apparent crater volume scaling factor ($\text{m}^3 (\text{lb TNT})^{-1.111}$)
 W = total munition yield (lb TNT).

The scaling factor depends on the type of soil, type of munition, and depth of burst. Both the half-buried static charges of the Dugway series of tests and the static charges of DIRT 1 had a scaling factor of about 0.03.

The fourth entry is the azimuth of the munition shell track. Azimuths are measured clockwise (toward the x axis) in degrees from the y axis. The azimuth is used in conjunction with the shape factors to define the initial main cloud shape and orientation. The shell azimuth input is not required for those bursts which are symmetric about the vertical axis (ie, for bursts with $C_T = C_p$).

C Card

The C card contains the transmitter-receiver information. A maximum of 10 transmitter-receiver pairs are permitted, so there can be up to 10 C cards.

The first and second entries are the frequency in GHz and the wavelength in microns of the transmitter-receiver pair. Only one of these two inputs is required; the other input is left blank. The input choice is for the user's convenience. Users working with millimeter waves generally prefer GHz frequencies, while infrared users prefer micron wavelengths.

The third through eighth entries are the coordinates of the transmitter and receiver. The z coordinate is the actual z coordinate of the transmitter or receiver (unlike the burst coordinate, where the z coordinate is the coordinate of the ground surface). The transmitter-receiver coordinates define the sight path, which is the straight line path between the transmitter and receiver.

D Card

The D card contains the complex index of refraction information. There should be one D card for each C card. If there are more C cards than D cards, the code automatically fills the missing D inputs with default values. If there are more D cards than C cards, the code simply ignores the excess D cards.

The complex index of refraction at the transmitter-receiver frequency is assumed to be

$$n = n_R - in_I \quad , \quad (61)$$

where

- n = complex index of refraction
- n_R = real part of the complex index of refraction
- n_I = imaginary part of the complex index of refraction
- i = $\sqrt{-1}$

Hence all input entries are positive.

The first and second entries are for mode A dust particles, the third and fourth are for mode B dust particles, and the fifth and sixth are for the carbon particles. Note that these indices are for the airborne particles. The indices of *in situ* soil generally differ from the indices of airborne dust grains. This difference is due to the air and water in the soil.

E Card

The E card carries various soil, dust, and carbon parameters and mass partitions. There is only one E card.

The first entry is the bulk density of the *in situ* soil in g cm^{-3} . This variable is used along with the calculated apparent crater volume to calculate the total mass of soil that was in the apparent crater. Typical values for soil density are about 1.5 g cm^{-3} for loose soil and about 2.5 g cm^{-3} for rock. *In situ* soil is assumed to consist of dust grains, air, and water.

The second entry is the density in g cm^{-3} of the airborne dust grains. For soils this grain density is larger than the soil density; a typical grain density value is 2.5 g cm^{-3} . Nonporous rock can have the same value for the *in situ* soil density and the grain density.

The third entry is the soil moisture fraction. This is defined as the mass of water in the soil divided by the mass of the soil (including the water). The mass of the solid dust grains is taken as the mass of the soil minus the mass of the water.

The fourth entry is the density of the carbon particulates in g cm^{-3} . The default value is 1.5 g cm^{-3} .

The fifth entry is the carbon yield fraction. One of the combustion products from the burning of the explosive is carbon. The carbon yield fraction is defined as the mass of the carbon produced divided by the mass of the explosive. A typical value for TNT is 0.3.

The sixth entry is the ratio of mode A to mode B dust mass in the lofted cloud. We allow two types of dust in the cloud, and this entry specifies the relative importance of the two types. If a user wishes to have only one kind of dust, then this entry should be set to an insignificant number such as 10^{-3} . Remember that if this entry is left blank or set to zero, the code will automatically insert the default value, which is 0.25.

The seventh entry is the ratio of the mass in the base cloud to the mass in the main cloud. Although the base cloud generally has only a small fraction of the mass of the main cloud, the base cloud can have a large effect on sight paths very near the ground since it is nonrising. Typical estimates of this ratio are in the range 0.05 to 0.1; we take 0.1 as the default value.

F Card

The F card specifies the size distribution parameters for the mode A dust particles. There is only one F card. At present three types of size probability distributions are allowed: log normal, power law,

or hybrid. The hybrid distribution consists of a log normal distribution for particles with diameters from zero to a_{\min} ; this is then joined to a power law distribution for particles with diameters from a_{\min} to a_{\max} . To choose a log normal distribution, values are entered for entries one and two. To choose a power law distribution, values are entered for entries three, four, and five. To choose a hybrid distribution, values must be given for all five entries.

The log normal probability distribution is

$$P_{LN}(a) = \frac{\exp\left\{-\frac{1}{2} \left[\frac{\ln \frac{a}{a_m}}{\ln S}\right]^2\right\}}{\sqrt{2\pi} a \ln S} \quad 0 \leq a < \infty \quad (62)$$

where

a = particle diameter (microns)

$P_{LN}(a) da$ = fraction of the number of dust particles with diameters between a and $a + da$

a_m = mean particle diameter (microns)

S = standard deviation parameter.

The power law probability distribution is

$$P_p(a) = \frac{(p-1)a^{-p}}{a_{\min}^{-(p-1)} - a_{\max}^{-(p-1)}} \quad a_{\min} \leq a \leq a_{\max} \quad (63)$$

where

p = power law exponent

a_{\min} = minimum particle diameter in the power law size distribution (microns)

a_{\max} = maximum particle diameter in the distribution (microns).

The hybrid distribution is

$$P_H(a) = \begin{cases} C_1 P_{LN}(a) & 0 \leq a \leq a_{\min} \\ C_2 P_p(a) & a_{\min} \leq a \leq a_{\max} \end{cases} \quad (64)$$

where C_1 and C_2 are normalization constants.

The first entry on the F card is the mean diameter in microns of the log normal probability distribution. The second entry is the standard deviation parameter of the log normal distribution.

The third entry is the minimum diameter in microns of the power law distribution. The fourth entry is the maximum diameter in microns of the power law distribution. The fifth entry is the power law exponent of the power law distribution.

G Card

The G card specifies the size distribution parameters for the mode B dust particles. There is only one G card. The G card entries have the same definitions as the F card entries.

H Card

The H card specifies the size distribution parameters for the carbon particles. There is only one H card. The H card entries have the same definitions as the F and G card entries.

I Card

The I card is the first of two cards specifying the atmospheric parameters and the rising (main) cloud model parameters. There is only one I card.

The first entry is the atmospheric Pasquill stability factor, entered as a digit with the correspondence 1 = A, 2 = B, 3 = C, 4 = D, 5 = E, 6 = F. The default value is 4 (D), the neutral stability.

The second entry is the entrainment factor for the buoyant rising cloud model. Normally this entry is left blank and the code uses the default value of 1.

The third entry is the drag coefficient for the buoyant rising cloud model. Normally this entry is also left blank, thereby specifying the default value of 0.8.

The fourth entry is the air density in g cm^{-3} at ground level. If this entry is left blank, the code assumes the atmosphere is the U.S. Standard atmosphere and calculates the ground level density as

$$\rho_A = \rho_{AO} e^{-\frac{H_G}{8400}} \text{ g cm}^{-3}, \quad (65)$$

where

ρ_A = air density at ground level (g cm^{-3})

ρ_{AO} = U.S. Standard Atmosphere air density at mean sea level
 $= 1.225 \times 10^{-3} \text{ g cm}^{-3}$

H_G = elevation above mean sea level of the ground level (m).

The fifth entry is the elevation of the ground level above mean sea level in meters. This entry is only used to calculate the air density at ground level. Thus if the user specifies the fourth entry, ρ_A , then this entry is not used in the code.

The sixth and seventh entries are the air temperature at ground level and the temperature lapse rate in kelvins and kelvins per meter, respectively. At present these entries are not used in the code and need not be specified. In the future we expect these variables to enter into the models for main cloud stabilization and buoyant-atmospheric diffusion crossover. Anticipating the future model development, we have reserved these input slots.

The eighth entry is the altitude of the air temperature inversion layer in meters above ground level. Inversion layers are effective barriers for rising dust clouds. The code assumes the main dust cloud cannot rise above the inversion layer. Hence at present the temperature inversion layer is the stabilization altitude for the main dust cloud.

J Card

The J card is the second of the two cards specifying the atmospheric parameters. There is only one J card.

The first entry is the mean wind velocity in meters per second. The second entry is the reference altitude in meters at which the mean wind velocity is measured. The third entry is the power law exponent of the vertical profile of the mean wind velocity. The wind speed as a function of altitude is assumed to be

$$v_M(Z) = v_M(Z_R) \left(\frac{Z}{Z_R} \right)^{P_M} \text{ m s}^{-1}, \quad (66)$$

where

$$\begin{aligned} v_M(Z) &= \text{mean wind velocity at altitude } Z \text{ (m s}^{-1}\text{)} \\ v_M(Z_R) &= \text{mean wind velocity at reference altitude } Z_R \text{ (m s}^{-1}\text{)} \\ P_M &= \text{power law exponent.} \end{aligned}$$

The fourth entry is the azimuth of the mean wind velocity vector in degrees, measured clockwise from the y axis.

K Card

The K card contains the particle size group information. A maximum of 50 size groups are permitted, so there can be up to seven K cards. The entries are the maximum diameters in microns of the particles in the size groups. The diameters are entered in ascending order. The first size group includes particles of diameter zero up to the diameter of the first entry. The second size group includes particles with diameters from the first entry to the second entry.

A given size group includes all particles of all materials which have diameters within the specified diameter ranges. Thus a particular size group can have one, two, or three types of the different material particles in it, depending upon the size distributions of the three materials.

L Card

The L card contains the calculation times in seconds. All bursts are assumed to be detonated at time zero. A maximum of 25 calculation times are allowed, so there can be up to four L cards (the last card

having only one entry). The input times must be positive and arranged in ascending order.

M Card

The M card contains the print control option. The code computes the propagation along each sight path by summing the effects from each particle size group for each material for each burst. Unless suppressed, the code will automatically print out the details of each contributing effect. This detailed printing can produce a considerable amount of output which may not be of interest to the user. A 1 entered in column 10 of card M will suppress the printing of the details. Since the default value of the print control option is zero, the code will print the detailed output if card M is omitted. Naturally the summary output is printed in all cases.

SECTION 4 SAMPLE PROBLEM

Figure 4 shows the input data cards for the sample problem. We have a single 360-lb TNT burst at the origin. There is a single transmitter-receiver pair using a wavelength of 10.35 microns. The data chosen correspond to test event B8 of the DIRT-1 series of tests at White Sands Missile Range, New Mexico (Reference 6). The actual test consisted of three 120-lb TNT charges in a line with 15 meters spacing between charges. The three individual dust clouds rapidly (in less than a second) merged to form one large dust cloud. We simulate this one large dust cloud in the code by a single 360-lb burst and by increasing the entrainment factor (second entry, card I) to a value of 2.

Figure 5 shows the output generated by the code, which first writes out the input data. Next the code calculates the propagation constants for each significant size group for each material, assuming no mixing of particles between size groups. After the unmixed data are printed out, the propagation constants are recomputed assuming mixing of the size groups; the mixed data are then printed. Next the initial ($t = 0+$) parameters of the main cloud are computed and printed out. Then the initial dust and carbon masses lofted into the main and base clouds are written out. This completes the preliminary calculations. For each calculation time the propagation along each sight path is computed and printed out, first the detailed results (unless suppressed by the print control option) and then the summary results.

1	10	20	30	40	50	60	70	80
A	360	0.8	1*	1	1	0	0	0
B	0.1	0.50	0.03	0				
C		10.35	1.2	-1000	1.7	1.2	1000	1.7
D	1.65	0.14	1.65	0.14	3.4	2.8		
E	1.6	2.5	0.08	1.5	0.3	0.25	0.1	
F	3.1	2.34						
G	7.1	2.65						
I	4	2	0.8		1260	288	-9.8×10^{-3}	1000
J	1.8	2	0.19	26				
K	20	40	60	80	100	120	140	160
K	180	200	225	250	275	300	500	700
K	1000	2000						
L	60	80	100	120	140			
*Note that all entries which are default values could have been left blank								

Figure 4. Input cards for sample problem.

ASL MUNITION DUST CLOUD MODEL

INPUT DATA FOR PROBLEM NUMBER 1

MUNITION AND CRATER PARAMETERS

BURST	YIELD (LB TNT)	HYDRO FRACTION	INITIAL SHAPE FACTORS	BURST POINT COORDINATES	DEPTH OF BURST (METERS)	LOFTED MASS FRACTION	LOADING FACTOR	SHELL TRACK AZIMUTH (DEG)
1	360.0	0.6	ALONG TRACK 1.0 CROSS TRACK 1.0 VERTICAL 1.0	X COORD. 0. Y COORD. 0. Z COORD. 0.	0.1	0.50	(M3/LB TNT) 3.00E-02	0.

BULK DENSITY OF SOIL = 1.6 GM/CM3
SOIL MOISTURE FRACTION = 0.06

SIZE PROBABILITY DISTRIBUTION PARAMETERS

MATERIAL	DENSITY (GM/CM3)	MEAN DIAMETER (MICRONS)	STANDARD DEVIATION PARAMETER	MINIMUM DIAMETER (MICRONS)	MAXIMUM DIAMETER (MICRONS)	POWER LAW EXPONENT
DUST - A	2.50	3.10	2.3	0.	0.	0.
DUST - B	2.50	7.10	2.7	0.	0.	0.
CARBON	1.50	0.50	2.0	0.	0.	0.

CARBON YIELD FRACTION = 0.30
RATIO MODE A TO MODE B MASS = 0.25
RATIO BASE TO MAIN CLOUD MASS = 0.10

MAXIMUM DIAMETERS OF PARTICLES IN EACH SIZE GROUP

SIZE GROUP NUMBER	1	2	3	4	5	6	7	8	9	10
MAXIMUM DIAMETER (MICRONS)	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
	11	12	13	14	15	16	17	18		
	215.0	250.0	275.0	300.0	500.0	700.0	1000.0	2000.0		

Figure 5. ASL-DUST output for sample problem.

INPUT DATA FOR PROBLEM NUMBER 1 (CONTINUED)

TRANSMITTER - RECEIVER PARAMETERS

PAIR NUMBER	FREQUENCY (GHZ)	WAVELENGTH (MICRONS)	TRANSMITTER COORDINATES X COORD. (METERS)	Y COORD. (METERS)	Z COORD. (METERS)	RECEIVER COORDINATES X COORD. (METERS)	Y COORD. (METERS)	Z COORD. (METERS)
1	2.90E 04	10.4	1.2	-1000.0	1.7	1.2	1000.0	1.7

PAIR NUMBER	FREQUENCY (GHZ)	WAVELENGTH (MICRONS)	DUST - MODE A REAL PART	IMAG PART	DUST - MODE B REAL PART	IMAG PART	CARBON REAL PART	IMAG PART
1	2.90E 04	10.4	1.65	1.40E-01	1.65	1.40E-01	3.40	2.80E 00

INDICES OF REFRACTION

ATMOSPHERIC PARAMETERS

PASQUILL STABILITY FACTOR	CLOUD ALPHA ENTRAINMENT FACTOR	CLOUD DRAG COEFFICIENT	AIR DENSITY AT GROUND (GH/CM3)	GROUND ELEVATION (METERS)	GROUND AIR TEMPERATURE (DEG K)	TEMPERATURE LAPSE RATE (DEG K/ H)	INVERSION LAYER ALTITUDE (METERS)
0	2.0	0.6	1.05E-03	1260.0	266.0	-9.8E-03	1000.0

MEAN WIND VELOCITY (M/S)	WIND REFERENCE ALTITUDE (METERS)	WIND VERTICAL PROFILE POWER (DEG)	WIND AZIMUTH (DEG)
1.8	2.0	0.19	26.0

ASL MUNITION DUST CLOUD MODEL

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1
(SIZE DISTRIBUTION ONLY, NO FRACTIONIZATION)

DUST PARTICLES - MODE A

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	NUMBER OF PARTICLES PER GRAM IN GROUP	NUMBER FRACTION (NUMBER IN GROUP / TOTAL NUMBER)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	WAVELENGTH = 10.4 MICRONS (FREQUENCY = 2.90E 04 GHZ)	GROUP MASS COEFFICIENTS (FIRST LINE, CM ² /GM)			
						EXTINCTION	ABSORPTION	SCATTERING	BACKSCATTER
1	20.0	2.71E 09	9.858E-01	3.60E-01	1.427E 03	5.832E 02	8.438E 02	7.562E 01	2.767E-08
2	40.0	4.030E 07	1.284E-02	3.161E-01	5.197E 02	2.669E 02	2.528E 02	4.021E 00	9.978E-08
3	60.0	7.129E 06	1.066E-03	1.486E-01	1.290E-05	6.624E-06	6.273E-06	1.978E 02	1.031E-06
4	80.0	2.432E 06	1.801E-04	7.347E-02	2.880E 02	1.401E 02	1.074E-05	1.035E 02	5.519E 00
5	100.0	1.110E 06	4.384E-05	3.917E-02	8.078E-05	3.841E-05	4.257E-05	7.956E 01	2.269E-06
6	120.0	5.961E 05	1.342E-05	2.226E-02	1.493E 02	6.972E 01	7.167E-05	6.459E 01	3.449E 00
7	140.0	3.567E 05	4.823E-06	1.334E-02	1.345E-04	6.280E-05	1.080E-04	1.517E-04	8.124E-06
8	160.0	2.320E 05	1.950E-06	8.334E-03	1.004E 02	4.612E 01	5.403E 01	4.702E 01	2.525E 00
9	180.0	1.586E 05	8.644E-07	5.405E-03	3.726E-04	1.700E-04	2.027E-04	2.027E-04	1.008E-05
10	200.0	1.133E 05	4.123E-07	3.610E-03	4.777E-04	2.169E-04	3.441E 01	4.138E 01	2.224E 00
11	225.0	8.155E 04	2.439E-07	2.967E-03	6.746E 01	3.052E 01	3.694E 01	3.694E 01	1.909E 00
12	250.0	5.791E 04	1.118E-07	1.914E-03	5.956E-04	2.895E-04	3.261E-04	4.047E-04	1.756E-05
13	275.0	4.278E 04	5.486E-08	1.272E-03	6.012E 01	3.712E 01	3.300E 01	1.780E 00	2.748E-05
					7.372E-04	3.325E-04	4.047E-04	2.946E 01	1.591E 00
					9.245E-04	4.158E-04	5.087E-04	5.087E-04	2.748E-05
					4.825E 01	2.165E 01	2.660E 01	2.660E 01	1.439E 00
					1.128E-03	5.061E-04	6.218E-04	6.218E-04	3.364E-05

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1 (CONTINUED)

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	NUMBER OF PARTICLES PER GRAM IN GROUP	NUMBER FRACTION (NUMBER IN GROUP / TOTAL NUMBER)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	EXTINCTION	AVERAGE CROSS SECTION (FIRST LINE, CM ² /GM)	SCATTERING (SECOND LINE, CM ² /PARTICLE)	BACKSCATTER
14	300.0	3.250E 04	2.841E-08	8.671E-04	4.391E 01 1.351E-03	1.967E 01 6.052E-04	2.425E 01 7.461E-04	1.313E 00 4.042E-05
15	500.0	1.772E 04	3.644E-08	2.040E-03	3.511E 01 1.982E-03	1.569E 01 6.857E-04	1.942E 01 1.096E-03	1.054E 00 5.946E-05
16	700.0	4.294E 03	1.029E-09	2.377E-04	2.205E 01 5.134E-03	9.848E 00 2.293E-03	1.220E 01 2.641E-03	6.622E-01 1.542E-04
17	1000.0	1.564E 03	8.603E-11	5.456E-05	1.573E 01 1.006E-02	7.027E 00 4.493E-03	6.705E 00 5.566E-03	4.725E-01 3.021E-04
18	2000.0	4.989E 02	5.418E-12	1.077E-05	1.064E 01 2.133E-02	4.753E 00 9.528E-03	5.809E 00 1.180E-02	3.194E-01 6.407E-04
ENTIRE DISTRIBUTION					7.475E 02	3.277E 02	4.198E 02	3.035E 01

ASL MUNITION DUST CLOUD MODEL

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1
(SIZE DISTRIBUTION ONLY, NO FRACTIONIZATION)

DUST PARTICLES - MODE 8

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	NUMBER OF PARTICLES PER GRAM IN GROUP	NUMBER FRACTION (NUMBER IN GROUP / TOTAL NUMBER)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	WAVELENGTH = 10.4 MICRONS (FREQUENCY = 2.902 GHz)	GROUP MASS COEFFICIENTS (FIRST LINE, CM ² /GM)		
						EXTINCTION	ABSORPTION	SCATTERING BACKSCATTER
1	20.0	6.111E 00	8.560E-01	3.137E-02	1.264E 03	5.468E 02	7.376E 02	1.843E 01
					1.584E-06	6.742E-07	9.094E-07	2.273E-06
2	40.0	3.359E 07	1.059E-01	9.175E-02	4.875E 02	2.484E 02	2.392E 02	3.867E 00
					1.452E-05	7.395E-06	7.121E-06	1.151E-07
3	60.0	6.640E 06	2.378E-02	1.044E-01	2.808E 02	1.364E 02	1.444E 02	7.181E 00
					4.229E-05	2.054E-05	2.175E-05	1.082E-06
4	80.0	2.340E 06	7.789E-03	9.894E-02	1.944E 02	9.212E 01	1.023E 02	5.838E 00
					8.307E-05	3.937E-05	4.374E-05	2.324E-06
5	100.0	1.003E 06	3.152E-03	8.650E-02	1.481E 02	6.915E 01	7.897E 01	4.206E 00
					1.367E-04	6.384E-05	7.290E-05	3.883E-06
6	120.0	5.878E 05	1.864E-03	7.403E-02	1.195E 02	5.521E 01	6.424E 01	3.433E 00
					2.033E-04	9.392E-05	1.093E-04	5.840E-06
7	140.0	3.541E 05	7.497E-04	6.294E-02	1.002E 02	4.594E 01	5.424E 01	2.904E 00
					2.829E-04	1.297E-04	1.532E-04	8.202E-06
8	160.0	2.296E 05	4.132E-04	5.349E-02	8.620E 01	3.931E 01	4.689E 01	2.518E 00
					3.754E-04	1.712E-04	2.042E-04	1.097E-05
9	180.0	1.573E 05	2.813E-04	4.559E-02	7.542E 01	3.433E 01	4.124E 01	2.220E 00
					4.807E-04	2.183E-04	2.624E-04	1.411E-05
10	200.0	1.125E 05	1.476E-04	3.900E-02	6.734E 01	3.047E 01	3.607E 01	1.985E 00
					5.986E-04	2.709E-04	3.279E-04	1.765E-05
11	225.0	8.061E 04	1.116E-04	4.115E-02	5.998E 01	2.705E 01	3.293E 01	1.776E 00
					7.440E-04	3.356E-04	4.085E-04	2.203E-05
12	250.0	5.762E 04	6.648E-05	3.438E-02	5.344E 01	2.803E 01	2.940E 01	1.589E 00
					9.274E-04	4.171E-04	5.103E-04	2.757E-05
13	275.0	4.261E 04	4.126E-05	2.879E-02	4.819E 01	2.162E 01	2.656E 01	1.437E 00
					1.131E-03	5.073E-04	6.233E-04	3.373E-05

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1 (CONTINUED)

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	NUMBER OF PARTICLES PER GRAM IN GROUP	NUMBER FRACTION (NUMBER IN GROUP / TOTAL NUMBER)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	EXTINCTION	AVERAGE CROSS SECTIONS (FIRST LINE, CM ² /GM)	ABSORPTION	SCATTERING	BACKSCATTER
14	300.0	3.239E 04	2.651E-05	2.433E-02	4.385E 01 1.354E-03	1.964E 01 6.063E-04	2.921E 01 7.475E-04	1.312E 00 4.050E-05	
15	500.0	1.557E 04	5.484E-05	1.047E-01	3.340E 01 2.145E-03	1.492E 01 9.586E-04	1.847E 01 1.187E-03	1.002E 00 6.439E-05	
16	700.0	4.020E 03	5.109E-06	3.771E-02	2.157E 01 5.356E-03	9.635E 00 2.392E-03	1.194E 01 2.964E-03	6.479E-01 1.609E-04	
17	1000.0	1.456E 03	1.043E-06	2.130E-02	1.535E 01 1.054E-02	6.054E 00 4.708E-03	8.491E 00 5.033E-03	4.609E-01 3.166E-04	
18	2000.0	4.123E 02	1.801E-07	1.356E-02	9.887E 00 2.398E-02	4.416E 00 1.071E-02	5.471E 00 1.327E-02	2.970E-01 7.203E-04	
ENTIRE DISTRIBUTION					1.653E 02	5.766E 01	9.624E 01	3.701E 00	

ASL MUNITION DUST CLOUD MODEL

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1
(SIZE DISTRIBUTION ONLY, NO FRACTIONIZATION)

CARBON PARTICLES

WAVELENGTH * 10.4 MICRONS (FREQUENCY = 2.90E 04 GHZ)

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	NUMBER OF PARTICLES PER GRAM IN GROUP	NUMBER FRACTION (NUMBER IN GROUP / TOTAL NUMBER)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	EXTINCTION	AVERAGE CROSS SECTION	GROUP MASS COEFFICIENTS (FIRST LINE, CM2/GM)	SCATTERING	BACKSCATTER
1	20.0	1.173E 12	1.000E 00	9.994E-01	5.142E 03	3.238E 03	1.908E 03	1.908E 03	2.285E 03
					9.364E-09	2.761E-09	1.623E-09	1.623E-09	1.988E-09
2	40.0	1.031E 08	5.116E-08	5.819E-04	1.059E 03	3.327E 02	7.266E 02	7.266E 02	1.960E 02
					1.027E-05	3.228E-06	7.045E-06	7.045E-06	1.900E-06
3	60.0	1.432E 07	1.266E-10	1.037E-05	5.212E 02	1.545E 02	3.667E 02	3.667E 02	1.025E 02
					3.641E-05	1.079E-05	2.561E-05	2.561E-05	7.158E-06
4	80.0	4.500E 06	2.354E-12	6.138E-07	3.455E 02	9.970E 01	2.450E 02	2.450E 02	7.263E 01
					7.679E-05	2.216E-05	5.463E-05	5.463E-05	1.614E-05
ENTIRE DISTRIBUTION					5.140E 03	3.237E 03	1.903E 03	1.903E 03	2.284E 03

ASL MUNITION DUST CLOUD MODEL

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1
(FRACTIONIZATION EFFECTS INCLUDED)

DUST PARTICLES = MODF A

WAVELENGTH = 10.4 MICRONS (FREQUENCY = 2.90E 04 GHZ)

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	EXTINCTION	GROUP MASS ABSORPTION	GROUP MASS COEFFICIENTS (CM2/GH)	SCATTERING	BACKSCATTER
1	20.0	1.002E-01	1.427E 03	5.032E 02	6.438E 02	7.562E 01	
2	40.0	2.071E-01	0.867E 02	3.809E 02	4.658E 02	2.982E 01	
3	60.0	1.087E-01	7.554E 02	3.310E 02	4.244E 02	3.113E 01	
4	80.0	1.205E-01	7.206E 02	3.172E 02	4.114E 02	3.059E 01	
5	100.0	6.079E-02	7.170E 02	3.115E 02	4.055E 02	3.028E 01	
6	120.0	5.279E-02	7.170E 02	3.052E 02	4.024E 02	3.011E 01	
7	140.0	3.533E-02	7.072E 02	3.067E 02	4.005E 02	3.001E 01	
8	160.0	2.417E-02	7.047E 02	3.055E 02	3.992E 02	2.994E 01	
9	180.0	1.689E-02	7.030E 02	3.047E 02	3.983E 02	2.990E 01	
10	200.0	1.200E-02	7.010E 02	3.042E 02	3.976E 02	2.986E 01	
11	225.0	1.040E-02	7.007E 02	3.037E 02	3.971E 02	2.983E 01	
12	250.0	7.195E-03	6.999E 02	3.033E 02	3.966E 02	2.981E 01	
13	275.0	5.053E-03	6.992E 02	3.030E 02	3.962E 02	2.979E 01	
14	300.0	3.616E-03	6.987E 02	3.027E 02	3.960E 02	2.977E 01	
15	500.0	8.868E-04	6.977E 02	3.023E 02	3.954E 02	2.972E 01	
16	700.0	1.835E-03	6.969E 02	3.019E 02	3.949E 02	2.972E 01	
17	1000.0	5.282E-04	6.965E 02	3.017E 02	3.947E 02	2.971E 01	
18	2000.0	1.358E-04	6.960E 02	2.896E 02	3.792E 02	2.853E 01	

ASL MUNITION DUST CLOUD MODEL

PROPAGATION CONSTANTS FOR PROBLEM NUMBER 1
(FRACTIONIZATION EFFECTS INCLUDED)

DUST PARTICLES - MODE R

WAVELENGTH = 10.4 MICRONS (FREQUENCY = 2.90E 04 GHZ)

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	MASS FRACTION (MASS IN GROUP /TOTAL MASS)	GROUP MASS COEFFICIENTS (CM ² /GM)			
			EXTINCTION	ABSORPTION	SCATTERING	BACKSCATTER
1	20.0	1.569E-02	1.288E 03	5.468E 02	7.376E 02	1.633E 01
2	40.0	6.840E-02	5.126E 02	2.578E 02	2.508E 02	4.325E 00
3	60.0	6.066E-02	3.312E 02	1.593E 02	1.717E 02	7.532E 00
4	80.0	6.328E-02	2.636E 02	1.249E 02	1.267E 02	5.869E 00
5	100.0	6.172E-02	2.312E 02	1.088E 02	1.248E 02	5.006E 00
6	120.0	5.633E-02	2.130E 02	9.995E 01	1.131E 02	4.315E 00
7	140.0	5.419E-02	2.018E 02	9.457E 01	1.073E 02	4.208E 00
8	160.0	4.985E-02	1.943E 02	9.101E 01	1.033E 02	4.001E 00
9	180.0	4.569E-02	1.890E 02	8.652E 01	1.005E 02	3.852E 00
10	200.0	4.160E-02	1.852E 02	8.271E 01	9.885E 01	3.742E 00
11	225.0	4.653E-02	1.819E 02	8.520E 01	9.671E 01	3.649E 00
12	250.0	4.143E-02	1.772E 02	8.393E 01	9.525E 01	3.572E 00
13	275.0	3.692E-02	1.722E 02	8.301E 01	9.414E 01	3.513E 00
14	300.0	3.294E-02	1.756E 02	8.228E 01	9.326E 01	3.467E 00
15	500.0	1.869E-01	1.719E 02	8.062E 01	9.166E 01	3.358E 00
16	700.0	6.004E-02	1.691E 02	7.939E 01	8.973E 01	3.275E 00
17	1000.0	5.719E-02	1.580E 02	7.687E 01	8.699E 01	3.240E 00
18	2000.0	5.305E-02	1.474E 02	6.918E 01	7.818E 01	2.649E 00

ASL MUNITION DUST CLOUD MODEL

PROPAGATION CONSTANTS FOR PROBLEM NUMBR 1
(FRACTIONIZATION EFFECTS INCLUDED)

CARBON PARTICLES

WAVELENGTH # 10.0 MICRONS (FREQUENCY = 2.99E 04 GHZ)

SIZE GROUP	MAXIMUM DIAMETER (MICRONS)	MASS FRACTION (MASS IN GROUP / TOTAL MASS)	EXTINCTION	ABSORPTION	SCATTERING	BACKSCATTER
1	20.0	4.997E-01	5.142E 03	3.236E 03	1.904E 03	2.205E 03
2	50.0	4.907E-01	5.140E 03	3.237E 03	1.903E 03	2.204E 03
3	60.0	9.025E-03	5.139E 03	3.237E 03	1.903E 03	2.204E 03
4	80.0	5.393E-04	5.136E 03	3.235E 03	1.902E 03	2.202E 03

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

DETAILED SIZE GROUP RESULTS FOR TIME = 60.0 SECONDS
BURST NUMBER = 1

CLOUD GROUP NUMBER	DUST CENTROID (METERS)			CARBON CENTROID (METERS)			DUST RADII CROSS TRACK VERTICAL (METERS)		CARBON RADII CROSS TRACK VERTICAL (METERS)		TOTAL MASS IN GROUP DUST-MODE A DUST-MODE B (GRAMS)		CLOUD PATH NUMBER	GROUP MASS PENETRATED DUST-MODE A DUST-MODE B (GM/CM2)		OPTICAL DEPTH EXTINCTION SCATTERING DUST-MODE A DUST-MODE B CARBON		ALONG PATH DUE TO GROUP ABSORPTION				
	X-COORD.	Y-COORD.	Z-COORD.	X-COORD.	Y-COORD.	Z-COORD.	WIND TRACK	CROSS TRACK	WIND TRACK	CROSS TRACK	DUST-MODE A	DUST-MODE B		DUST-MODE A	DUST-MODE B	EXTINCTION	SCATTERING	DUST-MODE A	DUST-MODE B	EXTINCTION	SCATTERING	
MAIN 1	57.8	110.5	142.9	57.8	110.5	143.9	94.9	94.9	94.9	94.9	7.82E 05	0.	MAIN	0.	0.	0.	0.	0.	0.	0.	0.	0.
							48.4	48.4	48.4	48.4	2.72E 05	0.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.
BASE 1	46.4	95.0	8.9	46.4	95.0	9.5	57.9	57.9	57.9	57.9	7.82E 04	7.93E-04	BASE	7.93E-04	6.69E-01	1.13E 00	0.69E-01	2.04E-01	1.13E 00	0.69E-01	2.04E-01	4.62E-01
							25.6	25.6	25.6	25.6	2.23E 03	2.18E-05	1	2.18E-05	4.14E-02	1.12E-01	1.12E-01	4.14E-02	1.12E-01	1.12E-01	4.14E-02	1.12E-01
BASE 2	46.3	95.0	3.5	46.3	95.0	6.4	55.9	55.9	55.9	55.9	1.07E 05	1.24E-03	BASE	1.24E-03	5.77E-01	1.05E 00	5.77E-01	2.47E-01	1.05E 00	5.77E-01	2.47E-01	4.72E-01
							24.9	24.9	24.9	24.9	2.19E 03	2.43E-05	1	2.43E-05	4.62E-02	1.25E-01	1.25E-01	4.62E-02	1.25E-01	1.25E-01	4.62E-02	1.25E-01
BASE 3	46.3	95.0	-5.3	46.3	95.0	1.0	48.9	48.9	48.9	48.9	8.19E 04	6.11E-04	BASE	6.11E-04	2.60E-01	0.62E-01	2.60E-01	1.35E-01	0.62E-01	2.60E-01	1.35E-01	2.02E-01
							22.6	22.6	22.6	22.6	4.02E 01	4.51E-07	1	4.51E-07	8.58E-04	2.32E-05	2.32E-05	8.58E-04	2.32E-05	2.32E-05	8.58E-04	2.32E-05
MAIN 4	57.7	110.4	107.4	57.7	110.4	-122.2	93.4	93.4	93.4	93.4	5.40E 07	2.34E-08	MAIN	2.34E-08	9.61E-06	1.70E-05	9.61E-06	6.58E-06	1.70E-05	9.61E-06	6.58E-06	7.41E-06
							47.1	47.1	47.1	47.1	2.40E 01	0.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.
BASE 4	46.3	94.9	-17.1	46.3	95.0	-6.2	37.2	37.2	37.2	37.2	5.40E 04	1.77E-05	BASE	1.77E-05	7.29E-03	1.29E-02	7.29E-03	5.00E-03	1.29E-02	7.29E-03	5.00E-03	5.63E-03
							18.5	18.5	18.5	18.5	2.40E 00	1.60E-08	1	1.60E-08	3.04E-05	8.21E-05	8.21E-05	3.04E-05	8.21E-05	8.21E-05	3.04E-05	8.21E-05
MAIN 5	57.7	110.3	88.0	57.7	110.4	115.0	91.6	91.6	91.6	91.6	3.50E 05	9.30E-07	MAIN	9.30E-07	3.77E-04	6.67E-04	3.77E-04	3.49E-04	6.67E-04	3.77E-04	3.49E-04	2.90E-04
							46.7	46.7	46.7	46.7	1.07E 06	2.85E-06	1	2.85E-06	0.	0.	0.	0.	0.	0.	0.	0.
MAIN 6	57.7	110.3	66.4	57.7	110.4	95.9	89.0	89.0	89.0	89.0	2.29E 05	1.53E-05	MAIN	1.53E-05	6.14E-03	1.08E-02	6.14E-03	7.63E-03	1.08E-02	6.14E-03	7.63E-03	4.71E-03
							47.1	47.1	47.1	47.1	1.01E 04	6.74E-05	1	6.74E-05	0.	0.	0.	0.	0.	0.	0.	0.
MAIN 7	57.5	110.2	43.6	57.7	110.4	80.6	86.0	86.0	86.0	86.0	1.53E 05	1.36E-04	MAIN	1.36E-04	5.43E-02	9.59E-02	5.43E-02	8.93E-02	9.59E-02	5.43E-02	8.93E-02	9.16E-02
							46.3	46.3	46.3	46.3	0.41E 05	8.32E-04	1	8.32E-04	0.	0.	0.	0.	0.	0.	0.	0.

DETAILED SIZE GROUP RESULTS (CONTINUED)

CLOUD GROUP NUMBER	DUST CENTROID X-COORD. Y-COORD. Z-COORD. (METERS)	CARBON CENTROID X-COORD. Y-COORD. Z-COORD. (METERS)	DUST RADIUS WIND TRACK CROSS TRACK VERTICAL (METERS)	CARBON RADIUS WIND TRACK CROSS TRACK VERTICAL (METERS)	TOTAL MASS IN GROUP DUST-MODE A DUST-MODE B CARBON (GRAMS)	CLOUD PATH NUMBER	GROUP MASS PENETRATED DUST-MODE A DUST-MODE B CARBON (GM/CM2)	OPTICAL DEPTH ALONG PATH DUE TO GROUP EXTINCTION SCATTERING DUST-MODE A DUST-MODE B CARBON	ABSORPTION
MAIN 8	57.6 110.1 20.4	57.7 110.3 64.4	62.8 62.8 42.4	66.6 66.6 45.3	1.05E 05 6.65E 05 0.	MAIN 1	4.80E-04 3.96E-03 0.	3.31E-01 7.70E-01 0.	1.47E-01 3.60E-01 0.
MAIN 9	57.6 110.0 -2.6	57.7 110.2 47.9	79.6 79.6 40.9	86.6 86.6 44.3	7.33E 04 7.82E 05 0.	MAIN 1	5.07E-04 5.48E-03 0.	3.57E-01 1.04E 00 0.	1.58E-01 4.65E-01 0.
MAIN 10	57.5 117.9 -25.0	57.6 118.2 31.5	76.6 76.6 39.4	84.3 84.3 43.2	5.82E 04 7.82E 05 0.	MAIN 1	1.27E-04 1.75E-03 0.	6.90E-02 3.24E-01 0.	3.86E-02 1.52E-01 0.
MAIN 11	57.5 117.8 -51.0	57.6 118.1 11.3	73.3 73.3 37.6	81.5 81.5 41.8	4.54E 04 6.07E 05 0.	MAIN 1	3.04E-06 5.41E-05 0.	2.13E-03 9.83E-03 0.	9.21E-04 4.61E-03 0.
MAIN 12	57.4 117.7 -77.2	57.5 118.0 -6.3	70.5 70.5 36.4	78.8 78.8 40.5	3.12E 04 7.19E 05 0.	MAIN 1	2.18E-09 5.03E-08 0.	1.53E-06 9.01E-06 0.	6.66E-07 4.79E-06 0.

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

SUMMARY OF PROPAGATION RESULTS FOR TIME = 60.0 SECONDS

PATH NUMBER	WAVELENGTH (MICRONS)	FREQUENCY (GHZ)	PATH COORDINATES (METERS)			TOTAL TRANSMISSION			TOTAL OPTICAL DEPTH			OPTICAL DEPTH CONTRIBUTIONS FROM EACH BURST					
			TRANSMITTER X-COORD.	RECEIVER X-COORD.	Y-COORD.	Z-COORD.	EXTINCTION	SCATTERING	ABSORPTION	EXTINCTION	SCATTERING	ABSORPTION	BURST NUMBER	EXTINCTION	SCATTERING	ABSORPTION	
1	10.4	2.90E 04	1.2	1.2	1000.0	1.7	1.7	7.23E-04	1.96E-02	3.69E-02	7.23E 00	3.93E 00	3.30E 00	1	7.23E 00	3.93E 00	3.30E 00

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

DETAILED SIZE GROUP RESULTS FOR TIME = 80.0 SECONDS
BURST NUMBER = 1

CLOUD GROUP NUMBER	DUST CENTROID (METERS)			CARRON CENTROID (METERS)			DUST RADII			CARRON RADII			TOTAL MASS IN GROUP			CLOUD PATH NUMBER			GROUP MASS PENETRATED DUST-MODE A CARBON (GM/CM2)			OPTICAL DEPTH ALONG PATH DUE TO GROUP		
	X-COORD.	Y-COORD.	Z-COORD.	X-COORD.	Y-COORD.	Z-COORD.	WIND TRACK	CROSS TRACK	VERTICAL	WIND TRACK	CROSS TRACK	VERTICAL	DUST-MODE A	DUST-MODE B	CARBON	BASE	TOP	NUMBER	DUST-MODE A	DUST-MODE B	CARBON	EXTINCTION	SCATTERING	ABSORPTION
MAIN 1	79.2	162.4	167.3	79.2	162.4	168.6	109.5	109.5	55.5	109.5	109.5	55.5	7.82E 05	2.72E 05	2.23E 04	1	1	0.	0.	0.	0.	0.	0.	0.
	139.5	139.5	8.3	139.5	139.5	9.2	66.6	66.6	29.9	66.6	66.6	29.9	7.82E 04	2.72E 04	2.23E 03	1	1	2.50E-04	8.71E-05	6.90E-06	3.57E-01	1.12E-01	6.42E-02	1.46E-01
	68.0	139.5	8.3	68.0	139.5	9.2	66.6	66.6	29.9	66.6	66.6	29.9	7.82E 04	2.72E 04	2.23E 03	1	1	2.50E-04	8.71E-05	6.90E-06	1.12E-01	6.42E-02	1.46E-02	4.76E-02
BASE 2	68.0	139.5	1.1	68.0	139.5	1.1	64.2	64.2	29.1	64.2	64.2	29.1	1.07E 05	8.40E 04	2.19E 03	1	1	3.95E-04	1.38E-04	7.36E-06	2.92E-01	1.38E-01	6.88E-02	1.31E-01
	139.5	139.5	-2.2	139.5	139.5	-2.2	56.2	56.2	26.4	56.2	56.2	26.4	8.19E 04	1.05E 05	4.02E 01	1	1	9.37E-05	1.21E-04	1.12E-07	7.08E-02	3.99E-02	2.07E-02	3.10E-02
	79.2	162.4	121.5	79.2	162.4	140.7	107.7	107.7	54.6	107.7	107.7	54.6	5.40E 05	1.10E 06	2.40E 01	1	1	1.07E-08	2.18E-08	0.	5.76E-06	3.03E-06	0.	3.41E-06
BASE 3	68.0	139.5	-26.4	68.0	139.5	-26.4	42.7	42.7	21.6	42.7	42.7	21.6	5.40E 04	1.10E 05	2.40E 00	1	1	3.05E-07	6.19E-07	2.21E-09	2.28E-04	1.63E-04	1.14E-05	9.66E-05
	139.5	139.5	-26.4	139.5	139.5	-26.4	42.7	42.7	21.6	42.7	42.7	21.6	5.40E 04	1.10E 05	2.40E 00	1	1	3.05E-07	6.19E-07	2.21E-09	1.63E-04	1.14E-05	4.20E-06	7.73E-05
	79.2	162.4	121.5	79.2	162.4	140.7	107.7	107.7	54.6	107.7	107.7	54.6	5.40E 05	1.10E 06	2.40E 01	1	1	1.07E-08	2.18E-08	0.	5.76E-06	3.03E-06	0.	3.41E-06
MAIN 4	68.0	139.5	-26.4	68.0	139.5	-26.4	105.6	105.6	53.6	105.6	105.6	53.6	3.50E 05	1.07E 06	0.	1	1	9.28E-07	2.84E-06	0.	6.65E-04	3.48E-04	0.	2.89E-04
	139.5	139.5	-26.4	139.5	139.5	-26.4	105.6	105.6	53.6	105.6	105.6	53.6	3.50E 05	1.07E 06	0.	1	1	9.28E-07	2.84E-06	0.	6.65E-04	3.48E-04	0.	2.89E-04
	79.2	162.4	121.5	79.2	162.4	140.7	107.7	107.7	54.6	107.7	107.7	54.6	3.50E 05	1.07E 06	0.	1	1	9.28E-07	2.84E-06	0.	6.65E-04	3.48E-04	0.	2.89E-04
BASE 5	68.0	139.5	-26.4	68.0	139.5	-26.4	102.6	102.6	52.1	102.6	102.6	52.1	2.29E 05	1.01E 06	0.	1	1	1.85E-05	8.16E-05	0.	1.31E-02	1.74E-02	0.	5.69E-03
	139.5	139.5	-26.4	139.5	139.5	-26.4	102.6	102.6	52.1	102.6	102.6	52.1	2.29E 05	1.01E 06	0.	1	1	1.85E-05	8.16E-05	0.	1.31E-02	1.74E-02	0.	5.69E-03
	79.2	162.4	121.5	79.2	162.4	140.7	107.7	107.7	54.6	107.7	107.7	54.6	2.29E 05	1.01E 06	0.	1	1	1.85E-05	8.16E-05	0.	1.31E-02	1.74E-02	0.	5.69E-03
MAIN 6	68.0	139.5	-26.4	68.0	139.5	-26.4	99.1	99.1	50.4	99.1	99.1	50.4	1.53E 05	9.81E 05	0.	1	1	1.51E-04	9.27E-04	0.	1.07E-01	9.95E-02	0.	6.63E-02
	139.5	139.5	-26.4	139.5	139.5	-26.4	99.1	99.1	50.4	99.1	99.1	50.4	1.53E 05	9.81E 05	0.	1	1	1.51E-04	9.27E-04	0.	1.07E-01	9.95E-02	0.	6.63E-02
	79.2	162.4	121.5	79.2	162.4	140.7	107.7	107.7	54.6	107.7	107.7	54.6	1.53E 05	9.81E 05	0.	1	1	1.51E-04	9.27E-04	0.	1.07E-01	9.95E-02	0.	6.63E-02

DETAILED SIZE GROUP RESULTS (CONTINUED)

CLOUD GROUP NUMBER	DUST CENTROID			CARBON CENTROID			DUST RADII		CARBON RADII		TOTAL MASS IN GROUP		CLOUD		GROUP MASS PENETRATED		OPTICAL DEPTH ALONG PATH		DUE TO GROUP ABSORPTION		
	X-COORD.	Y-COORD.	Z-COORD.	X-COORD.	Y-COORD.	Z-COORD.	WIND TRACK VERTICAL (METERS)	CROSS TRACK VERTICAL (METERS)	WIND TRACK VERTICAL (METERS)	CROSS TRACK VERTICAL (METERS)	DUST-MODE A CARBON (GRAMS)	DUST-MODE B CARBON (GRAMS)	PATH NUMBER	DUST-MODE A CARBON (GM/CM2)	DUST-MODE B CARBON (GM/CM2)	EXTINCTION	SCATTERING DUST-MODE A CARBON	SCATTERING DUST-MODE B CARBON	EXTINCTION	SCATTERING DUST-MODE A CARBON	SCATTERING DUST-MODE B CARBON
MAIN 6	79.0	162.1	9.2	79.1	162.2	66.1	95.4	95.4	102.3	1.05E 05	8.65E 05	1	3.38E-04	2.79E-03	2.38E-01	1.15E-01	2.86E-01	1.03E-01	2.54E-01	0.	0.
							48.6	48.6	52.0	0.	0.		0.	0.	0.	0.	0.	0.	0.	0.	0.
MAIN 9	79.0	162.0	-20.4	79.1	162.1	44.8	91.7	91.7	99.8	7.33E 04	7.92E 05	1	1.42E-04	1.53E-03	9.99E-02	5.66E-02	1.54E-01	4.33E-02	1.56E-01	0.	0.
							46.8	46.8	50.7	0.	0.		0.	0.	0.	0.	0.	0.	0.	0.	0.
MAIN 10	78.9	161.9	-49.3	79.1	162.1	23.6	88.3	88.3	97.1	5.22E 04	7.22E 05	1	8.39E-06	1.16E-04	5.89E-03	3.34E-03	1.14E-02	2.55E-03	1.01E-02	0.	0.
							45.1	45.1	49.4	0.	0.		0.	0.	0.	0.	0.	0.	0.	0.	0.
MAIN 11	78.9	161.7	-83.9	79.0	162.0	-2.5	84.5	84.5	93.9	4.54E 04	8.07E 05	1	1.37E-06	2.44E-07	9.60E-06	5.44E-06	2.36E-05	4.16E-06	2.08E-05	0.	0.
							43.2	43.2	47.9	0.	0.		0.	0.	0.	0.	0.	0.	0.	0.	0.

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

SUMMARY OF PROPAGATION RESULTS FOR TIME = 60.0 SECONDS

PATH NUMBER	WAVELENGTH (MICRONS)	FREQUENCY (GHZ)	PATH COORDINATES (METERS)			TOTAL TRANSMISSION	TOTAL OPTICAL DEPTH	OPTICAL DEPTH CONTRI-
			TRANSMITTER X-COORD.	RECEIVER X-COORD.	Z-COORD.			
1	10.4	2.90E 04	1.2	1.2	7.38E-02	2.61E 00	2.61E 00	
			-1000.0	1000.0	2.42E-01	1.42E 00	1.42E 00	
			1.7	1.7	3.05E-01	1.19E 00	1.19E 00	

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

DETAILED SIZE GROUP RESULTS FOR TIME = 100.0 SECONDS
BURST NUMBER = 1

CLOUD GROUP NUMBER	DUST CENTROID X-COORD. (METERS)	DUST CENTROID Y-COORD. (METERS)	DUST CENTROID Z-COORD. (METERS)	CARBON CENTROID X-COORD. (METERS)	CARBON CENTROID Y-COORD. (METERS)	CARBON CENTROID Z-COORD. (METERS)	DUST RADIUS WIND TRACK VERTICAL (METERS)	CARBON RADIUS WIND TRACK VERTICAL (METERS)	DUST TRACK CROSS TRACK VERTICAL (METERS)	CARBON TRACK CROSS TRACK VERTICAL (METERS)	TOTAL MASS IN GROUP DUST-MODE A DUST-MODE B (GRAMS)	CLOUD PATH NUMBER	GROUP MASS PENETRATED DUST-MODE A DUST-MODE B (GM/CM2)	OPTICAL DEPTH EXTINCTION	SCATTERING DUST-MODE A DUST-MODE B CARBON	ABSORPTION
MAIN 1	100.6	206.3	188.9	100.6	206.3	190.4	122.3	122.3	122.3	122.3	7.82E 05 2.72E 05 2.23E 04	MAIN 1	0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.
BASE 1	89.8	184.0	7.7	89.8	184.0	8.9	75.1	75.1	75.2	75.2	7.82E 04 2.72E 04 2.23E 03	BASE 1	8.43E-05 2.94E-05 2.34E-06	1.20E-01 3.77E-02 1.20E-02	7.11E-02 2.17E-02 4.46E-03	4.92E-02 1.81E-02 7.58E-03
BASE 2	89.7	184.0	-1.3	89.7	184.0	5.5	72.6	72.6	74.3	74.3	1.07E 05 8.40E 04 2.19E 03	BASE 1	1.03E-04 8.07E-05 2.39E-06	8.72E-02 4.13E-02 1.23E-02	4.80E-02 2.06E-02 4.54E-03	3.92E-02 2.08E-02 7.72E-03
BASE 3	89.7	184.0	-15.9	89.7	184.0	-5.4	63.5	63.5	70.5	70.5	8.19E 04 1.05E 05 4.02E 01	BASE 1	1.60E-05 2.05E-05 3.02E-08	1.21E-02 6.80E-03 1.55E-04	6.78E-03 3.53E-03 5.75E-05	5.29E-03 3.20E-03 9.78E-05
MAIN 4	100.6	206.2	133.0	100.6	206.3	156.3	120.3	120.3	121.5	121.5	5.40E 05 1.10E 06 2.80E 01	MAIN 1	8.62E-09 1.75E-08 0.	6.28E-06 4.62E-06 0.	3.55E-06 2.43E-06 0.	2.73E-06 2.19E-06 0.
BASE 4	89.7	183.9	-35.6	89.7	184.0	-17.5	48.2	48.2	62.3	62.3	5.40E 04 1.10E 05 2.80E 00	BASE 1	0. 0. 3.42E-10	0. 0. 1.76E-06	0. 0. 6.50E-07	0. 0. 1.11E-06
MAIN 5	100.6	206.2	102.4	100.6	206.3	137.1	117.9	117.9	120.5	120.5	3.80E 05 1.07E 06 0.	MAIN 1	9.76E-07 2.99E-06 0.	7.00E-04 6.92E-04 0.	3.96E-04 3.66E-04 0.	3.04E-04 3.26E-04 0.
MAIN 6	100.5	206.1	68.4	100.6	206.2	114.9	114.6	114.6	119.0	119.0	2.29E 05 1.01E 06 0.	MAIN 1	2.12E-05 9.36E-05 0.	1.50E-02 1.99E-02 0.	8.52E-03 1.06E-02 0.	6.53E-03 9.35E-03 0.
MAIN 7	100.5	206.1	32.4	100.6	206.2	90.7	110.7	110.7	116.8	116.8	1.53E 05 9.81E 05 0.	MAIN 1	1.41E-04 8.67E-04 0.	1.00E-01 1.75E-01 0.	5.66E-02 9.31E-02 0.	4.34E-02 6.20E-02 0.

DETAILED SIZE GROUP RESULT3 (CONTINUED)

CLOUD GROUP NUMBER	DUST CENTROID X-COORD. Y-COORD. Z-COORD. (METERS)	CARBON CENTROID X-COORD. Y-COORD. Z-COORD. (METERS)	DUST RADII WIND TRACK CROSS TRACK VERTICAL (METERS)	CARBON RADII WIND TRACK CROSS TRACK VERTICAL (METERS)	TOTAL MASS IN GROUP DUST-MODE A DUST-MODE B (GRAMS)	CLOUD PATH NUMBER	GROUP MASS PENETRATED DUST-MODE A DUST-MODE B (GM/CM2)	OPTICAL DEPTH EXTINCTION	ALONG PATH SCATTERING DUST-MODE A DUST-MODE B CARBON	DEPTH DUE TO GROUP ABSORPTION
MAIN 8	100.5	100.5	106.5	114.3	1.05E 05	MAIN 1	1.75E-04	1.23E-01	0.99E-02	5.35E-02
	206.0	206.1	106.5	114.3	8.65E 05		1.44E-03	2.81E-01	1.49E-01	1.32E-01
	-4.1	65.3	54.0	57.9	0.		0.	0.	0.	0.
MAIN 9	100.4	100.5	102.4	111.4	7.33E 04	MAIN 1	2.55E-05	1.60E-02	1.02E-02	7.79E-03
	205.9	206.1	102.4	111.4	7.92E 05		2.76E-04	5.22E-02	2.77E-02	2.44E-02
	-40.3	39.3	52.0	56.5	0.		0.	0.	0.	0.
MAIN 10	100.4	100.5	98.6	106.5	5.22E 04	MAIN 1	3.09E-07	2.17E-04	1.23E-04	9.40E-05
	205.6	206.0	98.6	106.5	7.22E 05		4.27E-06	7.91E-04	4.21E-04	3.70E-04
	-75.6	13.4	50.1	55.0	0.		0.	0.	0.	0.

ASL MURKIN DUST CLOUD MODEL

PROBLEM NUMBER 1

SUMMARY OF PROPAGATION RESULTS FOR TIME = 100.0 SECONDS

PATH NUMBER	WAVELENGTH (MICRONS)	FREQUENCY (GHZ)	PATH COORDINATES (METERS)	TRANSMITTER X-COORD.	TRANSMITTER Y-COORD.	TRANSMITTER Z-COORD.	RECEIVER X-COORD.	RECEIVER Y-COORD.	RECEIVER Z-COORD.	TOTAL TRANSMISSION EXTINCTION SCATTERING ABSORPTION	TOTAL OPTICAL DEPTH EXTINCTION SCATTERING ABSORPTION	OPTICAL DEPTH CONTRIBUTIONS FROM EACH BURST
1	10.4	2.90E 04	1.2	-1000.0	1.7	1.2	1000.0	1.7	1.2	3.27E-01 5.45E-01 6.01E-01	1.12E 00 6.08E-01 5.09E-01	1

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

DETAILED SIZE GROUP RESULTS FOR TIME = 120.0 SECONDS
BURST NUMBER = 1

CLOUD GROUP NUMBER	DUST CENTROID			CARBON CENTROID			DUST RADI		CARBON RADI		TOTAL MASS IN GROUP		CLOUD PATH NUMBER		GROUP MASS PENETRATED DUST-MODE A CARBON (GM/CM2)		OPTICAL DEPTH ALONG PATH DUE TO GROUP	
	X-COORD. (METERS)	Y-COORD. (METERS)	Z-COORD. (METERS)	X-COORD. (METERS)	Y-COORD. (METERS)	Z-COORD. (METERS)	WIND TRACK VERTICAL (METERS)	CROSS TRACK VERTICAL (METERS)	WIND TRACK VERTICAL (METERS)	CROSS TRACK VERTICAL (METERS)	DUST-MODE A CARBON (GRAMS)	DUST-MODE B CARBON (GRAMS)	BASE	MAIN	EXTINCTION	SCATTERING DUST-MODE A CARBON	ABSORPTION	
MAIN 1	122.1	250.3	208.4	122.1	250.3	210.2	133.8	133.8	133.8	133.8	7.82E 05	2.72E 05	1	MAIN	0.	0.	0.	0.
							67.6	153.8	153.8	2.73E 04	0.	0.	1		0.	0.	0.	0.
															4.47E-02	2.65E-02	1.83E-02	0.
BASE 1	111.5	228.5	7.1	111.5	228.5	8.5	83.7	83.7	83.7	7.82E 04	2.72E 04	1	BASE	4.47E-02	2.65E-02	1.83E-02	0.	
							38.0	83.7	83.7	2.23E 03	1.09E-05	8.76E-07	1		1.80E-02	8.05E-03	5.97E-03	0.
															4.50E-03	1.67E-03	2.60E-03	0.
BASE 2	111.4	228.5	-3.7	111.4	228.5	2.0	80.9	80.9	80.9	1.07E 05	6.40E 04	1	BASE	2.90E-02	1.59E-02	1.30E-02	0.	
							37.0	80.9	80.9	2.19E 03	2.68E-05	8.55E-07	1		1.39E-02	6.84E-03	6.91E-03	0.
															4.40E-03	1.63E-03	2.77E-03	0.
BASE 3	111.4	228.5	-21.3	111.4	228.5	-0.6	70.8	70.8	70.8	8.19E 04	1.05E 05	1	BASE	2.40E-03	1.35E-03	1.05E-03	0.	
							33.6	70.8	70.8	4.02E 01	4.08E-06	9.12E-09	1		7.01E-04	6.51E-04	6.51E-04	0.
															4.49E-05	1.74E-05	2.95E-05	0.
MAIN 4	122.0	250.2	182.5	122.0	250.2	170.0	131.7	131.7	131.7	5.40E 05	1.10E 06	1	MAIN	6.03E-06	4.54E-06	3.50E-06	0.	
							66.5	131.7	131.7	2.40E 01	2.24E-08	0.	1		5.91E-06	2.80E-06	2.80E-06	0.
															0.	0.	0.	0.
BASE 4	111.4	228.4	-80.9	111.4	228.4	-23.2	53.6	53.6	53.6	5.40E 04	1.10E 05	1	BASE	0.	0.	0.	0.	
							27.5	53.6	53.6	2.40E 00	6.21E-11	0.	1		0.	0.	0.	0.
															3.19E-07	1.16E-07	2.01E-07	0.
MAIN 5	122.0	250.1	106.5	122.0	250.1	147.3	129.1	129.1	129.1	3.50E 05	1.07E 06	1	MAIN	7.39E-04	9.18E-04	3.21E-04	0.	
							65.2	129.1	129.1	1.07E 06	3.16E-06	0.	1		7.30E-04	3.67E-04	3.44E-04	0.
															0.	0.	0.	0.
MAIN 6	122.0	250.1	66.3	122.0	250.1	121.2	125.5	125.5	125.5	2.29E 05	1.01E 06	1	MAIN	1.60E-02	9.07E-03	6.96E-03	0.	
							63.9	125.5	125.5	0.	9.97E-05	0.	1		2.12E-02	1.13E-02	9.96E-03	0.
															0.	0.	0.	0.
MAIN 7	121.4	250.0	23.9	121.4	250.0	92.6	121.1	121.1	121.1	1.53E 05	9.41E 05	1	MAIN	7.98E-02	4.82E-02	3.46E-02	0.	
							61.3	121.1	121.1	6.92E-04	6.92E-04	0.	1		1.48E-01	7.42E-02	6.54E-02	0.
															0.	0.	0.	0.

DETAILED SIZE GROUP RESULTS (CONTINUED)

CLOUD GROUP NUMBER	DUST CENTROID			CARRON CENTROID			DUST RADIUS		CARRON RADIUS		TOTAL MASS IN GROUP		CLOUD PENETRATED		OPTICAL DEPTH ALONG PATH		DUE TO GROUP					
	X-COORD. (METERS)	Y-COORD. (METERS)	Z-COORD. (METERS)	X-COORD. (METERS)	Y-COORD. (METERS)	Z-COORD. (METERS)	WIND TRACK VERTICAL (METERS)	CROSS TRACK VERTICAL (METERS)	WIND TRACK VERTICAL (METERS)	CROSS TRACK VERTICAL (METERS)	DUST-MODE A (GRAMS)	DUST-MODE B (GRAMS)	GROUP MASS DUST-MODE A (GM/CH2)	GROUP MASS DUST-MODE B (GM/CH2)	EXTINCTION	SCATTERING DUST-MODE A DUST-MODE B CARBON	EXTINCTION	SCATTERING DUST-MODE A DUST-MODE B CARBON	EXTINCTION	SCATTERING DUST-MODE A DUST-MODE B CARBON		
MAIN 8	121.9	299.9	-19.1	122.0	250.1	62.7	116.5	116.5	125.1	125.1	1.05E 05	8.11E 05	7.06E-05	5.82E-04	4.97E-02	2.82E-02	1.13E-01	6.02E-02	2.16E-02	5.30E-02	0.	0.
	121.8	299.8	-61.6	121.9	250.0	32.1	112.1	112.1	122.0	122.0	7.33E 04	7.92E 05	3.24E-06	3.50E-05	2.26E-03	1.29E-03	6.61E-03	3.52E-03	9.87E-04	3.10E-03	0.	0.
	121.6	299.7	-103.3	121.9	299.9	1.5	107.9	107.9	119.7	118.7	5.22E 00	7.22E 05	6.41E-09	6.86E-08	4.50E-06	2.55E-06	1.64E-05	6.72E-06	1.95E-06	7.68E-06	0.	0.

ASL MUNITION OUST CLOUD MODEL

PROBLEM NUMBER 1

SUMMARY OF PROPAGATION RESULTS FOR TIME = 120.0 SECONDS

PATH NUMBER	WAVELENGTH (MICRONS)	FREQUENCY (GHZ)	TRANSMITTER X-COORD.	TRANSMITTER Y-COORD.	TRANSMITTER Z-COORD.	RECEIVER X-COORD.	RECEIVER Y-COORD.	RECEIVER Z-COORD.	TOTAL TRANSMISSION EXTINCTION SCATTERING ABSORPTION	TOTAL OPTICAL DEPTH EXTINCTION SCATTERING ABSORPTION	OPTICAL DEPTH CONTRIBUIONS FROM EACH BURST NUMBER	EXTINCTION SCATTERING ABSORPTION
1	10.4	2.90E 04	1.2	-1000.0	1.7	1.2	1000.0	1.7	5.80E-01 7.44E-01 7.81E-01	5.44E-01 2.96E-01 2.48E-01	1	5.44E-01 2.96E-01 2.48E-01

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

DETAILED SIZE GROUP RESULTS FOR TIME = 140.0 SECONDS
 RURST NUMBER = 1

CLOUD GROUP NUMBER	DUST CENTROID			CARBON CENTROID			DUST RADII		CROSS TRACK WIND TRACK		CROSS TRACK WIND TRACK		CROSS TRACK WIND TRACK		CLOUD PATH NUMBER	GROUP MASS PENETRATED DUST-MODE A DUST-MODE B		OPTICAL DEPTH EXTINCTION	SCATTERING ALONG PATH DUE TO GROUP ABSORPTION	
	X-COORD. (METERS)	Y-COORD. (METERS)	Z-COORD. (METERS)	X-COORD. (METERS)	Y-COORD. (METERS)	Z-COORD. (METERS)	DUST-MODE A (MICRONS)	DUST-MODE B (MICRONS)	DUST-MODE A (GRAMS)	DUST-MODE B (GRAMS)	DUST-MODE A (GRAMS)	DUST-MODE B (GRAMS)	DUST-MODE A (GRAMS)	DUST-MODE B (GRAMS)		DUST-MODE A	DUST-MODE B		DUST-MODE A	DUST-MODE B
MAIN 1	143.5	294.2	226.3	143.5	294.2	226.3	144.5	144.5	7.82E 05	7.82E 05	1	1	0.	0.	0.	0.	0.	0.	0.	0.
	144.5	294.2	226.3	144.5	294.2	226.3	144.5	144.5	2.72E 05	2.72E 05	1	1	0.	0.	0.	0.	0.	0.	0.	0.
	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	2.23E 04	2.23E 04			0.	0.	0.	0.	0.	0.	0.	0.
BASE 1	133.2	273.0	6.5	133.2	273.0	6.5	92.3	92.3	7.82E 04	7.82E 04	BASE	BASE	1.29E-05	1.29E-05	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02	1.09E-02
	273.0	273.0	6.5	273.0	273.0	6.5	92.3	92.3	2.72E 04	2.72E 04	1	1	4.89E-05	4.89E-05	5.76E-03	5.76E-03	3.31E-03	3.31E-03	3.31E-03	3.31E-03
	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	2.23E 03	2.23E 03			3.62E-07	3.62E-07	1.86E-03	1.86E-03	6.89E-04	6.89E-04	6.89E-04	6.89E-04
BASE 2	133.1	273.0	6.1	133.1	273.0	6.1	89.2	89.2	1.07E 05	1.07E 05	BASE	BASE	1.27E-05	1.27E-05	1.08E-02	1.08E-02	5.92E-03	5.92E-03	5.92E-03	5.92E-03
	273.0	273.0	6.1	273.0	273.0	6.1	89.2	89.2	8.40E 04	8.40E 04	1	1	9.95E-06	9.95E-06	5.10E-03	5.10E-03	2.54E-03	2.54E-03	2.54E-03	2.54E-03
	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	2.19E 03	2.19E 03			3.40E-07	3.40E-07	1.75E-03	1.75E-03	6.47E-04	6.47E-04	6.47E-04	6.47E-04
BASE 3	133.1	273.0	-26.6	133.1	273.0	-26.6	78.1	78.1	8.19E 04	8.19E 04	BASE	BASE	7.38E-07	7.38E-07	5.56E-04	5.56E-04	3.12E-04	3.12E-04	3.12E-04	3.12E-04
	273.0	273.0	-26.6	273.0	273.0	-26.6	78.1	78.1	1.03E 05	1.03E 05	1	1	9.48E-07	9.48E-07	5.33E-04	5.33E-04	1.62E-04	1.62E-04	1.62E-04	1.62E-04
	-26.6	-26.6	-26.6	-26.6	-26.6	-26.6	37.0	37.0	8.02E 01	8.02E 01			3.10E-09	3.10E-09	1.59E-05	1.59E-05	5.90E-06	5.90E-06	5.90E-06	5.90E-06
MAIN 4	143.4	294.1	150.5	143.4	294.1	150.5	142.1	142.1	5.40E 05	5.40E 05	MAIN	MAIN	9.81E-09	9.81E-09	7.15E-06	7.15E-06	4.04E-06	4.04E-06	3.11E-06	3.11E-06
	294.1	294.1	150.5	294.1	294.1	150.5	142.1	142.1	1.10E 06	1.10E 06	1	1	1.99E-08	1.99E-08	5.26E-06	5.26E-06	2.77E-06	2.77E-06	2.49E-06	2.49E-06
	150.5	150.5	150.5	150.5	150.5	150.5	72.8	72.8	2.80E 01	2.80E 01			0.	0.	0.	0.	0.	0.	0.	0.
BASE 4	133.1	272.9	-54.1	133.1	272.9	-54.1	59.3	59.3	5.40E 04	5.40E 04	BASE	BASE	0.	0.	0.	0.	0.	0.	0.	0.
	272.9	272.9	-54.1	272.9	272.9	-54.1	59.3	59.3	1.10E 05	1.10E 05	1	1	0.	0.	0.	0.	0.	0.	0.	0.
	-54.1	-54.1	-54.1	-54.1	-54.1	-54.1	30.5	30.5	2.80E 00	2.80E 00			1.33E-11	1.33E-11	6.01E-08	6.01E-08	2.52E-08	2.52E-08	4.29E-08	4.29E-08
MAIN 5	143.4	294.1	109.1	143.4	294.1	109.1	139.4	139.4	3.50E 05	3.50E 05	MAIN	MAIN	1.07E-06	1.07E-06	7.69E-04	7.69E-04	4.35E-04	4.35E-04	3.38E-04	3.38E-04
	294.1	294.1	109.1	294.1	294.1	109.1	139.4	139.4	1.07E 06	1.07E 06	1	1	3.29E-06	3.29E-06	7.60E-04	7.60E-04	4.02E-04	4.02E-04	3.58E-04	3.58E-04
	109.1	109.1	109.1	109.1	109.1	109.1	70.3	70.3	0.	0.			0.	0.	0.	0.	0.	0.	0.	0.
MAIN 6	143.4	294.1	126.0	143.4	294.1	126.0	142.4	142.4	2.29E 05	2.29E 05	MAIN	MAIN	2.23E-05	2.23E-05	1.56E-02	1.56E-02	8.97E-03	8.97E-03	6.88E-03	6.88E-03
	294.1	294.1	126.0	294.1	294.1	126.0	142.4	142.4	1.07E 04	1.07E 04	1	1	9.85E-05	9.85E-05	2.10E-02	2.10E-02	1.11E-02	1.11E-02	9.05E-03	9.05E-03
	126.0	126.0	126.0	126.0	126.0	126.0	70.9	70.9	0.	0.			0.	0.	0.	0.	0.	0.	0.	0.
MAIN 7	143.4	294.1	14.2	143.4	294.1	14.2	138.1	138.1	1.53E 05	1.53E 05	MAIN	MAIN	7.83E-05	7.83E-05	5.54E-02	5.54E-02	3.14E-02	3.14E-02	2.40E-02	2.40E-02
	294.1	294.1	14.2	294.1	294.1	14.2	138.1	138.1	9.41E 05	9.41E 05	1	1	3.00E-04	3.00E-04	9.69E-02	9.69E-02	5.15E-02	5.15E-02	4.58E-02	4.58E-02
	14.2	14.2	14.2	14.2	14.2	14.2	88.7	88.7	0.	0.			0.	0.	0.	0.	0.	0.	0.	0.

DETAILED SIZE GROUP RESULTS (CONTINUED)

CLOUD GROUP NUMBER	DUST CENTROID X-COORD. Y-COORD. Z-COORD. (METERS)	CARBON CENTROID X-COORD. Y-COORD. Z-COORD. (METERS)	DUST RADIUS WIND TRACK VERTICAL (METERS)	CARBON RADIUS WIND TRACK VERTICAL (METERS)	TOTAL MASS IN GROUP DUST-MODE A DUST-MODE B (GRAMS)	CLOUD PATH NUMBER	GROUP MASS PENETRATED DUST-MODE A DUST-MODE B (GM/CM2)	OPTICAL DEPTH EXTINCTION	SCATTERING DUST-MODE A DUST-MODE B CARBON	ALONG PATH DUE TO GROUP ABSORPTION
MAIN 8	143.3 293.8 -35.3	143.4 294.0 58.7	125.8 125.8 63.6	135.0 135.0 68.2	1.05E 05 6.65E 05	MAIN 1	2.31E-05 1.90E-04 0.	1.63E-02 3.70E-02 0.	9.21E 03 1.97E 02 0.	7.05E-03 1.73E-02 0.
MAIN 9	143.3 293.8 -84.4	143.4 293.9 23.5	121.0 121.0 81.2	131.7 131.7 66.5	7.33E 04 7.92E 05 0.	MAIN 1	3.10E-07 3.34E-06 0.	2.18E-04 6.32E-04 0.	1.23E-04 3.36E-04 0.	9.48E-05 2.96E-04 0.

ASL MUNITION DUST CLOUD MODEL

PROBLEM NUMBER 1

SUMMARY OF PROPAGATION RESULTS FOR TIME = 140.0 SECONDS

PATH NUMBER	WAVELENGTH (MICRONS)	FREQUENCY (GHZ)	PATH COORDINATES (METERS)			TOTAL TRANSMISSION			TOTAL OPTICAL DEPTH			OPTICAL SOLUTIONS			DEPTH CONTAINED FROM EACH BURST						
			TRANSMITTER X-COORD.	TRANSMITTER Y-COORD.	TRANSMITTER Z-COORD.	RECEIVER X-COORD.	RECEIVER Y-COORD.	RECEIVER Z-COORD.	EXTINCTION	SCATTERING	ABSORPTION	EXTINCTION	SCATTERING	ABSORPTION	BURST NUMBER	EXTINCTION	SCATTERING	ABSORPTION			
1	10.0	2.90E 04	1.2	1.2	1.2	1000.0	1000.0	1000.0	1.2	1.7	1.7	1.2	1.7	1.7	1	2.89E-01	1.50E-01	1.32E-01	2.89E-01	1.50E-01	1.32E-01

SECTION 5 CODE LISTING

In this section we present the FORTRAN card source listings of the ASL-DUST code. In general, each routine defines the principal FORTRAN mnemonics of the variables used within the routine. Routine INPUT defines all input mnemonics. Comment cards are interspersed throughout the routines as a programming aid.

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1      C      EXECUTIVE ROUTINE FOR THE ASL MUNITION DUST CLOUD MODEL
2      C
3      C      THIS IS THE EXECUTIVE ROUTINE FOR THE COMPUTER CODE PROGRAM FOR
4      C      THE ASL MUNITION DUST CLOUD MODEL DOCUMENTED IN
5      C
6      C      MODELS FOR MUNITION DUST CLOUDS
7      C      BY JAMES H THOMPSON
8      C      ASL-CR-79-0005-2, (GF78TMP-99 ), GENERAL ELECTRIC -
9      C      TEMPO, NOVEMBER 22, 1978
10     C
11     C      ASL-DUST. A TACTICAL BATTLEFIELD DUST CLOUD AND
12     C      PROPAGATION CODE
13     C      VOLUME 1. MODEL FORMULATIONS
14     C      VOLUME 2. USERS MANUAL
15     C      BY JAMES H. THOMPSON
16     C      GEROTMP-5, GENERAL ELECTRIC - TEMPO, JANUARY 1980
17     C
18     C
19     C
20     C      SEE SUBROUTINE INPUT FOR THE DEFINITIONS OF VARIABLES IN THE
21     C      CINTP1 - CINTP7 LABELLED COMMON AREAS. SEE SUBROUTINE DEPTH FOR
22     C      VARIABLES IN CDEPTH LABELLED COMMON
23     C
24     C      COMMON / CINTP1 / W(10), FH(10), CI(10), CP(10), CV(10), XR(10),
25     1      YR(10), ZR(10), DOR(10), FCM(10), ACV(10),
26     2      PHIBDG(10)
27     C      COMMON / CINTP2 / FRFQ(10), XLAMDA(10), XT(10), YT(10), ZT(10),
28     1      XR(10), YR(10), ZR(10)
29     C      COMMON / CINTP3 / XNAR(10), XNAI(10), XNAR(10), XNRI(10), XNCR(10)
30     1      , XNCI(10), APA, SA, AMINA, AMAXA, PA, AMB, SB,
31     2      AMINB, AMAXB, PB, AMC, SC, AMINC, AMAXC, PC
32     C      COMMON / CINTP4 / RHGG, RHOD, RHOC, FH20, XLC, RMAH, RBASE
33     C      COMMON / CINTP5 / PSF, ALPHA, CDGAG, RHQA, ELEVQ, TAIR, TLAPSE,
34     1      ALTV, VWIND, ALTW, PVW, PHWDG
35     C      COMMON / CINTP6 / NW, NNG, NRT, NTIME, NPROB, IPRINT
36     C      COMMON / CINTP7 / DGROUP(50), TIME(25)
37     C      COMMON / CDEPTH / TAUW(10,10), TAUSW(10,10), TAUW(10,10),
38     1      TAU(10), TAUS(10), TAU(10)
39     C      SET DEFAULT TIMES
40     C      DIMENSION TFLT(25)
41     C      DATA TFLT / 2., 4., 6., 8., 10., 12., 14., 16., 18., 20., 22.5,
42     1      25., 27.5, 30., 32.5, 35., 37.5, 40., 45., 50., 55.,
43     2      60., 70., 80., 100. /
44     C
45     C      SET DEFAULT DIAMETERS OF SIZE GROUPS
46     C      DIMENSION DGFLT(50)
47     C      DATA DGFLT / 5., 10., 20., 30., 40., 50., 60., 70., 80., 90.,
48     1      100., 105., 110., 115., 120., 125., 130., 135., 140.,
49     2      145., 150., 155., 160., 165., 170., 175., 180., 185.,
50     3      190., 195., 200., 210., 220., 230., 240., 250., 260.,
51     4      270., 280., 290., 300., 350., 400., 450., 500., 600.,
52     5      750., 1000., 5000., 10000. /
53     C
54     C      INPUT - OUTPUT TAPE DESIGNATION
55     C      COMMON / TAPE / ITAPE, JTAPE
56     C      THE INPUT AND OUTPUT TAPE NUMBERS ARE SPECIFIED BY ASSIGNING
57     C      VALUES TO THE VARIABLES ITAPE AND JTAPE, RESPECTIVELY. THESE ARE
58     C      PRESENTLY SET TO 5 AND 6, BUT CAN EASILY BE CHANGED BY RESPECIFYING

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59      C      THE FOLLOWING TWO STATEMENTS
60      IIAPE = 5
61      JIAPE = 6
62      C
63      C      INITIALIZATION SECTION. SET THE DEFAULT VALUES
64      RHOG = 1.5
65      RHOD = 2.5
66      FH2O = 0.15
67      AMA = 1.
68      SA = 2.2
69      AMINA = 0.
70      AMAXA = 0.
71      PA = 0.
72      AMR = 20.
73      SR = 2.
74      AMINR = 180.
75      AMAXR = 1.E4
76      PR = 4.
77      AMC = 0.5
78      SC = 2.
79      AMINC = 0.
80      AMAXC = 0.
81      PC = 0.
82      RHOC = 1.5
83      XLC = 0.3
84      NDG = 50
85      DO 1 I = 1, 50
86      DGPOUP(I) = DGFLT(I)
87      1 CONTINUE
88      NRT = 1
89      FREQ(1) = 1.E5
90      XLAMDA(1) = 3.
91      XI(1) = 500.
92      YI(1) = 50.
93      ZI(1) = 2.
94      XR(1) = - 500.
95      YR(1) = 50.
96      ZR(1) = 2.
97      XNAR(1) = 1.66
98      XNAI(1) = 1.6E-2
99      XNRR(1) = 1.66
100     XNRI(1) = 1.6E-2
101     XNCR(1) = 2.
102     XNCI(1) = 1.
103     PSF = 4.
104     ALPHA = 1.
105     CDRAG = 0.8
106     RHQA = 1.225E-3
107     ELEVG = 0.
108     TAIR = 288.
109     TLAPSE = - 9.8E-3
110     ALTIV = 1.E3
111     VMIND = 3.
112     PHINDG = 0.
113     RMAH = 0.25
114     RRASE = 0.1
115     NTIME = 25
116     DO 2 I = 1, NTIME

```

```

117         TIME(I) = TFLT(I)
118     2 CONTINUE
119         NPROB = 0
120         IPRINT = 0
121     C
122     C READ THE INPUT FOR THIS PROBLEM
123     10 CALL INPUT
124     C
125     C FOR EACH TYPE OF MATERIAL, CALCULATE THE PROPAGATION PARAMETERS
126     C FOR EACH CONTRIBUTING SIZE GROUP FOR EACH FREQUENCY
127     CALL PGROUP
128     C
129     C CALCULATE THE INITIAL PROPERTIES OF THE DUST CLOUDS FOR EACH BURST
130     CALL INITCG
131     C
132     C TIME DEPENDENT CALCULATIONS
133     C
134     C LOOP OVER THE TIMES
135     DO 60 IT = 1, NTIME
136     T = TIME(IT)
137     C
138     C ZERO OUT THE OPTICAL DEPTH PARAMETERS
139     DO 25 IPT = 1, NRT
140     TAUE(IPT) = 0.
141     TA'U(IPT) = 0.
142     TANA(IPT) = 0.
143     DO 25 IW = 1, NW
144     TAUEW(IW,IPT) = 0.
145     TAUSW(IW,IPT) = 0.
146     TAUAW(IW,IPT) = 0.
147     25 CONTINUE
148     C
149     C LOOP OVER THE BURSTS
150     DO 50 IW = 1, NW
151     INC = IW
152     C
153     C FOR THIS TIME AND BURST CALCULATE THE LOCATION AND CLOUD SIZE OF
154     C THE ZERO DIAMETER PARTICLES
155     CALL TIMECO( T, INC )
156     C
157     C LOOP OVER THE SIZE GROUPS
158     DO 40 IDG = 1, NOG
159     IDGC = IDG
160     C
161     C FOR THIS TIME AND BURST FIND THE LOCATION AND GEOMETRY OF THE
162     C SIZE GROUP
163     CALL TIMECG( T, INC, IDGC )
164     C
165     C LOOP OVER THE RECEIVER - TRANSMITTER PAIRS
166     DO 30 IRT = 1, NRT
167     IRTC = IRT
168     C
169     C
170     C FOR THIS TIME, BURST, AND SIZE GROUP FIND THE MASS PENETRATED
171     C ALONG THE PATH BETWEEN THIS RECEIVER - TRANSMITTER PAIR DUE TO
172     C EACH MATERIAL IN THE SIZE GROUP
173     CALL PATH( INC, IDGC, IRTC )
174     C

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175 C FOR THIS TIME, BURST AND SIZE GROUP FIND THE EXTINCTION,  
176 C SCATTERING AND ABSORPTION OPTICAL DEPTHS ALONG THIS PATH DUE TO  
177 C EACH MATERIAL IN THE SIZE GROUP. SUM THE CONTRIBUTIONS  
178 C CALL DEPTH( T, IMC, IDGC, IRTC )  
179 C  
180 C 30 CONTINUE  
181 C  
182 C 40 CONTINUE  
183 C  
184 C 50 CONTINUE  
185 C  
186 C 60 CONTINUE  
187 C  
188 C  
189 C THIS PROBLEM IS COMPLETED. DO NEXT PROBLEM  
190 C GO TO 10  
191 C  
192 C END
```

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1      SUBROUTINE INPUT
2      C
3      C THIS ROUTINE READS THE INPUT FOR EACH PROBLEM, THEN WRITES THE
4      C INPUT VALUES OUT
5      C
6      C
7      C DEFINITIONS OF VARIABLES IN LABELED COMMON
8      C
9      C W(IW)      = EQUIVALENT TNT YIELD OF BURST IW (LBS TNT)
10     C FH(IW)   = FRACTION OF YIELD APPEARING AS HYDRODYNAMIC ENERGY
11     C          FOR BURST IW
12     C CT(IW)   = INITIAL MAIN CLOUD SHAPE FACTOR FOR THE DIRECTION
13     C          ALONG THE SHELL TRACK FOR BURST IW
14     C CP(IW)   = INITIAL MAIN CLOUD SHAPE FACTOR FOR THE DIRECTION
15     C          PERPENDICULAR TO THE SHELL TRACK FOR BURST IW
16     C CV(IW)   = INITIAL MAIN CLOUD SHAPE FACTOR FOR THE VERTICAL
17     C          DIRECTION
18     C IX(IW)   = X COORDINATE OF THE GROUND SURFACE AT BURST IW
19     C          (METERS)
20     C IY(IW)   = Y COORDINATE OF THE GROUND SURFACE AT BURST IW
21     C          (METERS)
22     C IZ(IW)   = Z COORDINATE OF THE GROUND SURFACE AT BURST IW
23     C          (METERS)
24     C DOB(IW)  = DEPTH OF BURST, IE, DISTANCE BELOW GROUND SURFACE OF
25     C          CENTER OF GRAVITY OF BURST IW (METERS)
26     C FCM(IW)  = FRACTION OF THE APPARENT CRATER MASS OF BURST IW THAT
27     C          IS LOFTED INTO THE AIR
28     C ACV(IW)  = APPARENT CRATER VOLUME SCALING FACTOR FOR BURST IW
29     C          (CUBIC METERS PER (LB TNT)**1.111 )
30     C PHIBSG(IW) = AZIMUTH OF SHELL TRACK OF BURST IW (DEGREES,
31     C          MEASURED CLOCKWISE FROM THE Y AXIS)
32     C FREQ(IRT) = FREQUENCY OF TRANSMITTER - RECEIVER PAIR IRT (GHZ)
33     C XLAMBDA(IRT) = WAVELENGTH OF TRANSMITTER - RECEIVER PAIR IRT
34     C          (MICRONS)
35     C XT(IRT)   = X COORDINATE OF TRANSMITTER IRT (METERS)
36     C YT(IRT)   = Y COORDINATE OF TRANSMITTER IRT (METERS)
37     C ZT(IRT)   = Z COORDINATE OF TRANSMITTER IRT (METERS)
38     C XR(IRT)   = X COORDINATE OF RECEIVER IRT (METERS)
39     C YR(IRT)   = Y COORDINATE OF RECEIVER IRT (METERS)
40     C ZR(IRT)   = Z COORDINATE OF RECEIVER IRT (METERS)
41     C XNAR(IRT) = REAL PART OF THE COMPLEX INDEX OF REFRACTION FOR MODE
42     C          A DUST PARTICLES AT THE WAVELENGTH OF TRANSMITTER -
43     C          RECEIVER IRT
44     C XNAI(IRT) = IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION FOR
45     C          MODE A DUST PARTICLES AT THE WAVELENGTH OF
46     C          TRANSMITTER - RECEIVER IRT
47     C XNBR(IRT) = REAL PART OF THE COMPLEX INDEX OF REFRACTION FOR MODE
48     C          B DUST PARTICLES AT THE WAVELENGTH OF TRANSMITTER -
49     C          RECEIVER IRT
50     C XNBI(IRT) = IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION FOR
51     C          MODE B DUST PARTICLES AT THE WAVELENGTH OF
52     C          TRANSMITTER - RECEIVER IRT
53     C XNCF(IRT) = REAL PART OF THE COMPLEX INDEX OF REFRACTION FOR
54     C          CARBON PARTICLES AT THE WAVELENGTH OF TRANSMITTER -
55     C          RECEIVER IRT
56     C XNCI(IRT) = IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION FOR
57     C          CARBON PARTICLES AT THE WAVELENGTH OF TRANSMITTER -
58     C          RECEIVER IRT

```

59	C	AMA	= MEAN DIAMETER OF THE LOG NORMAL DISTRIBUTION FOR MODE A DUST PARTICLES (MICRONS)
60	C		
61	C	SA	= STANDARD DEVIATION PARAMETER OF THE LOG NORMAL DISTRIBUTION FOR MODE A DUST PARTICLES
62	C		
63	C	AMINA	= MINIMUM DIAMETER OF THE POWER LAW DISTRIBUTION FOR MODE A DUST PARTICLES (MICRONS)
64	C		
65	C	AMAXA	= MAXIMUM DIAMETER OF THE POWER LAW DISTRIBUTION FOR MODE A DUST PARTICLES (MICRONS)
66	C		
67	C	AMB	= MEAN DIAMETER OF THE LOG NORMAL DISTRIBUTION FOR MODE B DUST PARTICLES (MICRONS)
68	C		
69	C	SB	= STANDARD DEVIATION PARAMETER OF THE LOG NORMAL DISTRIBUTION FOR MODE B DUST PARTICLES
70	C		
71	C	AMINB	= MINIMUM DIAMETER OF THE POWER LAW DISTRIBUTION FOR MODE B DUST PARTICLES (MICRONS)
72	C		
73	C	AMAXB	= MAXIMUM DIAMETER OF THE POWER LAW DISTRIBUTION FOR MODE B DUST PARTICLES (MICRONS)
74	C		
75	C	AMC	= MEAN DIAMETER OF THE LOG NORMAL DISTRIBUTION FOR CARBON PARTICLES (MICRONS)
76	C		
77	C	SC	= STANDARD DEVIATION PARAMETER OF THE LOG NORMAL DISTRIBUTION FOR CARBON PARTICLES
78	C		
79	C	AMINC	= MINIMUM DIAMETER OF THE POWER LAW DISTRIBUTION FOR CARBON PARTICLES (MICRONS)
80	C		
81	C	AMAXC	= MAXIMUM DIAMETER OF THE POWER LAW DISTRIBUTION FOR CARBON PARTICLES (MICRONS)
82	C		
83	C	RHOG	= BULK DENSITY OF IN SITU SOIL (GM/CM3)
84	C	RHOD	= BULK DENSITY OF THE LOFTED DUST GRAINS (GM/CM3)
85	C	RHOC	= BULK DENSITY OF THE CARBON PARTICLES (GM/CM3)
86	C	FH2O	= SOIL MOISTURE FRACTION (MASS OF WATER IN SOIL DIVIDED BY TOTAL MASS OF SOIL INCLUDING WATER)
87	C		
88	C	XLC	= CARBON YIELD FRACTION (LB OF CARBON PRODUCED PER LB OF TNT)
89	C		
90	C	RHAB	= RATIO OF THE MASS OF MODE A DUST PARTICLES TO THE MASS OF MODE B DUST PARTICLES IN THE LOFTED CLOUD
91	C		
92	C	RBASE	= RATIO OF THE MASS IN THE BASE CLOUD TO THE MASS IN THE MAIN CLOUD
93	C		
94	C	PSF	= ATMOSPHERIC PASQUILL STABILITY FACTOR (1 = A, 2 = B, 3 = C, 4 = D, 5 = E)
95	C		
96	C	ALPHA	= AIR ENTRAINMENT FACTOR FOR RISING CLOUD MODEL
97	C	CDRAG	= DRAG COEFFICIENT FOR RISING CLOUD MODEL
98	C	RHOA	= AMBIENT AIR DENSITY AT GROUND LEVEL (GM/CM3)
99	C	ELEVG	= ELEVATION OF GROUND LEVEL (METERS)
100	C	TATR	= AIR TEMPERATURE AT GROUND LEVEL (DEGREES K)
101	C	TLAPSE	= TEMPERATURE LAPSE RATE (DEGREES K/METER)
102	C	ALTIY	= ALTITUDE ABOVE GROUND OF INVERSION LAYER (METERS)
103	C	VWIND	= MEAN WIND VELOCITY AT REFERENCE ALTITUDE (METERS/S)
104	C	ALTM	= WIND REFERENCE ALTITUDE (METERS)
105	C	PVW	= POWER LAW EXPONENT OF VERTICAL PROFILE OF MEAN WIND VELOCITY
106	C		
107	C	PHWINDG	= AZIMUTH OF MEAN WIND VELOCITY (MEASURED CLOCKWISE FROM THE Y AXIS) (DEGREES)
108	C		
109	C	NW	= NUMBER OF BURSTS
110	C	NDG	= NUMBER OF PARTICLE DIAMETER SIZE GROUPS
111	C	NRT	= NUMBER OF TRANSMITTER - RECEIVER PAIRS
112	C	NTIME	= NUMBER OF CALCULATION TIMES
113	C		
114	C	NPRUR	= NUMBER OF THE PRESENT CASE BEING CALCULATED
115	C	IPRINT	= PRINT CONTROL OPTION (0 = PRINT DETAILS OF PATH INTEGRATION, 1 = PRINT ONLY SUMMARY OF THE PATH INTEGRATION)
116	C		

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117 C   DGROUP(IDG)= MAXIMUM DIAMETER OF THE PARTICLES IN THE IDG SIZE
118 C   GROUP (MICRONS)
119 C   TIME(IT)   = THE IT CALCULATION TIME (SECONDS)
120 C
121 C
122 C   COMMON / CINPT1 / W(10), FH(10), CT(10), CP(10), CV(10), XB(10),
123 1   YB(10), ZB(10), DOB(10), FCM(10), ACV(10),
124 2   PHIDG(10)
125 C   COMMON / CINPT2 / FREQ(10), XLAMDA(10), XT(10), YT(10), ZT(10),
126 1   XR(10), YR(10), ZR(10)
127 C   COMMON / CINPT3 / XNAR(10), XNAI(10), XNB(10), XNBI(10), XNCR(10)
128 1   , XNCI(10), AMA, SA, AMINA, AMAXA, PA, AMB, SB,
129 2   AMINB, AMAXB, PS, AMC, SC, AMINC, AMAXC, PC
130 C   COMMON / CINPT4 / RHGG, RHOD, RHOC, FH20, XLC, RMAB, RBASE
131 C   COMMON / CINPT5 / PSF, ALPHA, CORAC, RHOA, ELEVG, TAIR, TLAPSE,
132 1   ALTV, VWINO, ALTW, PVM, PHINDG
133 C   COMMON / CINPT6 / NW, NQG, NRT, NTIME, NPROB, IPRINT
134 C   COMMON / CINPT7 / DGROUP(50), TIME(25)
135 C   COMMON / TAPE / ITAPE, JTAPE
136 C
137 C   DIMENSION INDEX(50), HPSF(6), Y(8), CARD(15)
138 C   DAT INDEX / 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,
139 1   16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28,
140 2   29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41,
141 3   42, 43, 44, 45, 46, 47, 48, 49, 50 /
142 C   DATA HPSF / 1HA, 1HB, 1HC, 1HD, 1HE, 1HF /
143 C   DATA CARD / 1HA, 1HB, 1HC, 1HD, 1HE, 1HF, 1HG, 1HH, 1HI, 1HJ, 1HK,
144 1   1HL, 1HM, 1HN, 1HO /
145 C   DATA BLANK / 1H /
146 C
147 C   NCARD = 0
148 C   NA = 0
149 C   NB = 0
150 C   NC = 0
151 C   NJ = 0
152 C   NK = 0
153 C
154 C   READ NEXT INPUT CARD
155 C   1 READ(ITAPE, 2) XCARD, ( X(J), J = 1, 8 )
156 C   2 FORMAT( 1I, E9.0, 7E10.0 )
157 C
158 C   CHECK IF FIRST COLUMN IS BLANK, WHICH SIGNIFIES END OF INPUT DATA
159 C   FOR THIS PROBLEM
160 C   IF( XCARD .NE. BLANK ) GO TO 6
161 C
162 C   CHECK IF END OF JOB ( TWO BLANK CARDS IN A ROW )
163 C   IF( NCARD .EQ. 0 ) STOP
164 C
165 C   INPUT HAS BEEN READ, SET COUNTERS, FILL IN ANY DEFAULT VALUES
166 C   IF( NA .GT. 0 ) NH = NA
167 C   IF( NC .GT. 0 ) NRT = NC
168 C   IF( NJ .GT. 0 ) NQG = NJ
169 C   IF( NK .GT. 0 ) NTIME = NK
170 C   IF( NW .EQ. 0 ) GO TO 1
171 C   NPROB = NPROB + 1
172 C
173 C   CHECK IF THERE ARE MORE GROUP A SETS THAN GROUP B SETS, IF SO FILL
174 C   IN REST OF GROUP B SETS WITH DEFAULT VALUES

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175 NDIF = NM - NB
176 IF( NDIF .LE. 0 ) GO TO 4
177 NR1 = NB + 1
178 NEND = NR + NDIF
179 DO 3 N = NR1, NEND
180 DGR(N) = 0.
181 FCM(N) = 0.25
182 ACV(N) = 0.03
183 PHIDG(N) = 0.
184 3 CONTINUE
185 C
186 C CHECK IF THERE ARE MORE GROUP C SETS THAN GROUP D SETS, IF SO FILL
187 C IN REST OF GROUP D SETS WITH DEFAULT VALUES
188 4 NDIF = NRT - ND
189 IF( NDIF .LE. 0 ) GO TO 100
190 ND1 = ND1 + 1
191 NEND = ND + NDIF
192 DO 5 N = ND1, NEND
193 XNAR(N) = 1.66
194 XNAI(N) = 1.6E-2
195 XNBR(N) = 1.66
196 XNBI(N) = 1.6E-2
197 XNCR(N) = 2.
198 XNCI(N) = 1.
199 5 CONTINUE
200 C
201 C WRITE OUT THE INPUT DATA FOR THIS PROBLEM
202 GO TO 100
203 C
204 C
205 C GO TO THE APPROPRIATE INPUT GROUP. IF NO VALUE IS PROVIDED FOR A
206 C PARAMETER, USE DEFAULT VALUE
207 6 DO 7 ICARD = 1, 15
208 I = ICARD
209 IF( ICARD .EQ. CARD(I) ) GO TO 8
210 7 CONTINUE
211 GO TO 1
212 8 NCARD = NCARD + 1
213 GO TO( 10, 15, 20, 30, 40, 45, 48, 50, 55, 60, 65, 70, 80 ), I
214 C
215 C INPUT GROUP A, YIELD, HYDRO FRACTION, SHAPE FACTORS, BURST
216 C COORDINATES
217 10 IF( X(1) .LE. 0. ) GO TO 1
218 NA = NA + 1
219 W(NA) = X(1)
220 FH(NA) = 0.5
221 IF( X(2) .GT. 0. ) FH(NA) = X(2)
222 CT(NA) = 1.
223 IF( X(3) .GT. 0. ) CT(NA) = X(3)
224 CP(NA) = 1.
225 IF( X(4) .GT. 0. ) CP(NA) = X(4)
226 CV(NA) = 1.
227 IF( X(5) .GT. 0. ) CV(NA) = X(5)
228 XB(NA) = X(6)
229 YB(NA) = X(7)
230 ZB(NA) = X(8)
231 GO TO 1
232 C

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233 C INPUT GROUP B, DEPTH OF BURST, FRACTION OF APPARENT MASS LOFTED,
234 C LOADING FACTOR, SHELL TRACK AZIMUTH
235 15 NB = NB + 1
236 DGR(NB) = X(1)
237 FCM(NB) = 0.25
238 IF( X(2) .GT. 0. ) FCM(NB) = X(2)
239 ACV(NB) = 0.03
240 IF( X(3) .GT. 0. ) ACV(NB) = X(3)
241 PHIBDG(NB) = X(4)
242 GO TO 1
243
244 C INPUT GROUP C, FREQUENCY OR WAVELENGTH, COORDINATES OF TRANSMITTER
245 C AND RECEIVER
246 20 NC = NC + 1
247 IF( X(1) .EQ. 0. .AND. X(2) .EQ. 0. ) GO TO 22
248 IF( X(2) .EQ. 0. ) GO TO 21
249 XLAMDA(NC) = X(2)
250 FREQ(NC) = 3.E5 / XLAMDA(NC)
251 J TO 3
252 21 FREQ(NC) = X(1)
253 XLAMDA(NC) = 3.E5 / FREQ(NC)
254 GO TO 23
255 22 FREQ(NC) = 1.E5
256 XLAMDA(NC) = 3.
257 23 IF( X(3) .EQ. 0. .AND. X(4) .EQ. 0. .AND. X(5) .EQ. 0. ) GO TO 24
258 XT(NC) = X(3)
259 YT(NC) = X(4)
260 ZT(NC) = X(5)
261 GO TO 25
262 24 XT(NC) = 500.
263 YT(NC) = 50.
264 ZT(NC) = 2.
265 25 IF( X(6) .EQ. 0. .AND. X(7) .EQ. 0. .AND. X(8) .EQ. 0. ) GO TO 26
266 XR(NC) = X(6)
267 YR(NC) = X(7)
268 ZR(NC) = X(8)
269 GO TO 27
270 26 XR(NC) = - 500.
271 YR(NC) = 50.
272 ZR(NC) = 2.
273 27 GO TO 1
274
275 C INPUT GROUP D, INDICIES OF REFRACTION FOR MODE A DUST, MODE B DUST
276 C AND CARBON FOR EACH FREQUENCY
277 30 ND = ND + 1
278 XNAR(ND) = 1.66
279 IF( X(1) .GT. 0. ) XNAR(ND) = X(1)
280 XNAI(ND) = 1.6E-2
281 IF( X(2) .GT. 0. ) XNAI(ND) = X(2)
282 XNBR(ND) = 1.66
283 IF( X(3) .GT. 0. ) XNBR(ND) = X(3)
284 XNBI(ND) = 1.6E-2
285 IF( X(4) .GT. 0. ) XNBI(ND) = X(4)
286 XNCR(ND) = 2.
287 IF( X(5) .GT. 0. ) XNCR(ND) = X(5)
288 XNCI(ND) = 1.
289 IF( X(6) .GT. 0. ) XNCI(ND) = X(6)
290 GO TO 1

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291 C
292 C INPUT GROUP E, DENSITIES OF SOIL, DUST GRAINS AND CARBON, SOIL
293 C MOISTURE CONTENT, CARBON YIELD FRACTION, RATIOS OF MODE A, TO MODE
294 C B MASS AND BASE TO MAIN CLOUD MASS
295 40 RHOG = 1.5
296 IF( X(1) .GT. 0. ) RHOG = X(1)
297 RHOD = 2.5
298 IF( X(2) .GT. 0. ) RHOD = X(2)
299 FH2O = 0.15
300 IF( X(3) .GT. 0. ) FH2O = X(3)
301 RHOC = 1.5
302 IF( X(4) .GT. 0. ) RHOC = X(4)
303 XLC = 0.3
304 IF( X(5) .GT. 0. ) XLC = X(5)
305 RMAB = 0.25
306 IF( X(6) .GT. 0. ) RMAB = X(6)
307 RBASE = 0.1
308 IF( X(7) .GT. 0. ) RBASE = X(7)
309 GO TO 1
310 C
311 C INPUT GROUPS F, G, AND H, PROBABILITY DISTRIBUTION PARAMETERS FOR
312 C THE MODE A, MODE B, AND CARBON PARTICLES
313 45 IF( X(1) * X(2) .LE. 0. .AND. X(3) * X(4) * X(5) .LE. 0. ) GO TO 1
314 AMA = X(1)
315 SA = X(2)
316 AMINA = X(3)
317 AMAXA = X(4)
318 PA = X(5)
319 GO TO 1
320 48 IF( X(1) * X(2) .LE. 0. .AND. X(3) * X(4) * X(5) .LE. 0. ) GO TO 1
321 AMB = X(1)
322 SB = X(2)
323 AMINB = X(3)
324 AMAXB = X(4)
325 PB = X(5)
326 GO TO 1
327 50 IF( X(1) * X(2) .LE. 0. .AND. X(3) * X(4) * X(5) .LE. 0. ) GO TO 1
328 AMC = X(1)
329 SC = X(2)
330 AMINC = X(3)
331 AMAXC = X(4)
332 PC = X(5)
333 GO TO 1
334 C
335 C INPUT GROUP I, ATMOSPHERIC AND RISING CLOUD PARAMETERS
336 55 PSF = 0.
337 IF( X(1) .GT. 0. ) PSF = X(1)
338 ALPHA = 1.
339 IF( X(2) .GT. 0. ) ALPHA = X(2)
340 CORAG = 0.8
341 IF( X(3) .GT. 0. ) CORAG = X(3)
342 RHOA = X(4)
343 ELEVG = X(5)
344 IF( RHOA .LE. 1.E-4 ) RHOA = 1.225E-3 * EXP( - ELEVG / 0.4E3 )
345 TAIR = 288.
346 IF( X(6) .GT. 0. ) TAIR = X(6)
347 TLAPSE = - 9.8E-3
348 IF( X(7) .NE. 0. ) TLAPSE = X(7)

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349      ALTIV = 1.E3
350      IF( X(N) .GT. 0. ) ALTIV = X(N)
351      GO TO 1
352      C
353      C   INPUT GROUP J, MEAN WIND VELOCITY, WIND REFERENCE ALTITUDE, POWER
354      C   LAW EXPONENT OF VERTICAL PROFILE, WIND AZIMUTH
355      60  VWINC = 3.
356      IF( X(1) .GT. 0. ) VWINC = X(1)
357      ALTW = 10.
358      IF( X(2) .GT. 0. ) ALTW = X(2)
359      PVM = 0.1
360      IF( X(3) .GT. 0. ) PVM = X(3)
361      PHWDG = X(4)
362      GO TO 1
363
364      C   INPUT GROUP K, MAXIMUM DIAMETERS OF PARTICLES IN THE SIZE GROUPS
365      65  DO 67 N = 1, 8
366      IF( X(N) .LE. 0. ) GO TO 67
367      IF( X(N) .EQ. 0 ) GO TO 66
368      IF( X(N) .LE. DGROUP(NJ) ) GO TO 67
369      66  NJ = NJ + 1
370      DGROUP(NJ) = X(N)
371      67  CONTINUE
372      GO TO 1
373      C
374      C   INPUT GROUP L, CALCULATION TIMES
375      70  DO 72 N = 1, 8
376      IF( X(N) .LE. 0. ) GO TO 72
377      IF( NK .EQ. 0 ) GO TO 71
378      IF( X(N) .LE. TIME(NK) ) GO TO 72
379      71  NK = NK + 1
380      TIME(NK) = X(N)
381      72  CONTINUE
382      GO TO 1
383      C
384      C   INPUT GROUP M, CONTROL OPTIONS
385      80  IPRINT = 0
386      IF( X(1) .GT. 0. ) IPRINT = 1
387      GO TO 1
388      C
389      C
390      C   THIS SECTION WRITES OUT THE INPUT DATA FOR THIS PROBLEM
391      100 WRITE(JTAPE, 101) NPRDR
392      101 FORMAT(1H1,89H
393      . DUST CLOUD MODEL //
394      21H9,40H
395      3EM NUMBERS , 13 //
396      41H0,70H
397      5 PARAMETERS /
398      61H0,12CHBURST YIELD HYDRD INITIAL SHAPE FACTORS BURST
399      7POINT COORDINATES DEPTH OF LOFTED LOADING SHELL TRAC
400      8K/
401      91H ,123H (.8 TNT) FRACTION ALONG CROSS VERTICAL X COORD.
402      1 Y COORD. Z COORD. BURST MASS FACTOR AZIMUTH/
403      21H ,122H TRACK TRACK TRACK TRACK (METERS)
404      3 (METERS) (METERS) (METERS) FRACTION (M3/LB TNT,1) (DEG)
405      WRITE(JTAPE, 102) ( ( I, X(I), FM(I), CT(I), CP(I), CV(I), XB(I),
406      1YB(I), ZB(I), DB(I), FCM(I), ACV(I), PHWDG(I) ), I = 1, NM )

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407 102 FORMAT(1H , I3, F9.1, F9.1 , F9.1, F7.1, F8.1, F12.1, F10.1, F10.1
408 1, F9.1, F10.2, 1PE15.2, 0PF12.1 )
409 WRITE(JTAPE, 103) RHOG, FH2O, RHOD, AMA, SA, AMINA, AMAXA, PA,
410 1 RHOD, ANB, SB, AMINB, AMAXB, PB, RHOC, AMC, SC,
411 2 AMINC, AMAXC, PC, XLC, RMAB, RBASE
412 103 FORMAT(1H0,22HRULK DENSITY OF SOIL =, F4.1, 7H GH/CM3 /
413 1H , 24H SOIL MOISTURE FRACTION =, F5.2 /
414 21H0,77H SIZE PROBABILITY DISTR
415 31BUTION PARAMETERS / 1H0,
416 479H DENSITY MEAN STANDARD MINIMUM MAXIM
417 5UH POWER LAW / 1H ,
418 678HMATERIAL (GH/CM3) DIAMETER DEVIATION DIAMETER DIAME
419 7TER EXPONENT / 1H ,
420 867H (MICRONS) PARAMETER (MICRONS) (MICR
421 9ONS) /
422 11H , 8HDUST = A, F9.2, F12.2, F12.1, F13.1, F13.1, F10.1 /
423 21H , 8HDUST = B, F9.2, F12.2, F12.1, F13.1, F13.1, F10.1 /
424 31H , 6HCARBON, F11.2, F12.2, F12.1, F13.1, F13.1, F10.1 /
425 41H0,23HCARBON YIELD FRACTION =, F5.2 /
426 51H , 29HRATIO MODE A TO MODE B MASS =, F5.2 /
427 61H , 31HRATIO BASE TO MAIN CLUD MASS =, F5.2 // )
428 N = MINO( 10, NDG )
429 WRITE(JTAPE, 104) ( INDEX(I), I = 1, N )
430 104 FORMAT(1H0,80H MAXIMUM DIAMETERS OF
431 1PARTICLES IN EACH SIZE GROUP )
432 21H0, 17H SIZE GROUP NUMFR, I4, 9I11 )
433 WRITE(JTAPE, 105) ( DGROUP(I), I = 1, N )
434 105 FORMAT(1H , 16H MAXIMUM DIAMETER, F7.1, 9F11.1 )
435 WRITE(JTAPE, 106)
436 106 FORMAT(1H , 13H (MICRONS) )
437 DO 109 I = 1, 4
438 NS = 10 * I + 1
439 NF = NS + 9
440 IF( NDG .LT. NS ) GO TO 110
441 NF = MINO( NF, NDG )
442 WRITE(JTAPE, 107) ( INDEX(N), N = NS, NF )
443 107 FORMAT(1H0,11X, 10I11 )
444 WRITE(JTAPE, 108) ( DGROUP(N), N = NS, NF )
445 108 FORMAT(1H , 12X, 10F11.1 )
446 109 CONTINUE
447 110 WRITE(JTAPE, 111) NPROB
448 111 FORMAT(1H1,65H INPUT DATA FOR P
449 1PROBLEM NUMBER, I3, 12H (CONTINUED) //
450 21H0, 74H TRANSMITTER - REC
451 3EIVER PARAMETERS /
452 41H0, 90H PAIR FREQUENCY WAVELENGTH TRANSMITTER COORDINATES
453 5 RECEIVER COORDINATES /
454 61H , 95H NUMBER (GHZ) (MICRONS) X COORD. Y COORD. Z CO
455 7ORD. X COORD. Y COORD. Z COORD. /
456 81H , 95H (METERS) (METERS) (METERS) (METERS) (METERS) (MET
457 9ERS) (METERS) (METERS) (METERS) )
458 WRITE(JTAPE, 112) ( ( I, FREQ(I), XLAMDA(I), XT(I), YI(I), ZI(I),
459 1 XR(I), YR(I), ZR(I) ), I = 1, NRT )
460 112 FORMAT(1H , I3, 1PE14.2, 0PF10.1, F12.1, SF11.1 )
461 WRITE(JTAPE, 113) ( ( I, FREQ(I), XLAMDA(I), XNAR(I), XNAI(I),
462 1 XNBR(I), XNBI(I), XNCR(I), XNCI(I) ), I = 1, NRT )
463 113 FORMAT( 1H0/ 1H0,
464 168H INDICIES OF REFRA

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465      2CTION / 1H0,
466      392H PAIR FREQUENCY WAVELENGTH DUST - MODE A DUST
467      4 - MODE B CARBON / 1H ,
468      5100NUMBER (GHZ) (MICRONS) REAL PART IMAG PART REAL PA
469      6RT IMAG PART REAL PART IMAG PART /
470      7 ( 1H , 13, 1PE14.2, OPF10.1, F10.2, 1PE14.2, OPF10.2, 1PE14.2,
471      8 OPF10.2, 1PE14.2 ) )
472      IPSF = IFIX( PSF )
473      APSF = HPSF(IPSF)
474      WRITE(JTAPE, 114) APSF, ALPHA, CDRAQ, RHOA, ELEVQ, TAIR, TLAPSE,
475      1 ALTIV, VWIND, ALTN, PVW, PHWDG
476      114 FORMAT(1H0/
477      11H0,68H ATMOSPHERIC P
478      2PARAMETERS /
479      31H0, 98HPASQUILL CLOUD ALPHA CLOUD DRAG AIR DENSITY GROUND
480      4 GROUND AIR TEMPERATURE INVERSION /
481      51H ,101HSTABILITY ENTRAINMENT COEFFICIENT AT GROUND ELEVATIO
482      61 TEMPERATURE LAPSE RATE LAYER ALTITUDE /
483      71H , 98HFACTOR FACTOR (GM/CM3) (METERS)
484      8 (DEG K) (DEG K/ M) (METERS) /
485      9/1H ,2X, A1, F15.1, F12.1, 1PE17.2, OPF11. , F11.1, 1PE14.1,
486      1 OPF15.1 /
487      21H0,47HMEAN WIND WIND REFERENCE WIND VERTICAL WIND /
488      31H ,49HVELOCITY ALTITUDE PROFILE POWER AZIMUTH /
489      41H ,48H (M/S) (METERS) LAW EXPONENT (DEG) /
490      51H , F6.1, F14.1, F15.2, F13.1 )
C
491      RETURN
C
492
493      END
494

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1      SUBROUTINE FGROUP
2      C
3      C THIS SUBROUTINE IS THE EXECUTIVE ROUTINE FOR THE CALCULATION OF
4      C THE PROPAGATION PARAMETERS FOR EACH CONTRIBUTING SIZE GROUP FOR
5      C EACH TYPE OF PARTICULATE MATERIAL FOR EACH FREQUENCY. THIS ROUTINE
6      C SETS UP THE INPUT TO SUBROUTINE SGROUP, STORES THE OUTPUT IN THE
7      C APPROPRIATE VARIABLES, AND AFTER ALL CALCULATIONS ARE COMPLETE
8      C WRITES OUT THE RESULTS
9      C
10     C
11     C INPUTS FROM CINFY COMMON AREAS
12     C RHOD = DENSITY OF THE DUST GRAINS (GM/CM3)
13     C RHOC = DENSITY OF THE CARBON PARTICULATES (GM/CM3)
14     C XNAR = REAL PART OF THE INDEX OF REFRACTION FOR MODE A DUST
15     C PARTICULATES
16     C XNAI = IMAGINARY PART OF THE INDEX OF REFRACTION FOR MODE A DUST
17     C PARTICULATES
18     C XNBR = REAL PART OF THE INDEX OF REFRACTION FOR MODE B DUST
19     C PARTICULATES
20     C XNBI = IMAGINARY PART OF THE INDEX OF REFRACTION FOR MODE B DUST
21     C PARTICULATES
22     C XNCR = REAL PART OF THE INDEX OF REFRACTION FOR CARBON PARTICLES
23     C XNCI = IMAGINARY PART OF THE INDEX OF REFRACTION FOR CARBON
24     C PARTICULATES
25     C AMA = LOG NORMAL MEAN DIAMETER PARAMETER FOR MODE A DUST
26     C PARTICLES (MICRONS)
27     C AMB = LOG NORMAL MEAN DIAMETER PARAMETER FOR MODE B DUST
28     C PARTICLES (MICRONS)
29     C AMC = LOG NORMAL MEAN DIAMETER PARAMETER FOR CARBON PARTICLES
30     C (MICRONS)
31     C SA = LOG NORMAL STANDARD DEVIATION PARAMETER FOR MODE A DUST
32     C PARTICLES
33     C SB = LOG NORMAL STANDARD DEVIATION PARAMETER FOR MODE B DUST
34     C PARTICLES
35     C SC = LOG NORMAL STANDARD DEVIATION PARAMETER FOR CARBON
36     C PARTICLES
37     C AMINA = POWER LAW MINIMUM DIAMETER FOR MODE A DUST PARTICLES.
38     C (MICRONS)
39     C THIS IS THE DIAMETER AT WHICH THE LOG NORMAL AND POWER
40     C LAW PROBABILITY DISTRIBUTIONS ARE JOINED TO FORM THE
41     C HYBRID PROBABILITY DISTRIBUTION
42     C AMINB = POWER LAW MINIMUM DIAMETER FOR MODE B DUST PARTICLES.
43     C (MICRONS)
44     C AMINC = POWER LAW MINIMUM DIAMETER FOR CARBON PARTICLES.
45     C (MICRONS)
46     C AMAXA = POWER LAW MAXIMUM DIAMETER FOR MODE A DUST PARTICLES
47     C (MICRONS)
48     C AMAXB = POWER LAW MAXIMUM DIAMETER FOR MODE B DUST PARTICLES
49     C (MICRONS)
50     C AMAXC = POWER LAW MAXIMUM DIAMETER FOR CARBON PARTICLES
51     C (MICRONS)
52     C PA = EXPONENT FOR POWER LAW PROBABILITY DISTRIBUTION FOR THE
53     C MODE A DUST PARTICLES
54     C PB = EXPONENT FOR POWER LAW PROBABILITY DISTRIBUTION FOR THE
55     C MODE B DUST PARTICLES
56     C PC = EXPONENT FOR POWER LAW PROBABILITY DISTRIBUTION FOR THE
57     C CARBON PARTICLES
58     C DGROUP = ARRAY OF MAXIMUM DIAMETERS OF PARTICLES IN EACH SIZE

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59     L      GROUP (MICRONS)
60     C      XLAMDA = ARRAY OF THE WAVELENGTHS OF THE TRANSMITTER - RECEIVER
61     C      PAIRS (MICRONS)
62     C
63     C      OUTPUTS TO CPGRP COMMON
64     C      FNA(I) = NUMBER FRACTION OF PARTICLES IN SIZE GROUP I FOR MODE
65     C              A DUST PARTICLES (RATIO OF NUMBER OF PARTICLES IN SIZE
66     C              GROUP TO TOTAL NUMBER OF PARTICLES IN DISTRIBUTION )
67     C      FNB(I) = NUMBER FRACTION OF PARTICLES IN SIZE GROUP I FOR MODE
68     C              B DUST PARTICLES
69     C      FNC(I) = NUMBER FRACTION OF PARTICLES IN SIZE GROUP I FOR
70     C              CARBON PARTICLES
71     C      FMA(I) = MASS FRACTION FOR SIZE GROUP I FOR MODE A DUST
72     C              PARTICLES ( RATIO OF MASS OF PARTICLES IN SIZE GROUP I
73     C              TO TOTAL MASS IN DISTRIBUTION )
74     C      FMB(I) = MASS FRACTION FOR SIZE GROUP I FOR MODE B DUST
75     C              PARTICLES
76     C      FMC(I) = MASS FRACTION FOR SIZE GROUP I FOR CARBON PARTICLES
77     C      PNGA(I) = NUMBER OF PARTICLES PER GRAM OF MATERIAL IN SIZE GROUP
78     C              I FOR MODE A DUST PARTICLES (NUMBER/GM)
79     C      PNGB(I) = NUMBER OF PARTICLES PER GRAM OF MATERIAL IN SIZE GROUP
80     C              I FOR MODE B DUST PARTICLES (NUMBER/GM)
81     C      PNGC(I) = NUMBER OF PARTICLES PER GRAM OF MATERIAL IN SIZE GROUP
82     C              I FOR CARBON PARTICLES (NUMBER/GM)
83     C      SIGAA(I,J) = AVERAGE ABSORPTION CROSS SECTION PER PARTICLE IN SIZE
84     C              GROUP I FOR WAVELENGTH J FOR MODE A DUST PARTICLES
85     C              (CM2)
86     C      SIGAB(I,J) = AVERAGE ABSORPTION CROSS SECTION PER PARTICLE IN SIZE
87     C              GROUP I FOR WAVELENGTH J FOR MODE B DUST PARTICLES
88     C              (CM2)
89     C      SIGAC(I,J) = AVERAGE ABSORPTION CROSS SECTION PER PARTICLE IN SIZE
90     C              GROUP I FOR WAVELENGTH J FOR CARBON PARTICLES (CM2)
91     C      SIGSA(I,J) = AVERAGE SCATTERING CROSS SECTION PER PARTICLE IN SIZE
92     C              GROUP I FOR WAVELENGTH J FOR MODE A DUST PARTICLES
93     C              (CM2)
94     C      SIGSB(I,J) = AVERAGE SCATTERING CROSS SECTION PER PARTICLE IN SIZE
95     C              GROUP I FOR WAVELENGTH J FOR MODE B DUST PARTICLES
96     C              (CM2)
97     C      SIGSC(I,J) = AVERAGE SCATTERING CROSS SECTION PER PARTICLE IN SIZE
98     C              GROUP I FOR WAVELENGTH J FOR CARBON PARTICLES (CM2)
99     C      SIGEA(I,J) = AVERAGE EXTINCTION CROSS SECTION PER PARTICLE IN SIZE
100    C              GROUP I FOR WAVELENGTH J FOR MODE A DUST PARTICLES
101    C              (CM2)
102    C      SIGEB(I,J) = AVERAGE EXTINCTION CROSS SECTION PER PARTICLE IN SIZE
103    C              GROUP I FOR WAVELENGTH J FOR MODE B DUST PARTICLES
104    C              (CM2)
105    C      SIGEC(I,J) = AVERAGE EXTINCTION CROSS SECTION PER PARTICLE IN SIZE
106    C              GROUP I FOR WAVELENGTH J FOR CARBON PARTICLES (CM2)
107    C      SIGBA(I,J) = AVERAGE BACKSCATTER CROSS SECTION PER PARTICLE IN
108    C              SIZE GROUP I FOR WAVELENGTH J FOR MODE A DUST
109    C              PARTICLES (CM2)
110    C      SIGBB(I,J) = AVERAGE BACKSCATTER CROSS SECTION PER PARTICLE IN
111    C              SIZE GROUP I FOR WAVELENGTH J FOR MODE B DUST
112    C              PARTICLES (CM2)
113    C      SIGBC(I,J) = AVERAGE BACKSCATTER CROSS SECTION PER PARTICLE IN
114    C              SIZE GROUP I FOR WAVELENGTH J FOR CARBON PARTICLES
115    C              (CM2)
116    C      CHUAA(I,J) = MASS ABSORPTION COEFFICIENT FOR SIZE GROUP I AT

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117 C
118 C CMUAR(I,J) = WAVELENGTH J FOR MODE A DUST PARTICLES (CM2/GM)
119 C
120 C CMUAC(I,J) = MASS ABSORPTION COEFFICIENT FOR SIZE GROUP I AT
121 C WAVELENGTH J FOR CARBON PARTICLES (CM2/GM)
122 C CMUSA(I,J) = MASS SCATTERING COEFFICIENT FOR SIZE GROUP I AT
123 C WAVELENGTH J FOR MODE A DUST PARTICLES (CM2/GM)
124 C CMUSR(I,J) = MASS SCATTERING COEFFICIENT FOR SIZE GROUP I AT
125 C WAVELENGTH J FOR MODE B DUST PARTICLES (CM2/GM)
126 C CMUSC(I,J) = MASS SCATTERING COEFFICIENT FOR SIZE GROUP I AT
127 C WAVELENGTH J FOR CARBON PARTICLES (CM2/GM)
128 C CMUEA(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
129 C WAVELENGTH J FOR MODE A DUST PARTICLES (CM2/GM)
130 C CMUER(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
131 C WAVELENGTH J FOR MODE B DUST PARTICLES (CM2/GM)
132 C CMUEC(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
133 C WAVELENGTH J FOR CARBON PARTICLES (CM2/GM)
134 C CMUBA(I,J) = MASS BACKSCATTER COEFFICIENT FOR SIZE GROUP I AT
135 C WAVELENGTH J FOR MODE A DUST PARTICLES (CM2/GM)
136 C CMUBB(I,J) = MASS BACKSCATTER COEFFICIENT FOR SIZE GROUP I AT
137 C WAVELENGTH J FOR MODE B DUST PARTICLES (CM2/GM)
138 C CMUBC(I,J) = MASS BACKSCATTER COEFFICIENT FOR SIZE GROUP I AT
139 C WAVELENGTH J FOR CARBON PARTICLES (CM2/GM)
140 C CMUEMA(IRT) = MEAN MASS EXTINCTION COEFFICIENT FOR THE ENTIRE MODE
141 C A PARTICLE DISTRIBUTION AT WAVELENGTH IRT (CM2/GM)
142 C CMUEMB(IRT) = MEAN MASS EXTINCTION COEFFICIENT FOR THE ENTIRE MODE
143 C B PARTICLE DISTRIBUTION AT WAVELENGTH IRT (CM2/GM)
144 C CMUEMC(IRT) = MEAN MASS EXTINCTION COEFFICIENT FOR THE ENTIRE
145 C CARBON PARTICLE DISTRIBUTION AT WAVELENGTH IRT
146 C (CM2/GM)
147 C CMUSMA(IRT) = MEAN MASS SCATTERING COEFFICIENT FOR THE ENTIRE MODE
148 C A PARTICLE DISTRIBUTION AT WAVELENGTH IRT (CM2/GM)
149 C CMUSMB(IRT) = MEAN MASS SCATTERING COEFFICIENT FOR THE ENTIRE MODE
150 C B PARTICLE DISTRIBUTION AT WAVELENGTH IRT (CM2/GM)
151 C CMUSMC(IRT) = MEAN MASS SCATTERING COEFFICIENT FOR THE ENTIRE
152 C CARBON PARTICLE DISTRIBUTION AT WAVELENGTH IRT
153 C (CM2/GM)
154 C CMUBMA(IRT) = MEAN MASS BACKSCATTER COEFFICIENT FOR THE ENTIRE
155 C A PARTICLE DISTRIBUTION AT WAVELENGTH IRT (CM2/GM)
156 C CMUBMB(IRT) = MEAN MASS BACKSCATTER COEFFICIENT FOR THE ENTIRE
157 C B PARTICLE DISTRIBUTION AT WAVELENGTH IRT (CM2/GM)
158 C CMUBMC(IRT) = MEAN MASS BACKSCATTER COEFFICIENT FOR THE ENTIRE
159 C CARBON PARTICLE DISTRIBUTION AT WAVELENGTH IRT
160 C (CM2/GM)
161 C
162 C NOTE THAT THE MASS ABSORPTION COEFFICIENTS AND ALL AVERAGE CROSS
163 C SECTIONS ARE NOT CARRIED EXPLICITLY BUT ARE CALCULATED WHEN NEEDED
164 C BY CMUAA(I,J) = CMUEA(I,J) - CMUSA(I,J)
165 C SIGAA(I,J) = CMUAA(I,J) / PNGA(I)
166 C WITH SIMILAR RELATIONS FOR THE B AND C MATERIALS AND THE OTHER
167 C AVERAGE CROSS SECTIONS
168 C
169 C
170 C COMMON / CCGRP / MGRP, MSIZE, MSPHER, DLW, DHIGH, DM, S, DHIN,
171 C 1 DMAX, P, XR, XI, RHO, PNG, FN, FM, SIGA, SIGS,
172 C 2 SIGB, SIGC, SPN(21), CMUA, CMUS, CMUE, CMUB, ML
173 C COMMON / CJNPT2 / FREQ(10), XLAMDA(10), XT(10), YT(10), ZT(10),
174 C 1 RX(10), YR(10), ZR(10)

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175      COMMON / CINPT3 / XNAR(10), XNAI(10), XNBR(10), XNBI(10), XNCR(10)
176      1      , XNCI(10), AMA, SA, AMINA, AMAXA, PA, AMB, SB,
177      2      AMINB, AMAXB, PB, AMC, SC, AMINC, AMAXC, PC
178      COMMON / CINPT4 / RHOG, RHOD, RHOC, FHZ, XLC, RHAB, RBASE
179      COMMON / CINPT6 / NW, NOG, NRT, NTIME, NPROB, IPRINT
180      COMMON / CINPT7 / DGROUP(50), TIME(25)
181      COMMON / EPGRP / FNA(50), FNB(50), FNC(50), FMA(50), FMB(50),
182      1      FMC(50), PNGA(50), PNGB(50), PNGC(50),
183      2      CMUSA(50,10), CMUSB(50,10), CMUSC(50,10),
184      3      CMUEA(50,10), CMUEB(50,10), CMUEC(50,10),
185      4      CMURA(50,10), CMURB(50,10), CMURC(50,10)
186      COMMON / TAPE / IIAPE, JTAPE
187      DIMENSION ISKIP(10)
188      DIMENSION CMUEMA(10), CMUEMB(10), CMUEMC(10), CMUSMA(10),
189      1      CMUSMB(10), CMUSMC(10), CMUBMA(10), CMUBMB(10),
190      2      CMURMC(10), FMD(50), PHAS3F(50)
191      C
192      C      SET FRACTIONALIZATION PARAMETER
193      DATA FRZT / 0.5 /
194      C
195      C      ZERO OUT THE FREQUENCY CALCULATION CONTROL INDEX
196      C      ZERO OUT THE MEAN MASS COEFFICIENTS FOR THE THREE MATERIALS
197      DO 5 IRT = 1, NRT
198      ISKIP(IRT) = 0
199      CMUEMA(IRT) = 0.
200      CMUEMB(IRT) = 0.
201      CMUEMC(IRT) = 0.
202      CMUSMA(IRT) = 0.
203      CMUSMB(IRT) = 0.
204      CMUSMC(IRT) = 0.
205      CMUBMA(IRT) = 0.
206      CMUBMB(IRT) = 0.
207      CMURMC(IRT) = 0.
208      5 CONTINUE
209      C
210      C      ZERO OUT NUMBER AND MASS FRACTION PARAMETERS
211      DO 6 IDG = 1, 4DG
212      FNA(IDG) = 0.
213      FNB(IDG) = 0.
214      FNC(IDG) = 0.
215      FMA(IDG) = 0.
216      FMB(IDG) = 0.
217      FMC(IDG) = 0.
218      6 CONTINUE
219      C
220      C      LOOP OVER THE MATERIALS
221      DO 175 IMAT = 1, 3
222      C
223      C      SET CONTROL VARIABLES AND INPUT PARAMETERS
224      7 GO TO( 8, 10, 20 ), IMAT
225      C
226      C      IMAT = 1 THE MATERIAL IS MADE A DUST PARTICLES
227      8 HLN = 0
228      MPL = 0
229      IF( AMA * SA .GT. 0. ) HLN = -1
230      IF( AMINA * AMAXA * PA .GT. 0. ) MPL = -2
231      MSIZE = HLN + MPL
232      MSPHER = 1

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233      RHO = RHOD
234      DM = 1.E-4 * AMA
235      S = SA
236      DMIN = 1.E-4 * AMINA
237      DMAX = 1.E-4 * AMAXA
238      P = PA
239      GO TO 30
240
241      C
242      C      IMAT = 2 THE MATERIAL IS MODE B DUST PARTICLES
243      10 MLN = 0
244      MPL = 0
245      IF( AMB * SB .GT. 0. ) MLN = -1
246      IF( AMINB * AMAXB * PB .GT. 0. ) MPL = -2
247      HSIZE = MLN + MPL
248      MSPHER = 1
249      RHO = RHOD
250      DM = 1.E-4 * AMB
251      S = SB
252      DMIN = 1.E-4 * AMINB
253      DMAX = 1.E-4 * AMAXB
254      P = PB
255      GO TO 30
256
257      C
258      C      IMAT = 3 THE MATERIAL IS CARBON PARTICLES
259      20 MLN = 0
260      MPL = 0
261      IF( AMC * SC .GT. 0. ) MLN = -1
262      IF( AMINC * AMAXC * PC .GT. 0. ) MPL = -2
263      HSIZE = MLN + MPL
264      MSPHER = 1
265      RHO = RHOD
266      DM = 1.E-4 * AMC
267      S = SC
268      DMIN = 1.E-4 * AMINC
269      DMAX = 1.E-4 * AMAXC
270      P = PC
271
272      C
273      C      FOR THIS MATERIAL LOOP OVER WAVELENGTHS
274      30 DO 170 IRT = 1, NRT
275
276      C
277      C      CHECK IF THIS FREQUENCY IS THE SAME AS A PREVIOUSLY CALCULATED
278      C      FREQUENCY
279      IF( IRT .EQ. 1 ) GO TO 38
280      IF( ISKIP(IRT) .GT. 0 ) GO TO 33
281      IRT1 = IRT - 1
282      DO 31 IRTC = 1, IRT1
283      IRTP = IRTC
284      IF( XLAMDA(IRT) .EQ. XLAMDA(IRT1) ) GO TO 32
285      31 CONTINUE
286      GO TO 38
287
288      C
289      C      FREQUENCY HAS BEEN CALCULATED PREVIOUSLY, USE PREVIOUS RESULTS
290      32 ISKIP(IRT) = IRTP
291      33 IRTP = ISKIP(IRT)
292      DO 37 IDG = 1, NDG
293      GO TO( 34, 35, 36 ), IMAT
294      34 CMUEA(IDG,IRT) = CMUEA(IDG,IRT1)
295      CMUSA(IDG,IRT) = CMUSA(IDG,IRT1)

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291          CMURA(IGG,IRT) = CMURA(IGG,IRTP)
292          CMUEHA(IRT) = CMUEHA(IRTP)
293          CMUSHA(IRT) = CMUSHA(IRTP)
294          CMUBHA(IRT) = CMUBHA(IRTP)
295          GO TO 37
296          35 CMUEB(IGG,IRT) = CMUEB(IGG,IRTP)
297          CMUSB(IGG,IRT) = CMUSB(IGG,IRTP)
298          CMUEB(IGG,IRT) = CMUEB(IGG,IRTP)
299          CMUEMB(IRT) = CMUEMB(IRTP)
300          CMUSMB(IRT) = CMUSMB(IRTP)
301          CMUBMB(IRT) = CMUBMB(IRTP)
302          GO TO 37
303          36 CMUEC(IGG,IRT) = CMUEC(IGG,IRTP)
304          CMUSC(IGG,IRT) = CMUSC(IGG,IRTP)
305          CMURC(IGG,IRT) = CMURC(IGG,IRTP)
306          CMUEMC(IRT) = CMUEMC(IRTP)
307          CMUSMC(IRT) = CMUSMC(IRTP)
308          CMUBMC(IRT) = CMUBMC(IRTP)
309          37 CONTINUE
310          GO TO 170
311          C
312          C FREQUENCY HAS NOT BEEN CALCULATED PREVIOUSLY, DO CALCULATIONS
313          C
314          C GET WAVELENGTH FOR CCGRP COMMON
315          39 WL = 1.E-4 * XLAMDA(IRT)
316          C
317          C SET SIZE GROUP CALCULATION INDICATOR
318          C INITIALIZE THE MAXIMUM GROUP EXTINCTION CONTRIBUTION
319          ICALC = 1
320          FMAX = 0.
321          C
322          C SET INDICES OF REFRACTION
323          GO TO( 40, 50, 60 ), IMAT
324          40 XR = XNAR(IRT)
325          XI = XNAI(IRT)
326          GO TO 70
327          50 XR = XNBR(IRT)
328          XI = XNBI(IRT)
329          GO TO 70
330          60 XR = XNCR(IRT)
331          XI = XNCI(IRT)
332          70 CONTINUE
333          C
334          C LOOP OVER SIZE GROUPS, START WITH THE SMALLEST SIZE GROUP, STOP
335          C GROUP CALCULATIONS WHEN EXTINCTION CONTRIBUTION FROM LAST GROUP IS
336          C LESS THAN 1.E-6 OF MAXIMUM GROUP EXTINCTION CONTRIBUTION
337          DO 160 IDG = 1, NCG
338          C
339          C CHECK IF EXTINCTION CONTRIBUTIONS FROM THE SIZE GROUPS HAVE
340          C BECOME NEGLIGIBLE
341          IF( ICALC .EQ. 0 ) GO TO 154
342          C
343          C SET GROUP NUMBER FOR CCGRP COMMON
344          MGRP = IDG
345          C
346          C SET THE SIZE LIMITS FOR THIS SIZE GROUP
347          IF( IGG .EQ. 1 ) GO TO 80
348          DLOW = 1.E-4 * DGROUP(IGG - 1)

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349      DNHIGH = 1.E-4 * DGROUP(IDG)
350      GO TO 90
351      NO DLOW = 0.
352      DNHIGH = 1.E-4 * DGROUP(1)
353      90 IF( DNHIGH .LE. 0. ) GO TO 160
354      C
355      C   CALCULATE THE PROPAGATION PARAMETERS FOR THIS SIZE GROUP,
356      C   WAVELENGTH, AND MATERIAL
357      C   CALL CGROUP
358      C
359      C   SET THE PROPAGATION PARAMETER#
360      154 GO TO( 156, 157, 158 ), INAT
361      C
362      156 IF( FNA(IDG) .LE. 0. ) FNA(IDG) = FN
363      IF( FMA(IDG) .LE. 0. ) FMA(IDG) = FM
364      PNGA(IDG) = PNG
365      CMUSA(IDG,IRT) = CMUS
366      CMUEA(IDG,IRT) = CMUE
367      CMUBA(IDG,IRT) = CMUB
368      CMUEMA(IRT) = CMUEMA(IRT) + FNA(IDG) * CMUEA(IDG,IRT)
369      CMUSMA(IRT) = CMUSMA(IRT) + FMA(IDG) * CMUSA(IDG,IRT)
370      CMUBMA(IRT) = CMUBMA(IRT) + FMA(IDG) * CMUBA(IDG,IRT)
371      GO TO 159
372      C
373      157 IF( FNB(IDG) .LE. 0. ) FNB(IDG) = FN
374      IF( FMB(IDG) .LE. 0. ) FMB(IDG) = FM
375      PNGB(IDG) = PNG
376      CMUSB(IDG,IRT) = CMUS
377      CMUEB(IDG,IRT) = CMUE
378      CMUBB(IDG,IRT) = CMUB
379      CMUEMB(IRT) = CMUEMB(IRT) + FNB(IDG) * CMUEB(IDG,IRT)
380      CMUSMB(IRT) = CMUSMB(IRT) + FMB(IDG) * CMUSB(IDG,IRT)
381      CMUBMB(IRT) = CMUBMB(IRT) + FMB(IDG) * CMUBB(IDG,IRT)
382      GO TO 159
383      C
384      158 IF( FNC(IDG) .LE. 0. ) FNC(IDG) = FN
385      IF( FMC(IDG) .LE. 0. ) FMC(IDG) = FM
386      PNGC(IDG) = PNG
387      CMUSC(IDG,IRT) = CMUS
388      CMUEC(IDG,IRT) = CMUE
389      CMUBC(IDG,IRT) = CMUB
390      CMUEMC(IRT) = CMUEMC(IRT) + FNC(IDG) * CMUEC(IDG,IRT)
391      CMUSMC(IRT) = CMUSMC(IRT) + FMC(IDG) * CMUSC(IDG,IRT)
392      CMUBMC(IRT) = CMUBMC(IRT) + FMC(IDG) * CMUBC(IDG,IRT)
393      E
394      C   SET MAXIMUM VALUE OF EXTINGUISHMENT CONTRIBUTION
395      159 EMAX = AMAX1( EMAX, FM * CMUE )
396      IF( EMAX .LE. 0. ) GO TO 160
397      C
398      C   CHECK IF EXTINGUISHMENT CONTRIBUTION IS NEGLIGIBLE
399      IF( FM * CMUE .GT. 1.E-6 * EMAX ) GO TO 160
400      C
401      C   EXTINGUISHMENT CONTRIBUTION HAS BECOME NEGLIGIBLE, SET CONTROL
402      C   PARAMETER TO SKIP REST OF CROSS SECTION CALCULATIONS
403      ICALC = 0
404      FN = 0.
405      FM = 0.
406      PNG = 0.

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407          CMUS = 0.
408          CMUE = 0.
409          CMUB = 0.
410      C
411      160 CONTINUE
412      C
413      170 CONTINUE
414      C
415      175 CONTINUE
416      C
417      C
418      C WRITE OUT THE SIZE DISTRIBUTION PROPAGATION PARAMETERS FOR THIS
419      C PROBLEM
420      C
421      180 DO 300 IMAT = 1, 3
422      C
423      DO 290 IRT = 1, NRT
424      C
425      C CHECK IF THIS FREQUENCY IS THE SAME AS A PREVIOUS FREQUENCY
426      C IF SO SK'P REPRINTING THE PROPAGATION PARAMETERS
427      C IF ISKIP(IRT) .GT. 0 ) GO TO 390
428      C
429      C SET PRINT LINE COUNTER
430      C ILINE = 13
431      C
432      WRITE(JTAPE, 190) NPROB
433      190 FORMAT(1H1,74H
434      111ION DUST (CLOUD) MODEL / /
435      21H0,70H
436      3 FOR PROBLEM NUMBER , 13 /
437      41H ,84H
438      5NLY, NO FRACTIONIZATION ) )
439      C
440      GO TO( 200, 210, 220 ), IMAT
441      C
442      200 WRITE(JTAPE, 202)
443      202 FORMAT(1H0,70H
444      1PARTICLES - MODE A )
445      GO TO 230
446      210 WRITE(JTAPE, 212)
447      212 FORMAT(1H0,70H
448      1PARTICLES - MODE B )
449      GO TO 230
450      220 WRITE(JTAPE, 225)
451      225 FORMAT(1H0,66H
452      1IRON PARTICLES )
453      C
454      230 WRITE(JTAPE, 235) XLAMDA(IRT), FREQ(IRT)
455      235 FORMAT(1H0, 46H
456      1 F7.1, 21H MICRONS (FREQUENCY = , 1PE9.2, 5H GHZ) / 1H0,
457      2114HSIZE MAXIMUM NUMBER OF NUMBER FRACTION MASS FRACTI
458      30N GROUP MASS COEFFICIENTS ( FIRST LINE, CM2/GM ) / 1H ,
459      4120HGROUP DIAMETER PARTICLES PER (NUMBER IN GROUP (MASS IN GR
460      50UP AVERAGE CROSS SECTIONS ( SECOND LINE, CM2/PARTICLE ) / 1H ,
461      6121H (MICRONS) GRAM IN GROUP /TOTAL NUMBER) /TOTAL HAS
462      7S) EXTINCTION ABSORPTION SCATTERING BACKSCATTER )
463      C
464      DO 280 IDG = 1, NOG

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ASL MUN
PROPAGATION CONSTANTS
( SIZE DISTRIBUTION O

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DUST
DUST
CA

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465 C
466 GO TO( 240, 260, 270 ), IMAT
467 240 IF( CMUEA(IDG,IRT) .EQ. 0. ) GO TO 280
468 CMUAA = CMUEA(IDG,IRT) - CMUSA(IDG,IRT)
469 SIGEA = CMUEA(IDG,IRT) / PNGA(IDG)
470 SIGAA = CMUAA / PNGA(IDG)
471 SIGSA = CMUSA(IDG,IRT) / PNGA(IDG)
472 SIGBA = CMUBA(IDG,IRT) / PNGA(IDG)
473 WRITE(JTAPE, 250) IDG, DGROUP(IDG), PNGA(IDG), FNA(IDG), FMA(IDG),
474 1 CMUEA(IDG,IRT), CMUAA, CMUSA(IDG,IRT),
475 2 CMUBA(IDG,IRT), SIGEA, SIGAA, SIGSA, SIGBA
476 250 FORMAT(1H0, I3, F11.1, 1PE15.3, 2E17.3, E15.3, 3E14.3 /
477 11H ,63X, 1PE15.3, 3E14.3 )
478 GO TO 277
479
480 C
481 260 IF( CMUEB(IDG,IRT) .EQ. 0. ) GO TO 280
482 CMUAB = CMUEB(IDG,IRT) - CMUSR(IDG,IRT)
483 SIGEB = CMUEB(IDG,IRT) / PNGB(IDG)
484 SIGAB = CMUAB / PNGB(IDG)
485 SIGSB = CMUSB(IDG,IRT) / PNGB(IDG)
486 SIGBB = CMUBB(IDG,IRT) / PNGB(IDG)
487 WRITE(JTAPE, 265) IDG, DGROUP(IDG), PNGB(IDG), FNB(IDG), FMB(IDG),
488 1 CMUEB(IDG,IRT), CMUAB, CMUSB(IDG,IRT),
489 2 CMUBB(IDG,IRT), SIGEB, SIGAB, SIGSB, SIGBB
490 265 FORMAT(1H0, I3, F11.1, 1PE15.3, 2E17.3, E15.3, 3E14.3 /
491 11H ,63X, 1PE15.3, 3E14.3 )
492 GO TO 277
493
494 C
495 270 IF( CMUEC(IDG,IRT) .EQ. 0. ) GO TO 280
496 CMUAC = CMUEC(IDG,IRT) - CMUSC(IDG,IRT)
497 SIGEC = CMUEC(IDG,IRT) / PNGC(IDG)
498 SIGAC = CMUAC / PNGC(IDG)
499 SIGSC = CMUSC(IDG,IRT) / PNGC(IDG)
500 SIGBC = CMUBC(IDG,IRT) / PNGC(IDG)
501 WRITE(JTAPE, 275) IDG, DGROUP(IDG), PNGC(IDG), FNC(IDG), FMC(IDG),
502 1 CMUEC(IDG,IRT), CMUAC, CMUSC(IDG,IRT),
503 2 CMUBC(IDG,IRT), SIGEC, SIGAC, SIGSC, SIGBC
504 275 FORMAT(1H0, I3, F11.1, 1PE15.3, 2E17.3, E15.3, 3E14.3 /
505 11H ,63X, 1PE15.3, 3E14.3 )
506
507 C
508 277 I LINES = I LINES + 3
509 IF( I LINES .LT. 50 ) GO TO 280
510 I LINES = 7
511 WRITE(JTAPE, 278 ) NPROB
512 278 FORMAT(1H1,734 PROPAGATION CONSTANT
513 13 FOR PROBLEM NUMBER: , I3, 12H (CONTINUED) / / 1H0,
514 2114MSIZE MAXIMUM NUMBER OF NUMBER FRACTION MASS FRACTI
515 30N GROUP MASS COEFFICIENTS ( FIRST LINE, CM2/GM ) / 1H ,
516 4120HGROUP DIAMETER PARTICLES PER (NUMBER IN GROUP (MASS GR
517 50UP AVERAGE CROSS SECTIONS ( SECOND LINE, CM2/PARTICLE ) / 1H ,
518 6121H (MICRONS) GRAM IN GROUP /TOTAL NUMBER) /TOTAL MAS
519 79) EXTINCTION ABSORPTION SCATTERING BACKSCATTER )
520
521 C
522 280 CONTINUE
523
524 C
525 GO TO( 281, 283, 285 ), IMAT
526 281 CHUAA = CMUEA(IRT) - CHUSMA(IRT)
527 WRITE(JTAPE, 282) CMUEA(IRT), CHUAMA, CHUSMA(IRT), CHUBMA(IRT)

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523      282 FORMAT( 1H0, 9H  ENTIRE, 55X, 1P4E14.3/ 1H , 12HDISTRIBUTION )
524      GO TO 290
525      283 CMUAMB = CMUEMB(IRT) - CMUSHB(IRT)
526      WRITE(JTAPE, 284) CMUEMB(IRT), CMUAMB, CMUSMB(IRT), CMUSMB(IRT)
527      284 FORMAT( 1H0, 9H  ENTIRE, 55X, 1P4E14.3/ 1H , 12HDISTRIBUTION )
528      GO TO 290
529      285 C ,AMC = CMUEMC(IRT) - CMUSHC(IRT)
530      WRITE(JTAPE, 286) CMUEMC(IRT), CMUAMC, CMUSMC(IRT), CMUSMC(IRT)
531      286 FORMAT( 1H0, 9H  ENTIRE, 55X, 1P4E14.3/ 1H , 12HDISTRIBUTION )
532      C
533      290 CONTINUE
534      C
535      300 CONTINUE
536      :
537      C
538      C      FRACTIONIZATION SECTION
539      C      THIS SECTION REDEFINES THE MASS FRACTIONS AND CROSS SECTIONS IN
540      C      EACH SIZE GROUP FOR EACH MATERIAL TO ACCOUNT FOR THE EFFECTS OF
541      C      FRACTIONIZATION
542      C
543      C      LOOP OVER THE MATERIALS
544      C      DO 610 IMAT = 1, 3
545      C
546      C      SET THE SIZE DISTRIBUTION MASS FRACTIONS FOR THIS MATERIAL
547      C      GO TO ( 400, 420, 440 ), IMAT
548      C
549      C      DUST - MODE A
550      C      DO 410 IDG = 1, NDG
551      C      FMD(IDG) = FMA(IDG)
552      C      410 CONTINUE
553      C      GO TO 460
554      C
555      C      DUST - MODE B
556      C      DO 420 IDG = 1, NDG
557      C      FMD(IDG) = FMB(IDG)
558      C      420 CONTINUE
559      C      GO TO 460
560      C
561      C      CARBON
562      C      DO 430 IDG = 1, NDG
563      C      FMD(IDG) = FMC(IDG)
564      C      430 CONTINUE
565      C
566      C      CALCULATE THE PARTIAL MASS FRACTIONS ( MASS OF MATERIAL IN THE IDG
567      C      SIZE GROUP DIVIDED BY THE SUM OF MASSES IN ALL GROUPS LARGER THAN
568      C      THE IDG SIZE GROUP )
569      C      460 PMASSF(NDG) = 0.
570      C      SUMASS = 0.
571      C      DO 470 LDG = 2, NDG
572      C      IDG = NDG + 1 - LDG
573      C      SUMASS = SUMASS + FMD(IDG + 1)
574      C      PMASSF(IDG) = 0.
575      C      IF( SUMASS .GT. 0. ) PMASSF(IDG) = FMD(IDG) / SUMASS
576      C      470 CONTINUE
577      C
578      C      CALCULATE THE NEW MASS FRACTION FOR EACH SIZE GROUP
579      C      SUMPMF = 0.
580      C      DO 520 IDG = 1, NDG

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581      FRZT1 = 1.
582      IF( IDG .EQ. NDG ) GO TO 475
583      IF( FMD(IDG + 1) .GT. 0. ) FRZT1 = 1. - FRZT
584      GO TO ( 480, 490, 500 ), IMAT
585      475 FMA(IDG) = FMA(IDG) * ( FRZT1 + FRZT * SUMPWF )
586      GO TO 510
587      490 FMB(IDG) = FMB(IDG) * ( FRZT1 + FRZT * SUMPWF )
588      GO TO 510
589      500 FMC(IDG) = FMC(IDG) * ( FRZT1 + FRZT * SUMPWF )
590      510 SUMPWF = SUMPWF + PHASSF(IDG)
591      520 CONTINUE
592      C
593      C      CALCULATE THE CROSS SECTIONS FOR EACH SIZE GROUP FOR EACH
594      C      FREQUENCY
595      C      LOOP OVER THE FREQUENCIES
596      DO 605 IRT = 1, NRT
597      C
598      C      CHECK IF THIS FREQUENCY IS THE SAME AS A PREVIOUS FREQUENCY
599      IF( ISKIP(IRT) .LE. 0 ) GO TO 565
600      C
601      C      FREQUENCY IS THE SAME, USE PREVIOUS RESULTS
602      IRTP = ISKIP(IRT)
603      DO 560 IDG = 1, NDG
604      GO TO ( 530, 540, 550 ), IMAT
605      530 CMUEA(IDG,IRT) = CMUEA(IDG,IRT)
606      CMUSA(IDG,IRT) = CMUSA(IDG,IRT)
607      CMUBA(IDG,IRT) = CMUBA(IDG,IRT)
608      GO TO 560
609      540 CMUEB(IDG,IRT) = CMUEB(IDG,IRT)
610      CMUSB(IDG,IRT) = CMUSB(IDG,IRT)
611      CMURB(IDG,IRT) = CMURB(IDG,IRT)
612      GO TO 560
613      550 CMUEC(IDG,IRT) = CMUEC(IDG,IRT)
614      CMUSC(IDG,IRT) = CMUSC(IDG,IRT)
615      CMURC(IDG,IRT) = CMURC(IDG,IRT)
616      560 CONTINUE
617      GO TO 675
618      C
619      C      FREQUENCY NOT THE SAME, DO CALCULATIONS
620      565 SUHE = 0.
621      SUMS = 0.
622      SUMB = 0.
623      DO 600 IDG = 2, NDG
624      LDG = IDG - 1
625      FRZT1 = 1.
626      IF( IDG .EQ. NDG ) GO TO 568
627      IF( FMD(IDG + 1) .GT. 0. ) FRZT1 = 1. - FRZT
628      GO TO ( 570, 580, 590 ), IMAT
629      570 SUHE = SUHE + PHASSF(LDG) * CMUEA(LDG,IRT)
630      SUMS = SUMS + PHASSF(LDG) * CMUSA(LDG,IRT)
631      SUMB = SUMB + PHASSF(LDG) * CMUBA(LDG,IRT)
632      IF( FMA(IDG) .LE. 0. ) GO TO 600
633      CMUEA(IDG,IRT) = FMD(IDG) * ( FRZT1 + CMUEA(LDG,IRT)
634      + FRZT * SUHE ) / FMA(IDG)
635      CMUSA(IDG,IRT) = FMD(IDG) * ( FRZT1 + CMUSA(LDG,IRT)
636      + FRZT * SUMS ) / FMA(IDG)
637      CMUBA(IDG,IRT) = FMD(IDG) * ( FRZT1 + CMUBA(LDG,IRT)
638      + FRZT * SUMB ) / FMA(IDG)

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639      GO TO 600
640 580 SUNE = SUNE + PHASSF(LDG) * CMUEB(LDG,IRT)
641     SUNS = SUNS + PHASSF(LDG) * CMUSR(LDG,IRT)
642     SUMB = SUMB + PHASSF(LDG) * CMUBB(LDG,IRT)
643     IF( FMB(IDG) .LE. 0. ) GO TO 600
644     CMUER(IDG,IRT) = FMD(IDG) * ( FRZT1 * CMUEB(IDG,IRT)
645     + FRZT * SUNE ) / FMB(IDG)
646     CMUSR(IDG,IRT) = FMD(IDG) * ( FRZT1 * CMUSR(IDG,IRT)
647     + FRZT * SUNS ) / FMB(IDG)
648     CMUBB(IDG,IRT) = FMD(IDG) * ( FRZT1 * CMUBB(IDG,IRT)
649     + FRZT * SUMB ) / FMB(IDG)
650     GO TO 600
651 590 SUNE = SUNE + PHASSF(LDG) * CMUEC(LDG,IRT)
652     SUNS = SUNS + PHASSF(LDG) * CMUSC(LDG,IRT)
653     SUMB = SUMB + PHASSF(LDG) * CMUBC(LDG,IRT)
654     IF( FMC(IDG) .LE. 0. ) GO TO 600
655     CMUEC(IDG,IRT) = FMD(IDG) * ( FRZT1 * CMUEC(IDG,IRT)
656     + FRZT * SUNE ) / FMC(IDG)
657     CMUSC(IDG,IRT) = FMD(IDG) * ( FRZT1 * CMUSC(IDG,IRT)
658     + FRZT * SUNS ) / FMC(IDG)
659     CMUBC(IDG,IRT) = FMD(IDG) * ( FRZT1 * CMUBC(IDG,IRT)
660     + FRZT * SUMB ) / FMC(IDG)
661 C
662 C 600 CONTINUE
663 C
664 C 605 CONTINUE
665 C
666 C 610 CONTINUE
667 C
668 C WRITE OUT THE PROPAGATION PARAMETERS INCLUDING THE EFFECTS OF
669 C FRACTIONIZATION
670 C
671 C DO 690 IMAT = 1, 3
672 C
673 C DO 790 I I = 1, NSI
674 C
675 C CHECK IF THIS FREQUENCY IS THE SAME AS A PREVIOUS FREQUENCY
676 C IF SO SKIP REPRINTING THE PROPAGATION PARAMETERS
677 C IF( ISKIP(IPT) .GT. 0 ) GO TO 790
678 C
679 C SET PRINT LINE COUNTER
680 C I LINES = 13
681 C
682 C WRITE(JTAPE, 615) NPROB
683 C 615 FORMAT(1M1,70M ASL KUN
684 C 1110M DUST CLOUD MODEL / /
685 C 21M0,70M PROPAGATION CONSTANTS
686 C 3 FOR PROBLEM NUMBER , I3 /
687 C 41M , 73M ( FRACTIONIZATION EFF
688 C 51CTS INCLUDED ) )
689 C
690 C GO TO ( 620, 640, 660 ), IMAT
691 C
692 C 620 WRITE(JTAPE, 630)
693 C 630 FORMAT(1K0,70M DJST
694 C 1PARTICLES - MODE A )
695 C GO TO 660
696 C 640 WRITE(JTAPE, 650)

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697      650 FORMAT(1H0,70H                                DUST
698      1PARTICLES = MODE B )
699      GO TO 680
700      660 WRITE(JTAPE, 670)
701      670 FORMAT(1H0,66H                                CA
702      IRRON PARTICLES )
703      C
704      680 WRITE(JTAPE, 690) XLAMDA(IRT), FREQ(IRT)
705      690 FORMAT(1H0, 46H                                WAVELENGTH = ,
706      1 F7.1, 21H MICRONS (FREQUENCY = , 1PE9.2, 5H GHZ) / 1H0,
707      2 76HSIZE MAXIMUM MASS FRACTION                GROUP MASS COEFFICIE
708      3NTS ( CM2/GM ) / 1H ,
709      4 86HGROUP DIAMETER (MASS IN GROUP EXTINCTION  ABSORPTION  S
710      SCATTERING BACKSCATTER /
711      6 30H (MICRONS) /TOTAL MASS) / 1H )
712      C
713      DO 780 IDG = 1, NDG
714      C
715      GO TO ( 700, 720, 740 ), IMAT
716      700 IF( CHUEA(IDG,IRT) .EQ. 0. ) GO TO 780
717      CHUAA = CHUEA(IDG,IRT) - CMUSA(IDG,IRT)
718      WRITE(JTAPE, 710) IDG, DGROUP(IDG), FMA(IDG), CHUEA(IDG,IRT),
719      1 CHUAA, CMUSA(IDG,IRT), CHUBA(IDG,IRT)
720      710 FORMAT(1H , 13, F11.1, 1PE13.3, 2X, 4E14.3 )
721      GO TO 760
722      C
723      720 IF( CHUEB(IDG,IRT) .EQ. 0. ) GO TO 780
724      CHUAR = CHUEB(IDG,IRT) - CMUSB(IDG,IRT)
725      WRITE(JTAPE, 730) IDG, DGROUP(IDG), FMB(IDG), CHUEB(IDG,IRT),
726      1 CHUAB, CMUSB(IDG,IRT), CHUBB(IDG,IRT)
727      730 FORMAT(1H , 13, F11.1, 1PE13.3, 2X, 4E14.3 )
728      GO TO 760
729      C
730      740 IF( CHUEC(IDG,IRT) .EQ. 0. ) GO TO 780
731      CHUAC = CHUEC(IDG,IRT) - CMUSC(IDG,IRT)
732      WRITE(JTAPE, 750) IDG, DGROUP(IDG), FMC(IDG), CHUEC(IDG,IRT),
733      1 CHUAC, CMUSC(IDG,IRT), CHUBC(IDG,IRT)
734      750 FORMAT(1H , 13, F11.1, 1PE13.3, 2X, 4E14.3 )
735      C
736      760 I LINES = I LINES + 1
737      IF( I LINES .LT. 50 ) GO TO 780
738      I LINES = 7
739      WRITE(JTAPE, 770 ) NPR0B
740      770 FORMAT(1H1,73H                                PROPAGATION CONSTANT
741      13 FOR PROBLEM NUMBER , 13, 12H (CONTINUED) / / 1H0,
742      2 76HSIZE MAXIMUM MASS FRACTION                GROUP MASS COEFFICIE
743      3NTS ( CM2/GM ) / 1H ,
744      4 86HGROUP DIAMETER (MASS IN GROUP EXTINCTION  ABSORPTION  S
745      SCATTERING BACKSCATTER /
746      6 30H (MICRONS) /TOTAL MASS) / 1H0 )
747      C
748      780 CONTINUE
749      C
750      790 CONTINUE
751      C
752      800 CONTINUE
753      C
754      RETURN
755      C
756      END

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1      SUBROUTINE CGROUP
2      C
3      C THIS SUBROUTINE CALCULATES THE SCATTERING AND
4      C EXTINCTION PARAMETERS FOR A GIVEN SIZE GROUP. THE RANGE OF
5      C PARTICLE SIZES IN THE SIZE GROUP CAN BE ONLY A SMALL SUBSET OF THE
6      C WHOLE PARTICLE DISTRIBUTION RANGE OR CAN INCLUDE THE WHOLE
7      C DISTRIBUTION. THREE TYPES OF PARTICLE SIZE PROBABILITY
8      C DISTRIBUTIONS ARE ALLOWED - LOG NORMAL, POWER LAW, OR HYBRID ( A
9      C LOG NORMAL JOINED TO A POWER LAW )
10     C
11     C INPUT VARIABLES FROM CCGRP COMMON
12     C AGRP = NUMBER OF THE GIVEN SIZE GROUP
13     C MSIZE = 1 THE PARTICLE SIZE DISTRIBUTION IS LOG NORMAL
14     C          COMPUTE PARAMETERS INCLUDING SCATTERING PATTERN
15     C          = -1 THE PARTICLE SIZE DISTRIBUTION IS LOG NORMAL
16     C          COMPUTE PARAMETERS ( NO SCATTERING PATTERN )
17     C          = 2 THE PARTICLE SIZE DISTRIBUTION IS POWER LAW
18     C          COMPUTE PARAMETERS INCLUDING SCATTERING PATTERN
19     C          = -2 THE PARTICLE SIZE DISTRIBUTION IS POWER LAW
20     C          COMPUTE PARAMETERS ( NO SCATTERING PATTERN )
21     C          = 3 THE PARTICLE SIZE DISTRIBUTION IS HYBRID
22     C          COMPUTE PARAMETERS INCLUDING SCATTERING PATTERN
23     C          = -3 THE PARTICLE SIZE DISTRIBUTION IS HYBRID
24     C          COMPUTE PARAMETERS ( NO SCATTERING PATTERN )
25     C MSPHER = 1 THE PARTICLES ARE SPHERICAL, USE STANDARD MIE THEORY
26     C          = 2 THE PARTICLES ARE NON-SPHERICAL, USE MODIFIED MIE
27     C          THEORY
28     C DLOW = LOWER LIMIT OF PARTICLE DIAMETER RANGE ( CM )
29     C DHIGH = UPPER LIMIT OF PARTICLE DIAMETER RANGE ( CM )
30     C DM = MEAN DIAMETER PARAMETER FOR LOG NORMAL AND HYBRID
31     C          DISTRIBUTIONS ( CM )
32     C S = STANDARD DEVIATION PARAMETER FOR LOG NORMAL AND HYBRID
33     C          DISTRIBUTIONS
34     C DMIN = MINIMUM PARTICLE DIAMETER FOR POWER LAW AND POINT AT
35     C          WHICH LOG NORMAL AND POWER LAW JOIN IN HYBRID
36     C          DISTRIBUTION ( CM )
37     C DMAX = MAXIMUM PARTICLE DIAMETER FOR POWER LAW AND HYBRID
38     C          DISTRIBUTIONS ( CM )
39     C P = POWER LAW EXPONENT FOR THE POWER LAW AND HYBRID
40     C          PROBABILITY DISTRIBUTIONS
41     C WL = WAVELENGTH OF THE INCIDENT RADIATION ( CM )
42     C XR = REAL PART OF THE COMPLEX INDEX OF REFRACTION OF THE
43     C          PARTICLES
44     C XI = IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION OF THE
45     C          PARTICLES ( THE INDEX IS  $n = XR + iXI$  SO THAT BOTH XR
46     C          AND XI ARE POSITIVE )
47     C RHO = DENSITY OF THE PARTICLES ( GM/CM3 )
48     C
49     C CALCULATED PARAMETERS, OUTPUTS TO CCGRP COMMON
50     C PNG = NUMBER OF PARTICLES PER GRAM ( OF MATERIAL IN THE SIZE
51     C          GROUP )
52     C FN = NUMBER FRACTION OF PARTICLES IN SIZE GROUP ( RATIO OF
53     C          NUMBER OF PARTICLES IN SIZE GROUP TO TOTAL NUMBER OF
54     C          PARTICLES IN DISTRIBUTION )
55     C FM = MASS FRACTION ( RATIO OF MASS OF PARTICLES IN SIZE
56     C          GROUP TO TOTAL MASS IN DISTRIBUTION )
57     C SIGA = AVERAGE ABSORPTION CROSS SECTION PER PARTICLE
58     C          IN THE GROUP ( CM2 )

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59 C SIGS = AVERAGE SCATTERING CROSS SECTION PER PARTICLE
60 C IN THE GROUP ( CM2 )
61 C SIGE = AVERAGE EXTINCTION CROSS SECTION PER PARTICLE
62 C IN THE GROUP ( CM2 )
63 C SIGB = AVERAGE BACKSCATTER CROSS SECTION PER PARTICLE
64 C IN THE GROUP ( CM2 )
65 C SPN = NORMALIZED SCATTERING PATTERN FOR THE PARTICLES IN THE
66 C GIVEN SIZE RANGE DLOW TO DHIGH. SPN(J) = SCATTERING
67 C FUNCTION AT THE SCATTERING ANGLE WHOSE COSINE IS
68 C  $0.1*(J-1)$ , SPN IS NORMALIZED SO THAT THE INTEGRAL OF
69 C SPN OVER 4 PI STERADIANS EQUALS 4 PI ( IE, AN ISOTROPIC
70 C SCATTERING PATTERN HAS SPN(J) = 1.0 FOR ALL J )
71 C CMUA = MASS ABSORPTION COEFFICIENT ( CM2/GM )
72 C WHERE THE GRAM OF MASS PENETRATED REFERS TO THE MASS
73 C OF PARTICLES IN THE SIZE GROUP
74 C CMUS = MASS SCATTERING COEFFICIENT ( CM2/GM )
75 C CMUE = MASS EXTINCTION COEFFICIENT ( CM2/GM )
76 C CMUB = MASS BACKSCATTER COEFFICIENT ( CM2/GM )
77 C THE MASS COEFFICIENTS ARE CALCULATED BY MULTIPLYING THE AVERAGE
78 C CROSS SECTION PER PARTICLE BY THE NUMBER OF PARTICLES PER GRAM
79 C
80 C NOTES
81 C THE PROBABILITY DISTRIBUTIONS ARE
82 C LOG NORMAL =  $\text{EXP}(-0.5*(\text{LN}(D/DH)/\text{LN}(S))**2) / (\text{SORT}(2*PI)*D*\text{LN}(S))$ 
83 C WHERE D = PARTICLE DIAMETER ( CM )
84 C POWER LAW =  $(P-1)*D**(-P) / (DMIN**(-P)-DMAX**(-P))$ 
85 C HYBRID = C1 * LOG NORMAL FOR D BETWEEN D AND DMIN
86 C = C2 * POWER LAW FOR D BETWEEN DMIN AND DMAX
87 C WHERE C1 AND C2 ARE NORMALIZING CONSTANTS WHICH INSURE THAT
88 C THE INTEGRAL OVER THE HYBRID PROBABILITY DISTRIBUTION FROM
89 C 0 TO DMAX EQUALS ONE, AND THAT THE LOG NORMAL AND POWER
90 C LAW DISTRIBUTIONS JOIN AT DMIN
91 C
92 C
93 C DIMENSION SPNLN(21), SPNPL(21)
94 C
95 C SET VALUE OF PI
96 C DATA PI / 3.14159265 /
97 C
98 C COMMON / CCGRP / MGRP, MSIZE, MSPHER, DLOW, DHIGH, DM, S, DMIN,
99 C 1 DMAX, P, XR, XI, RHO, PNG, FN, FH, SIGA, SIGS,
100 C 2 SIGE, SIGB, SPN(21), CMUA, CMUS, CMUE, CMUB, WL
101 C
102 C ZERO OUT VARIABLES
103 C SIGALN = 0.
104 C SIGSLN = 0.
105 C SIGELN = 0.
106 C SIGBLN = 0.
107 C SIGAPL = 0.
108 C SIGSPL = 0.
109 C SIGEPL = 0.
110 C SIGBPL = 0.
111 C DO 5 I = 1, 21
112 C SPNLN( I ) = 0.
113 C SPNPL( I ) = 0.
114 C 5 CONTINUE
115 C

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116 C   DEFAULT VALUES
117     IF( MSIZE .EQ. 0 ) GO TO 83
118     IF( MSPHER .EQ. 0 ) MSPHER = 1
119     IF( RHO .EQ. 0. ) RHO = 2.5
120 C
121 C   CHECK THAT GROUP SIZE RANGE IS WITHIN SIZE DISTRIBUTION LIMITS
122     IF( WL .LE. 0. ) GO TO 83
123     IMSIZE = IABS( MSIZE )
124     IF( DLOW .GE. DHIGH ) GO TO 83
125     IF( DLOW .LT. 0. ) DLOW = 0.
126     IF( IMSIZE .EQ. 1 ) GO TO 84
127     IF( IMSIZE .EQ. 2 .AND. DLOW .LT. DHIGH ) DLOW = DHIGH
128     IF( DHIGH .GT. DMAX ) DHIGH = DMAX
129     IF( DLOW .LT. DHIGH ) GO TO 84
130 C
131 83 SIGA = 0.
132     SIGS = 0.
133     SIGE = 0.
134     SIGB = 0.
135     PNG = 0.
136     FN = 0.
137     FM = 0.
138     GO TO 156
139 C
140 C   CHECK WHICH DISTRIBUTION IS TO BE USED
141 84 GO TO( 85, 95, 118 ), IMSIZE
142 C
143 C
144 C   DISTRIBUTION IS LOG NORMAL
145 C   COMPUTE NUMBER AND MASS FRACTIONS
146 85 ALNS = ALOG( S )
147     SD1 = -1.
148     FN1 = 0.
149     FM1 = 0.
150     SD2 = ALOG( DHIGH / DM ) / ALNS
151     SD3 = 3. * ALNS
152     IF( DLOW .LE. 0. ) GO TO 90
153     SD1 = ALOG( DLOW / DM ) / ALNS
154     FN1 = CUMNOR( SD1 )
155     FM1 = CUMNOR( SD1 - SD3 )
156 90 FN2 = CUMNOR( SD2 )
157     FM2 = CUMNOR( SD2 - SD3 )
158     IF( SD1 * SD2 .LE. 0. ) GO TO 91
159     FN = FN1 - FN2
160     IF( SD2 .LT. 0. ) FN = - FN
161     GO TO 92
162 91 FN = 1. - FN1 - FN2
163 92 IF( ( SD1 - SD3 ) * ( SD2 - SD3 ) .LE. 0. ) GO TO 93
164     FN = FN1 - FN2
165     IF( SD2 - SD3 .LT. 0. ) FN = -FN
166     GO TO 94
167 93 FN = 1. - FN1 - FN2
168 C
169 C   COMPUTE AVERAGE CUBED DIAMETER OF GROUP
170 94 D3AV = FN * DM**3 * EXP( 9. * ALNS**2 / 2. ) / FN
171 C
172 C   COMPUTE CROSS SECTIONS AND SCATTERING PATTERN( FOR POSITIVE MSIZE)
173     CALL CROSS( MSIZE, MSPHER, DLOW, DHIGH, DM, S, DUM, WL, XR, XI,

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174      1      SIGA, SIGS, SICE, SIGB, SPN )
175      GO TO 155
176      C
177      C
178      C      DISTRIBUTION IS POWER LAW
179      C      COMPUTE NUMBER AND MASS FRACTION
180      95  OMP = 1. - P
181      FN = ( DLOW ** OMP - DHIGH ** OMP ) / ( DMIN ** OMP - DMAX ** OMP )
182      IF ( P .EQ. 4. ) GO TO 100
183      FMP = 4. - P
184      FM = ( DLOW ** FMP - DHIGH ** FMP ) / ( DMIN ** FMP - DMAX ** FMP )
185      GO TO 105
186      100  FM = ALOG( DHIGH / DLOW ) / ALOG ( DMAX / DMIN )
187      C
188      C      COMPUTE AVERAGE CUBED DIAMETER OF GROUP
189      105  CON1 = -OMP / ( DMIN ** OMP - DMAX ** OMP )
190      IF ( P .EQ. 4. ) GO TO 110
191      D3AVT = CON1 * ( DMAX ** FMP - DMIN ** FMP ) / FMP
192      GO TO 115
193      110  D3AVT = CON1 * ALOG( DMAX / DMIN )
194      115  D3AV = D3AVT * FM / FN
195      C
196      C      COMPUTE CROSS SECTIONS AND SCATTERING PATTERN( FOR POSITIVE MSIZE)
197      CALL CROSS( MSIZE, MSPHER, DLOW, DHIGH, DMIN, DMAX, P, NL, XR, XI,
198      1      SIGA, SIGS, SICE, SIGB, SPN )
199      GO TO 155
200      C
201      C
202      C      DISTRIBUTION IS HYBRID
203      C      PRELIMINARY CALCULATIONS, DO ONLY ONCE
204      C
205      118  IF( HGRP .GT. 1 ) GO TO 126
206      C
207      C      COMPUTE NORMALIZING CONSTANTS C1 AND C2
208      OMP = 1. - P
209      PPI = -OMP * DMIN ** ( -P ) / ( DMIN ** OMP - DMAX ** OMP )
210      ALNS = ALOG( S )
211      SD1 = ALOG( DMIN / DM ) / ALNS
212      PL1 = EXP( -SD1 ** 2 / 2. ) / ( SORT( 2. * PI ) * DMIN * ALNS )
213      CUM = CUMNOR ( SD1 )
214      IF( SD1 .GT. 0. ) CUM = 1. - CUM
215      C2 = 1. / ( 1. + CUM * PPI / PL1 )
216      C1 = C2 * PPI / PL1
217      C
218      C      CALCULATE THE NUMBER AND MASS FRACTIONS OF THE LOG NORMAL AND
219      C      POWER LAW SEGMENTS OF THE HYBRID DISTRIBUTION
220      FNPL = C2
221      FNLN = 1. - C2
222      D3AVLN = DM ** 3 * EXP( 9. * ALNS ** 2 / 2. )
223      CON1 = -OMP / ( DMIN ** OMP - DMAX ** OMP )
224      IF ( P .EQ. 4. ) GO TO 120
225      FMP = 4. - P
226      D3AVPL = CON1 * ( DMAX ** FMP - DMIN ** FMP ) / FMP
227      GO TO 125
228      120  D3AVPL = CON1 * ALOG( DMAX / DMIN )
229      125  CUM = CUMNOR( SD1 * 3. * ALNS )
230      IF( SD1 * 3. * ALNS .GT. 0. ) CUM = 1. - CUM
231      D3AVH = C1 * D3AVLN * CUM + C2 * D3AVPL

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232      FMPL = C2 * D3AVPL / D3AVH
233      FMLN = 1. - FMPL
234      126 CONTINUE
235      C
236      C COMPUTE THE NUMBER FRACTION AND MASS FRACTION FOR THAT PART OF THE
237      C SIZE GROUP THAT LIES IN THE LOG NORMAL PORTION OF THE HYBRID
238      C DISTRIBUTION
239      FMGLN = 0.
240      FMGLN = 0.
241      IF( DLOW .GE. DMIN ) GO TO 135
242      DUPPER = AMIN1( DMIGH, DMIN )
243      FN1 = 0.
244      FM1 = 0.
245      SD1 = -1.
246      SD2 = ALOG( DUPPER / DM ) / ALNS
247      SD3 = 3. * ALNS
248      IF( DLOW .LE. 0. ) GO TO 130
249      SD1 = ALOG( DLOW / DM ) / ALNS
250      FN1 = CUMNOR( SD1 )
251      FM1 = CUMNOR( SD1 - SD3 )
252      130 FN2 = CUMNOR( SD2 )
253      FM2 = CUMNOR( SD2 - SD3 )
254      IF( SD1 * SD2 .LE. 0. ) GO TO 131
255      FMGLN = C1 * ( FM1 + FM2 )
256      IF( SD2 .LT. 0. ) FMGLN = -FMGLN
257      GO TO 132
258      131 FMGLN = C1 * ( 1. - FM1 - FM2 )
259      132 IF( ( SD1 - SD3 ) * ( SD2 - SD3 ) .LE. 0. ) GO TO 133
260      FMGLN = C1 * D3AVLN * ( FM1 + FM2 ) / D3AVH
261      IF( SD2 - SD3 .LT. 0. ) FMGLN = -FMGLN
262      GO TO 134
263      133 FMGLN = C1 * D3AVLN * ( 1. - FM1 - FM2 ) / D3AVH
264      C
265      C COMPUTE CROSS SECTIONS FOR THIS PORTION OF THE SIZE GROUP
266      134 MSIZEH = 1
267      IF( MSIZE .LE. 0 ) MSIZEH = -1
268      CALL CROSS( MSIZEH, MSPHER, DLOW, DUPPER, DM, S, DUM, WL, XR, XI,
269      1 SIGALN, SIGSLN, SIGELN, SIGBLN, SPNLN )
270      C
271      C COMPUTE THE NUMBER FRACTION AND MASS FRACTION FOR THAT PART OF THE
272      C SIZE GROUP THAT LIES IN THE POWER LAW PORTION OF THE HYBRID
273      C DISTRIBUTION
274      135 FMGPL = 0.
275      FMGPL = 0.
276      IF( DMIGH .LE. DMIN ) GO TO 147
277      DLOWER = AMAX1( DLOW, DMIN )
278      FMGPL = C2 * ( DLOWER ** GMP - DMIGH ** GMP ) / ( DMIN ** GMP
279      1 - DMAX ** GMP )
280      IF( P .EQ. 4. ) GO TO 140
281      FMGPL = FMPL * ( DLOWER ** FMP - DMIGH ** FMP ) / ( DMIN ** FMP
282      1 - DMAX ** FMP )
283      GO TO 145
284      140 FMGPL = FMPL * ALOG( DMIGH / DLOWER ) / ALOG( DMAX / DMIN )
285      C
286      C COMPUTE CROSS SECTIONS FOR THIS PORTION OF THE SIZE GROUP
287      145 MSIZEH = 2
288      IF( MSIZE .LE. 0 ) MSIZEH = -2
289      CALL CROSS( MSIZEH, MSPHER, DLOWER, DMIGH, DMIN, DMAX, P, WL, XR,

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290          1          XI, SIGAPL, SIGSPL, SIGEPL, SIGBPL, SPNPL )
291      C
292      C
293      C      COMPUTE NUMBER AND MASS FRACTIONS FOR THE SIZE GROUP
294      147 FM = FNGLN + FNGPL
295          FM = FNGLN + FNGPL
296      C
297      C      COMPUTE AVERAGE CUBED DIAMETER OF GROUP
298          D3AV = FM * D3AVN / FN
299      C
300      C      COMPUTE CROSS SECTIONS FOR THE WHOLE SIZE GROUP
301          CON1 = FNGLN / ( FNGLN + FNGPL )
302          CON2 = 1. - CON1
303          SIGA = CON1 * SIGALN + CON2 * SIGAPL
304          SIGS = CON1 * SIGSLN + CON2 * SIGSPL
305          SIGE = CON1 * SIGELN + CON2 * SIGEPL
306          SIGR = CON1 * SIGRLN + CON2 * SIGBPL
307      C
308      C      COMPUTE NORMALIZED SCATTERING PATTERN FOR POSITIVE NSIZE
309          IF( NSIZE .LE. 0 ) GO TO 155
310          CON1 = CON1 * SIGSLN / SIGS
311          CON2 = 1. - CON1
312          DO 150 I = 1, 21
313              SPN( I ) = CON1 * SPNLN( I ) + CON2 * SPNPL( I )
314      150 CONTINUE
315      C
316      C
317      C      COMPUTE NUMBER OF PARTICLES PER GRAM OF MATERIAL IN THE GROUP
318      155 PNG = 6. / ( PI * RHO * D3AV )
319      C
320      C      COMPUTE MASS COEFFICIENTS
321      156 CMJA = PNG * SIGA
322          CMUS = PNG * SIGS
323          CMUE = PNG * SIGE
324          CMUB = PNG * SIGB
325      C
326      C
327      C      THE CALCULATION FOR THIS SIZE GROUP ARE COMPLETE
328      C
329      C      RETURN
330      C
331      C      END

```

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1      SUBROUTINE CROSS( MSIZE, MSPHER, DLOW, DHIGH, DIM, D2S, P, WL, XR,
2      1, XI, SIGA, SIGS, SIGE, SIGB, SPN )
3      C
4      C
5      C THIS ROUTINE CALCULATES THE AVERAGE ABSORPTION, SCATTERING,
6      C EXTINCTION AND BACKSCATTER CROSS SECTIONS PER PARTICLE AND THE
7      C NORMALIZED SCATTERING PATTERN FOR PARTICLES WITH DIAMETERS IN THE
8      C SIZE INTERVAL DLOW TO DHIGH. THESE PARTICLES ARE A SUBSET OF A
9      C COLLECTION OF PARTICLES WHOSE SIZES HAVE A LOG NORMAL OR A POWER
10     C LAW PROBABILITY DISTRIBUTION. THE PARTICLES CAN BE SPHERICAL OR
11     C NONSPHERICAL
12     C
13     C      INPUTS
14     C MSIZE = 1 THE PARTICLES HAVE A LOG NORMAL SIZE DISTRIBUTION,
15     C          COMPUTE CROSS SECTIONS AND SCATTERING PATTERN
16     C          = -1 THE PARTICLES HAVE A LOG NORMAL SIZE DISTRIBUTION,
17     C          COMPUTE CROSS SECTIONS
18     C          = 2 THE PARTICLES HAVE A POWER LAW SIZE DISTRIBUTION,
19     C          COMPUTE CROSS SECTIONS AND SCATTERING PATTERN
20     C          = -2 THE PARTICLES HAVE A POWER LAW SIZE DISTRIBUTION,
21     C          COMPUTE CROSS SECTIONS
22     C MSPHER = 1 THE PARTICLES ARE SPHERICAL, USE STANDARD MIE THEORY
23     C          = 2 THE PARTICLES ARE NONSPHERICAL, USE MODIFIED MIE
24     C          THEORY
25     C DLOW  = LOWER LIMIT OF PARTICLE DIAMETER RANGE (L, WHERE L IS A
26     C          LENGTH UNIT SUCH AS MICRONS, CENTIMETERS, METERS, ETC. )
27     C DHIGH = UPPER LIMIT OF PARTICLE DIAMETER RANGE (L)
28     C DIM   = MEAN DIAMETER PARAMETER FOR THE LOG NORMAL DISTRIBUTION
29     C          (L)
30     C          = MINIMUM DIAMETER OF POWER LAW DISTRIBUTION (L)
31     C D2S   = STANDARD DEVIATION PARAMETER OF THE LOG NORMAL
32     C          DISTRIBUTION
33     C          = MAXIMUM DIAMETER OF THE POWER LAW DISTRIBUTION (L)
34     C F     = POWER LAW EXPONENT OF THE POWER LAW DISTRIBUTION
35     C WL    = WAVELENGTH OF THE INCIDENT RADIATION (L)
36     C XR    = REAL PART OF THE COMPLEX INDEX OF REFRACTION OF THE
37     C          PARTICLES
38     C XI    = IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION OF THE
39     C          PARTICLES ( THE INDEX IS  $n = XR - iXI$  SO THAT BOTH XR
40     C          AND XI ARE POSITIVE )
41     C
42     C      OUTPUTS
43     C SIGA  = AVERAGE ABSORPTION CROSS SECTION PER PARTICLE (  $L^2$  )
44     C SIGS  = AVERAGE SCATTERING CROSS SECTION PER PARTICLE (  $L^2$  )
45     C SIGE  = AVERAGE EXTINCTION CROSS SECTION PER PARTICLE (  $L^2$  )
46     C SIGB  = AVERAGE BACKSCATTER CROSS SECTION PER PARTICLE (  $L^2$  )
47     C SPN   = NORMALIZED SCATTERING PATTERN FOR THE PARTICLES IN THE
48     C          GIVEN SIZE RANGE DLOW TO DHIGH. SPN(J) = SCATTERING
49     C          FUNCTION AT THE SCATTERING ANGLE WHOSE COSINE IS
50     C           $0.1*(J-1)$ , SPN IS NORMALIZED SO THAT THE INTEGRAL OF
51     C          SPN OVER  $4\pi$  STERADIANs EQUALS  $4\pi$  ( IE, AN ISOTROPIC
52     C          SCATTERING PATTERN HAS SPN(J) = 1.0 FOR ALL J )
53     C
54     C      NOTES
55     C THE UNITS TO BE USED FOR L ( LENGTH ) ARE THE USERS CHOICE, BUT ALL
56     C DISTANCE INPUTS - DLOW, DHIGH, DIM, D2S( FOR POWER LAW ), WL -
57     C MUST BE IN THE SAME UNITS. THE CROSS SECTION OUTPUTS - SIGA, SIGS,
58     C SIGE, SIGB - ARE THEN IN UNITS OF  $L^2$ 

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59 C THE OUTPUTS CALCULATED BY THIS ROUTINE ARE
60 C CROSS SECTIONS - ONE DIVIDED BY FN TIMES THE INTEGRAL OVER
61 C PARTICLE DIAMETER FROM DLOW TO DHIGH OF PROBABILITY
62 C DISTRIBUTION TIMES CROSS SECTIONAL AREA ( PI * DIAMETER / 4 )
63 C TIMES MIE EFFICIENCY, FN IS THE FRACTION OF THE TOTAL NUMBER
64 C OF PARTICLES THAT ARE WITHIN THE SIZE RANGE DLOW TO DHIGH
65 C SPN = NORMALIZED SCATTERING PATTERN FOR THE PARTICLES WITH
66 C DIAMETERS BETWEEN DLOW AND DHIGH, EVALUATED AT 21 POINTS,
67 C WHERE THE COSINE OF THE SCATTERING ANGLE VARIES FROM -1 TO
68 C +1 BY 0.1 INCREMENTS, EQUATION IS ONE OVER THE SCATTERING
69 C CROSS SECTION TIMES THE INTEGRAL OVER PARTICLE DIAMETER FROM
70 C DLOW TO DHIGH OF NORMALIZED SCATTERING PATTERN AT PARTICLE
71 C DIAMETER TIMES PROBABILITY DISTRIBUTION TIMES AREA( PI *
72 C DIAMETER**2 / 4 ) TIMES MIE SCATTERING EFFICIENCY
73 C THE PROBABILITY DISTRIBUTIONS ARE
74 C LOG NORMAL = EXP( -0.5*(LN(D/DH)/LN(S))**2 )/( SQRT(2*PI)*D*LN(S))
75 C WHERE D = PARTICLE DIAMETER ( L )
76 C DH = DIM, MEAN PARTICLE DIAMETER PARAMETER ( L )
77 C S = D2S, STANDARD DEVIATION PARAMETER
78 C POWER LAW = (P-1)*D**(-P)/(DM*LN*(1-P)-DMAX*(1-P))
79 C WHERE DMIN = DIM, MINIMUM PARTICLE DIAMETER OF
80 C DISTRIBUTION
81 C DMAX = D2S, MAXIMUM PARTICLE DIAMETER OF
82 C DISTRIBUTION
83 C IF FOR THE LOG NORMAL DISTRIBUTION DLOW = 0 AND DHIGH IS
84 C ESSENTIALLY INFINITE( LN(DHIGH/DIM) .GT. 20*LN(D2S) ) THE WHOLE
85 C RANGE OF THE DISTRIBUTION IS COVERED AND THE OUTPUTS ARE FOR ALL
86 C THE PARTICLES IN THE DISTRIBUTION, SIMILARLY IF DLOW = DIM AND
87 C DHIGH = D2S, THEN THE WHOLE POWER LAW DISTRIBUTION IS INCLUDED
88 C
89 C
90 C DIMENSION SPN(21), SP(21), SP1(21), SPL(21), SPU(21), SPI(21)
91 C
92 C SET VALUES OF PI, 2*PI, SQRT(2*PI), AND SQRT(2)
93 C DATA PI / 3.14159265 /, FOURPI / 12.5663706 /, SQ2PI / 2.50662827/
94 C 1 , SQ2 / 1.41421356 /
95 C
96 C INITIALIZATION = ZERO OUT VARIABLES
97 C SIGS = 0.
98 C SIGE = 0.
99 C SIGR = 0.
100 C DSIGEL = 0
101 C DD 2 IP = 1, 21
102 C SPN( IP ) = 0.
103 C 2 CONTINUE
104 C SET NUMBER OF STEPS INDICATOR
105 C NSTEP = 0
106 C SET MIE DIMENSIONLESS SIZE PARAMETER INDICATOR
107 C LIMITA = 0
108 C
109 C CHECK WHICH DISTRIBUTION IS TO BE USED - LOG NORMAL OR POWER LAW
110 C IF( IABS( MSIZE ) .EQ. 2 ) GO TO 6
111 C
112 C
113 C DISTRIBUTION IS LOG NORMAL
114 C SET MEAN VALUE AND STANDARD DEVIATION PARAMETERS
115 C DM = DIM

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116      S = D28
117      ALNS = ALOG( S )
118      C
119      C CALCULATE DIAMETER AT PEAK OF PROBABILITY DISTRIBUTION
120      DPEAK = DM * EXP( -ALNS**2 )
121      C
122      C
123      C CALCULATE FN, THE FRACTION OF THE TOTAL NUMBER OF PARTICLES THAT
124      C ARE IN THE GIVEN SIZE RANGE ( NUMBER OF PARTICLES WITH DIAMETERS
125      C BETWEEN DLOW AND DHIGH DIVIDED BY TOTAL NUMBER OF PARTICLES IN THE
126      C DISTRIBUTION )
127      FN1 = 0.
128      E1 = -1.
129      IF( DLOW .LE. 0. ) GO TO 3
130      E1 = ALOG( DLOW / DM ) / ALNS
131      FN1 = CUMNOR( E1 )
132      3 E2 = ALOG( DHIGH / DM ) / ALNS
133      FN2 = CUMNOR( E2 )
134      IF( E1 * E2 .LT. 0. ) GO TO 4
135      FN = FN1 - FN2
136      IF( E2 .LT. 0. ) FN = -FN
137      GO TO 5
138      4 FN = 1. - FN1 - FN2
139      C
140      C
141      C SET CONSTANT FACTOR IN LOG NORMAL PROBABILITY EQUATION
142      5 CONLN = 1. / ( SQ2PI * ALNS * FN )
143      C INTEGRATION STRATEGY
144      C IF DPEAK IS WITHIN INTEGRATION RANGE DLOW - DHIGH, START AT DPEAK
145      C AND INTEGRATE FORWARD TO DHIGH, THEN RETURN TO DPEAK AND
146      C INTEGRATE BACKWARDS TO DLOW. OTHERWISE IF DPEAK IS LESS THAN DLOW
147      C START AT DLOW AND INTEGRATE FORWARDS TO DHIGH, IF DPEAK IS GREATER
148      C THAN DHIGH, START AT DHIGH AND INTEGRATE BACKWARDS TO DLOW
149      DSTART = -1.
150      IF( DPEAK .GT. DHIGH ) GO TO 100
151      DSTART = DPEAK
152      IF( DPEAK .LE. DLOW ) DSTART = DLOW
153      GO TO 7
154      C
155      C
156      C DISTRIBUTION IS POWER LAW
157      C SET MINIMUM AND MAXIMUM DIAMETERS
158      6 DMIN = D14
159      DMAX = D28
160      C
161      C CALCULATE FN FOR POWER LAW DISTRIBUTION
162      OMP = 1. - P
163      FN = ( DLOW**OMP - DHIGH**OMP ) / ( DMIN**OMP - DMAX**OMP )
164      C
165      C SET CONSTANT FACTOR IN POWER LAW PROBABILITY EQUATION
166      CONPL = -OMP / ( ( DMIN**OMP - DMAX**OMP ) * FN )
167      C
168      C INTEGRATION STRATEGY
169      C START AT DLOW, INTEGRATE FORWARD TO DHIGH
170      DSTART = DLOW
171      C
172      C
173      C THIS IS THE FORWARD INTEGRATION SECTION

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174 C
175 C SET THE INITIAL INTEGRATION STEP SIZE AND STARTING DIAMETER
176 C 7 D = DSTART
177 C DELTA = 0.2 * DSTART
178 C
179 C THIS IS THE FORWARD INTEGRATION LOOP
180 C INCREMENT NUMBER OF INTEGRATION STEPS
181 C 10 NSTEP = NSTEP + 1
182 C
183 C CALCULATE THE DIMENSIONLESS MIE PARAMETER FOR THE CURRENT DIAMETER
184 C A = AMINI( PI * D / ML, 100. )
185 C
186 C IN THIS VERSION WE LIMIT THE MIE SIZE PARAMETER TO BE EQUAL TO 100
187 C OR LESS. THIS LIMIT IS IMPOSED TO CONSERVE COMPUTER RUNNING TIME.
188 C THERE WILL BE NO LOSS OF ACCURACY ON CROSS SECTION CALCULATIONS.
189 C THERE MAY BE SOME ACCURACY LOSS IN THE SCATTERING PATTERN FOR A
190 C DISTRIBUTION OF EXTREMELY LARGE SIZE PARTICLES
191 C
192 C CALCULATE MIE PARAMETERS
193 C IF MIE SIZE LIMIT HAS BEEN REACHED LAST TIME, USE PREVIOUSLY COMPUTED
194 C VALUES
195 C IF( LIMITA .EQ. 1 ) GO TO 11
196 C CALL MIE( MSIZE, MSPHER, A, XR, XI, QSCA, QEXT, QB, SPU )
197 C
198 C CHECK IF MIE SIZE PARAMETER LIMIT HAS BEEN REACHED
199 C IF( A .EQ. 100. ) LIMITA = 1
200 C
201 C EVALUATE INTEGRANDS AND NORMALIZED SCATTERING PATTERN( FOR
202 C POSITIVE MSIZE ) AT CURRENT D VALUE
203 C 11 AREA = PI * D**2 / 4.
204 C IF( IARS( MSIZE ) .EQ. 2 ) GO TO 12
205 C PROB = CONLN * EXP( -0.5 * ( ALOG( D / DM ) / ALNS )**2 ) / D
206 C GO TO 13
207 C 12 PROB = CONPL / D**P
208 C 13 CNST = PROR * AREA
209 C XINTS = CNST * QSCA
210 C XINTE = CNST * QEXT
211 C XINTR = CNST * QB
212 C IF( MSIZE .LE. 0 ) GO TO 15
213 C CONS = 4. / ( A**2 * QSCA )
214 C DO 14 IP = 1, 21
215 C SP( IP ) = CONS * SPU ( IP )
216 C 14 CONTINUE
217 C
218 C CHECK IF THIS IS THE FIRST EVALUATION POINT
219 C 15 IF( NSTEP .GT. 1 ) GO TO 17
220 C
221 C SAVE INTEGRAND VALUES FROM DSTART FOR BACKWARDS INTEGRATION
222 C XINTS1 = XINTS
223 C XINTE1 = XINTE
224 C XINTR1 = XINTR
225 C IF( MSIZE .LE. 0 ) GO TO 55
226 C DO 16 IP = 1, 21
227 C SP1( IP ) = SP( IP )
228 C 16 CONTINUE
229 C GO TO 55
230 C
231 C USE POWER LAW INTEGRATION BETWEEN THIS POINT AND PREVIOUS POINT

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232 C COMPUTE EXPONENT OF POWER LAW
233 17 ALDDL = ALOG( D / DL )
234 EXS = ALOG( XINTS / XINTSL ) / ALDDL
235 EXE = ALOG( XINTE / XINTEL ) / ALDDL
236 EXR = ALOG( XINTB / XINTRL ) / ALDDL
237
238 C
239 IF( ABS( EXS + 1. ) .LE. 1.E-3 ) GO TO 18
240 DSIGS = XINTSL * DL * ( ( D / DL ) ** ( EXS + 1. ) - 1. ) / ( EXS + 1. )
241 GO TO 20
242 18 DSIGS = XINTSL * DL * ALDDL
243 20 IF( ABS( EXE + 1. ) .LE. 1.E-3 ) GO TO 25
244 DSIGE = XINTEL * DL * ( ( D / DL ) ** ( EXE + 1. ) - 1. ) / ( EXE + 1. )
245 GO TO 21
246 21 DSIGE = XINTEL * DL * ALDDL
247 25 IF( ABS( EXR + 1. ) .LE. 1.E-3 ) GO TO 35
248 DSIGR = XINTRL * DL * ( ( D / DL ) ** ( EXR + 1. ) - 1. ) / ( EXR + 1. )
249 GO TO 22
250 22 DSIGR = XINTRL * DL * ALDDL
251
252 35 DSIGR = XINTRL * DL * ALDDL
253
254 C
255 C ADD CONTRIBUTION FROM THIS INCREMENT TO TOTAL
256 40 SIGS = SIGS + DSIGS
257 SIGE = SIGE + DSIGE
258 SIGB = SIGB + DSIGB
259 IF( NSIZE .LE. 0. ) GO TO 45
260 CON2 = DSIGS / SIGS
261 CON1 = 1. - CON2
262 DO 43 IP = 1, 21
263 EXSP = ALOG( XINTS * SP( IP ) / ( XINTSL * SPL( IP ) ) ) / ALDDL
264 IF( ABS( EXSP + 1. ) .LE. 1.E-3 ) GO TO 41
265 SPT( IP ) = XINTSL * SPL( IP ) * DL * ( ( D / DL ) ** ( EXSP + 1. ) - 1. ) / ( ( EXSP + 1. ) * DSIGS )
266 GO TO 42
267 41 SPT( IP ) = XINTSL * SPL( IP ) * DL * ALDDL / DSIGS
268 42 SPN( IP ) = CON1 * SPN( IP ) + CON2 * SPT( IP )
269 43 CONTINUE
270
271 C
272 C CHECK IF THE INTEGRAL PARTIAL SUMS HAVE ALREADY CONVERGED TO FINAL
273 C VALUES ( IE, IF ALL SENSIBLE CONTRIBUTIONS TO THE INTEGRALS HAVE
274 C ALREADY BEEN INCLUDED ) CRITERION IS THAT THE LAST CONTRIBUTION TO
275 C THE EXTINCTION CROSS SECTION IS LESS THAN 10**4 OF THE TOTAL
276 C COMPUTED THUS FAR
277 45 IF( DSIGE / SIGE .LT. 1.E-4 ) GO TO 100
278
279 C
280 C CONVERGENCE HAS NOT YET BEEN REACHED, DO NEXT INCREMENT
281 C SAVE INTEGRAND VALUES AND DIAMETER FROM THIS STEP
282 55 XINTSL = XINTS
283 XINTEL = XINTE
284 XINTRL = XINTB
285 DL = D
286 IF( NSIZE .LE. 0 ) GO TO 61
287 DO 60 IP = 1, 21
288 SPL( IP ) = SP( IP )
289 60 CONTINUE
290 61 IF( NSTEP .LE. 1 ) GO TO 65

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```

290 C COMPUTE STEP SIZE FOR NEXT INCREMENT
291 DELTA = D * AMAX1( 0.2, EXP( 1. / AMAX1( ABS( EXE ), 1. ) ) - 1. )
292 RATIO = DSIGEL / DSIGE
293 IF( RATIO .GT. 1. ) DELTA = DELTA * RATIO
294 C
295 C SAVE DSIGE VALUE
296 DSIGEL = DSIGE
297 C
298 C CHECK IF FORWARD INTEGRATION LIMIT HAS BEEN REACHED
299 IF( D .GE. DHIGH ) GO TO 100
300 C
301 C LIMIT HAS NOT YET BEEN REACHED, INCREMENT D FOR NEXT STEP
302 65 D = D + DELTA
303 IF( D .GT. DHIGH ) D = DHIGH
304 C DO NEXT STEP
305 GO TO 10
306 C
307 C
308 C THIS IS THE BACKWARDS INTEGRATION SECTION FOR THE LOG NORMAL
309 C DISTRIBUTION .
310 C
311 C CHECK IF THE FORWARD INTEGRATION INCLUDED WHOLE INTEGRATION RANGE
312 100 IF( DSTART .EQ. DLOW ) GO TO 200
313 C
314 C RESET INTEGRATION STEP COUNTER AND DSIGEL VALUE
315 NSTEP = 0
316 DSIGEL = 0.
317 C
318 C IF FORWARD INTEGRATION BEGAN AT PROBABILITY PEAK, USE SAVED VALUES
319 C FOR STARTING POINT, OTHERWISE CALCULATE STARTING VALUES
320 IF( DSTART .EQ. DPEAK ) GO TO 105
321 DSTART = DHIGH
322 D = DSTART
323 DELTA = -0.2 * DSTART
324 GO TO 115
325 105 XINTSL = XINTS1
326 XINTEL = XINTE1
327 XINTBL = XINTB1
328 D = DSTART
329 DL = DSTART
330 DELTA = -0.2 * DSTART
331 NSTEP = 1
332 IF( MSIZE .LE. 0 ) GO TO 165
333 DO 110 IP = 1, 21
334 SPL( IP ) = SPI( IP )
335 110 CONTINUE
336 GO TO 165
337 C
338 C
339 C
340 C THIS IS THE BACKWARDS INTEGRATION LOOP
341 C
342 115 NSTEP = NSTEP + 1
343 C
344 C CALCULATE THE DIMENSIONLESS MVE PARAMETER FOR THE CURRENT DIAMETER
345 A = AMIN1( PI * D / WL, 100. )
346 C
347 C CALCULATE MIF PARAMETERS

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346 C IF MIE SIZE LIMIT WAS REACHED LAST TIME, USE PREVIOUSLY COMPUTED
349 C VALUES
350 IF( LIMITA .EQ. 1 .AND. A .GE. 100. ) GO TO 117
351 C
352 CALL MIE( MSIZE, MSPHER, A, XR, XI, QSCA, QEXT, QB, SPU )
353 C
354 C CHECK IF MIE SIZE PARAMETER LIMIT HAS BEEN REACHED
355 IF( A .EQ. 100. ) LIMITA = 1
356 C
357 C EVALUATE INTEGRANDS AND NORMALIZED SCATTERING PATTERN( FOR
358 C POSITIVE MSIZE ) AT CURRENT D VALUE
359 117 AREA = PI * D**2 / 4.
360 PROB = CONLN * EXP( -0.5 * ( ALOG( D / DH ) / ALNS )**2 ) / D
361 CNST = PROB * APEA
362 XINTS = CNST * QSCA
363 XINTE = CNST * QEXT
364 XINTR = CNST * QB
365 IF( MSIZE .LE. 0 ) GO TO 119
366 CONS = 4. / ( A**2 * QSCA )
367 DO 118 IP = 1, 21
368 SP( IP ) = CONS * SPU ( IP )
369 118 CONTINUE
370 C
371 C CHECK IF THIS IS THE FIRST EVALUATION POINT
372 119 IF( NSTEP .LF. 1 ) GO TO 155
373 C
374 C USE POWER LAW INTEGRATION BETWEEN THIS POINT AND PREVIOUS POINT
375 C COMPUTE EXPONENT OF POWER LAW
376 ALDDL = ALOG( DL / D )
377 EXS = ALOG( XINTSL / XINTS ) / ALDDL
378 EXE = ALOG( XINTEL / XINTE ) / ALDDL
379 EXB = ALOG( XINTRL / XINTR ) / ALDDL
380 C
381 IF( ABS( EXS + 1. ) .LE. 1.E-3 ) GO TO 120
382 DSIGS = XINTS * D * ( ( DL / D )**( EXS + 1. ) - 1. ) / ( EXS + 1.
383 1)
384 GO TO 125
385 120 DSIGS = XINTS * D * ALDDL
386 125 IF( ABS( EXE + 1. ) .LE. 1.E-3 ) GO TO 130
387 DSIGE = XINTE * D * ( ( DL / D )**( EXE + 1. ) - 1. ) / ( EXE + 1.
388 1)
389 GO TO 135
390 130 DSIGE = XINTE * D * ALDDL
391 135 IF( ABS( EXB + 1. ) .LE. 1.E-3 ) GO TO 140
392 DSIGB = XINTR * D * ( ( DL / D )**( EXB + 1. ) - 1. ) / ( EXB + 1.
393 1)
394 GO TO 145
395 140 DSIGB = XINTR * D * ALDDL
396 C
397 C ADD CONTRIBUTION FROM THIS INCREMENT TO TOTAL
398 145 SIGS = SIGS + DSIGS
399 SIGE = SIGE + DSIGE
400 SIGB = SIGB + DSIGB
401 IF( MSIZE .LE. 0. ) GO TO 150
402 CON2 = DSIGS / SIGS
403 CON1 = 1. - CON2
404 DO 148 IP = 1, 21
405 EXSP = ALUG( XINTSL * SP( IP ) / ( XINTS * SP( IP ) ) ) / ALDDL

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406      IF( ABS( EXSP + 1. ) .LE. 1.E-3 ) GO TO 146
407      SPI( IP ) = XINTS * SP( IP ) * D * ( ( DL / D ) ** ( EXSP + 1. )
408      1 - 1. ) / ( ( EXSP + 1. ) * DSIGS )
409      GO TO 147
410      146 SPI( IP ) = XINTS * SP( IP ) * D * ALDDL / DSIGS
411      147 SPN( IP ) = CON1 * SPN( IP ) + CON2 * SPI( IP )
412      148 CONTINUE
413      C
414      C CHECK IF CONVERGENCE HAS BEEN REACHED. CRITERION IS THAT THE LAST
415      C CONTRIBUTION TO THE EXTINCTION CROSS SECTION IS LESS THAN 10**4
416      C OF THE TOTAL
417      C 150 IF( DSIGE / SIGE .LT. 1.E-4 ) GO TO 200
418      C
419      C CONVERGENCE HAS NOT YET BEEN REACHED, DO NEXT INCREMENT
420      C SAVE INTEGRAND VALUES AND DIAMETER FROM THIS STEP
421      155 XINT9L = XINTS
422      XINT9L = XINTE
423      XINT9L = XINTB
424      DL = D
425      IF( NSTE .LE. 0 ) GO TO 161
426      DO 160 IP = 1, 21
427      SPL( IP ) = SP( IP )
428      160 CONTINUE
429      161 IF( NSTEP .LE. 1 ) GO TO 165
430      C
431      C COMPUTE STEP SIZE FOR NEXT INCREMENT
432      DELTA = -D * AMAX1( 0.2, 1. - EXP( -1. / AMAX1( ABS( EXE ), 1. ) )
433      1)
434      RATIO = DSIGEL / DSIGE
435      IF( RATIO .GT. 1. ) DELTA = AMAX1( -0.9 * D, DELTA * RATIO )
436      C
437      C SAVE DSIGE VALUE
438      DSIGEL = DSIGE
439      C
440      C CHECK IF BACKWARD INTEGRATION LIMIT HAS BEEN REACHED
441      IF( D .LE. DLOW ) GO TO 200
442      C
443      C LIMIT HAS NOT YET BEEN REACHED, INCREMENT D FOR NEXT STEP
444      165 D = D + DELTA
445      IF( D .LT. DLOW ) D = DLOW
446      C DO NEXT STEP
447      GO TO 115
448      C
449      C
450      C INTEGRATION COMPLETE, SET VALUE OF SIGA
451      200 SIGA = SIGE - SIGS
452      C
453      RETURN
454      END

```

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1      SUBROUTINE MIE( MSIZE, MSPHER, X, DR, DI, QSCA, QEXT, QBS, S )
2      C
3      C THIS ROUTINE USES MIE THEORY TO CALCULATE THE EFFICIENCIES FOR
4      C SCATTERING AND ABSORPTION AND THE SCATTERING PATTERN FOR A SINGLE
5      C UNIFORM SPHERICAL PARTICLE
6      C
7      C THE METHOD FOR MODIFYING THE MIE CALCULATION FOR NONSPHERICAL
8      C PARTICLES IS THAT OF CHYLEK, GRAMS, AND PINNICK
9      C LIGHT SCATTERING BY IRREGULAR RANDOMLY ORIENTED PARTICLES
10     C SCIENCE, VOL 193, 6 AUGUST 1976, PP 480-482
11     C THE METHOD IS BASED ON THE ASSUMPTION THAT SURFACE WAVES ARE
12     C PRESENT IN SCATTERING BY SPHERICAL PARTICLES, BUT THEY ARE ABSENT
13     C IN SCATTERING BY IRREGULAR PARTICLES
14     C
15     C INPUTS
16     C MSIZE = POSITIVE INTEGER, COMPUTE BOTH CROSS SECTIONS AND
17     C SCATTERING PATTERN
18     C = NEGATIVE INTEGER, COMPUTE CROSS SECTIONS ONLY
19     C MSPHER = 1 THE PARTICLES ARE SPHERICAL, USE STANDARD MIE THEORY
20     C = 2 THE PARTICLES ARE NONSPHERICAL, USE MODIFIED MIE
21     C THEORY
22     C X = NORMALIZED SIZE PARAMETER, WHICH EQUALS TWO PI TIMES
23     C THE RADIUS OF THE SPHERE DIVIDED BY THE WAVELENGTH OF THE
24     C INCIDENT RADIATION
25     C DR = REAL PART OF THE COMPLEX INDEX OF REFRACTION OF THE
26     C SPHERE
27     C DI = IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION OF THE
28     C SPHERE ( NOTE THAT THE COMPLEX INDEX OF REFRACTION IS
29     C ASSUMED TO BE  $M = DR - I*DI$  SO THAT BOTH DR AND DI ARE
30     C POSITIVE )
31     C
32     C OUTPUTS
33     C QSCA = SCATTERING EFFICIENCY, WHICH EQUALS THE SCATTERING CROSS
34     C SECTION OF THE SPHERE DIVIDED BY THE CROSS SECTIONAL AREA
35     C OF THE SPHERE (  $SIGMA/(PI*RADIUS**2)$  )
36     C QEXT = EXTINCTION EFFICIENCY, WHICH EQUALS THE TOTAL
37     C ( SCATTERING + ABSORPTION ) CROSS SECTION OF THE SPHERE
38     C DIVIDED BY THE CROSS SECTIONAL AREA OF THE SPHERE
39     C QBS = BACKSCATTER EFFICIENCY, WHICH EQUALS THE SCATTERING CROSS
40     C SECTION( IN THE BACKWARDS DIRECTION) DIVIDED BY THE CROSS
41     C SECTIONAL AREA OF THE SPHERE(  $SIGMA/(PI*RADIUS**2)$  )
42     C S = SCATTERING PATTERN OF THE RADIATION SCATTERED BY THE
43     C SPHERE, ASSUMING INCIDENT UNPOLARIZED RADIATION, S(J) =
44     C SCATTERING FUNCTION FOR THE SCATTERING ANGLE WHOSE COSINE
45     C IS  $0.1+(J-1)$ , S IS UN-NORMALIZED, THAT IS, THE INTEGRAL
46     C OF S OVER 4 PI STERADIANES EQUALS  $PI*QSCA*X**2$ 
47     C
48     C
49     C DIMENSION S(21), XMU(21), S1(21), S2(21), PP1(21), PP2(21),
50     C 1 PT1(21), PT2(21), PI(21), PP(21)
51     C DIMENSION ANR(200)
52     C COMPLEX D,Z,EH1,EH2,EN,ANF,ANR,ANZ,AN,BN,CBSC
53     C COMPLEX S1, S2
54     C
55     C SET THE VALUES OF THE COSINE OF THE SCATTERING ANGLE AT WHICH THE
56     C SCATTERING PATTERN IS TO BE EVALUATED
57     C DATA XMU / -1., -.9, -.8, -.7, -.6, -.5, -.4, -.3, -.2, -.1, 0.,
58     C 1 .1, .2, .3, .4, .5, .6, .7, .8, .9, 1. /

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```

59      C
60      C
61      C   SET VALUES OF COMPLEX INDEX OF REFRACTION AND MIE VARIABLE
62      D = CMPLX( DR, -DI )
63      Z = X * D
64      C
65      C   SET INITIAL VALUES OF RICCATI-BESSEL FUNCTION
66      EM1 = CMPLX( SIN( X ), COS( X ) )
67      EM2 = CMPLX( COS( X ), -SIN( X ) )
68      C
69      C   ZERO OUT EFFICIENCY VARIABLES AND SCATTERING PATTERN VARIABLES
70      IF( MSIZE .LE. 0 ) GO TO 20
71      DO 10 I = 1, 21
72      S1( I ) = ( 0., 0. )
73      S2( I ) = ( 0., 0. )
74      PP1( I ) = 0.
75      PT1( I ) = 0.
76      PP2( I ) = 0.
77      PT2( I ) = 0.
78      10 CONTINUE
79      20 QSCA = 0.
80      WEXT = 0.
81      WISC = ( 0., 0. )
82      C
83      C   SET UP ARRAY OF ANF VALUES - (USE LENZ BACKWARDS RECURSION
84      C   TECHNIQUE ( SEE COMPLEX FUNCTION ANF )
85      NX = 1.5 * X
86      NX = MAX0( 2, MIN0( NX, 200 ) )
87      ANR( NX ) = ANF( NX, Z )
88      NXM1 = NX - 1
89      DO 30 I = 1, NXM1
90      N = NX + 1 - I
91      CN = FLOAT( N )
92      ANR( N-1 ) = CN / Z - ( 1., 0. ) / ( CN / Z + ANR( N ) )
93      30 CONTINUE
94      C
95      C
96      C   CALCULATE THE EFFICIENCIES AND SCATTERING PATTERN USING THE MIE
97      C   INFINITE SERIES EXPANSION FORMULAS
98      X2 = X ** 2
99      ONE = -1.
100     DO 100 M = 1, 200
101     FN = N
102     ONE = -ONE
103     C1 = 2. * FN - 1.
104     EN = C1 * EM1 / X - EM2
105     IF ( N .LE. NX ) ANZ = ANR( N )
106     IF ( N .GT. NX ) ANZ = ANF( N, Z )
107     CFNOX = FN / X
108     C1 = REAL( EN )
109     C2 = REAL( EM1 )
110     AN = ( ( ANZ / D + CFNOX ) * C1 - C2 ) /
111     ) ( ( ANZ / D + CFNOX ) * EN - EM1 )
112     RN = ( ( D * ANZ + CFNOX ) * C1 - C2 ) /
113     ) ( ( D * ANZ + CFNOX ) * EN - EM1 )
114     C
115     C   CHECK IF PARTICLES ARE SPHERICAL OR NONSPHERICAL

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116      IF( NSPHER .LE. 1 ) GO TO 35
117      C
118      C THE PARTICLES ARE NONSPHERICAL, MODIFY THE VALUES OF AN AND BN IF
119      C THEY ARE NEAR A RESONANCE PEAK ( DUE TO SURFACE WAVES )
120      C MAYBE MODIFICATION ONLY FOR HIGH ORDERS OF THREE AND ABOVE
121      C IF( N .LT. 3 ) GO TO 35
122      C
123      C CHECK IF DIMENSIONLESS SIZE PARAMETER IS BEYOND THE RESONANCE
124      C REGION
125      C IF( X .GT. 1.1 * FN ) GO TO 35
126      C
127      C WE ARE NOT BEYOND THE RESONANCE, LIMIT AN AND BN
128      C IF( REAL( AN ) .GT. 0.5 ) AN = ( 0.5, 0. )
129      C IF( REAL( BN ) .GT. 0.5 ) BN = ( 0.5, 0. )
130      C
131      35 XFACT = 2. * FN + 1.
132      XFACT = ONE * ( FN + 0.5 )
133      QSCA = QSCA + XFACT * ( CABS( AN ) **2 + CABS( BN ) **2 )
134      QEXT = QEXT + XFACT * REAL( AN + BN )
135      QWSC = QWSC + XFACT * ( AN - BN )
136      EM2 = EM1
137      EM1 = EN
138      IF( NSIZE .LE. 0 ) GO TO 80
139      DO 70 J = 1, 2
140      IF ( N .GT. 2 ) GO TO 50
141      IF ( N .EQ. 2 ) GO TO 40
142      PP(I) = 1.
143      PT(I) = XHU(I)
144      G) TO 40
145      40 PP(I) = 2. * XHU(I)
146      PT(I) = 6. * XHU(I) **2 - 3.
147      GO TO 40
148      50 PP(I) = ( ( 2. * FN - 1. ) * XHU(I) * PP1(I) - FN * PP2(I) ) /
149      1 ( FN - 1. )
150      PT(I) = XHU(I) * ( PP1(I) - PP2(I) ) - ( 2. * FN - 1. ) *
151      1 ( 1. - XHU(I) **2 ) * PP1(I) + PT2(I)
152      60 CXFACT = ( 2. * FN + 1. ) / ( FN **2 + FN )
153      C1 = PP(I)
154      C2 = PT(I)
155      S1(I) = S1(I) + CXFACT * ( AN * C1 + BN * C2 )
156      S2(I) = S2(I) + CXFACT * ( BN * C1 + AN * C2 )
157      PP2(I) = PP1(I)
158      PT2(I) = PT1(I)
159      PP1(I) = PP(I)
160      PT1(I) = PT(I)
161      70 CONTINUE
162      80 IF( FN .LT. 1.2 * X .OR. N .EQ. 1 ) GO TO 90
163      C
164      C CHECK IF THE INFINITE SERIES HAS CONVERGED
165      C IF ( ABS( 1. - AMAX1( QEXT, QEXTST ) / AMIN1( QEXT, QEXTST ) )
166      C 1 .LE. 1.E-3 ) GO TO 110
167      C
168      C CONVERGENCE HAS NOT BEEN REACHED, COMPUTE NEXT TERM IN SERIES
169      90 QEXTST = QEXT
170      100 CONTINUE
171      C
172      C SERIES HAS CONVERGED, SET THE CROSS SECTION VALUES
173      110 QEXT = 2. * QEXT / X2

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174      QSCA = 2. * QSCA / X2
175      QRS = 4. * ( CABS( QRSC ) ** 2 ) / X2
176      C
177      C   FOR POSITIVE MSIZE, SET THE VALUES OF THE UNPOLARIZED SCATTERING
178      C   PATTERN
179      IF( MSIZE .LE. 0 ) RETURN
180      DO 120 I = 1, 21
181      S(I) = 0.5 * ( CABS( S1(I) ) **2 + CABS( S2(I) ) **2 )
182      120 CONTINUE
183      C
184      RETURN
185      END

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1      COMPLEX FUNCTION ANF( INDEX, Z )
2      C
3      C THIS ROUTINE IS CALLED BY MIE
4      C THIS IS A WOF ROUTINE - DOCUMENTED IN REPORT GE77TMP-22
5      C
6      C THIS FUNCTION EVALUATES THE COMPLEX QUANTITY A(N,Z) WHICH IS USED
7      C IN THE MIE FORMULAS, WHERE
8      C  $A(N,Z) = -N/Z + J(N-1/2,Z)/J(N+1/2,Z)$ 
9      C Z = M*ALPHA
10     C M = M(REAL)-I*M(IMAGINARY) = COMPLEX INDEX OF REFRACTION
11     C ALPHA = 2*PI*R/WAVELENGTH = NORMALIZED SIZE PARAMETER
12     C R = RADIUS OF SPHERE
13     C N = ORDER OF THE FUNCTION
14     C J = BESSEL FUNCTION OF COMPLEX ARGUMENT AND HALF-INTEGER
15     C ORDER
16     C
17     C THE METHOD OF EVALUATION USES THE CONTINUED FRACTION ALGORITHM OF
18     C WILLIAM J LENTZ - GENERATING BESSEL FUNCTIONS IN MIE SCATTERING
19     C CALCULATIONS USING CONTINUED FRACTIONS
20     C APPLIED OPTICS, VOL. 15, NO. 3, MARCH 1976
21     C
22     C
23     C INPUTS
24     C INDEX = ORDER OF A(N,Z), THAT IS, INDEX = N
25     C Z = COMPLEX ARGUMENT
26     C
27     C OUTPUT
28     C ANF = A(N,Z)
29     C
30     C
31     C COMPLEX Z, N, D, T, PN, PD, T1, T2, E
32     C
33     C DEFINE ARITHMETIC STATEMENT
34     C C( X ) = 2. * S * ( FN - 0.5 + XI )
35     C
36     C SET VALUE OF FIRST PARTIAL FRACTION TERM FOR NUMERATOR (PN)
37     C FN = INDEX
38     C S = -1.
39     C CP = 2. + FN + 1.
40     C PN=CP/Z
41     C
42     C SET VALUE OF FIRST PARTIAL CONVERGENT FOR NUMERATOR (N)
43     C N=PN
44     C
45     C CALCULATE SECOND PARTIAL FRACTION AND CONVERGENT FOR NUMERATOR
46     C CP = -2. * FN - 3.
47     C T=CP/Z
48     C PN=T*(1.+0.)/PN
49     C N=N*PN
50     C
51     C SET VALUE OF FIRST PARTIAL FRACTION (PD) AND CONVERGENT (D) FOR
52     C DENOMINATOR
53     C PD=T
54     C D=PD
55     C
56     C
57     C CALCULATE THE HIGHER ORDERS OF THE PARTIAL FRACTIONS AND
58     C CONVERGENTS

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59      NI=2.
60      DO 30 J = 1 , 100
61      XI=XJ+1.
62      S = -S
63      T = C( X ) / Z
64      PN=T+(1.,0.)/PN
65      PD=T+(1.,0.)/PD
66      C
67      C
68      C   IN THE RARE INSTANCE THAT THE NUMERATOR PARTIAL FRACTION TERM IS
69      C   NEAR ZERO, USE THE LENTZ ALGORITHM IMPROVEMENT METHOD TO INSURE
70      C   ACCURACY
71      C   IF ( CABS( PN ) .GT. 1.E-4 ) GO TO 20
72      S = -S
73      XI = XI + 1.
74      T1 = C( X ) / Z
75      E = T1 * PN + (1.,0.)
76      N = N + E
77      S = -S
78      XI = XI + 1.
79      T2 = C( X ) / Z
80      PN = T2 + PN / E
81      C
82      C   IF THE DENOMINATOR PARTIAL FRACTION TERM IS NEAR ZERO, USE THE
83      C   ALGORITHM IMPROVEMENT METHOD
84      C   IF ( CABS( PD ) .GT. 1.E-4 ) GO TO 10
85      E = T1 * PD + (1.,0.)
86      D = D + E
87      PD = T2 + PD / E
88      GO TO 20
89      C
90      C 10 D = D + PD
91      PD=T1+(1.,0.)/PD
92      D = D + PD
93      PD=T2+(1.,0.)/PD
94      C
95      C
96      C 20 N = N + PN
97      D = D + PD
98      C
99      C   CHECK IF CONVERGENCE HAS BEEN REACHED
100     C   IF ( ABS( CABS( PN ) / CABS( PD ) - 1. ) .LE. 1.E-6 ) GO TO 40
101     C 30 CONTINUE
102     C
103     C
104     C   CONVERGENCE HAS BEEN REACHED, SET VALUE CI ANF
105     C 40 ANF = -FN / Z + N / D
106     C
107     C   RETURN
108     C   END

```

```

1      FUNCTION CUMNOR( X )
2      C
3      C      CUMNOR IS THE CUMULATIVE DISTRIBUTION OF THE NORMAL RANDOM
4      C      PROBABILITY DISTRIBUTION FOR NEGATIVE X AND IS ONE MINUS THE
5      C      CUMULATIVE DISTRIBUTION FOR POSITIVE X
6      C
7      C      THE CUMULATIVE DISTRIBUTION OF THE NORMAL RANDOM VARIABLE IS
8      C      1/SQRT(2*PI) TIMES THE INTEGRAL FROM MINUS INFINITY TO X OF
9      C      EXP(-T**2 / 2 ) DT
10     C
11     C      FOR ABS(X) LESS THAN 5, WE USE THE POLYNOMIAL APPROXIMATION
12     C      FORMULA 26.2.17 IN THE HANDBOOK OF MATHEMATICAL FUNCTIONS BY
13     C      ABRAMOWITZ AND STEGUN, MARCH 1965. FOR ABS(X) GREATER OR EQUAL TO
14     C      5, WE USE THE ASYMPTOTIC APPROXIMATION FORMULA 26.2.24
15     C
16     C      SET POLYNOMIAL CONSTANTS
17     C      DATA B1/ .31938153/, B2/ -.356563782/, B3/ 1.781477937/,
18     C      B4/ -1.821255478/, B5/ 1.330274429/, P/ .2316419/
19     C
20     C      SET VALUE OF SQRT( 2*PI )
21     C      DATA SQ2PI/ 2.50662827/
22     C
23     C
24     C      AX = ABS( X )
25     C      IF( AX .GE. 5. ) GO TO 10
26     C
27     C
28     C      ABS(X) IS LESS THAN 5, USE POLYNOMIAL APPROXIMATION
29     C      T = 1. / ( 1. + P * AX )
30     C      APPROX = EXP( -AX ** 2 / 2. ) * T * ( B1 + T * ( B2 + T * ( B3 + T
31     C      * ( B4 + T * B5 ) ) ) ) / SQ2PI
32     C      GO TO 20
33     C
34     C
35     C      ABS(X) IS GREATER THAN OR EQUAL TO 5, USE ASYMPTOTIC APPROXIMATION
36     C      10 APPROX = 0.
37     C      IF( AX .LT. 13. ) APPROX = ( SQRT( 4. + AX **2 ) - AX ) *
38     C      1      Exp( - AX ** 2 / 2. ) / ( 2. * SQ2PI )
39     C
40     C
41     C      SET VALUE OF CUMNOR
42     C      20 CUMNOR = APPROX
43     C
44     C      RETURN
45     C
46     C      END

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1      SUBROUTINE INITCG
2      C
3      C THIS ROUTINE CALCULATES THE INITIAL PROPERTIES OF THE DUST CLOUDS
4      C FOR EACH BURST
5      C
6      C INPUTS FROM CINPUT COMMON AREAS
7      C M(IM) = EQUIVALENT TNT YIELD OF BURST IM (LBS TNT)
8      C FH(IM) = FRACTION OF YIELD APPEARING AS HYDRODYNAMIC ENERGY
9      C FOR BURST IM
10     C CT(IM) = INITIAL MAIN CLOUD SHAPE FACTOR FOR THE DIRECTION
11     C ALONG THE SHELL TRACK FOR BURST IM
12     C CP(IM) = INITIAL MAIN CLOUD SHAPE FACTOR FOR THE DIRECTION
13     C PERPENDICULAR TO THE SHELL TRACK FOR BURST IM
14     C CV(IM) = INITIAL MAIN CLOUD SHAPE FACTOR FOR THE VERTICAL
15     C DIRECTION
16     C FCM(IM) = FRACTION OF THE APPARENT CRATER MASS OF BURST IM THAT
17     C IS LOFTED INTO THE AIR
18     C ACV(IM) = APPARENT CRATER VOLUME SCALING FACTOR FOR BURST IM
19     C (CUBIC METERS PER (LB TNT)**0.111 )
20     C PHIBOC(IM) = AZIMUTH OF SHELL TRACK OF BURST IM (DEGREES,
21     C MEASURED CLOCKWISE FROM THE Y AXIS)
22     C RHOD = BULK DENSITY OF THE LOFTED DUST GRAINS (GM/CM3)
23     C RHDC = BULK DENSITY OF THE CARBON PARTICLES (GM/CM3)
24     C FH2O = SOIL MOISTURE FRACTION (MASS OF WATER IN SOIL DIVIDED
25     C BY TOTAL MASS OF SOIL INCLUDING WATER)
26     C XLC = CARBON YIELD FRACTION (LB OF CARBON PRODUCED PER LB
27     C OF TNT)
28     C RMAB = RATIO OF THE MASS OF MODE A DUST PARTICLES TO THE
29     C MASS OF MODE B DUST PARTICLES IN THE LOFTED CLOUD
30     C RBASF = RATIO OF THE MASS IN THE BASE CLOUD TO THE MASS IN
31     C THE MAIN CLOUD
32     C ALPHA = AIR ENTRAINMENT FACTOR FOR RISING CLOUD MODEL
33     C CDRAE = DRAG COEFFICIENT FOR RISING CLOUD MODEL
34     C RHOA = AMBIENT AIR DENSITY AT GROUND LEVEL (GM/CM3)
35     C VWIND = MEAN WIND VELOCITY AT REFERENCE ALTITUDE (METERS/S)
36     C ALTM = WIND REFERENCE ALTITUDE (METERS)
37     C PVW = POWER LAW EXPONENT OF VERTICAL PROFILE OF MEAN WIND
38     C VELOCITY
39     C PHINDG = AZIMUTH OF MEAN WIND VELOCITY (MEASURED CLOCKWISE
40     C FROM THE Y AXIS) ( DEGREES)
41     C
42     C OUTPUTS TO CINITG COMMON
43     C RI(IM) = INITIAL RADIUS OF THE EQUIVALENT SPHERICAL CLOUD FOR
44     C BURST NUMBER IM (METERS)
45     C RTI(IM) = DUST CLOUD INITIAL RADIUS IN THE SHELL TRACK DIRECTION
46     C (METERS)
47     C RPI(IM) = DUST CLOUD INITIAL RADIUS IN THE SHELL CROSS TRACK
48     C DIRECTION (METERS)
49     C RVI(IM) = DUST CLOUD INITIAL RADIUS IN THE VERTICAL DIRECTION
50     C (METERS)
51     C XKS(IM) = IDEAL SPHERICAL CLOUD HORIZONTAL DIFFUSION CONSTANT
52     C (METERS2/S)
53     C FR(IM) = IDEAL SPHERICAL CLOUD RISE CONSTANT
54     C XKV(IM) = DUST CLOUD VERTICAL DIFFUSION CONSTANT (METERS2/S)
55     C RTD(IM) = INITIAL RADIUS OF DUST CLOUD IN WIND TRACK DIRECTION
56     C (METERS)
57     C RPD(IM) = INITIAL RADIUS OF DUST CLOUD IN WIND CROSS TRACK
58     C DIRECTION (METERS)

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59 C FMAC = FRACTION OF MAIN CLOUD DUST MASS IN MODE A PARTICLES
60 C FMBC = FRACTION OF MAIN CLOUD DUST MASS IN MODE B PARTICLES
61 C SINPM = SINE OF THE WIND AZIMUTH ANGLE
62 C COSPM = COSINE OF THE WIND AZIMUTH ANGLE
63 C VM10 = WIND VELOCITY AT 10 METERS ALTITUDE (METERS/S)
64 C VM10X = X COMPONENT OF THE WIND VELOCITY AT 10 METERS ALTITUDE
65 C (METERS/S)
66 C VM10Y = Y COMPONENT OF THE WIND VELOCITY AT 10 METERS ALTITUDE
67 C (METERS/S)
68 C VMRVI(IM) = WIND VELOCITY AT THE ALTITUDE OF THE INITIAL VERTICAL
69 C RADIUS OF BURST IM (METERS/S)
70 C VMRVIX(IM) = X COMPONENT OF THE WIND VELOCITY AT THE ALTITUDE OF
71 C THE INITIAL VERTICAL RADIUS OF BURST IM ( METERS/S)
72 C VMRVIY(IM) = Y COMPONENT OF THE WIND VELOCITY AT THE ALTITUDE OF
73 C THE INITIAL VERTICAL RADIUS OF BURST IM ( METERS/S)
74 C TDMAIN(IM) = TIME DELAY BEFORE HORIZONTAL MOTION DUE TO WIND FOR
75 C THE MAIN DUST CLOUD OF BURST IM (SECONDS)
76 C TDBASE(IM) = TIME DELAY BEFORE HORIZONTAL MOTION DUE TO WIND FOR
77 C THE BASE DUST CLOUD OF BURST IM (SECONDS)
78 C TMASSD(IM) = TOTAL INITIAL DUST MASS LOFTED IN MAIN CLOUD OF BURST
79 C IM (GM)
80 C TMASSC(IM) = TOTAL INITIAL CARBON MASS LOFTED IN MAIN CLOUD OF
81 C BURST IM (GM)
82 C
83 COMMON / CINPT1 / W(10), FH(10), CT(10), CP(10), CV(10), XB(10),
84 1 YB(10), ZB(10), DOB(10), FCM(10), ACV(10),
85 2 PHIBDG(10)
86 COMMON / CINPT4 / RH0G, RH0D, RH0C, FH2D, XLC, RMAB, RBASE
87 COMMON / CINPT5 / PSF, ALPHA, CDRAG, RH0A, ELEVG, TAIR, TLAPSE.
88 1 ALTV, VMIND, ALTM, PVM, PHINDG
89 COMMON / CINPT6 / NW, NDG, NRT, NTIME, NPR0E, IPRINT
90 COMMON / CINITG / RI(10), RTI(10), RPI(10), RVI(10), XKS(10),
91 1 FR(10), XKV(10), RTO(10), RPO(10), SIMPW, COSPM,
92 2 VM10, VM10X, VM10Y, VMRVI(10), VMRVIX(10),
93 3 VMRVIY(10), TMASSD(10), TMASSC(10), FMAC, FMBC,
94 4 POWER, TDMAIN(10), TDBASE(10)
95 COMMON / TAPE / ITAPP, JTAPE
96 C
97 DATA THIRD / 0.33333333 /, PAB / 57.295786 /, RH0D / 1.225E-3 /
98 C
99 C COMPUTE FRACTION OF TOTAL DUST LOFTED IN BASE CLOUD
100 FBASE = RBASE / ( 1. + RBASE )
101 C
102 C COMPUTE FRACTIONS OF THE MAIN DUST CLOUD MASS IN MODE A AND MODE B
103 C PARTICLES
104 FMAC = 1. / ( 1. + RMAB )
105 FMBC = 1. - FMAC
106 C
107 C
108 C LOOP OVER THE BURSTS
109 DO 25 IM = 1, NW
110 C
111 C COMPUTE TOTAL DUST MASS LOFTED IN MAIN CLOUD. ( DUST GRAINS ONLY,
112 C NO WATER)
113 TMASSD(IM) = 1.FE * FCM(IM) * ( 1. - FH2D ) * ( 1. - FRASE ) *
114 1 RH0D * ACV(IM) * W(IM) ** 1.111
115 C
116 C COMPUTE TOTAL MASS OF CARBON IN MAIN CLOUD

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117      THASCC(IM) = 453.59 * ( 1. - FRASE ) * W(IM) * XLC
118      C
119      C      CALCULATE INITIAL RADIUS OF EQUIVALENT SPHERICAL CLOUD
120      RI(IM) = 1.54 * ( W(IM) * FH(IM) * RH00 / RHOA ) ** THIRD
121      C
122      C      CALCULATE INITIAL RADII IN THE SHELL TRACK, CROSS TRACK AND THE
123      C      VERTICAL DIRECTIONS FOR THE MUNITION CLOUD
124      RTI(IM) = CT(IM) * RI(IM)
125      RPI(IM) = CP(IM) * RI(IM)
126      RVI(IM) = CV(IM) * RI(IM)
127      C
128      C      CALCULATE IDEAL SPHERICAL CLOUD HORIZONTAL DIFFUSION CONSTANT
129      XKS(IM) = ALPHA * SORT( W(IM) * FH(IM) / ( ALPHA + 0.5 * CDAG ) )
130      C
131      C      CALCULATE IDEAL SPHERICAL CLOUD RISE CONSTANT
132      IF( ALPHA .GT. 1. ) GO TO 10
133      FR(IM) = 5.31 / ALPHA ** 0.857
134      GO TO 20
135      10 FR(IM) = 5.31 / ALPHA ** 0.717
136      C
137      C      CALCULATE MUNITION CLOUD VERTICAL DIFFUSION CONSTANT
138      20 XKV(IM) = 0.8464 * XKS(IM)
139      C
140      C      CALCULATE ANGLE ( IN RADIANS ) BETWEEN SHELL TRACK AND WIND TRACK
141      C      AZIMUTHS
142      ASWRAD = ( PHIBDG(IM) - PHINDG ) / RAD
143      C
144      C      FIND INITIAL RADIUS OF HORIZONTAL ELLIPSE IN WIND TRACK AND CROSS
145      C      TRACK DIRECTIONS
146      RTP = RTI(IM) * RPI(IM)
147      SASWRD = SIN( ASWRAD )
148      CASWRD = COS( ASWRD )
149      RT0(IM) = RTP / SORT( ( RTI(IM) * SASWRD ) ** 2 + ( RPI(IM) *
150      1      CASWRD ) ** 2 )
151      RPO(IM) = RTP / SORT( ( RTI(IM) * CASWRD ) ** 2 + ( RPI(IM) *
152      1      SASWRD ) ** 2 )
153      C
154      25 CONTINUE
155      C
156      C      FIND WIND VELOCITY COMPONENTS IN THE X AND Y DIRECTIONS
157      PHINRD = PHINDG / RAD
158      SINPW = SIN( PHINRD )
159      COSPW = COS( PHINRD )
160      C
161      C      FIND THE WIND VELOCITY AT 10 METERS ALTITUDE
162      VM10 = VWIND * ( 10. / ALTM ) ** PVK
163      C
164      VM10X = VM10 * SINPW
165      VM10Y = VM10 * COSPW
166      C
167      C      FIND THE WIND VELOCITY AT THE ALTITUDE OF THE INITIAL VERTICAL
168      C      RADIUS
169      C      CALCULATE THE TIME DELAYS BEFORE THE WIND BEGINS MOVING THE MAIN
170      C      AND BASE CLOUDS HORIZONTALLY
171      DD 27 IM = 1, NM
172      VNRVI(IM) = VM10 * ( RVI(IM) / ALTM ) ** PVW
173      VNRVIX(IM) = VNRVI(IM) * SINPW
174      VNRVITY(IM) = VNRVI(IM) * COSPW

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175      VRISE = FR(IM) * XKS(IM) / RI(IM)
176      TOMAIN(IM) = 4. * RTO(IM) / SQRT( VM10 ** 2 + VRISE ** 2 )
177      TORASE(IM) = 4. * RTO(IM) / AMAX1( 0.1, VMRVI(IM) )
178 27 CONTINUE
179
180 C
181      WRITE OUT THE INITIAL DATA
182      WRITE(JTAPE, 30) ( ( IM, RI(IM), RTI(IM), RPI(IM), RVI(IM),
183      1      RTO(IM), RPO(IM), FR(IM), XKS(IM), XKV(IM) ),
184      2      IM = 1, NM )
185 30 FORMAT(1H1//, 1H0,
186      183H
187      2 INITIAL DUST CLOUDS / 1H0,
188      412CH EQUIVALENT RADIUS IN RAD. IN RADIUS IN RADIUS
189      5 IN RADIUS IN SPHERICAL SPHERICAL CLOUD DUST CLOUD VER- /
190      61H ,
191      712CHBURST SPHERICAL SHELL TRACK SHELL CROSS VERTICAL WIND T
192      8RACK WIND CROSS CLOUD RISE DIFFUSION COEF- TICAL DIFFUSION /
193      91H ,
194      1129HNUMBER CLOUD RADIUS DIRECTION TRACK DIREC- DIRECTION DIRECT
195      210M TRACK DIREC- CONSTANT FICIENT COEFFICIENT / 1H ,
196      3122H (METERS) (METERS) TION(METERS) (METERS) (METE
197      4RS) TION(METERS) (METERS2/S) (METERS2/S) /
198      5( 13, F11.1, F13.1, F12.1, F12.1, F11.1, F12.1, F13.2, F13.2,
199      6 F17.2 ) )
200 C
201      WRITE(JTAPE, 40)
202 40 FORMAT(1H0/ 1H0,
203      179H
204      285ES LOGGED (GM) / 1H0,
205      3119HBURST
206      4 CLOUD
207      5130HNUMBER DUST-MODE A DUST-MODE B CARBON DUST-MODE A DUST
208      6-MODE B CARBON DUST-MODE A DUST-MODE B CARBON SUN(A+B+
209      7C) )
210      DO 60 IM = 1, NM
211      XMDA = FMAC * (MASSD(IM)
212      XMDG = FMBC * (MASSD(IM)
213      XMC = (THASSC(IM)
214      BMDA = RBASE * XMDA
215      BMDG = RBASE * XMDG
216      BMC = RBASE * XMC
217      TMDA = XMDA + BMDA
218      TMDG = XMDG + BMDG
219      TMC = XMC + BMC
220      TM = TMDA + TMDG + TMC
221      WRITE(JTAPE, 50) IM, XMDA, XMDG, XMC, BMDA, BMDG, BMC, TMDA, TMDG,
222      1      TMC, TM
223 50 FORMAT(1H , 13, 2X, 1P2E13.2, E11.2, 2E13.2, E11.2, 2E13.2, E12.2,
224      1      E11.2 )
225 60 CONTINUE
226 C
227      RETURN
228      END

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1      SUBROUTINE TIMECO( T, IM )
2      C
3      C      THIS ROUTINE CALCULATES THE LOCATION AND CLOUD DIMENSIONS OF THE
4      C      ZERO DIAMETER PARTICLES IN THE MAIN AND BASE CLOUDS OF BURST IM AT
5      C      TIME T
6      C
7      C      INPUTS FROM CALL STATEMENT
8      C      T = TIME AFTER BURST (S)
9      C      IM = BURST NUMBER
10     C
11     C      INPUTS FROM CINPT COMMON AREAS
12     C      ALTIV = ALTITUDE ABOVE GROUND OF INVERSION LAYER (METERS)
13     C      XB(IM) = X COORDINATE OF THE GROUND SURFACE AT BURST IM
14     C              (METERS)
15     C      YB(IM) = Y COORDINATE OF THE GROUND SURFACE AT BURST IM
16     C              (METERS)
17     C      ZB(IM) = Z COORDINATE OF THE GROUND SURFACE AT BURST IM
18     C              (METERS)
19     C      PSF = ATMOSPHERIC PASQUILL STABILITY FACTOR (1 = A, 2 = B,
20     C              3 = C, 4 = D, 5 = E)
21     C
22     C      INPUTS FROM CINTG COMMON
23     C      RI(IM) = INITIAL RADIUS OF THE EQUIVALENT SPHERICAL CLOUD FOR
24     C              BURST NUMBER IM (METERS)
25     C      RTI(IM) = DUST CLOUD INITIAL RADIUS IN THE SHELL TRACK DIRECTION
26     C              (METERS)
27     C      RPI(IM) = DUST CLOUD INITIAL RADIUS IN THE SHELL CROSS TRACK
28     C              DIRECTION (METERS)
29     C      RVI(IM) = DUST CLOUD INITIAL RADIUS IN THE VERTICAL DIRECTION
30     C              (METERS)
31     C      XKS(IM) = IDEAL SPHERICAL CLOUD HORIZONTAL DIFFUSION CONSTANT
32     C              (METERS2/S)
33     C      FR(IM) = IDEAL SPHERICAL CLOUD RISE CONSTANT
34     C      XKV(IM) = DUST CLOUD VERTICAL DIFFUSION CONSTANT (METERS2/S)
35     C      RTO(IM) = INITIAL RADIUS OF DUST CLOUD IN WIND TRACK DIRECTION
36     C              (METERS)
37     C      RPO(IM) = INITIAL RADIUS OF DUST CLOUD IN WIND CROSS TRACK
38     C              DIRECTION (METERS)
39     C      SINPW = SINE OF THE WIND AZIMUTH ANGLE
40     C      COSPW = COSINE OF THE WIND AZIMUTH ANGLE
41     C      VM10 = WIND VELOCITY AT 10 METERS ALTITUDE (METERS/S)
42     C      VM10X = X COMPONENT OF THE WIND VELOCITY AT 10 METERS ALTITUDE
43     C              (METERS/S)
44     C      VM10Y = Y COMPONENT OF THE WIND VELOCITY AT 10 METERS ALTITUDE
45     C              (METERS/S)
46     C      VMRVI(IM) = WIND VELOCITY AT THE ALTITUDE OF THE INITIAL VERTICAL
47     C              RADIUS OF BURST IM (METERS/S)
48     C      VMRVIX(IM) = X COMPONENT OF THE WIND VELOCITY AT THE ALTITUDE OF
49     C              THE INITIAL VERTICAL RADIUS OF BURST IM (METERS/S)
50     C      VMRVIY(IM) = Y COMPONENT OF THE WIND VELOCITY AT THE ALTITUDE OF
51     C              THE INITIAL VERTICAL RADIUS OF BURST IM (METERS/S)
52     C      TDMAIN(IM) = TIME DELAY BEFORE HORIZONTAL MOTION DUE TO WIND FOR
53     C              THE MAIN DUST CLOUD OF BURST IM (SECONDS)
54     C      TDBASE(IM) = TIME DELAY BEFORE HORIZONTAL MOTION DUE TO WIND FOR
55     C              THE BASE DUST CLOUD OF BURST IM (SECONDS)
56     C
57     C      OUTPUTS TO CTIME COMMON
58     C      XCENTO = X COORDINATE OF THE CENTROID FOR ZERO DIAMETER

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59 C PARTICLES IN THE MAIN CLOUD (METERS)
60 C YCENTO = Y COORDINATE OF THE CENTROID FOR ZERO DIAMETER
61 C PARTICLES IN THE MAIN CLOUD (METERS)
62 C ZCENTO = Z COORDINATE OF THE CENTROID FOR ZERO DIAMETER
63 C PARTICLES IN THE MAIN CLOUD (METERS)
64 C BXCNT0 = X COORDINATE OF THE CENTROID FOR ZERO DIAMETER
65 C PARTICLES IN THE BASE CLOUD (METERS)
66 C BYCNT0 = Y COORDINATE OF THE CENTROID FOR ZERO DIAMETER
67 C PARTICLES IN THE BASE CLOUD (METERS)
68 C BZCNT0 = Z COORDINATE OF THE CENTROID FOR ZERO DIAMETER
69 C PARTICLES IN THE BASE CLOUD (METERS)
70 C RS = RADIUS OF THE IDEAL SPHERICAL BUBBLE AT TIME T
71 C (METERS)
72 C HS = ALTITUDE ABOVE GROUND LEVEL OF THE CENTER OF THE
73 C IDEAL SPHERICAL BUBBLE (METERS)
74 C RT = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE MAIN
75 C CLOUD IN THE WIND TRACK DIRECTION (METERS)
76 C RP = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE MAIN
77 C DIRECTION PERPENDICULAR TO THE WIND TRACK DIRECTION
78 C (METERS)
79 C RV = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE MAIN
80 C CLOUD IN THE VERTICAL DIRECTION (METERS)
81 C BRT = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE BASE
82 C CLOUD IN THE WIND TRACK DIRECTION (METERS)
83 C BRP = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE BASE
84 C DIRECTION PERPENDICULAR TO THE WIND TRACK DIRECTION
85 C (METERS)
86 C BRV = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE BASE
87 C CLOUD IN THE VERTICAL DIRECTION (METERS)
88 C
89 COMMON / CINPT1 / M(10), FH(10), CT(10), CP(10), CV(10), XB(10),
90 1 YB(10), ZB(10), OOB(10), FCH(10), ACV(10),
91 2 PHIBDG(10)
92 COMMON / CINPT5 / PRF, ALPHA, CORAG, RHOA, ELEVG, TAIR, TLAPSE,
93 1 ALTIY, VMIND, ALTM, PVW, PHIWDG
94 COMMON / CINITG / RI(10), RTI(10), RPI(10), RVI(10), XKS(10),
95 1 FR(10), XKV(10), RTO(10), RPO(10), SINPW, COSPW,
96 2 VM10, VM10X, VM10Y, VMRVI(10), VMRVI(10),
97 3 VHRVI(10), TMASSD(10), TMASSC(10), FMAC, FMBC,
98 4 POWER, TDMAIN(10), TDBASE(10)
99 COMMON / CTIME / XCENTO, YCENTO, ZCENTO, XCNTC, YCNTC, ZCNTC,
100 1 RTO, RPO, RVC, RTC, RPC, RVC, RS, HS, RT, RP,
101 2 RV, XCENTG, YCENTO, ZCENTO, BXCNTD, BYCNTD,
102 3 BZCNTD, BXCNTC, BYCNTC, BZCNTC, BRTD, BRPD,
103 4 BRVD, BRTC, BRPC, BRVC, BXCNTO, BYCNTO, BZCNTO,
104 5 BRT, BRP, BRV
105 C
106 DIMENSION BSZ(6), BCZ(6), BCXY(6)
107 DATA BSZ / 0.90, 0.85, 0.80, 0.76, 0.73, 0.67 /,
108 1 BCZ / 0.5675, 0.4266, 0.3088, 0.3282, 0.2093, 0.1279 /,
109 2 BCXY / 30., 22.5, 15., 10., 7.5, 5. /, RAD / 57.296 /,
110 3 RHR / 3. /
111 C
112 C MAIN CLOUD
113 C
114 C FIND THE RADIUS AND ALTITUDE OF THE IDEAL SPHERICAL BUBBLE
115 RS = SQRT( 2. * XKS(IP) * T + RI(IM) ** 2 )
116 HS = RVI(IM) + FR(IM) * ( RS - RI(IM) )

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117 C
118 C LIMIT RISE ALTITUDE TO ALTITUDE OF INVERSION LAYER
119 IF( HS .GT. ALTIV ) HS = ALTIV
120 C
121 C FOR THIS TIME AND BURST, FIND THE CENTROID COORDINATES OF THE ZERO
122 C DIAMETER PARTICLES
123 TM = AMAXI( 0., T - TDMAIN(IM) )
124 XCENTO = XB(IM) + VMIOX * TM
125 YCENTO = YB(IM) + VMIOY * TM
126 ZCENTO = ZB(IM) + HS
127 C
128 C FIND THE RADII OF THE ZERO DIAMETER PARTICLES IN THE WIND TRACK,
129 C CROSS TRACK AND VERTICAL DIRECTIONS
130 RT = SQRT( 0. * XKV(IM) * T + RTO(IM) ** 2 )
131 RP = SQRT( 0. * XKV(IM) * T + RPO(IM) ** 2 )
132 RV = SQRT( 2. * XKV(IM) * T + RVI(IM) ** 2 )
133 C
134 C BASE CLOUD
135 TB = AMAXI( 0., T - TDBASE(IM) )
136 BXCNTU = XB(IM) + VMRVIX(IM) * TB
137 BYCNTU = YB(IM) + VMRVIY(IM) * TB
138 BZCNTU = ZB(IM) + RVI(IM)
139 C
140 C INDEX OF PASQUILL STABILITY CATEGORY
141 IPSF = IFIX( PSF )
142 S = BSZ(IPSF)
143 S1 = 1. / S
144 POWER = S / ( 4. * S - 2. )
145 DIST = VMRVI(IM) * T
146 BRT = BHR * RTO(IM) + BCXY(IPSF) * DIST / RAD
147 BRP = BHR * RPO(IM) + BCXY(IPSF) * DIST / RAD
148 BRV = ( RVI(IM) ** S1 + BCZ(IPSF) * DIST ) ** S
149 C
150 RETURN
151 END

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1      SURROUTINE TIMECG( T, IM, IDG )
2      C
3      C THIS ROUTINE CALCULATES THE GEOMETRIC PARAMETERS OF SIZE GROUP IDG
4      C AT TIME T FOR BURST NUMBER IM
5      C
6      C INPUTS FROM CALL STATEMENT
7      C T = TIME AFTER BURST (S)
8      C IM = BURST NUMBER
9      C IDG = NUMBER OF THE SIZE GROUP
10     C
11     C INPUTS FROM CINTP COMMON AREAS
12     C RHDA = AMBIENT AIR DENSITY AT GROUND LEVEL (GM/CM3)
13     C RHOD = BULK DENSITY OF THE LOFTED DUST GRAINS (GM/CM3)
14     C RHOC = BULK DENSITY OF THE CARBON PARTICLES (GM/CM3)
15     C DGROUP(IDG) = MAXIMUM DIAMETER OF THE PARTICLES IN THE IDG SIZE
16     C GROUP (MICRONS)
17     C ZB(IM) = Z COORDINATE OF THE GROUND SURFACE AT BURST IM
18     C (METERS)
19     C
20     C INPUTS FROM CINITG COMMON
21     C RI(IM) = INITIAL RADIUS OF THE EQUIVALENT SPHERICAL CLOUD FOR
22     C BURST NUMBER IM (METERS)
23     C RVI(IM) = DUST CLOUD INITIAL RADIUS IN THE VERTICAL DIRECTION
24     C (METERS)
25     C XKS(IM) = IDEAL SPHERICAL CLOUD HORIZONTAL DIFFUSION CONSTANT
26     C (METERS2/S)
27     C FR(IM) = IDEAL SPHERICAL CLOUD RISE CONSTANT
28     C XKV(IM) = DUST CLOUD VERTICAL DIFFUSION CONSTANT (METERS2/S)
29     C RTO(IM) = INITIAL RADIUS OF DUST CLOUD IN WIND TRACK DIRECTION
30     C (METERS)
31     C RPO(IM) = INITIAL RADIUS OF DUST CLOUD IN WIND CROSS TRACK
32     C DIRECTION (METERS)
33     C SINPW = SINE OF THE WIND AZIMUTH ANGLE
34     C COSPW = COSINE OF THE WIND AZIMUTH ANGLE
35     C VMI0 = WIND VELOCITY AT 10 METERS ALTITUDE (METERS/S)
36     C V-RVI(IM) = WIND VELOCITY AT THE ALTITUDE OF THE INITIAL VERTICAL
37     C RADIUS OF BURST IM (METERS/S)
38     C TDMAIN(IM) = TIME DELAY BEFORE HORIZONTAL MOTION DUE TO WIND FOR
39     C THE MAIN DUST CLOUD OF BURST IM (SECONDS)
40     C TDBASE(IM) = TIME DELAY BEFORE HORIZONTAL MOTION DUE TO WIND FOR
41     C THE BASE DUST CLOUD OF BURST IM (SECONDS)
42     C
43     C INPUTS FROM CTIME COMMON
44     C XCENTO = X COORDINATE OF THE CENTROID FOR ZERO DIAMETER
45     C PARTICLES IN THE MAIN CLOUD (METERS)
46     C YCENTO = Y COORDINATE OF THE CENTROID FOR ZERO DIAMETER
47     C PARTICLES IN THE MAIN CLOUD (METERS)
48     C ZCENTO = Z COORDINATE OF THE CENTROID FOR ZERO DIAMETER
49     C PARTICLES IN THE MAIN CLOUD (METERS)
50     C BXCENTO = X COORDINATE OF THE CENTROID FOR ZERO DIAMETER
51     C PARTICLES IN THE BASE CLOUD (METERS)
52     C BYCENTO = Y COORDINATE OF THE CENTROID FOR ZERO DIAMETER
53     C PARTICLES IN THE BASE CLOUD (METERS)
54     C BZCENTO = Z COORDINATE OF THE CENTROID FOR ZERO DIAMETER
55     C PARTICLES IN THE BASE CLOUD (METERS)
56     C RS = RADIUS OF THE IDEAL SPHERICAL BUBBLE AT TIME T
57     C (METERS)
58     C HS = ALTITUDE ABOVE GROUND LEVEL OF THE CENTER OF THE

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59 C
 60 C
 61 C RT = IDEAL SPHERICAL BUBBLE (METERS)
 62 C = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE MAIN
 63 C CLOUD IN THE WIND TRACK DIRECTION (METERS)
 64 C RP = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE MAIN
 65 C DIRECTION PERPENDICULAR TO THE WIND TRACK DIRECTION
 66 C (METERS)
 67 C RV = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE MAIN
 68 C CLOUD IN THE VERTICAL DIRECTION (METERS)
 69 C BRV = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE BASE
 70 C CLOUD IN THE WIND TRACK DIRECTION (METERS)
 71 C = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE BASE
 72 C DIRECTION PERPENDICULAR TO THE WIND TRACK DIRECTION
 73 C (METERS)
 74 C BRV = RADIUS OF THE ZERO DIAMETER PARTICLES IN THE BASE
 75 C CLOUD IN THE VERTICAL DIRECTION (METERS)
 76 C
 77 C OUTPUTS TO CTIME COMMON
 78 C XCENTO = X COORDINATE OF THE CENTROID FOR DUST PARTICLES (BOTH
 79 C MODE A AND MODE B) FOR THE MAIN CLOUD IN SIZE GROUP
 80 C IDG FOR BURST NUMBER IW AT TIME T (METERS)
 81 C YCENTD = Y COORDINATE OF THE CENTROID FOR DUST PARTICLES IN SIZE
 82 C GROUP IDG FOR BURST IW AT TIME T (METERS)
 83 C ZCENTD = Z COORDINATE OF THE CENTROID FOR DUST PARTICLES IN SIZE
 84 C GROUP IDG FOR BURST IW AT TIME T (METERS)
 85 C XCENTC = X COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
 86 C GROUP IDG FOR BURST IW AT TIME T (METERS)
 87 C YCENTC = Y COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
 88 C GROUP IDG FOR BURST IW AT TIME T (METERS)
 89 C ZCENTC = Z COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
 90 C GROUP IDG FOR BURST IW AT TIME T (METERS)
 91 C RTD = RADIUS IN THE WIND TRACK DIRECTION FOR DUST PARTICLES IN
 92 C THE MAIN CLOUD IN SIZE GROUP IDG FOR BURST IW AT TIME T
 93 C (METERS)
 94 C RPD = RADIUS IN THE DIRECTION PERPENDICULAR TO WIND TRACK
 95 C DIRECTION FOR DUST PARTICLES IN SIZE GROUP IDG FOR BURST
 96 C IW AT TIME T (METERS)
 97 C RVD = RADIUS IN THE VERTICAL DIRECTION FOR DUST PARTICLES IN
 98 C SIZE GROUP IDG FOR BURST IW AT TIME T (METERS)
 99 C RTC = RADIUS IN THE WIND TRACK DIRECTION FOR CARBON PARTICLES
 100 C IN SIZE GROUP IDG FOR BURST IW AT TIME T (METERS)
 101 C RPC = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
 102 C DIRECTION FOR CARBON PARTICLES IN SIZE GROUP IDG FOR
 103 C BURST IW AT TIME T (METERS)
 104 C RVC = RADIUS IN THE VERTICAL DIRECTION FOR CARBON PARTICLES IN
 105 C SIZE GROUP IDG FOR BURST IW AT TIME T (METERS)
 106 C BXCNTD = X COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
 107 C PARTICLES (BOTH MODE A AND MODE B) FOR SIZE GROUP IDG FOR
 108 C BURST NUMBER IW AT TIME T (METERS)
 109 C BYCNTD = Y COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
 110 C PARTICLES FOR SIZE GROUP IDG FOR BURST IW AT TIME T
 111 C (METERS)
 112 C BZCNTD = Z COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
 113 C PARTICLES FOR SIZE GROUP IDG FOR BURST IW AT TIME T
 114 C (METERS)
 115 C BXCNTC = X COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
 116 C PARTICLES FOR SIZE GROUP IDG FOR BURST IW AT TIME T
 (METERS)
 BYCNTC = Y COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON

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117 C          PARTICLES FOR SIZE GROUP IDG FOR BURST IW AT TIME T
118 C          (METERS)
119 C      BZCNTC = Z COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
120 C          PARTICLES FOR SIZE GROUP IDG FOR BURST IW AT TIME T
121 C          (METERS)
122 C      BRTO = RADIUS IN THE WIND TRACK DIRECTION FOR THE BASE CLOUD
123 C          DUST PARTICLES IN SIZE GROUP IDG FOR BURST IW AT TIME T
124 C          (METERS)
125 C      BRPO = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
126 C          DIRECTION FOR THE BASE CLOUD DUST PARTICLES IN SIZE GROUP
127 C          IDG FOR BURST IW AT TIME T (METERS)
128 C      BRVO = RADIUS IN THE VERTICAL DIRECTION FOR THE BASE CLOUD DUST
129 C          PARTICLES IN SIZE GROUP IDG FOR BURST IW AT TIME T
130 C          (METERS)
131 C      BRTOC = RADIUS IN THE WIND TRACK DIRECTION FOR THE BASE CLOUD
132 C          CARBON PARTICLES IN SIZE GROUP IDG FOR BURST IW AT TIME T
133 C          (METERS)
134 C      BRPOC = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
135 C          DIRECTION FOR THE BASE CLOUD CARBON PARTICLES IN SIZE
136 C          GROUP IDG FOR BURST IW AT TIME T (METERS)
137 C      BRVOC = RADIUS IN THE VERTICAL DIRECTION FOR THE BASE CLOUD
138 C          CARBON PARTICLES IN SIZE GROUP IDG FOR BURST IW AT TIME T
139 C          (METERS)
140 C
141 C      COMMON / CINPT1 / W(10), FH(10), CT(10), CF(10), CV(10), XB(10),
142 C          1          YB(10), ZB(10), DGR(10), FCM(10), ACV(10),
143 C          2          PHINDG(10)
144 C      COMMON / CINPT4 / RHOG, RHOD, RHOC, FH20, XLC, RMAB, RBASE
145 C      COMMON / CINPT5 / PCF, ALPHA, CORAG, RHOA, ELEVG, TAIR, TLAPSE,
146 C          1          ALTIV, VWINO, ALTW, PYW, PHINDG
147 C      COMMON / CINPT7 / DGROUP(50), TIME(25)
148 C      COMMON / CINITG / RI(10), RTI(10), RPI(10), RVI(10), XKS(10),
149 C          1          FR(10), XKV(10), RTO(10), RPO(10), SINPW, COSPW,
150 C          2          VW10, VW10X, VW10Y, VHRVI(10), VHRVIX(10),
151 C          3          VHRVIV(10), TMASSD(10), TMASSC(10), FMAC, FMBC,
152 C          4          PGMER, TOMATH(10), TDBASE(10)
153 C      COMMON / CTIME / XCENTD, YCENTD, ZCENTD, XCENTC, YCENTC, ZCENTC,
154 C          1          RTO, RPO, RYD, RTC, RPC, RVC, RS, HS, RT, RP,
155 C          2          RV, XCNTD, YCENTD, ZCENTD, BXCNTD, BYCNTD,
156 C          3          BZCNTD, BXCNTC, BYCNTC, BZCNTC, BRTO, BRPO,
157 C          4          BRVO, BRTOC, BRPOC, BRVOC, BXCNTD, BYCNTD, BZCNTD,
158 C          5          BRT, BRP, BRV
159 C
160 C      FIND INITIAL CLOUD RISE VELOCITY
161 C          VRISE = FR(IW) * XKS(IW) / RI(IW)
162 C
163 C      CALCULATE TERMINAL VELOCITIES FOR DUST AND CARBON PARTICLES
164 C          C3 = 48.87 / ( RHOA * DGROUP(IDG) )
165 C          VTD = 1.E-2 * ( SQRT( C3 ** 2 + 0.2942 * RHOC * DGROUP(IDG) /
166 C          1          RHOA ) - C3 )
167 C          VTC = 1.E-2 * ( SQRT( C3 ** 2 + 0.2942 * RHOC * DGROUP(IDG) /
168 C          1          RHOA ) - C3 )
169 C
170 C      CALCULATE C1 AND C2 CONSTANTS FOR HORIZONTAL CENTROID COORDINATES
171 C          C1D = 1.E6 * RHOA / ( 3. * RHOD * DGROUP(IDG) )
172 C          C1C = 1.E6 * RHOA / ( 3. * RHOC * DGROUP(IDG) )
173 C          C2D = 3.258E5 / ( RHOD * DGROUP(IDG) ** 2 )
174 C          C2C = 3.258E5 / ( RHOC * DGROUP(IDG) ** 2 )

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175 C
176 C MAIN CLOUD CALCULATIONS
177 C
178 C FIND Z COMPONENT OF CENTROID FOR DUST AND CARBON
179 ZCENTD = ZB(IW) + ( ZCENTO - ZB(IW) ) *
180 1 ( 1. - AMI1( 1., VTD / VRISE ) ) - VTD * T
181 ZCENTC = ZB(IW) + ( ZCENTO - ZB(IW) ) *
182 1 ( 1. - AMI1( 1., VTC / VRISE ) ) - VTC * T
183 C
184 C CALCULATE DISTANCE THE SIZE GROUP HAS LAGGED BEHIND THE ZERO
185 C DIAMETER GROUP
186 DLAGD = 0.
187 TH = AMAX1( 0., T - TDMAIN(IW) )
188 IF( TH .LE. 0. ) GO TO 40
189 C4 = C1D * VM10 / C2D
190 IF( C2D * TH .GT. 20. ) GO TO 10
191 DLAGD = ( ALOG( ( 1. + C4 ) * EXP( C2D * TH ) - C4 ) - C2D * TH )
192 1 / C1D
193 GO TO 20
194 10 DLAGD = ALOG( 1. + C4 ) / C1D
195 20 C4 = C1C * VM10 / C2C
196 IF( C2C * TH .GT. 20. ) GO TO 30
197 DLAGC = ( ALOG( ( 1. + C4 ) * EXP( C2C * TH ) - C4 ) - C2C * TH )
198 1 / C1C
199 GO TO 40
200 30 DLAGC = ALOG( 1. + C4 ) / C1C
201 C
202 40 XCEN1D = XCENTO - DLAGD * SINPM
203 YCENTD = YCENTO - DLAGD * COSPM
204 XCEN1C = XCENTO - DLAGC * SINPM
205 YCENTC = YCENTO - DLAGC * COSPM
206 C
207 C CALCULATE EFFECTIVE DIFFUSION COEFFICIENTS FOR THIS SIZE GROUP
208 VH2 = VM10 ** 2 + VRISE ** 2
209 XKVD = XKV(IW) / SQRT( 16. * VTD ** 2 / VH2 + 1. )
210 XKVC = XKV(IW) / SQRT( 16. * VTC ** 2 / VH2 + 1. )
211 C
212 C CALCULATE RADIUS OF SIZE GROUP IN VERTICAL, WIND TRACK AND CROSS
213 C TRACK DIRECTIONS
214 RVD = SQRT( 2. * XKVD * T + RV1(IW) ** 2 )
215 RVC = SQRT( 2. * XKVC * T + RV1(IW) ** 2 )
216 RTD = SQRT( 8. * XKVD * T + RT0(IW) ** 2 )
217 RTC = SQRT( 8. * XKVC * T + RT0(IW) ** 2 )
218 RPD = SQRT( 8. * XKVD * T + RP0(IW) ** 2 )
219 RPC = SQRT( 8. * XKVC * T + RP0(IW) ** 2 )
220 C
221 C BASE CLOUD CALCULATIONS
222 C
223 C CENTROID LOCATIONS
224 C FIND Z COMPONENT OF CENTROID FOR DUST AND CARBON
225 BZCNTD = BZCNTO - VTD * T
226 BZCNTC = BZCNTO - VTC * T
227 C
228 C CALCULATE DISTANCE THE SIZE GROUP HAS LAGGED BEHIND THE ZERO
229 C DIAMETER GROUP
230 C4 = C1D * VM10 / C2D
231 DLAGC = 0.
232 TB = AMAX1( 0., T - TDBASE(IW) )

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233      IF( TB .LE. 0. ) GO TO 80
234      IF( C2D * TB .GT. 20. ) GO TO 50
235      DLAGD = ( ALOG( ( 1. + C4 ) * EXP( C2D * TB ) - C4 ) - C2D * TB )
236      1 / C1D
237      GO TO 60
238      50 DLAGD = ALOG( 1. + C4 ) / C1D
239      60 C4 = C1C * VWRVI(IN) / C2C
240      IF( C2C * TB .GT. 20. ) GO TO 70
241      DLAGC = ( ALOG( ( 1. + C4 ) * EXP( C2C * TB ) - C4 ) - C2C * TB )
242      1 / C1C
243      GO TO 80
244      70 DLAGC = ALOG( 1. + C4 ) / C1C
245      C
246      80 BXCNTD = BXCNTD - DLAGD * SINPM
247      BYCNTD = BYCNTD - DLAGD * COSPM
248      BXCNTC = BXCNTD - DLAGC * SINPM
249      BYCNTC = BYCNTD - DLAGC * COSPM
250      C
251      C
252      RADII OF SIZE GROUP
253      DENOMD = 16. * VTD ** 2 / AMAX1( VWRVI(IN) ** 2, 1. ) + 1.
254      DENOMC = 16. * VTC ** 2 / AMAX1( VWRVI(IN) ** 2, 1. ) + 1.
255      BRTD = BRT / DENOMD
256      BRPC = BRP / DENOMC
257      BRVD = BRV / DENOMD ** POWER
258      BRVC = BRV / DENOMC ** POWER
259      C
260      RETURN
261      END
262

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1      SUBROUTINE PATH( IM, IDG, IRT )
2      C
3      C THIS ROUTINE COMPUTES THE MASSES PENETRATED (GM/CM2) ALONG THE
4      C PATH BETWEEN RECEIVER AND TRANSMITTER NUMBER IRT DUE TO EACH
5      C MATERIAL ( MODE A DUST, MODE B DUST AND CARBON ) IN SIZE GROUP
6      C IDG FROM BURST IM
7      C
8      C INPUTS FROM CALL STATEMENT
9      C IM = BURST NUMBER
10     C IDG = SIZE GROUP NUMBER
11     C IRT = RECEIVER - TRANSMITTER PAIR NUMBER
12     C
13     C INPUTS FROM CIMP1 COMMON AREAS
14     C XR(IRT) = X COORDINATE OF RECEIVER NUMBER IRT (METERS)
15     C YR(IRT) = Y COORDINATE OF RECEIVER NUMBER IRT (METERS)
16     C ZR(IRT) = Z COORDINATE OF RECEIVER NUMBER IRT (METERS)
17     C XT(IRT) = X COORDINATE OF TRANSMITTER NUMBER IRT (METERS)
18     C YT(IRT) = Y COORDINATE OF TRANSMITTER NUMBER IRT (METERS)
19     C ZT(IRT) = Z COORDINATE OF TRANSMITTER NUMBER IRT (METERS)
20     C FCM(IM) = FRACTION OF APPARENT CRATER MASS LOFTED FOR BURST IM
21     C ACV(IM) = APPARENT CRATER VOLUME SCALING FACTOR (M3/(LB TNT)1.111)
22     C W(IM) = YIELD OF BURST IM (LB TNT)
23     C YLC = LOADING FACTOR FOR CARBON ( RATIO OF THE WEIGHT OF
24     C CARRON IN THE CLOUD TO THE YIELD WEIGHT )
25     C RHOD = BULK DENSITY OF SOIL (GM/CM3)
26     C RHOC = CARBON DENSITY (GM/CM3)
27     C RBASE = RATIO OF THE MASS IN THE BASE CLOUD TO THE MASS IN THE
28     C MAIN CLOUD
29     C
30     C INPUTS FROM CTIME COMMON
31     C XCENCT = X COORDINATE OF THE CENTROID FOR DUST PARTICLES (BOTH
32     C MODE A AND MODE B) FOR THE MAIN CLOUD IN SIZE GROUP
33     C IDG FOR BURST NUMBER IM AT TIME T (METERS)
34     C YCENCT = Y COORDINATE OF THE CENTROID FOR DUST PARTICLES IN SIZE
35     C GROUP IDG FOR BURST IM AT TIME T (METERS)
36     C ZCENCT = Z COORDINATE OF THE CENTROID FOR DUST PARTICLES IN SIZE
37     C GROUP IDG FOR BURST IM AT TIME T (METERS)
38     C XCENCTC = X COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
39     C GROUP IDG FOR BURST IM AT TIME T (METERS)
40     C YCENCTC = Y COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
41     C GROUP IDG FOR BURST IM AT TIME T (METERS)
42     C ZCENCTC = Z COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
43     C GROUP IDG FOR BURST IM AT TIME T (METERS)
44     C RTD = RADIUS IN THE WIND TRACK DIRECTION FOR DUST PARTICLES IN
45     C THE MAIN CLOUD IN SIZE GROUP IDG FOR BURST IM AT TIME T
46     C (METERS)
47     C RPD = RADIUS IN THE DIRECTION PERPENDICULAR TO WIND TRACK
48     C DIRECTION FOR DUST PARTICLES IN SIZE GROUP IDG FOR BURST
49     C IM AT TIME T (METERS)
50     C RVD = RADIUS IN THE VERTICAL DIRECTION FOR DUST PARTICLES IN
51     C SIZE GROUP IDG FOR BURST IM AT TIME T (METERS)
52     C RTC = RADIUS IN THE WIND TRACK DIRECTION FOR CARBON PARTICLES
53     C IN SIZE GROUP IDG FOR BURST IM AT TIME T (METERS)
54     C RPC = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
55     C DIRECTION FOR CARBON PARTICLES IN SIZE GROUP IDG FOR
56     C BURST IM AT TIME T (METERS)
57     C RVC = RADIUS IN THE VERTICAL DIRECTION FOR CARBON PARTICLES IN
58     C SIZE GROUP IDG FOR BURST IM AT TIME T (METERS)

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59 C BXCNTD = X COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
60 C PARTICLES (BOTH MODE A AND MODE B) FOR SIZE GROUP IDG FOR
61 C BURST NUMBER IM AT TIME T (METERS)
62 C BYCNTD = Y COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
63 C PARTICLES FOR SIZE GROUP IDG FOR BURST IM AT TIME T
64 C (METERS)
65 C BZCNTD = Z COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
66 C PARTICLES FOR SIZE GROUP IDG FOR BURST IM AT TIME T
67 C (METERS)
68 C BXCNTC = X COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
69 C PARTICLES FOR SIZE GROUP IDG FOR BURST IM AT TIME T
70 C (METERS)
71 C BYCNTC = Y COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
72 C PARTICLES FOR SIZE GROUP IDG FOR BURST IM AT TIME T
73 C (METERS)
74 C BZCNTC = Z COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
75 C PARTICLES FOR SIZE GROUP IDG FOR BURST IM AT TIME T
76 C (METERS)
77 C BRD = RADIUS IN THE WIND TRACK DIRECTION FOR THE BASE CLOUD
78 C DUST PARTICLES IN SIZE GROUP IDG FOR BURST IM AT TIME T
79 C (METERS)
80 C BRPD = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
81 C DIRECTION FOR THE BASE CLOUD DUST PARTICLES IN SIZE GROUP
82 C IDG FOR BURST IM AT TIME T (METERS)
83 C BRVD = RADIUS IN THE VERTICAL DIRECTION FOR THE BASE CLOUD DUST
84 C PARTICLES IN SIZE GROUP IDG FOR BURST IM AT TIME T
85 C (METERS)
86 C BRTC = RADIUS IN THE WIND TRACK DIRECTION FOR THE BASE CLOUD
87 C CARBON PARTICLES IN SIZE GROUP IDG FOR BURST IM AT TIME T
88 C (METERS)
89 C BRPC = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
90 C DIRECTION FOR THE BASE CLOUD CARBON PARTICLES IN SIZE
91 C GROUP IDG FOR BURST IM AT TIME T (METERS)
92 C BRVC = RADIUS IN THE VERTICAL DIRECTION FOR THE BASE CLOUD
93 C CARBON PARTICLES IN SIZE GROUP IDG FOR BURST IM AT TIME T
94 C (METERS)
95 C
96 C INPUTS FROM CINITC COMMON
97 C FMAC = FRACTION OF MAIN CLOUD DUST MASS IN MODE A PARTICLES
98 C FMBC = FRACTION OF MAIN CLOUD DUST MASS IN MODE B PARTICLES
99 C THASSD(IM) = TOTAL INITIAL DUST MASS LOFTED IN MAIN CLOUD OF BURST
100 C IM (GM)
101 C THASSC(IM) = TOTAL INITIAL CARBON MASS LOFTED IN MAIN CLOUD OF
102 C BURST IM (GM)
103 C
104 C INPUTS FROM CPGRP COMMON
105 C FMA(I) = MASS FRACTION FOR SIZE GROUP I FOR MODE A DUST
106 C PARTICLES (RATIO OF MASS OF PARTICLES IN SIZE GROUP I
107 C TO TOTAL MASS IN DISTRIBUTION)
108 C FMB(I) = MASS FRACTION FOR SIZE GROUP I FOR MODE B DUST
109 C PARTICLES
110 C FMC(I) = MASS FRACTION FOR SIZE GROUP I FOR CARBON PARTICLES
111 C CMUEA(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
112 C WAVELENGTH J FOR MODE A DUST PARTICLES (CM²/GM)
113 C CMUEB(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
114 C WAVELENGTH J FOR MODE B DUST PARTICLES (CM²/GM)
115 C CMUEC(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
116 C WAVELENGTH J FOR CARBON PARTICLES (CM²/GM)

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117 C
118 C
119 C   OUTPUTS TO CPATH COMMON
120 C   PHASSA = MASS PENETRATED ALONG THE PATH BETWEEN RECEIVER AND
121 C           TRANSMITTER NUMBER IRT DUE TO MODE A DUST PARTICLES IN
122 C           SIZE GROUP IDG IN THE MAIN CLOUD OF BURST IN (GM/CM2)
123 C   PHASSB = MODE B DUST PARTICLE MASS PENETRATED (GM/CM2)
124 C   PHASSC = CARBON PARTICLE MASS PENETRATED (GM/CM2)
125 C   BPHASA = MASS PENETRATED ALONG THE PATH BETWEEN RECEIVER AND
126 C           TRANSMITTER NUMBER IRT DUE TO MODE A DUST PARTICLES IN
127 C           SIZE GROUP IDG IN THE BASE CLOUD OF BURST IN (GM/CM2)
128 C   BPHASB = MODE B DUST PARTICLE MASS PENETRATED (GM/CM2)
129 C   BPHASC = CARBON PARTICLE MASS PENETRATED (GM/CM2)
130 C   GHASSA = MASS OF MODE A DUST PARTICLES IN SIZE GROUP IDG IN
131 C           THE MAIN CLOUD OF BURST IN (GM)
132 C   GHASSB = MASS OF MODE B DUST PARTICLES IN SIZE GROUP IDG IN
133 C           THE MAIN CLOUD OF BURST IN (GM)
134 C   GHASSC = MASS OF CARBON PARTICLES IN SIZE GROUP IDG FROM BURST IN
135 C           IN THE MAIN CLOUD OF BURST IN (GM)
136 C   BGHASA = MASS OF MODE A DUST PARTICLES IN SIZE GROUP IDG IN
137 C           THE BASE CLOUD OF BURST IN (GM)
138 C   BGHASB = MASS OF MODE B DUST PARTICLES IN SIZE GROUP IDG IN
139 C           THE BASE CLOUD OF BURST IN (GM)
140 C   BGHASC = MASS OF CARBON PARTICLES IN SIZE GROUP IDG FROM BURST IN
141 C           IN THE BASE CLOUD OF BURST IN (GM)
142 C
143 C   COMMON / CPGRP / FNA(50), FNB(50), FNC(50), FMA(50), FMB(50),
144 C           1 FMC(50), PNGA(50), PNGB(50), PNGC(50),
145 C           2 CMUSA(50,10), CMUSB(50,10), CMUSC(50,10),
146 C           3 CMUEA(50,10), CMUEB(50,10), CMUEC(50,10),
147 C           4 CMUBA(50,10), CMUBB(50,10), CMUBC(50,10)
148 C   COMMON / CINPT1 / W(10), FH(10), CT(10), CF(10), CV(10), XB(10),
149 C           1 YB(10), ZB(10), COB(10), FCM(10), ACV(10),
150 C           2 PHTBDC(10)
151 C   COMMON / CINPT2 / FREQ(10), XLAMD(10), XT(10), YT(10), ZT(10),
152 C           1 XR(10), YR(10), ZR(10)
153 C   COMMON / CINPT4 / RHOG, RHOD, RHOC, FH20, XLC, RMAB, RBASE
154 C   COMMON / CTIME / XCENTO, YCENTO, ZCENTO, XCENTC, YCENTC, ZCENTC,
155 C           1 RTO, RPD, RVD, RTC, RPC, RVC, RS, HS, RT, RP,
156 C           2 RV, XCENTO, YCENTO, ZCENTO, BXCNTD, BYCNTD,
157 C           3 BZCNTD, BXCNTC, BYCNTC, BZCNTC, BRTO, BRPD,
158 C           4 BRVD, BRTC, BRPC, BRVC, BXCNTO, BYCNTO, BZCNTO,
159 C           5 BRT, BRP, BRV
160 C   COMMON / CINITG / RI(10), RTI(10), RPI(10), RVI(10), XKS(10),
161 C           1 FR(10), XKV(10), RTO(10), RPO(10), SINPW, COSPW,
162 C           2 VM10, VM10X, VM10Y, VMRVI(10), VMRVIX(10),
163 C           3 VMRVIY(10), TMASD(10), TMASSC(10), FMAC, FMBC,
164 C           4 POKER, TDHAIN(10), TOBASE(10)
165 C   COMMON / CPATH / PHASSA, PHASSB, PHASSC, GHASSA, GHASSB, GHASSC
166 C           1 , BPHASA, BPHASB, BPHASC, BGHASA, BGHASB, BGHASC
167 C
168 C   SET VALUE OF RATIO OF GROUP SIZE RADIUS TO GROUP STANDARD
169 C   DEVIATION
170 C   DATA CR / 2.15 /
171 C
172 C   DIMENSION VECR(3), VECT(3), VECEN(3), VECTCN(3), VECTR(3),
173 C           1 VECBTR(3), VECINT(3), VECIC(3)
174 C
175 C   CHECK IF RECEIVER - TRANSMITTER LOCATIONS FOR THIS FREQUENCY ARE

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175 C THE SAME AS FOR THE PREVIOUS CALCULATION. IF THE SAME, SKIP THE
176 C PATH INTEGRATION
177 IF( IRT .EQ. 1 ) GO TO 30
178 IRT1 = IRT - 1
179 IF( XR(IRT) .NE. XR(IRT1) .OR. YR(IRT) .NE. YR(IRT1) .OR.
180 1 ZR(IRT) .NE. ZR(IRT1) ) GO TO 30
181 IF( XT(IRT) .NE. XT(IRT1) .OR. YT(IRT) .NE. YT(IRT1) .OR.
182 1 ZT(IRT) .NE. ZT(IRT1) ) GO TO 30
183 GO TO 200
184
185 C
186 C SET VECTORS FOR RECEIVER AND TRANSMITTER LOCATIONS
187 30 VECR(1) = XR(IRT)
188 VECR(2) = YR(IRT)
189 VECR(3) = ZR(IRT)
190 VECT(1) = XT(IRT)
191 VECT(2) = YT(IRT)
192 VECT(3) = ZT(IRT)
193
194 C
195 C LOOP OVER THE MATERIALS WITH DIFFERENT DENSITIES
196 DO 199 ID = 1, 2
197 IF( ID .EQ. 2 ) GO TO 35
198 C
199 C MATERIAL IS DUST
200 CHECK IF SIZE GROUP HAS INSIGNIFICANT PROPAGATION EFFECT
201 PHASN = 0.
202 BPHASN = 0.
203 IF( CMUEA(IDG,IRT) .EQ. 0. .AND. CMUEB(IDG,IRT) .EQ. 0. ) GO TO 170
204 GO TO 40
205 C
206 C MATERIAL IS CARBON, CHECK IF CARBON DENSITY IS THE SAME AS THE
207 DUST DENSITY. IF THE DENSITIES ARE THE SAME USE THE PREVIOUSLY
208 CALCULATED DUST NORMALIZED MASS PENETRATED VALUES( IF NONZERO )
209 35 IF( RHOC .EQ. RHOD .AND. AMAX( PHASN, BPHASN ) .NE. 0. )
210 1 GO TO 160
211 C
212 C CHECK IF SIZE GROUP HAS INSIGNIFICANT PROPAGATION EFFECT
213 PHASN = 0.
214 BPHASN = 0.
215 IF( CMUEC(IDG,IRT) .EQ. 0. ) GO TO 180
216 C
217 C FIRST FIND THE MASS PENETRATED FOR THE MAIN CLOUD, THEN FOR THE
218 BASE CLOUD
219 40 DO 160 I CLOUD = 1, 2
220 C
221 C SET VALUES FOR PARTICLE RADII AND CENTROID LOCATIONS
222 IF( ID .EQ. 2 ) GO TO 50
223 C
224 C SET THE DUST PARAMETERS FOR PATH INTEGRATION
225 IF( I CLOUD .EQ. 2 ) GO TO 45
226 C
227 C MAIN CLOUD
228 RVCEM = RVD
229 RTCEM = RTD
230 RPEM = RPD
231 VECCEN(1) = XCENID
232 VECCEN(2) = YCENID
233 VECCEN(3) = ZCENID
234 GO TO 60

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233 C
234 C   BASE CLOUD
235 45 RVCEN = BRVD
236   RTCEN = BRTO
237   RPCEN = BRPD
238   VECCEN(1) = BXCNTD
239   VECCEN(2) = BYCNTD
240   VECCEN(3) = BZCNTD
241   GO TO 60
242 C
243 C   SET THE CARBON PARAMETERS FOR THE PATH INTEGRATION
244 50 IF( ICLOUD .EQ. 2 ) GO TO 55
245 C
246 C   MAIN CLOUD
247   RVCEN = RVC
248   RTCEN = RTC
249   RPCEN = RPC
250   VECCEN(1) = XCENTC
251   VECCEN(2) = YCENTC
252   VECCEN(3) = ZCENTC
253   GO TO 60
254 C
255 C   BASE CLOUD
256 55 RVCEN = BRVC
257   RTCEN = BRTC
258   RPCEN = BRPC
259   VECCEN(1) = BXCNTC
260   VECCEN(2) = BYCNTC
261   VECCEN(3) = BZCNTC
262 C
263 C
264 C   SET GAUSSIAN STANDARD DEVIATIONS, SET GAUSSIAN DENSITY CALCULATION
265 C   CONSTANT
266 60 STANT = RTCEN / CR
267   STANP = RPCEN / CR
268   STANV = RVCEN / CR
269   STAN = AMAX1( STANT, STANP )
270   CONST = 6.3493939E-8 / ( STANT * STANP * STANV )
271 C
272 C   FIND THE POINT OF CLOSEST APPROACH OF THE PATH TO THE CENTROID
273 C   LOCATION
274   CALL SUBVECC( VECT, VECCEN, VECTCN )
275   CALL SUBVECC( VECT, VECTR, VECTR )
276   CALL DOTVECC( VECTR, VECTR, TR2 )
277   CALL DOTVECC( VECTCN, VECTR, TCTR )
278   BETA = TCTR / TR2
279 C
280 C   CHECK IF GROUP CENTROID IS MORE THAN 5 STANDARD DEVIATIONS FROM
281 C   THE POINT OF CLOSEST APPROACH. IF IT IS, SKIP INTEGRATION
282   CALL DOTVECC( VECTCN, VECTCN, DTCM2 )
283   DCP = SQRT( DTCM2 - TR2 * BETA ** 2 )
284   IF( DCP / STAN .GT. 5. ) GO TO 160
285 C
286 C   IF POINT OF CLOSEST APPROACH IS OUTSIDE ENDPOINTS OF PATH
287 C   INTEGRATION, SET TO NEAREST PATH ENDPOINT
288   IF( BETA .LT. 0. ) BETA = 0.
289   IF( BETA .GT. 1. ) BETA = 1.
290 C

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291 C INTEGRATION STRATEGY - START AT POINT OF CLOSEST APPROACH,
292 C INTEGRATE FORWARD TO THE FIRST ENDPOINT, THEN BACKWARDS TO THE
293 C SECOND ENDPOINT. STOP INTEGRATION IF DISTANCE FROM INTEGRATION
294 C POINT TO GROUP CENTROID POINT EXCEEDS 5 STANDARD DEVIATIONS
295 C WE USE A SIMPSONS RULE INTEGRATION WITH STEP SIZES OF ABOUT 0.2
296 C OF THE LARGEST OF THE THREE GAUSSIAN STANDARD DEVIATIONS
297 C
298 C FIND TOTAL PATH LENGTH BETWEEN RECEIVER AND TRANSMITTER
299 C CALL DSTVECC( VECT, VECR, DRT )
300 C
301 C INTEGRATE FORWARDS AND BACKWARDS FROM POINT OF CLOSEST APPROACH
302 C DO 100 INT = 1, 2
303 C IF( INT .EQ. 2 ) GO TO 70
304 C
305 C FORWARD INTEGRATION SEGMENT. INTEGRATE FROM CLOSEST APPROACH POINT
306 C TO RECEIVER
307 C
308 C GET STEP SIZE
309 C DIR = CRT = ( 1. - BETA )
310 C NSTEP = IFIX( 5. * DIR / STAN )
311 C DBETA = ( 1. - BETA ) / FLOAT( NSTEP )
312 C IF( NSTEP .EQ. 0 ) GO TO 170
313 C IF( MOD( NSTEP, 2 ) .EQ. 1 ) NSTEP = NSTEP + 1
314 C GO TO 80
315 C
316 C SECOND HALF OF INTEGRATION. INTEGRATE FROM POINT OF CLOSEST
317 C APPROACH TO TRANSMITTER
318 C 70 DRT = CRT + BETA
319 C NSTEP = IFIX( 5. * DRT / STAN )
320 C IF( NSTEP .EQ. 0 ) GO TO 170
321 C IF( MOD( NSTEP, 2 ) .EQ. 1 ) NSTEP = NSTEP + 1
322 C DBETA = - BETA / FLOAT( NSTEP )
323 C
324 C 80 IGO = 1
325 C SUM = 0.
326 C BETAI = BETA - DBETA
327 C
328 C DO 120 ISTEP = 1, NSTEP
329 C BETAI = BETAI + DBETA
330 C
331 C FIND VECTOR TO INTEGRATION POINT
332 C CALL MULVECC( VECTH, - BETAI, VECCTR )
333 C CALL ADDVECC( VECT, VECCTR, VECINT )
334 C
335 C FIND PROJECTIONS OF THE VECTOR FROM THE CENTROID TO THE
336 C INTEGRATION POINT IN THE TRACK, CROSS TRACK, AND VERTICAL
337 C DIRECTIONS
338 C CALL SUBVECC( VECINT, VECCTR, VECIC )
339 C PROJ = VECIC(3)
340 C PROJH = VECIC(1) * SINPM + VECIC(2) * COSPM
341 C PROJV = VECIC(1) * COSPM - VECIC(2) * SINPM
342 C
343 C CHECK IF DISTANCE FROM INTEGRATION POINT TO CENTROID IS MORE THAN
344 C 5 STANDARD DEVIATIONS. IF SO, STOP THIS PORTION OF THE INTEGRATION
345 C SDEV = 0.5 * ( ( PROJH / STANH ) ** 2 + ( PROJV / STANV ) ** 2
346 C + ( PROJ / STAN ) ** 2 )
347 C IF( SDEV .GT. 12.5 ) GO TO 130
348 C

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349 C ASSUMING UNIT MASS IN THE SIZE GROUP, CALCULATE EXPONENT FACTOR
350 C OF THE GAUSSIAN DENSITY AT THE INTEGRATION POINT
351 EXPF = EXP( - SDEV )
352 C
353 IF( ISTEP .EQ. NSTEP ) GO TO 90
354 GO TO( 90, 100, 110 ), IGR
355 90 SUM = SUM + EXPF
356 IGO = 2
357 GO TO 120
358 100 SUM = SUM + 4. * EXPF
359 IGO = 3
360 GO TO 120
361 110 SUM = SUM + 2. * EXPF
362 IGO = 2
363 120 CONTINUE
364 C
365 C THIS PHASE OF INTEGRATION COMPLETED, SET CONTRIBUTION
366 130 IF( INT .EQ. 2 ) GO TO 140
367 C
368 SET NORMALIZED PENETRATED MASS ( GM / CM2 ) CONTRIBUTION FROM
369 C FIRST INTEGRATION
370 IF( ICLOUD .EQ. 2 ) GO TO 135
371 PHASN = 100. * SUM * CONST1 * DBETA * DRT / 3.
372 GO TO 150
373 135 BPHASN = 100. * SUM * CONST1 * DBETA * DRT / 3.
374 GO TO 150
375 C
376 C ADD NORMALIZED PENETRATED MASS CONTRIBUTION FROM SECOND HALF OF
377 C PATH INTEGRATION
378 140 IF( ICLOUD .EQ. 2 ) GO TO 145
379 PHASN = PHASN + 100. * SUM * CONST1 * DBETA * DRT / 3.
380 GO TO 150
381 145 BPHASN = BPHASN + 100. * SUM * CONST1 * DBETA * DRT / 3.
382 C
383 150 CONTINUE
384 C
385 160 CONTINUE
386 C
387 C NORMALIZED PENETRATED MASS INTEGRATION COMPLETED
388 IF( ID .EQ. 2 ) GO TO 180
389 C
390 C COMPUTE MAIN CLOUD DUST MASSES IN SIZE GROUP
391 170 GHASSA = FM_C * TMASSD(IM) * FMA(IDG)
392 GHASSB = FMRC * TMASSD(IM) * FMB(IDG)
393 C
394 C COMPUTE THE ACTUAL MAIN CLOUD DUST MASS PENETRATED FOR THIS SIZE
395 C GROUP
396 PHASSA = GHASSA * PHASN
397 PHASSB = GHASSB * PHASN
398 C
399 C COMPUTE DUST MASS PARAMETERS FOR THE BASE CLOUD
400 BGMASA = RB*SE * GHASSA
401 BGMASB = RB*SE * GHASSB
402 BPHASA = BGMASA * BPHASN
403 BPHASB = BGMASB * BPHASN
404 GO TO 190
405 C
406 C COMPUTE MAIN CLOUD CARBON MASS IN GROUP

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407      180 GMASSC = FMC(IDG) * TMASSC(IW)
408      C
409      C   COMPUTE ACTUAL MAIN CLOUD CARBON MASS PENETRATED FOR THIS SIZE
410      C   GROUP
411      C   PHMASSC = GMASSC * PHMASSN
412      C
413      C   COMPUTE CARBON MASS PARAMETERS FOR THE BASE CLOUD
414      C   BGMASC = RBASC * GMASSC
415      C   BPMASC = BGMASC * BPMASN
416      C
417      C   190 CONTINUE
418      C
419      C   200 RETURN
420      C   END
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1      SUBROUTINE DEPTH( T, IW, IOG, IRT )
2      C
3      C THIS ROUTINE CALCULATES THE OPTICAL DEPTHS FOR EXTINCTION,
4      C SCATTERING AND ABSORPTION FOR THE GIVEN TIME, BURST, SIZE GROUP,
5      C AND RECEIVER - TRANSMITTER PATH. THIS ROUTINE ALSO WRITES OUT THE
6      C DETAILED AND SUMMARY TIME DEPENDENT RESULTS
7      C
8      C INPUTS FROM CALL STATEMENT
9      C T = TIME AFTER BURST (S)
10     C IW = BURST NUMBER
11     C IOG = SIZE GROUP NUMBER
12     C IRT = TRANSMITTER - RECEIVER PAIR NUMBER
13     C
14     C INPUTS FROM CINPT COMMON AREAS
15     C NM = NUMBER OF BURSTS
16     C NDG = NUMBER OF PARTICLE DIAMETER SIZE GROUPS
17     C NRT = NUMBER OF TRANSMITTER - RECEIVER PAIRS
18     C NPROB = NUMBER OF THE PRESENT CASE BEING CALCULATED
19     C IPRINT = PRINT CONTROL OPTION (0 = PRINT DETAILS OF PATH
20     C INTEGRATION, 1 = PRINT ONLY SUMMARY OF THE PATH
21     C INTEGRATION)
22     C FREQ(IRT) = FREQUENCY OF TRANSMITTER - RECEIVER PAIR IRT (GHZ)
23     C XLAND(IRT) = WAVELENGTH OF TRANSMITTER - RECEIVER PAIR IRT
24     C (MICRONS)
25     C XT(IRT) = X COORDINATE OF TRANSMITTER IRT (METERS)
26     C YT(IRT) = Y COORDINATE OF TRANSMITTER IRT (METERS)
27     C ZT(IRT) = Z COORDINATE OF TRANSMITTER IRT (METERS)
28     C XR(IRT) = X COORDINATE OF RECEIVER IRT (METERS)
29     C YR(IRT) = Y COORDINATE OF RECEIVER IRT (METERS)
30     C ZR(IRT) = Z COORDINATE OF RECEIVER IRT (METERS)
31     C
32     C INPUTS FROM CPATH COMMON
33     C PMASSA = MASS PENETRATED ALONG THE PATH BETWEEN RECEIVER AND
34     C TRANSMITTER NUMBER IRT DUE TO MODE A DUST PARTICLES IN
35     C SIZE GROUP IOG FROM BURST IW (GM/CM2)
36     C PHASSB = MODE B DUST PARTICLE MASS PENETRATED (GM/CM2)
37     C PMASSC = CARBON PARTICLE MASS PENETRATED (GM/CM2)
38     C GMASSA = MASS OF MODE A DUST PARTICLES IN SIZE GROUP IOG AT TIME
39     C T DUE TO BURST IW (GM)
40     C GMASSB = MASS OF MODE B DUST PARTICLES IN SIZE GROUP IOG AT TIME
41     C T DUE TO BURST IW (GM)
42     C GMASSC = MASS OF CARBON PARTICLES IN SIZE GROUP IOG AT TIME T DUE
43     C TO BURST IW (GM)
44     C
45     C INPUTS FROM CPGRP COMMON
46     C CHUSA(I,J) = MASS SCATTERING COEFFICIENT FOR SIZE GROUP I AT
47     C WAVELENGTH J FOR MODE A DUST PARTICLES (CM2/GM)
48     C CHUSB(I,J) = MASS SCATTERING COEFFICIENT FOR SIZE GROUP I AT
49     C WAVELENGTH J FOR MODE B DUST PARTICLES (CM2/GM)
50     C CHUSC(I,J) = MASS SCATTERING COEFFICIENT FOR SIZE GROUP I AT
51     C WAVELENGTH J FOR CARBON PARTICLES (CM2/GM)
52     C CHUEA(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
53     C WAVELENGTH J FOR MODE A DUST PARTICLES (CM2/GM)
54     C CHUER(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
55     C WAVELENGTH J FOR MODE B DUST PARTICLES (CM2/GM)
56     C CHUEC(I,J) = MASS EXTINCTION COEFFICIENT FOR SIZE GROUP I AT
57     C WAVELENGTH J FOR CARBON PARTICLES (CM2/GM)
58     C

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59 C INPUTS FROM CTIME COMMON (USED ONLY FOR PRINTING DETAILED RESULTS)
 60 C XCENTO = X COORDINATE OF THE CENTROID FOR DUST PARTICLES (BOTH
 61 C MODE A AND MODE B) FOR THE MAIN CLOUD IN SIZE GROUP
 62 C IDG FOR BURST IN AT TIME T (METERS)
 63 C YCENTO = Y COORDINATE OF THE CENTROID FOR DUST PARTICLES IN SIZE
 64 C GROUP IDG FOR BURST IN AT TIME T (METER)
 65 C ZCENTO = Z COORDINATE OF THE CENTROID FOR DUST PARTICLES IN SIZE
 66 C GROUP IDG FOR BURST IN AT TIME T (METERS)
 67 C XCENTC = X COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
 68 C GROUP IDG FOR BURST IN AT TIME T (METERS)
 69 C YCENTC = Y COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
 70 C GROUP IDG FOR BURST IN AT TIME T (METERS)
 71 C ZCENTC = Z COORDINATE OF THE CENTROID FOR CARBON PARTICLES IN SIZE
 72 C GROUP IDG FOR BURST IN AT TIME T (METERS)
 73 C RTD = RADIUS IN THE WIND TRACK DIRECTION FOR DUST PARTICLES IN
 4 C THE MAIN CLOUD IN SIZE GROUP IDG FOR BURST IN AT TIME T
 75 C (METERS)
 76 C RPD = RADIUS IN THE DIRECTION PERPENDICULAR TO WIND TRACK
 77 C DIRECTION FOR DUST PARTICLES IN SIZE GROUP IDG FOR BURST
 78 C IN AT TIME T (METERS)
 79 C RVD = RADIUS IN THE VERTICAL DIRECTION FOR DUST PARTICLES IN
 80 C SIZE GROUP IDG FOR BURST IN AT TIME T (METERS)
 81 C RTC = RADIUS IN THE WIND TRACK DIRECTION FOR CARBON PARTICLES
 82 C IN SIZE GROUP IDG FOR BURST IN AT TIME T (METERS)
 83 C RPC = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
 84 C DIRECTION FOR CARBON PARTICLES IN SIZE GROUP IDG FOR
 85 C BURST IN AT TIME T (METERS)
 86 C RVC = RADIUS IN THE VERTICAL DIRECTION FOR CARBON PARTICLES IN
 87 C SIZE GROUP IDG FOR BURST IN AT TIME T (METERS)
 88 C BXCNTD = X COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
 89 C PARTICLES (BOTH MODE A AND MODE B) FOR SIZE GROUP IDG FOR
 90 C BURST NUMBER IN AT TIME T (METERS)
 91 C BYCNTD = Y COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
 92 C PARTICLES FOR SIZE GROUP IDG FOR BURST IN AT TIME T
 93 C (METERS)
 94 C BZCNTD = Z COORDINATE OF THE BASE CLOUD CENTROID FOR DUST
 95 C PARTICLES FOR SIZE GROUP IDG FOR BURST IN AT TIME T
 96 C (METERS)
 97 C BXCNTC = X COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
 98 C PARTICLES FOR SIZE GROUP IDG FOR BURST IN AT TIME T
 99 C (METERS)
 100 C BYCNTC = Y COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
 101 C PARTICLES FOR SIZE GROUP IDG FOR BURST IN AT TIME T
 102 C (METERS)
 103 C BZCNTC = Z COORDINATE OF THE BASE CLOUD CENTROID FOR CARBON
 104 C PARTICLES FOR SIZE GROUP IDG FOR BURST IN AT TIME T
 105 C (METERS)
 106 C BRTD = RADIUS IN THE WIND TRACK DIRECTION FOR THE BASE CLOUD
 107 C DUST PARTICLES IN SIZE GROUP IDG FOR BURST IN AT TIME T
 108 C (METERS)
 109 C BRPD = RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
 110 C DIRECTION FOR THE BASE CLOUD DUST PARTICLES IN SIZE GROUP
 111 C IDG FOR BURST IN AT TIME T (METERS)
 112 C BRVD = RADIUS IN THE VERTICAL DIRECTION FOR THE BASE CLOUD DUST
 113 C PARTICLES IN SIZE GROUP IDG FOR BURST IN AT TIME T
 114 C (METERS)
 115 C BRTC = RADIUS IN THE WIND TRACK DIRECTION FOR THE BASE CLOUD
 116 C CARBON PARTICLES IN SIZE GROUP IDG FOR BURST IN AT TIME T

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117 C (METERS)
118 C BRPC * RADIUS IN THE DIRECTION PERPENDICULAR TO THE WIND TRACK
119 C DIRECTION FOR THE BASE CLOUD CARBON PARTICLES IN SIZE
120 C GROUP IDG FOR BURST IW AT TIME T (METERS)
121 C BRVC * RADIUS IN THE VERTICAL DIRECTION FOR THE BASE CLOUD
122 C CARBON PARTICLES IN SIZE GROUP IDG FOR BURST IW AT TIME T
123 C (METERS)
124 C
125 C OUTPUTS
126 C TAUEN * OPTICAL DEPTH FOR EXTINCTION AT TIME T ALONG PATH BETWEEN
127 C TRANSMITTER - RECEIVER IRT DUE TO MODE A DUST PARTICLES IN
128 C SIZE GROUP IDG GENERATED BY BURST IW
129 C TAUENB * OPTICAL DEPTH FOR EXTINCTION DUE TO MODE B DUST PARTICLES
130 C TAUEN * OPTICAL DEPTH FOR EXTINCTION DUE TO CARBON PARTICLES
131 C TAUEN * OPTICAL DEPTH FOR SCATTERING DUE TO MODE A DUST PARTICLES
132 C TAUEN * OPTICAL DEPTH FOR SCATTERING DUE TO MODE B DUST PARTICLES
133 C TAUEN * OPTICAL DEPTH FOR SCATTERING DUE TO CARBON PARTICLES
134 C TAUEN * OPTICAL DEPTH FOR ABSORPTION DUE TO MODE A DUST PARTICLES
135 C TAUEN * OPTICAL DEPTH FOR ABSORPTION DUE TO MODE B DUST PARTICLES
136 C TAUEN * OPTICAL DEPTH FOR ABSORPTION DUE TO CARBON PARTICLES
137 C
138 C OUTPUTS TO CDEPTH COMMON
139 C TAUEN(IW,IRT) * TOTAL EXTINCTION OPTICAL DEPTH ALONG PATH IRT DUE
140 C TO ALL SIZE GROUPS AND MATERIALS FROM BURST IW
141 C TAUEN(IW,IRT) * TOTAL SCATTERING OPTICAL DEPTH DUE TO BURST IW
142 C TAUEN(IW,IRT) * TOTAL ABSORPTION OPTICAL DEPTH DUE TO BURST IW
143 C TAUEN(IRT) * TOTAL EXTINCTION OPTICAL DEPTH ALONG PATH IRT DUE
144 C TO ALL MATERIALS IN ALL SIZE GROUPS AND ALL BURSTS
145 C TAUEN(IRT) * TOTAL SCATTERING OPTICAL DEPTH
146 C TAUEN(IRT) * TOTAL ABSORPTION OPTICAL DEPTH
147 C
148 C COMMON / CINPT2 / FREQ(10), XLAMDA(10), XT(10), YT(10), ZT(10),
149 C XR(10), YR(10), ZR(10)
150 C COMMON / CINPT6 / NN, NDC, NRT, NTIME, NPROB, IPRINT
151 C COMMON / CPGRP / FNA(50), FNB(50), FNC(50), FMA(50), FMB(50),
152 C FMC(50), PNGA(50), PNGB(50), PNGC(50),
153 C 1 CMUSA(50,10), CMUSB(50,10), CMUSC(50,10),
154 C 2 CMUEA(50,10), CMUEB(50,10), CMUEC(50,10),
155 C 3 CMUBA(50,10), CMUBB(50,10), CMUBC(50,10)
156 C COMMON / CTIME / XCENTD, YCENTD, ZCENTD, XCENTC, YCENTC, ZCENTC,
157 C 1 RTD, RPD, RVD, RTC, RPC, RVC, RS, HS, RT, RP,
158 C 2 RV, XCENTD, YCENTD, ZCENTD, BXCNTD, BYCNTD,
159 C 3 BZCNTD, BXCNTC, BYCNTC, BZCNTC, BRD, BRPD,
160 C 4 BRVD, BRVC, BRPC, BRVC, BXCNTD, BYCNTD, BZCNTD,
161 C 5 BRT, BRP, BRV
162 C COMMON / CDEPTH / TAUEN(10,10), TAUEN(10,10), TAUEN(10,10),
163 C 1 TAUEN(10), TAUEN(10), TAUEN(10)
164 C COMMON / CPATH / PHASSA, PHASSB, PHASSC, GMASSA, GMASSB, GMASSC
165 C 1 BPHASA, BPHASB, BPHASC, BGMASA, BGMASB, BGMASC
166 C COMMON / TAPE / ITAPE, JTAPE
167 C
168 C COMPUTE THE OPTICAL DEPTH FOR EXTINCTION, SCATTERING, AND
169 C ABSORPTION FOR THIS SIZE GROUP FOR EACH MATERIAL
170 C COMPUTE OPTICAL PARAMETERS FOR THE MAIN CLOUD FIRST, THEN FOR THE
171 C BASE CLOUD
172 C DO 105 I CLOUD = 1, 2
173 C IF( I CLOUD .EQ. 2 ) GO TO 5
174 C

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175 C MAIN CLOUD
176 TAUEA = PHASSA * CMUEA(IDG,IRT)
177 TAUEB = PHASSB * CMUEB(IDG,IRT)
178 TAUEC = PHASSC * CMUEC(IDG,IRT)
179 TAUSA = PHASSA * CMUSA(IDG,IRT)
180 TAUSB = PHASSB * CMUSB(IDG,IRT)
181 TAUSC = PHASSC * CMUSC(IDG,IRT)
182 CMUAA = CMUEA(IDG,IRT) + CMUSA(IDG,IRT)
183 CMUAB = CMUEB(IDG,IRT) + CMUSB(IDG,IRT)
184 CMUAC = CMUEC(IDG,IRT) + CMUSC(IDG,IRT)
185 TAUAA = PHASSA * CMUAA
186 TAUAB = PHASSB * CMUAB
187 TAUAC = PHASSC * CMUAC
188 GO TO 7
189
190 C
191 C BASE CLOUD
192 5 TAUEA = BPHASSA * CMUEA(IDG,IRT)
193 TAUEB = BPHASSB * CMUEB(IDG,IRT)
194 TAUEC = BPHASSC * CMUEC(IDG,IRT)
195 TAUSA = BPHASSA * CMUSA(IDG,IRT)
196 TAUSB = BPHASSB * CMUSB(IDG,IRT)
197 TAUSC = BPHASSC * CMUSC(IDG,IRT)
198 TAUAA = BPHASSA * CMUAA
199 TAUAB = BPHASSB * CMUAB
200 TAUAC = BPHASSC * CMUAC
201
202 C
203 C SUM THE EXTINCTION, SCATTERING AND ABSORPTION CONTRIBUTIONS FROM
204 C THE THREE MATERIALS
205 7 TAUET = TAUEA + TAUEB + TAUEC
206 TAUST = TAUSA + TAUSB + TAUSC
207 TAUAT = TAUAA + TAUAB + TAUAC
208
209 C
210 C ADD THE CONTRIBUTIONS TO THE TOTALS FOR EACH BURST AND FOR ALL
211 C BURSTS
212 TAUEM(IM,IRT) = TAUEM(IM,IRT) + TAUET
213 TAUSM(IM,IRT) = TAUSM(IM,IRT) + TAUST
214 TAUAM(IM,IRT) = TAUAM(IM,IRT) + TAUAT
215 TAUE(IRT) = TAUE(IRT) + TAUET
216 TAUS(IRT) = TAUS(IRT) + TAUST
217 TAUA(IRT) = TAUA(IRT) + TAUAT
218
219 C
220 C WRITE OUT THE DETAILED RESULTS UNLESS SUPPRESSED BY IPRINT OPTION
221 IF( IPRINT .GT. 0 ) GO TO 105
222 IF( IDG .EQ. 1 .AND. IRT .EQ. 1 .AND. ICLOUD .EQ. 1 ) GO TO 20
223 XMSHAX = AMAX1( PHASSA, PHASSB, PHASSC )
224 IF( ICLOUD .EQ. 2 ) XMSHAX = AMAX1( BPHASSA, BPHASSB, BPHASSC )
225 IF( XMSHAX .LE. 0 ) GO TO 105
226 IF( NLINES .LT. 50 ) GO TO 60
227 WRITE(JTAPE, 10)
228
229 10 FORMAT(1H1,79H DETAILED SIZE
230 1E GROUP RESULTS (CONTINUED) )
231 NLINES = 9
232 GO TO 40
233
234 20 WRITE(JTAPE, 30) NPROB, T, IM ASL MUN
235 30 FORMAT(1H1,74H PROBLEM NUMBER
236 11TION DUST CLOUD MODEL // 1H ,
237 263H
238 3 , 13 / 1H0.

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233          472H
234          50R TIME = , F6.1, 8H SECONDS ; 1H ,
235          672H
236          7 NUMBER = , 13 )
237          N LINES = 15
238          40 WRITE(JTAPE, 50)
239          50 FORMAT(1H0 / 1H0,
240          1126HCLOUD DUST CARBON DUST RADII CARBON RADII TOTAL M
241          2AS5 CLOUD GROUP MASS OPTICAL DEPTH ALONG PATH DUE TO GROUP /
242          31H ,
243          4125H CENTROID CENTROID WIND TRACK WIND TRACK IN GROU
244          5P PENETRATED EXTINCTION SCATTERING ABSORPTION /
245          61H ,
246          7113HGROUP X-COORD. X-COORD. CROSS TRACK CROSS TRACK DUST-MO
247          80E A PATH DUST-MODE A DUST-MODE A / 1H ,
248          9113HNUMBER Y-COORD. Y-COORD. VERTICAL VERTICAL DUST-MO
249          10E B NUMBER DUST-MODE B DUST-MODE B / 1H ,
250          2110H Z-COORD. Z-COORD. (METERS) (METERS) CARBO
251          3N CARBON CARBON / 1H ,
252          4 85H (METERS) (METERS)
253          5S) (GM/CM2) )
254          60 IF( XMSMA .GT. 0. ) GO TO 65
255          IF( IRT .EQ. 1 .AND. IDG .EQ. 1 ) GO TO 65
256          GO TO 105
257          65 IF( ICLOUD .EQ. 2 ) GO TO 80
258          WRITE(JTAPE, 70) XCEN1D, XCEN1C, RTD, RTC, GMASSA, PMASSA, TAUAA,
259          1 TAUSA, TAUAA, IDG, YCENT1, YCENTC, RPD, RPC,
260          2 GMASSB, IRT, PMASSB, TAUAB, TAUSB, TAUAB, ZCENTD,
261          3 ZCENTC, RVD, RVC, GMASSC, PMASSC, TAUAC, TAUSC,
262          4 TAUAC
263          70 FORMAT(1H0, 4HMAIN, 2F11.1, 2F12.1, 1PE14.2, 5X, 4HMAIN, 1PE12.2,
264          1 3E13.2 / 1H , 13, 0PF12.1, F11.1, 2F12.1, 1PE14.2, 17, E14.2,
265          2 3E13.2 / 1H , 0PF15.1, F11.1, 2F12.1, 1PE14.2, E21.2, 3E13.2 )
266          GO TO 100
267          80 WRITE(JTAPE, 90) BXCNTD, BXCNTC, BRD, BRT, BGMASA, BPHASA, TAUAA,
268          1 TAUSA, TAUAA, IDG, BYCNTD, BYCNTC, BRPD, BRPC,
269          2 BGMASB, IRT, BPHASB, TAUAB, TAUSB, TAUAB, BZCNTD,
270          3 BZCNTC, BRVD, BRVC, BGMASC, BPHASC, TAUAC, TAUSC,
271          4 TAUAC
272          90 FORMAT(1H0, 4HBASE, 2F11.1, 2F12.1, 1PE14.2, 5X, 4HBASE, 1PE12.2,
273          1 3E13.2 / 1H , 13, 0PF12.1, F11.1, 2F12.1, 1PE14.2, 17, E14.2,
274          2 3E13.2 / 1H , 0PF15.1, F11.1, 2F12.1, 1PE14.2, E21.2, 3E13.2 )
275          100 N LINES = N LINES - 4
276          105 CONTINUE
277          IF( IM .EQ. NW .AND. IDG .EQ. NDG .AND. IRT .EQ. NRT ) GO TO 110
278          GO TO 240
279          C
280          C ALL CALCULATIONS ARE COMPLETE FOR THIS TIME. WRITE OUT SUMMARY OF
281          C RESULTS FOR EACH PATH
282          110 WRITE(JTAPE, 120) HPROB, T
283          120 FORMAT(1H1, 5PH
284          1D MODEL // 1-10,
285          248H
286          362H
287          4F6.1, 8H SECONDS // )
288          N LINES = 11
289          C
290          DO 230 KRT = 1, NRT

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291 C
292 C CALCULATE THE TRANSMISSIONS CORRESPONDING TO THE TOTAL OPTICAL
293 C DEPTHS
294 TRANE = 0.
295 TRANS = 0.
296 TRANA = 0.
297 IF( TAU(KRT) .LT. 40. ) TRANE = EXP( - TAU(KRT) )
298 IF( TAUS(KRT) .LT. 40. ) TRANS = EXP( - TAUS(KRT) )
299 IF( TAA(KRT) .LT. 40. ) TRANA = EXP( - TAA(KRT) )
300 C
301 DO 220 KW = 1, NW
302 IF( KRT .EQ. 1 .AND. KW .EQ. 1 ) GO TO 170
303 IF( N(LINES) .LE. 50 ) GO TO 170
304 WRITE(JTAPE, 140)
305 140 FORMAT(1H1,53H
306 1(CONTINUED) // )
307 N(LINES) = 8
308 150 WRITE(JTAPE, 160)
309 160 FORMAT( 1H0,
310 1 97H WAVELENGTH PATH COORDINATES(METERS) TOTAL T
311 201H OPTICAL DEPTH CONTRI- / 1H ,
312 3 99H PATH (MICRONS) TRANSMITTER RECEIVER TRANSMISSION
313 4 DEPTH BURSTIONS FROM EACH BURST / 1H ,
314 5 99HNUMBER FREQUENCY X-COORD. X-COORD. EXTINCTION
315 6EXTINCTION BURST EXTINCTION / 1H ,
316 7 94H (GMZ) Y-COORD. Y-COORD. SCATTERING
317 8SCATTERING NUMBER SCATTERING / 1H ,
318 9 94H Z-COORD. Z-COORD. ABSORPTION
319 1ABSORPTION ABSORPTION )
320 170 IF( KW .GT. 1 ) GO TO 190
321 WRITE(JTAPE, 180) KRT, XLAMDA(KRT), XT(KRT), XR(KRT), TRANE,
322 1 TAU(KRT), KW, TAUW(KW,KRT), FREQ(KRT),
323 2 YT(KRT), YR(KRT), TRANS, TAUS(KRT),
324 3 TAUSW(KW,KRT), ZT(KRT), ZR(KRT), TRANA,
325 4 TAA(KRT), TAAW(KW,KRT)
326 180 FORMAT(1H0, I3, F13.1, F14.1, F11.1, 1PE16.2, E15.2, I8, E14.2 /
327 1 1H , 1PE16.2, 0PF14.1, F11.1, 1PE16.2, E15.2, E22.2 /
328 2 1H , 16X, 0PF14.1, F11.1, 1PE16.2, E15.2, E22.2 )
329 GO TO 210
330 190 WRITE(JTAPE, 200) KW, TAUW(KW,KRT), TAUSW(KW,KRT), TAAW(KW,KRT)
331 200 FORMAT(1H0, 72X, I8, 1PE14.2 /
332 11H , 80X, 1PE14.2 /
333 21H , 80X, 1PE14.2 )
334 210 N(LINES) = N(LINES) + 5
335 C
336 220 CONTINUE
337 C
338 230 CONTINUE
339 C
340 240 RETURN
341 END

```

```

1      SUBROUTINE ADDVEC( V1, V2, V3 )
2      C
3      C THIS ROUTINE ADDS TWO THREE VECTORS TOGETHER
4      C
5      C INPUTS
6      C V1 = FIRST THREE VECTOR
7      C V2 = SECOND THREE VECTOR
8      C
9      C OUTPUT
10     C
11     C V3 = THREE VECTOR WHICH IS THE SUM OF V1 AND V2
12     C
13     C DIMENSION V1(3), V2(3), V3(3)
14     C
15     DO 10 I = 1, 3
16     V3(I) = V1(I) + V2(I)
17     10 CONTINUE
18     C
19     RETURN
20     END

```

```

1      SUBROUTINE SUBVEC( V1, V2, V3 )
2      C
3      C      THIS ROUTINE SUBTRACTS TWO THREE VECTORS
4      C
5      C      INPUTS
6      C      V1 = FIRST THREE VECTOR
7      C      V2 = SECOND THREE VECTOR
8      C
9      C      OUTPUT
10     C      V3 = THREE VECTOR WHICH IS V1 - V2
11     C
12     C      DIMENSION V1(3), V2(3), V3(3)
13     C
14     DO 10 I = 1, 3
15     V3(I) = V1(I) - V2(I)
16     10 CONTINUE
17     C
18     RETURN
19     END

```

```

1      SUBROUTINE MULVECC( V1, S, V3 )
2      C
3      C      THIS ROUTINE MULTIPLIES A THREE VECTOR BY A SCALAR
4      C
5      C      INPUTS
6      C      V1 = THREE VECTOR
7      C      S  = A SCALAR
8      C
9      C      OUTPUT
10     C      V3 = THE THREE VECTOR RESULTING FROM MULTIPLYING V1 BY S
11     C
12     C      DIMENSION V1(3), V3(3)
13     C
14     C      V3(1) = S * V1(1)
15     C      V3(2) = S * V1(2)
16     C      V3(3) = S * V1(3)
17     C
18     C      RETURN
19     C      END

```

```

1      SUBROUTINE DOTVEC( V1, V2, S )
2      C
3      C THIS ROUTINE CALCULATES THE DOT PRODUCT OF TWO THREE VECTORS
4      C
5      C INPUTS
6      C V1 = FIRST THREE VECTOR
7      C V2 = SECOND THREE VECTOR
8      C
9      C OUTPUT
10     C S = SCALAR DOT PRODUCT OF V1 AND V2
11     C
12     C DIMENSION V1(3), V2(3)
13     C
14     C S = V1(1) * V2(1) + V1(2) * V2(2) + V1(3) * V2(3)
15     C
16     C RETURN
17     C END

```

```

1      SUBROUTINE DSTVEC( V1, V2, DIST )
2      C
3      C      THIS ROUTINE CALCULATES THE DISTANCE BETWEEN THE ENDPOINTS OF
4      C      VECTORS V1 AND V2
5      C
6      C
7      C      INPUTS
8      C      V1 = FIRST THREE VECTOR
9      C      V2 = SECOND THREE VECTOR
10     C
11     C      OUTPUT
12     C      DIST = DISTANCE BETWEEN ENDPOINTS OF VECTORS V1 AND V2
13     C
14     C      DIMENSION V1(3), V2(3)
15     C
16     C      DIST = SQRT( ( V1(1) - V2(1) ) ** 2 + ( V1(2) - V2(2) ) ** 2
17     C      1      + ( V1(3) - V2(3) ) ** 2 )
18     C
19     C      RETURN
20     C      END

```

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