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MESOI: An Interactive Lagrangian Trajectory Puff Diffusion Model

J. V. Ramsdell
G. F. Athey

December 1981

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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PUFF DIFFUSION MODEL

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ABSTRACT

MESOI is an interactive Lagrangian trajectory puff diffusion model based on an earlier model by Start and Wendell at the Air Resources Laboratory Field Office at Idaho Falls, Idaho. Puff trajectories are determined using spatially and temporally varying wind fields. Diffusion in the puffs is computed as a function of distance traveled and atmospheric stability. Exposures are computed at nodes of a 31 by 31 grid. There is also provision for interpolation of short term exposures at off-grid locations.

This report discusses: the theoretical bases of the model, the numerical approach used in the model, and the sensitivity and accuracy of the model. It contains a description of the computer program and a listing of the code. MESOI is written in FORTRAN. A companion report (Athey, Allwine and Ramsdell, 1981) contains a user's guide to MESOI and documents utility programs that maintain the data files needed by the model.

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MESOI: AN INTERACTIVE LAGRANGIAN TRAJECTORY PUFF DIFFUSION MODEL

INTRODUCTION

In the event of an actual or potential release of radioactive or toxic material to the atmosphere at Hanford, the forecasting staff of the Hanford Meteorology Station assists in the identification of the area exposed to the material and in the estimation of the concentrations involved. One of the tools used by the forecasting staff is an atmospheric transport and diffusion model called MESOI. MESOI is based upon a model developed originally by Start and Wendell (1974) at NOAA's Air Resources Laboratory at the National Reactor Testing Station (NRTS) [now the Idaho National Engineering Laboratory (INEL)]. Initial implementation of the Start and Wendell model at Hanford occurred in about 1977. Since then there have been several modifications to the code. Neither the original implementation of the model nor the modifications have been documented. The purpose of this report is to document the current version of MESOI.

Motivation for documentation of MESOI at this time includes:

- Making the model available to others at Hanford and elsewhere for use in emergency response applications,
- Providing a basis for model evaluation and verification studies,
- Providing a framework for further model development.

With the development of the power generation facilities and other nuclear facilities at Hanford, coordinated emergency response planning is needed. The documentation of MESOI will facilitate this coordination. Evaluation and verification studies are needed to increase confidence in the MESOI transport and diffusion predictions or to identify model shortcomings. These studies can also be used to determine the optimum locations for additional meteorological instrumentation. However, before these studies take place the basic model should be documented. Finally, the further development of MESOI will be simplified by documentation of the current version of the model. Likely modifications

include: addition of elevated and multiple source capabilities, addition of deposition and precipitation scavenging subroutines, and addition of the capability to treat the spatial variation of the meteorological conditions other than wind. Documentation of the current version of MESOI will facilitate further development by providing a proper reference point.

The report is divided into 4 sections. The first section covers the theoretical basis for the model and the numerical approach followed in the simulation. The following section discusses the results of tests of the sensitivity of MESOI to variations in model parameters and tests performed to check the accuracy of the numerical algorithms. The final two sections deal directly with the MESOI computer program. The first of these sections describes the overall organization of the program and identifies the major program elements, common blocks and variables. The last section of the report presents the MESOI computer code by program elements. A companion report (Athey, Allwine and Ramsdell, 1981) has been prepared to provide users with a guide to program execution. It contains detailed instructions and several test and practice data sets.

THEORY AND NUMERICAL APPROACH

The theoretical basis for MESOI is developed in full in Start and Wendell (1974). An outline of the development is included here for completeness.

Two assumptions are basic to MESOI. These assumptions are: (1) that transport and diffusion of material released to the atmosphere can be approximated to an acceptable degree by considering the transport and diffusion of discrete puffs released in sequence, and, (2) that transport and diffusion can be treated separately. By making the first assumption we avoid problems associated with the reorientation of plumes as they are advected through the wind field. The error in the approximation can be made small by increasing puff release rate and increasing the frequency with which we compute the concentrations at receptors. The second assumption permits us to consider the puff as a point for advection purposes and estimate concentrations within the puff without regard to its position. This is a simplified model of reality because it does not permit the puff to divide or become distorted due to wind shear, but it is a significant improvement over straight line diffusion models that only use meteorological data from a single point. In MESOI the transport and diffusion are recoupled when the exposures to the receptors are computed.

TRANSPORT

The advection of puffs is controlled by the wind field, which is defined on a 16x16 grid that covers the spatial domain of the model. Wind fields are determined hourly from observed or forecast winds. Currently the model is programmed to accommodate winds from 30 instrument locations. The winds at grid points are estimated by interpolation using weighted averages of the winds at the closest instrument locations. The weight given to each wind included in the average is proportional to the inverse of the square of the distance between the grid point and the instrument location. Wendell (1972) describes the interpolation scheme used in MESOI in detail.

Two wind fields are retained in MESOI at all times. These are: the wind field from the most recent observation, and the wind field for the next

observation time. The wind at the center of mass of each puff is used in advection and is determined by inverse square spatial interpolation between the grid points and linear interpolation in time between the two wind fields. The advection wind is the vector average of the wind at the center of mass of a puff at the beginning of an advection step, and the wind at the projected position of the center of mass of the same puff at the end of the advection step. Once an advection wind has been determined for a puff, it is assumed to persist until the next puff is released. Thus, if 6 puffs are being released each hour, the advection wind for each puff will be changed 6 times per hour. The changes will reflect the variation in the wind due to advection of the puff through the wind field and due to the changes in the wind field in time.

During the time that a puff remains within the MESOI domain, a record is maintained of the position, last displacement and total distance traveled by the center of mass of each puff. A flag is also associated with each puff to indicate when the puff no longer need be considered. When the total number of puffs released and still being considered exceeds 200, this flag is checked and inactive puffs are deleted.

DIFFUSION

The diffusion of each puff is described by the Gaussian puff model (Gifford, 1968) for point sources, and ground level releases and receptors. As implemented, the model assumes that material in the puff is conserved during transport and diffusion. Neither decay nor deposition processes are included. Along-wind and crosswind diffusion of the puff are assumed to be equal. As a result, the horizontal cross-section of a puff is circular.

With these assumptions, the concentration at a point in a puff is given by

$$\chi(|\underline{r}|) = \frac{2Q}{(2\pi)^{3/2} \sigma_h^2 \sigma_z} \exp - \frac{1}{2} \frac{|\underline{r}|^2}{\sigma_h^2} \quad (1)$$

where $\chi(|\underline{r}|)$ is the concentration at the position $\underline{r}$ relative to the puff center of mass, Q is the total amount of material contained in the puff, σ_h and σ_z are

the horizontal and vertical diffusion parameters, respectively, all evaluated at time t . The factor 2 in the numerator results from an assumption that material reaching the ground is reflected rather than deposited.

The horizontal and vertical diffusion parameters are determined as a function of distance and atmospheric stability. The vertical parameter is also a function of the atmospheric mixing layer. As the magnitude of σ_z approaches the thickness of the mixing layer, parameter growth becomes a linear function of distance. Finally when σ_z is equal to 0.8 of the thickness, further parameter growth is suppressed.

The growth of the vertical diffusion parameter is governed by the following relationships

$$\sigma_z = \begin{cases} AX^\gamma & \sigma_z/LDEPTH < 0.465 & (2a) \\ 0.465 + 0.335 \frac{X - X_L}{X_L} LDEPTH & 0.465 \leq \sigma_z/LDEPTH < 0.800 & (2b) \\ 0.8 * LDEPTH & \sigma_z/LDEPTH \geq 0.80 & (2c) \end{cases}$$

where X is the distance from the source and A and γ are constants that depend upon atmospheric stability, $LDEPTH$ is the thickness of the atmospheric mixing layer, and X_L is the distance at which σ_z reaches $0.465 * LDEPTH$, i.e.

$$X_L = (0.465 LDEPTH/A)^{1/\gamma} \quad (3)$$

It should be immediately obvious that X_L is a function of stability.

The relationship between σ_z and X in Equation (2a) is an approximation to curves originally developed by Markee (Yanskey, Markee and Richter, 1966). Markee's curves are significantly different than the σ_z curves developed by Hilsmeier and Gifford (1962) that are presented in Appendix A of Meteorology and Atomic Energy - 1968 (Slade, 1968) and in NRC Regulatory Guide 1.145. The primary differences occur in extremely unstable or stable atmospheric conditions. In unstable atmospheric conditions at distances greater than 1 km, the growth of σ_z predicted by Markee's curve is much less rapid than the growth predicted

by the Hilsmeir and Gifford curves. Equation (2a) gives even less rapid growth. In stable conditions, Markee's curves again predict slower growth of σ_z . Figure 1 shows the σ_z curves defined by Equation (2a). It also shows the modification of the unrestricted growth caused by imposing limits to vertical mixing by assuming thicknesses of 100 and 1000 m.

FIGURE 1. Vertical Diffusion Parameter as a Function of Distance and Stability

The restriction is defined in Equations (2b) and (2c) and is based on the work of Turner (1970). When σ_z exceeds $0.8 \cdot \text{LDEPTH}$, the diffusing material is essentially uniformly mixed in the vertical. Until the thickness of the mixing layer increases, vertical diffusion is suppressed and reduction of concentration can only be achieved by horizontal diffusion. It is interesting to note that given the constant values for the unrestricted growth curves, the formulation of the restriction in Equation (2b) actually results in acceleration of

the vertical diffusion as σ_z approaches $0.8 \cdot \text{LDEPTH}$ under stable atmospheric conditions. This is illustrated in the modification shown for stability class 5 for $\text{LDEPTH} = 100 \text{ m}$ in Figure 1.

The relationships used to define the growth of the horizontal diffusion parameter are:

$$\sigma_H = \begin{cases} BX^{0.85} & X \leq 20,000 \text{ m} \\ B'X^{0.50} & X \geq 20,000 \text{ m} \end{cases} \quad (4a)$$

$$X \geq 20,000 \text{ m} \quad (4b)$$

where B and B' are again stability dependent. Curves showing these relationships are contained in Figure 2. These curves are based upon diffusion data collected at NRTS and Hanford, and are approximations to curves presented by Yanskey, Markee and Richter (1966).

As was the case with the σ_H curves, there is a significant difference between the curves in Figure 2 and the more familiar curves of Hilsmeier and Gifford (1962) that are presented in Appendix A of Meteorology and Atomic Energy - 1968 and Regulatory Guide 1.145. In Figure 2, the value of σ_H reaches a minimum in neutral stability (Stability Class 4--D in Pasquill-Gifford nomenclature). This is not the case in the more familiar curves where σ_y continues to decrease as stability increases.

Table 1 gives the values for the constants required for Equations (2) and (4). The values of A , B and B' presented in the table are dimensional; if distances are given in units other than meters, appropriate corrections must be applied. The units of A are $\text{m}^{(1 - \gamma)}$, those for B are $\text{m}^{0.15}$ and those for B' are $\text{m}^{0.5}$.

The diffusion parameter curves presented in Figures 1 and 2 were initially meant to be used with stability classes determined using a scheme based on sky cover, wind speed, time-of-day and insolation. The scheme, developed by Markee for use in the desert climate of the NRTS, is a modification of the original scheme proposed by Pasquill (1961). Markee's scheme is presented in Table 2.

The use of this scheme at locations other than NRTS is open to question. However, it might well be argued that its use at Hanford is reasonable because

FIGURE 2. Horizontal Diffusion Parameter as a Function of Distance and Stability

TABLE 1. Constant Values for Evaluation of Diffusion Parameter Equations

Stability Class	A	γ	B	B'
1	0.100	1.033	0.718	23.0
2	0.105	0.975	0.425	13.6
3	0.128	0.891	0.349	11.2
4	0.146	0.824	0.267	8.55
5	0.331	0.567	0.299	9.57
6	0.812	0.307	0.401	12.8

TABLE 2. Stability Estimates Using Time of Day, Windspeed, and Cloud Cover for the NRTS

Time of Day by Season			Cloud Cover					Solar Altitude (degrees)
November through January	February through April August through October	May through July	Windspeed at 8 m (m/sec)	0 through 5/10	6/10 through 10/10	Heavy Overcast	Insolation	
10 through 12	08 through 11	06 through 09	< 6	B	C	D	Slight	15 through 35
13 through 16	14 through 18	17 through 20	06 through 09	C	C through D	D		
			> 9	D	D	D		
12 through 13	11 through 14	09 through 11	< 6	A	B	C	Moderate	35 through 60
		14 through 17	06 through 09	B	B through C	C		
			09 through 11	C	C	D		
			> 11	D	D	D		
		11 through 14	< 9	A	A through B	B	Strong	> 60
			09 through 11	B	B through C	C		
			> 11	C	C	C		
16 through 10	18 through 08	20 through 06	< 3	G	F	E	None (night)	< 15
			03 through 09	F	E	E		
			09 through 11	E	E	D		
			> 11	D	D	D		

A = Extremely Unstable E = Slightly Stable
 B = Moderately Unstable F = Moderately Stable
 C = Slightly Unstable G = Extremely Stable
 D = Neutral

Hanford diffusion data were used in development of the scheme. Similarly, the use of other atmospheric stability typing schemes with the curves presented in Figures 1 and 2 will have an unknown effect on the accuracy of the model. Intercomparisons (e.g. Gifford, 1976; Horst, Doran and Nickola, 1979; Sedefian and Bennett, 1980) do not show a great deal of consistency between schemes. On the average most schemes tend to agree, but in a relatively large number of individual cases there are significant differences among predicted values of diffusion parameters and among concentrations.

Equations (2a-c) and (4a) and (4b) are appropriate for use in estimating the horizontal and vertical diffusion parameters when the atmospheric stability is constant. When the stability is a function of time, however, the use of these equations results in discontinuities in diffusion parameter magnitudes at the time of the stability changes, and the puffs expand or contract unnaturally. To avoid this problem, the diffusion parameters in MESOI are evaluated by numerical integration of derivatives of Equations (2) and (4). At time increment n following puff release, the diffusion parameters are given by:

$$\sigma(n) = \sum_{i=1}^n \frac{d\sigma}{dx}_i \Delta X_i \quad (5)$$

where the index i indicates the time increment and ΔX_i is the distance moved in the sampling interval corresponding to time increment i . The magnitude of the diffusion parameter in the last sampling interval and the current atmospheric stability are used to define an effective puff travel distance for use in evaluation of the derivative. This approach was taken by Start and Wendell for the vertical diffusion parameter; we have extended it to evaluation of the horizontal parameter for consistency.

Using a heavy line, Figures 3 and 4 show the growth of the vertical and horizontal diffusion parameters for a 12 hour period with several changes in atmospheric stability. A wind speed of 2 m/s and a mixing layer depth of 1000 m have been assumed for the example. During the 12 hour period the progression of stabilities is: 1 hour of 6, 1 hour of 5, 1 hour of 4, 5 hours of 5, 1 hour of 4 and 3 hours of 3. The horizontal dashed lines indicate the changes in effective travel distance required by changes in atmospheric stability. The growth of the diffusion parameters with time is shown in Figure 5. Figure 5 shows that the continuity of the diffusion parameter magnitudes is maintained during changes in stability even though the effective puff travel distance is changed.

Figures 3 and 4 also illustrate another important point. The effective travel distance is not necessarily the same for the two diffusion parameters. In the example the actual travel distance at the end of the 12 hour period is 86.4 km. However, the effective travel distance for the vertical parameter is about 31 km and the effective travel distance for the horizontal is 70 km. The differences are a function of the combination of stabilities encountered. If the stability is constant, the distances will be the same. But, if the range of stabilities is large, the differences are also likely to be large. It should also be noted that the effective distances are not necessarily less than the

FIGURE 3. Growth of the Vertical Diffusion Parameter During a Period with Several Changes in Stability. The Horizontal dashed lines show the changes in effective travel distance that accompany changes in stability

FIGURE 4. Growth of the Horizontal Diffusion Parameter During a Period with Several Changes in Stability. The horizontal dashed lines show the changes in effective travel distance that accompany changes in stability.

FIGURE 5. Diffusion Parameters as a Function of Time for the Example of Parameter Growth Illustrated in Figures 3 and 4

actual distance. A different example in which the atmospheric stability tended to decrease with time would show effective travel distances greater than the actual travel distance.

EXPOSURE COMPUTATION

As the puffs are advected through the model domain, the exposures at grid points are accumulated by superposition of the contributions from all nearby puffs. Thus, the exposure at point x, y from time zero to time T is given by

$$E(x, y, T) = \sum_{t=1}^T \sum_{i=1}^{NP} x_i(|r|t) \Delta t \quad (6)$$

where NP is the number of puffs contributing to the exposure at time t, $|r|$ is the distance between the grid point and the center of the puff, and Δt is the sampling interval. The numerical integration used to obtain the exposure provides a good approximation to the Gaussian continuous plume model as long as $U\Delta t < \sigma H$, where U is the wind speed. Exposures at grid points are representative of the grid interior for plumes when σH is larger than the grid spacing. The representativeness also increases as the accumulation period, T, increases.

To speed computation, a minimum concentration of interest and a maximum puff radius are defined within the program. The minimum concentration is set by the user. When the concentration at the center of a puff falls below the minimum value, the puff is not considered further in the computation of exposures. In essence the minimum concentration is the model zero level. The puff radius is defined as the distance from the puff center of mass at which the concentration falls below the minimum concentration of interest. It is computed for each sampling interval from the concentration at the puff center and the current value of the horizontal diffusion parameter. The puff radius is used to limit the number of grid points involved in exposure computations.

When desired, exposures at off-grid receptors are estimated by interpolation from the exposures at surrounding grid points using inverse square weighted interpolation. Because the model accumulates total exposure, the exposures of off-grid receptors for shorter periods are determined by subtraction, i.e., for a sampling period Δt , the exposure at an off-grid sampling position (x', y') is estimated by

$$E_s(x', y', \Delta t) = E_s(x', y', t + \Delta t) - E_s(x', y', t) . \quad (7)$$

The average concentration during a sampling period can be estimated by dividing the exposure by the duration of the period.

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MESOI SENSITIVITY AND ACCURACY

MESOI and its predecessor at NRTS have undergone a number of tests to determine their sensitivity to parameter changes and to verify their numerical accuracy. This section discusses the results of some of those tests.

Start and Wendell (1974) discuss the sensitivity of their model to variations in the number of puffs released per hour and the frequency of sampling at individual receptors. The accuracy with which the puff approximation approaches the continuous plume exposure is directly related to the frequency of sampling and the advection rate of the puff. The higher the advection rate the more puffs are required. Based on tests with a single puff, Start and Wendell determined that sampling should take place at 1 or 2 minute intervals. At this sampling rate the differences in exposures computed with their model and those computed with a continuous plume model should be less than a factor of 2 at receptors more than 10 km from the source at all but the highest wind speeds. At low wind speeds the differences between the models should be smaller.

During steady wind conditions the accuracy of the puff approximation to a continuous plume exposure depends on the sampling rate. During unsteady winds the frequency with which puffs are released is also important. This is particularly true when rapid wind direction shifts occur. When this happens the plume from a point source in essence becomes a plume from an instantaneous line source. If puffs are released too infrequently, the concentration distribution along the line will not be as even as it would in the case of a real plume. On the basis of cases studied at NRTS, Start and Wendell concluded that 3 puffs an hour normally provide adequate definition in the event of wind shifts. They also concluded that there was little difference in computed exposure when 6 or 12 puffs per hour were used.

To determine the effects of puff release frequency and sampling rate on doses accumulated over periods of the order of days, we conducted a number of simulations using a common data set. The assumed release occurred for a period of 96 hours. During this period the average wind speed at the Hanford Meteorological Tower 50 foot level was just under 1.9 m/s (4.24 mph). In addition to releasing 6 puffs per hour and sampling at 2 minute intervals, simulations were

made with the following combinations of puff release rates and sampling intervals: 5 hr⁻¹, 3 min; 4 hr⁻¹, 3 min; 3 hr⁻¹, 2 min and 3 hr⁻¹, 4 min. Figure 6 shows a comparison of the exposures computed for these release rates and sampling intervals with the exposures computed for the same positions using a 6 puff per hour release rate and a 2 minute sampling interval. In general the computed exposures tend to decrease with reduction of the release rate or increase in the sampling interval.

Table 3 gives regression and correlation coefficients for the relationships between the computed exposures using reduced release rates and increased sampling intervals and those computed using 6 puffs per hour and 2 minute sampling. The form of the relationship assumed is

$$E_2 = aE_1^b \quad (8)$$

where E_1 is the computed exposure from the reference conditions and E_2 is the exposure estimated using reduced release rates and increased sampling intervals. The value of the square of the correlation coefficient, r^2 , indicates the fraction of the variability in E_2 accounted for by the variations in E_1 given the relationship assumed in Equation (8). If r^2 is near 1.000, E_1 and E_2 contain essentially the same information. In the case at hand, the correlation should be high because both variables are results of MESOI run with a common input data set. The results in Table 3 confirm this expectation. The scatter shown in Figure 6 is the result of variation of the model puff release and sampling parameters. It appears to be large, but in reality, it is small when compared with the range of computed exposure estimates. It is this comparison that is reflected in the correlation coefficients.

The regression coefficients a and b describe the relationship between E_1 and E_2 . Rewriting the assumed relationship as

$$E_2/E_1 = aE_1^{b-1}$$

provides an insight to the optimum or desired coefficient values. If $b = 1.000$ the relationship is simply a constant ratio equal to a . Further, if $a = 1.000$,

FIGURE 6. Comparison of Exposures Computed Using Reduced Release Rates with Those Computed Using a Release Rate of 6 Puffs per Hour and a 2 Minute Sampling Interval

TABLE 3. Regression and Correlation Coefficients for Relationship Between MESOI Exposure Estimates for Different Model Parameter Combinations

NPH	SI (min)	Grid Point Receptors			Off-Grid Receptors			All Receptors		
		a	b	r ²	a	b	r ²	a	b	r ²
5	3	0.759	0.991	0.994	1.206	1.006	0.999	0.770	0.991	0.995
4	3	0.575	0.987	0.988	0.956	1.004	0.999	0.586	0.988	0.991
3	2	0.381	0.996	0.972	0.396 ^(a)	0.991	1.000	0.347 ^(a)	0.990	0.981
3	4	0.222 ^(a)	0.961	0.969	0.754	1.001	0.998	0.230 ^(a)	0.961	0.978

(a) Significantly different from 1.000 at the 95% confidence level.

the exposures at any given position tend to have the same value on the average with either set of parameters. If a does not equal 1.000, a single correction can be applied to all exposure estimates to correct for systematic differences that result from the variation of MESOI puff release parameters. If b does not equal 1.000, the factor is a function of the exposure magnitude.

The hypotheses that the regression coefficients are equal to 1.000 were tested statistically for each set of puff release parameters using a Student's t test. Those cases where the hypotheses could be rejected at the 95% confidence level are indicated with asterisks. The assumption hypothesis that $b = 1.000$ is accepted for all combinations of puff release parameters tested, but the hypothesis with respect to a is rejected for some puff release rates of 3 per hour. Additional evaluation runs need to be made to properly define the variation of a with changing puff release rates and sampling intervals.

Following the completion of the computer code modifications required to produce MESOI, a computational check was made to determine the accuracy of the numerical approximations used in the integrations and to ensure that there were no programming errors. The check consisted of a one hour simulated release (6 puffs) in a uniform wind field. The time integration was continued until the last puff left the grid. Exposures along the plume centerline were then compared with exposures computed using a continuous plume model. With no programming errors and perfect numerical algorithms, the exposures computed from the techniques should be identical. Realistically, however, small differences are to be expected because of the numerical techniques being used.

Figure 7 shows the results of the computational check. The MESOI exposures match the exposures computed using the continuous plume model at all distances. For the off-grid receptors the maximum difference occurred close to the source, where the puff dimensions were small compared to the spacing of the grid used for accumulation of exposures. As the dimensions of the puffs increase, the off-grid exposure estimates more closely approximate the continuous plume estimates. Beyond about 10 km, the off-grid receptor estimates can be considered to be within a factor of 2 of the continuous plume exposures. Programming errors did not cause any of the differences noted.

FIGURE 7. Comparison of MESOI Exposure Estimates with Estimates from a Continuous Plume Model

This test is a particularly severe test for the off-grid receptors because of the plume width and uniform direction of travel. The interpolation scheme uses the exposure at four grid points to estimate the exposure at off-grid receptor locations. In the computational check, the puffs were advected along a diagonal of the computational grid; thus, two of the points used in estimating the exposure at off-grid receptors (also along the diagonal) were off the plume center. Near the source, the off-centerline grid point receptors used had zero exposure, thus the exposure at the off-grid point was significantly underestimated. As the distance from the source increased and the plume width became large enough, all four points used in the interpolation were within the plume. By 32 km, the distances from the plume centerline of the off-centerline grid points were about one sigma H. As a result, the estimated exposure at the off-grid receptor was consistent with the exposure that would have been expected had the location been a grid-point.

Evaluation of the results of the computational check for off-grid locations leads to the conclusion that the off-grid receptor capability should not be used near the source for estimating short term exposures. It is most appropriately used where the horizontal exposure gradients are small. Small horizontal exposure gradients are most likely to exist more than 10 km from the source or when the exposure integration period is sufficiently long that it includes a reasonable amount of wind direction variability.

MESOI COMPUTER PROGRAM DESCRIPTION

MESOI is a modified version of the regional transport and diffusion model developed by Start and Wendell (1974). The major modifications made to the original program were: to reconstitute the program as an interactive computer code, to increase the modularization of the code, to revise the numerical algorithms used in computation of the diffusion parameters, to make provision for estimation of exposure at off-grid receptor locations, and to modify the code so that positions entered interactively are entered as distances from the center of the grid. There were no fundamental changes made to the basic approach taken by Start and Wendell. A listing of MESOI is contained in the next section.

PROGRAM ORGANIZATION

Structurally, the computer code is based upon a set of 5 nested loops. Three of the loops are transparent to the user of the program. The two loops that the user sees are the outer loops that control the number of simulation runs and the duration of each run. Figure 8 shows a flow chart of the program as it appears to the user. The outer-most of the loops essentially encompasses the entire program. Within this loop the user has control over the extent of re-initialization to be accomplished before the second and subsequent model runs in a series, and has the option of restarting the model if an error is made in data entry or additional data becomes available. The other loop controls the duration of the simulation. In the figure it is indicated by the branch labeled "CONTINUE MODEL SIMULATION?". The program is set to run a maximum of 48 hours in any single simulation. However, the user may elect to terminate model execution at the end of any hour. The MESOI user's guide (Athey, Allwine, and Ramsdell, 1981) describes these aspects of the program in detail.

The three inner loops of the program deal with the release, advection and sampling of the puffs. These loops contain the essence of the transport and diffusion algorithms. Figure 9 shows a more comprehensive flow chart for MESOI. In the flow chart, the inner 3 loops are found immediately following the block marked "COMPUTE NEW WIND FIELD". The first of the loops transparent to the user starts with the release of a new puff. Puffs are released at

FIGURE 8. MESOI as Seen by the User

FIGURE 9. MESOI Flow Chart

equally spaced times within the hour. The interval between puff releases is the advection interval. The number of puffs per hour must be an integer factor of 60. The number of advection intervals each hour, also referred to as advection steps is equal to the puff release rate in puffs per hour.

Prior to the movement of any puff, including newly released puffs, the wind acting on the puff for the advection interval is computed by spatial and temporal interpolation. This wind is assumed to remain constant during the advection interval. The loop accomplishing the actual movement of the puffs starts with computation of the puff position at the end of the advection interval.

The inner-most loop is used to accumulated the exposures at grid points by sampling the puffs near each grid point. The sampling interval is the frequency of puff sampling and is expressed in hours when used in computation of exposures. The sampling interval is set at 2 minutes in the current model version, but it can be increased or decreased within limits. The primary constraint on the sampling interval is that it must be an interger factor of the advection period when both are expressed in minutes. Table 4 gives the possible release rates in puffs per hour, the advection period associated with each release rate and the permissible sampling intervals for each release rate.

MESOI execution time is a function of the number of puffs on the grid, the advection period, and the sampling interval. In terms of meteorological conditions, this means that MESOI execution speed is a function of the steadiness of the wind direction and the wind speed because these variables directly affect the time that puffs reside on the grid. Similarly, the execution time is a function of the duration of the release being simulated. Because of these factors, it is not reasonable to attempt to establish a method of predicting MESOI execution times. Generally, however, the computations for the first few hours of a simulation will occur much more rapidly than those occurring several days into a release. Also, the time required to simulate a release of a given duration (on the order of days) will be less if the average wind speed is high than if it is low.

Once the meteorological conditions are fixed and the release parameters are specified, the time required for a given simulation is determined by the

TABLE 4. Permissible Sampling Intervals

Release Rate (puffs/hour)	Advection Period (minutes)	Permissible Sampling Intervals
		(minutes)
60	1	1
30	2	1, 2
20	3	1, 3
15	4	1, 2, 4
12	5	1, 5
10	6	1, 2, 3, 6
6	10	1, 2, 5, 10
5	12	1, 2, 3, 4, 6, 12
4	15	1, 3, 5, 15
3	20	1, 2, 4, 5, 10, 20
2	30	1, 2, 3, 5, 6, 10, 15, 30
1	60	1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60

puff release rate and the sampling interval. Under these conditions, the number of arithmetic operations involved in a given simulation is approximately proportional to the product of the puff release rate and the number of sampling intervals, i.e.

$$\text{NOPS} \approx \text{NPH} * 60/\text{SI}$$

where NOPS is the number of operations, NPH is the puff release rate and SI is the sampling interval in minutes. If we adopt a standard release rate and program execution time associated with that release rate, we can estimate the effects of changing the advection period or sampling interval on execution time. The MESOI tests discussed earlier provide data for evaluation of this approach. Arbitrarily we have adopted the 6 puff per hour release rate and 2 minute sampling interval as standards. Using the test data set, the time required for the 96 hour simulation with the standard release rate and sampling interval was 314.2 seconds. This time is associated with NOPS = 180. Dividing NOPS and the time required for simulations with the other sets of release rates and sampling intervals by these values gives the relative number of operations and times

associated with each set. Figure 10 shows the relationship between the relative number of operations and the relative execution times. The assumption that the relative execution time is equal to the relative number of operations is clearly tenable. Extending this assumption to the full range of advection periods and sampling intervals, Table 5 gives the relative execution times for all permissible combinations of release rate and sampling interval.

PROGRAM ELEMENTS, COMMON BLOCKS AND VARIABLES

The flow chart in Figure 9 provides a general overview of the operation of MESOI; however, it doesn't show the functional division of the program elements. Functionally, MESOI is divided into 18 program elements. These elements are listed in Table 6 along with brief descriptions of their functions and their lengths. The indentation of the program element names shows the hierarchy of the calling sequence. CNTRL is the main program element; it calls 13 subroutines. The remaining 4 subroutines are called by other subroutines. Each of the program elements will be described in more detail in the section on the MESOI computer code.

FIGURE 10. Relative Execution Time for MESOI as a Function of the Relative Number of Operations Determined from the Puff Release Rate and Sampling Interval

TABLE 5. Relative Execution Times for All Permissible Combinations of Release Rates and Sampling Interval

Release Rate (puffs/hr)	1	2	3	4	5	6	10	12	15	20	30	60
1	0.333	0.167	0.111	0.083	0.067	0.056	0.033	0.028	0.022	0.017	0.011	0.006
2	0.667	0.333	0.222		0.133	0.111	0.067		0.044		0.022	
3	1.000	0.500		0.250	0.200		0.100			0.050		
4	1.333		0.444		0.267				0.889			
5	1.667	0.833	0.556	0.417		0.278		0.139				
6	2.00	1.000			0.400		0.200					
10	3.333	1.667	1.111			0.556						
12	4.00				0.800							
15	5.00	2.500		1.250								
20	6.67		2.222									
30	10.00	5.000										
60	20.00											

TABLE 6. MESOI Program Elements

Program Element Name	Element Purpose	Length
CNTRL	Program Control, Major Computational Loops	12946 ^(a)
ADATE ^(b)	Date and Time of Program Execution	
GRIDIN	Grid and Wind Station Initialization	1274 ^(c)
REARNG	Order Wind Stations and Delete Inactive Stations	68
STRAY	Compute Distance to Grid Points from Stations and Determine Order by Distance	230
ASCND	Place Stations in Order of Increasing Distance	113
INIT	Primary Model Initializations	592
JULIAN	Convert Month, Day and Year to Julian Date	108
LOCATE	Position Observed Data File for Start	600
WIND	Decode Wind Data and Compute u and v Components	557
RCPTIN	Initialize Off-Grid Receptors	715
RELEAS	Define Source Location and Parameters	727
JULIAN		
LOCATE	Position Forecast File	
CLEAN	Remove Puffs No Longer Being Considered	94
WIND		
PUFFR	Release Puffs	39
PUFFM	Compute Puff Movement	281
SIGMA	Compute Horizontal and Vertical Diffusion Parameter Values	321
RCPTR	Compute Doses to Off-Grid Receptors	129
PRINTE	Printer and Screen Output	764
	Total	19558

(a) Includes 11825 words in common blocks

(b) Includes 182 words in common blocks not included in CNTRL

(c) UNIVAC 1100/44 system subroutine

Within MESOI the primary method of exchanging data and computational results between program elements is through labeled common blocks. There are 6 labeled common blocks, with each block containing information on a specific aspect of the model. These blocks and their contents and lengths are listed in Table 6. Specific contents for each common block can be determined from the program listings. It is clear from the program element lengths in Table 6 and the common block lengths in Table 7 that the variables contained in common blocks WINDS and PUFFS contribute most to the overall program size. Table 8 shows the relationship between the program elements and the labeled common blocks.

Table 9 contains a listing of the variables used in more than one program element. It also defines the use of the variable, shows program elements in which the variable is set and used, and gives the method by which the variable is passed from one element to another. In some cases the variable may have a different name in a called subroutine than in the calling element. This is most frequently found where variables are passed through a call list rather than through common blocks. One example of this is found in subroutine JULIAN. Comparison of the call lists in the calling element and in the called subroutine provides a quick means of determining if variable names are the same in both elements.

TABLE 7. MESOI Common Blocks

<u>Name</u>	<u>Contents</u>	<u>Length</u>
MASTER	Model Run Identification, Control Parameters, Exposure Accumulation Array	1087
RCPT	Off-Grid Receptor Identification, Control Parameters and Exposure Accumulation Array	83
REL	Source Term Specification	7
PUFFS	Puff Characteristics and Positions	4504
WINDS	Identification and Distances to Closest Wind Stations for Each Grid Point in the Wind Grid, Interpolated Wind Fields	6144
STATN	Wind Station Positions, Names and Statuses	182

TABLE 8. Relationship Between Program Elements and Labeled Common Blocks

<u>Program Element</u>	<u>Common Block</u>					
	<u>Master</u>	<u>RCPT</u>	<u>REL</u>	<u>PUFFS</u>	<u>WINDS</u>	<u>STATN</u>
CNTRL	X	X	X	X	X	
GRIDIN						X
REARNG						X
STRAY					X	X
INIT	X				X	
RCPTIN		X				
RELEAS			X			
CLEAN				X		
WIND					X	X
PUFFR			X	X		
PUFFM				X	X	
RCPTR	X	X				
PRINTE	X	X	X			

ADATE, ASCND, JULIAN, LOCATE and SIGMA do not use common blocks.

TABLE 9. Variables Used in More Than One Program Element

<u>Name</u>	<u>Contents</u>	<u>How Passed</u>	<u>Where Set</u>	<u>Where Used</u>
ACNST	Constant Terms in Puff Diffusion Equation	MASTER	INIT	CNTRL, PUFFR
ACTSTA	Number of Active Wind Stations	WINDS	GRIDIN	WIND
ADT	Time Between Puff Releases, (advection period, hours)	PUFFS	INIT	CNTRL, INIT, PUFFM
CHI	Array for Accumulation of Exposures at Grid Points	MASTER	CNTRL, INIT	CNTRL, RCPTR, PRINTE
CHIMIN	Minimum Puff Concentration	MASTER	INIT	CNTRL
DATA	Array with Station Wind Data	call	CNTRL	CNTRL, WIND
DDAY	Day of Current Meteorological Data Record	MASTER	CNTRL	CNTRL, WIND, PRINTE
DELXY	Grid Spacing (meters)	call	GRIDIN	CNTRL, GRIDIN, INIT, RCPTIN, RELEAS
DFLAG	Flag Used to Switch Between Observed and Forecast Meteorological Data	call	CNTRL, INIT, LOCATE	CNTRL, INIT, LOCATE
DHR	Hour of Current Meteorological Data Record	MASTER	CNTRL	CNTRL, WIND, PRINTE
DSMTR	Distance Puff Moves in Advection Period (meters)	call	CNTRL	SIGMA, CNTRL
DT	Sampling Interval (minutes)	MASTER	INIT	INIT
DXM	x Grid Units Puff Moves in Sampling Interval	call	CNTRL, PUFFM	CNTRL
DXS	x Grid Units Puff Moves in Advection Period	PUFFS	CNTRL, CLEAN	CNTRL, CLEAN
DYM	Grid Units Puff Moves in Sampling Period	call	CNTRL, PUFFM	CNTRL
DYS	y Grid Units Puff Moves in Advection Period	PUFFS	CNTRL, CLEAN	CNTRL, CLEAN
FAC	Conversion Factor for Wind Speed (m/s to grid units)	PUFFS	INIT	CNTRL, PUFFM
IDY	Day of Month for Start of Simulation	call	INIT, JULIAN, RELEAS	INIT, JULIAN, RELEAS
IEXIT	Flag Used to Exit from Simulation	call	CNTRL, PRINTE,	CNTRL

TABLE 9 (contd).

Name	Contents	How Passed	Where Set	Where Used
IMO	Month of Start of Simulation	call	RELEAS, INIT, JULIAN	RELEAS, INIT, JULIAN
IP	Array with Positions of Off-Grid Receptors	RCPT	RCPTIN	RCPTIN, RCPTR, PRINTE
IPSUM	Number of Active Puffs	call	CNTRL	CNTRL, PRINTE
IYR	Year of Start of Simulation	call	INIT, JULIAN	INIT, JULIAN
JN	Number of the Sampling Interval Within the Advection Period	call	CNTRL	CNTRL, SIGMA
LDEPTH	Atmospheric Mixing Depth	call	CNTRL	CNTRL, SIGMA
LERROR	Flag Used to Indicate Requested Meteorological Data are Not Available	call	LOCATE	CNTRL
M	Puff Number (highest = most recently released)	call	CNTRL	CNTRL, PUFFM, SIGMA
MAXPUF	Release Duration in Terms of Number Puffs to be Released	REL	RELEAS	CNTRL, RELEAS
MF	Flag Used to Indicate Puff is Not to be Used in Exposure Computation	PUFFS	CNTRL, CLEAN	CNTRL, CLEAN, PUFFR
MOFG	Flag Used to Indicate Puff Has Moved Off the Grid	call	CNTRL	CNTRL, PUFFM
NAMSTA	Array of Wind Station Names	WINDS	GRIDIN, REARNG	GRIDIN, REARNG
NPH	Number of Puffs to be Released Per Hour	MASTER	INIT	CNTRL, INIT, RELEAS
NPUFFS	Total Number of Puffs Released in Simulation to the Current Time	PUFFS	CNTRL, PUFFR	CNTRL, PUFFR
NRCPT	Number of Off-Grid Receptors	RCPT	RCPTIN	CNTRL, RCPTIN, PRINTE
NSI	Number of Sampling Intervals Between Puff Releases	MASTER	INIT	CNTRL
NUMSTA	Number of Wind Stations	call	GRIDIN	CNTRL, GRIDIN, STRAY, REARNG, ASCND, WIND
OFFTIM	Time-of-Day Off-Grid Receptors are Deactivated	RCPT	RCPTIN	CNTRL, RCPTIN, PRINTE

TABLE 9 (contd).

Name	Contents	How Passed	Where Set	Where Used
ONOFF	Flag Used to Activate/Deactivate Off-Grid Receptors	call	CNTRL	CNTRL, RCPTIN
ONTIM	Time-of-Day Off-Grid Receptors are Activated	RCPT	RCPTIN	CNTRL, RCPTIN
PARTHR	Number of Advection Steps Between Start of Release and Beginning of the Next Hour	REL	RELEAS	CNTRL
Q	Source Strength	REL	RELEAS, CLEAN, PUFFR	RELEAS, CLEAN
QP	Array with Q*ACNST for Each Puff	PUFFS	PUFFR	CNTRL
RCH	Wind Field Interpolation Radius	STATN	GRIDIN	GRIDIN, WIND
RDATE	Date of Model Run	MASTER	ADATE	RCPTR, PRINTE
RDOSE	Array with Off-Grid Exposures	RCPT	RCPTR	RCPTR, PRINTE
RELDAY	Julian Date of Release	REL	RELEAS	CNTRL, RELEAS
RELHR	Hour of Release	REL	RELEAS	CNTRL, RELEAS
RTIME	Time of Model Run	MASTER	ADATE	CNTRL, INIT, PRINTE
RWT	Array of Weights for Off-Grid Exposure Interpolation	RCPT	RCPTIN	RCPTIN, RCPTR
SDAY	Simulation Day (not used)	MASTER		
SHR	Simulation Hour	MASTER	CNTRL	CNTRL, PRINTE
SIGMAY	Array with Puff Horizontal Diffusion Parameters (meters)	PUFFS	CLEAN, PUFFR, SIGMA	CNTRL, CLEAN, SIGMA
SIGMAZ	Array with Puff Vertical Diffusion Parameters (meters)	PUFFS	CLEAN, PUFFR, SIGMA	CNTRL, CLEAN, SIGMA
STAB	Atmospheric Stability Class	call	CNTRL	CNTRL, SIGMA
STATUS	Array with Status of Each Wind Station	STATN	GRIDIN, WIND	GRIDIN, REARNG, WIND
STDAY	Julian Date for Start of Simulation	call	JULIAN	CNTRL, LOCATE, INIT

TABLE 9 (contd).

Name	Contents	How Passed	Where Set	Where Used
STDIST	Array with Distances from Grid Points to Closest Wind Stations	WINDS	STRAY	WIND
STHR	Hour for Start of Simulation	call	INIT	INIT, LOCATE
STNUM	Array with Station Numbers for Stations Closest to Each Grid Point	WINDS	STRAY	WIND
STOTAL	Array with Total Distance Traveled by Each Puff	PUFFS	CLEAN, PUFFR, SIGMA	CNTRL, CLEAN, SIGMA
TINC	Time Since Last Hour (fraction)	call	CNTRL	CNTRL, PUFFM
TITLE	Model Run Identification	MASTER	INIT	CNTRL, INIT PRINTE
TPUFFS	Number of Puffs Being Tracked	PUFFS	CNTRL, CLEAN, PUFFR	CNTRL, CLEAN, PUFFR, SIGMA
U	Array with u Component Wind Field for Previous Hour	WINDS	CNTRL	PUFFM
UU	Array with u Component Wind Field for Next Hour	WINDS	WIND	CNTRL, PUFFM
USTA	Array with u Component for Each Wind Station	STATN	GRIDIN, WIND	WIND
V	Array with v Component Wind Field for Previous Hour	WINDS	CNTRL	PUFFM
VV	Array with v Component Wind Field for Next Hour	WINDS	WIND	CNTRL, PUFFM
VSTA	Array with v Component for each Wind Station	STATN	GRIDIN, WIND	WIND
WT	Array with v Weights for Off-Grid Exposure Interpolation	RCPT	RCPTIN	RCPTR
XP	Array of Puff x Coordinates	PUFFS	CNTRL, CLEAN, PUFFR	CNTRL, CLEAN PUFFM
XS	x Grid Points for Use in Exposure Computations	call	INIT	CNTRL
XSOURC	x Coordinate of Release Point	REL	RELEAS	CNTRL, RELEAS, PUFFR, PRINTE

TABLE 9 (contd).

<u>Name</u>	<u>Contents</u>	<u>How Passed</u>	<u>Where Set</u>	<u>Where Used</u>
XSTA	Array with Wind Station x Coordinates	STATN	GIRDIN, REARNG	GRIDIN, REARNG, STRAY
YP	Array of Puff y Coordinates	PUFFS	CNTRL, CLEAN, PUFFR	CNTRL, CLEAN, PUFFM
YS	y Grid Points for Use in Exposure Computations	call	INIT	CNTRL
YSOURC	y Coordinate of Release Point	REL	RELEAS	CNTRL, RELEAS, PUFFR, PRINTE
YSTA	Array with Wind Station y Coordinates	STATN	GIRDIN, REARNG	GRIDIN, REARNG, STRAY

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MESOI COMPUTER CODE

In the last section we examined the organization of the MESOI program; this section presents the actual computer code. Interactive exchanges between MESOI and the user take place in CNTRL and the subroutines GRIDIN, INIT, RCPTIN, RELEAS and PRINTE. Read statements referencing logical unit 5 and write statements referencing logical unit 6 both involve the user's VDT. The five octal variables CLR, XYMOVE, SETAB, TAB and BOTTOM are used to control the VDT cursor and display. The values assigned to the variables represent ASCII characters and are set for a Televideo 912 terminal. Subroutines REARNG, STRAY, LOCATE, CLEAN and WIND provide the user with information on the program status, but do not require user input.

In addition to the user's VDT, MESOI requires access to 5 disk files. Logical units 10 and 11 are used to input meteorological data, and logical units 7, 9 and 12 are used for model output. The meteorological data files are described in detail in the User's Guide. Output from unit file 12 is directed to the printer; 7 and 9 are used as input for an undocumented display program NEWCONTUR. After printing and execution of NEWCONTUR, the files are deleted.

MESOI uses two grid systems. The first system is a 16 by 16 grid with spacing equal to DELXY. This grid is used for identification of positions, specification of the wind fields and tracking of puffs. All computations related to this grid are done in grid units. The second grid system is a 31 by 31 grid with spacing of DELXY/2. This grid is used for the accumulation of exposures. Computations done relating directly to the concentrations at the puff centers, e.g. estimates of the diffusion parameters, are in meters. The remaining computations, such as estimating the contribution of individual puffs to the exposure at the grid points, are done using the center concentration estimates and distances in grid units.

The following paragraphs describe each of the program elements.

CNTRL

CNTRL is the main program element of MESOI. It provides the framework within which the simulation occurs, and it performs the actual computation of exposures at the grid point receptors. The outermost of the primary loops includes lines 57 through 249. The first part of the loop controls program initialization (lines 57 through 72). The next loop (lines 73 through 220) is the primary simulation loop. Each trip through the loop corresponds to one hour of simulation. The puff release loop includes lines 120 through 190; the puff advection loop includes lines 125 through 189, and the puff sampling loop includes lines 145 through 188. The computation of exposures at the grid points is accomplished by the section of code from line 179 through line 187.

Local variables of interest in CNTRL that are not used in other program elements include: RP, ISTRT, ISTEP, JSTRT and JSTEP. RP is the radius of the puff under consideration in terms of grid units. The remaining 4 variables define the portion exposure accumulation grid affected by the puff.

```

1 C ** MESOI.CNTRL
2 C
3 C ** MAIN CONTROLLING ROUTINE FOR THE MESOI MODEL
4 C
5 C *****
6 C
7 C ** MESOI --- INTERACTIVE VERSION OF MESO
8 C **          VERSION 1.0   OCTOBER 1981
9 C
10 C ** PROGRAMS ASSEMBLED ----- MAY, 1981
11 C ** LAST MODIFICATIONS ----- OCTOBER, 1981
12 C
13 C *****
14 C
15 C   REAL CHI(32,32), STOTAL(500), QP(500)
16 C   REAL RWT(4,10), WT(10), RDOSE(10)
17 C   REAL XP(500),YP(500),DXS(500),DYS(500),SIGMAY(500),SIGMAZ(500)
18 C   REAL XSOURC,YSOURC,Q,XS(31),YS(31)
19 C   REAL STDIST(10,16,16),U(16,16),V(16,16),
20 C   1   UU(16,16),VV(16,16)
21 C
22 C
23 C   INTEGER SHR,SDAY,ONTIM,OFFTIM, IP(2,10), ONOFF
24 C   INTEGER DT,PFLAG, DFLAG
25 C   INTEGER RELDAY,RELTIM,RELHR,PARTHR,MAXPUF
26 C   INTEGER MF(500), TPUFFS, NPUFFS, DATA(30)
27 C   INTEGER ODAY, DHR, DREC, STAB, PREVHR, PREVDY
28 C   INTEGER TITLE(50), STNUM(10,16,16)
29 C
30 C   CHARACTER*8 RDATE,RTIME
31 C   CHARACTER SELECT*1
32 C
33 C   COMMON/MASTER/RDATE,RTIME,TITLE,NPH,DT,CHIMIN,DDAY,DHR,NSI,
34 C   1 CHI,ACNST,SDAY,SHR
35 C   COMMON/RCPT/IP,RWT,WT,ONTIM,OFFTIM,NRCPT,RDOSE
36 C   COMMON/REL/XSOURC,YSOURC,RELDAY,RELHR,PARTHR,
37 C   1   MAXPUF,Q
38 C   COMMON/PUFFS/MF,SIGMAY,SIGMAZ,QP,STOTAL,XP,YP,TPUFFS,
39 C   1   NPUFFS,DXS,DYS,FAC,ADT
40 C   COMMON/WINDS/STDIST,STNUM,U,V,UU,VV
41 C
42 C ** SCREEN CLEAR COMMAND STRING FOR TVI-912C
43 C   DATA CLR/0000033073000/
44 C
45 C ** DEFINE AND INITIALIZE GRID, MODEL, RECEPTORS AND RELEASE
46 C
47 C   CALL ADATE(RDATE,RTIME)
48 C
49 C   WRITE(6,2) CLR
50 C   2 FORMAT(1X,A4)
51 C   WRITE(6,4) RTIME, RDATE
52 C   4 FORMAT(//////,15X,'MESOI -- THE INTERACTIVE EDITION OF MESO',
53 C   +   //,26X,'VERSION 1.0   OCTOBER, 1981',
54 C   +   //,26X,'TIME = ',A8,//,26X,'DATE = ',A8,////)
55 C   PAUSE 'HIT RETURN TO CONTINUE'
56 C
57 C   10 CALL GRIDIN(DELXY,NUMSTA)
58 C   20 CALL INIT(FAC,ADT,DELXY,XS,YS,NUMSTA)
59 C   CALL RCPTIN(DELXY)
60 C   CALL RELEAS(NPH,DELXY)
61 C
62 C   ICOL = 16
63 C   IROW = 16
64 C   WRITE(9) TITLE,ICOL,IROW,XSOURC,YSOURC
65 C

```

CNTRL Computer Code

```

66      TPUFFS = 0
67      NPUFFS = 0
68      PFLAG = 0
69      NXTDAY = 0
70      DFLAG = 0
71      PREVDY = DDAY
72      PREVHR = DHR
73  C
74  C  ** HOURLY LOOP FOR SIMULATION
75      DO 100 SHR = 1,48
76          IF (DFLAG.EQ.1) GOTO 125
77  C  ** CHECK TO SEE IF OBSERVED DATA @LU=10! IS EXHAUSTED
78  C  ** IF SO, SWITCH TO FORECAST DATA @LU=11! AND SET DFLAG
79          IF (NXTDAY.NE.888) THEN
80              GOTO 105
81          ELSE
82              DFLAG = 1
83              CALL LOCATE (DDAY,DHR,LERROR,DFLAG)
84              GOTO 125
85          END IF
86      105  READ (10,110,END=500,ERR=600) DDAY,DHR,DREC,STAB,LDEPTH,
87          1  (DATA(I),I=1,10)
88      110  FORMAT (1X,I3,I2,I1,1X,I1,1X,I3,10(1X,I5))
89  C
90          READ (10,120,END=500,ERR=600) (DATA(I),I=11,20)
91          READ (10,120,END=500,ERR=600) (DATA(I),I=21,30)
92      120  FORMAT (13X,10(1X,I5))
93          READ (10,122,END=500,ERR=600) NXTDAY
94      122  FORMAT (1X,I3)
95          BACKSPACE 10
96          GOTO 128
97  C
98      125  READ (11,110,END=500,ERR=600) DDAY,DHR,DREC,STAB,LDEPTH,
99          1  (DATA(I),I=1,10)
100          READ (11,120,END=500,ERR=600) (DATA(I),I=11,20)
101          READ (11,120,END=500,ERR=600) (DATA(I),I=21,30)
102  C
103      128  LDEPTH = LDEPTH * 10
104  C
105  C
106          IF (TPUFFS.GT.200) CALL CLEAN
107  C
108          CALL WIND (DDAY,DHR,DATA,UU,VV,NUMSTA)
109  C
110          DO 340 IADV = 1, NPH
111              TINC = (IADV - 1) * ADT
112              IF (PFLAG.EQ.1) GOTO 130
113              IF (RELDAY.NE.PREVDY) GOTO 140
114              IF (RELHR.LT.PREVHR) GOTO 140
115              IF (RELHR.EQ.PREVHR.AND.IADV.EQ.PARTHR) THEN
116                  PFLAG = 1
117                  WRITE (6,135) PREVHR, IADV
118      135          FORMAT (5X,'PUFF RELEASE FLAG SET ---> AFTER HOUR ',I2,
119          1  ' ADV STEP ',I2,/)
120              ELSE
121                  GOTO 140
122              END IF
123  C
124      130  IF (NPUFFS.LT.MAXPUF) CALL PUFFR (ACNST)
125      140  DO 330 M = 1, TPUFFS
126              IF (MF(M).EQ.0) GOTO 330
127  C

```

CNTRL Computer Code (contd)

```

128      IF(XP(M).LE.0.0.OR.XP(M).GT.15.0) GOTO 150
129      IF(YP(M).LE.0.0.OR.YP(M).GT.15.0) GOTO 150
130      MOFG = 0
131      C
132      CALL PUFFM(M,DXM,DYM,TINC,MOFG)
133      C
134      IF(MOFG.NF.0) GOTO 150
135      DXS(M) = DXM
136      DYS(M) = DYM
137      GOTO 160
138      150      DXM = DXS(M)
139      DYM = DYS(M)
140      160      DS = SQRT(DXM**2 + DYM**2)
141      DXM = DXM / NSI
142      DYM = DYM / NSI
143      C
144      DSMTR = DS / NSI * DELXY
145      DO 320 JN = 1, NSI
146      CALL SIGMA(DSMTR,M,TPUFFS,STAB,LDEPTH,JN,
147      + SIGMAZ(M),SIGMAY(M),STOTAL(M))
148      C
149      SIGYSQ = SIGMAY(M) * SIGMAY(M)
150      HSGSQ = (-0.5 * (DELXY / 2.0) ** 2) / SIGYSQ
151      PUFCHI = OP(M) / (SIGYSQ * SIGMAZ(M))
152      IF(PUFCHI.LE.CHIMIN) GOTO 200
153      C
154      RP = (SIGMAY(M) * SQRT(-2.*ALOG(CHIMIN/PUFCHI)))/DELXY
155      XP(M) = XP(M) + DXM
156      YP(M) = YP(M) + DYM
157      C
158      IF(XP(M)+RP.LT.0.0) GOTO 200
159      IF(XP(M)-RP.GT.15.0) GOTO 200
160      IF(YP(M)+RP.LT.0.0) GOTO 200
161      IF(YP(M)-RP.LE.15.0) GOTO 210
162      200      MF(M) = 0
163      GOTO 330
164      C
165      210      RP = RP * 2.0
166      ISTRT = (XP(M) * 2.0) - RP + 2
167      ISTOP = (XP(M) * 2.0) + RP + 1
168      JSTRT = (YP(M) * 2.0) - RP + 2
169      JSTOP = (YP(M) * 2.0) + RP + 1
170      C
171      IF(ISTRT.LT.1) ISTRT = 1
172      IF(ISTOP.GT.31) ISTOP = 31
173      IF(JSTRT.LT.1) JSTRT = 1
174      IF(JSTOP.GT.31) JSTOP = 31
175      C
176      C ** CALCULATE NEW CONCENTRATIONS FOR EACH CHI GRID POINT
177      C ** INFLUENCED BY THE CURRENT PUFF
178      C
179      DO 310 I = ISTRT, ISTOP
180      DO 300 J = JSTRT, JSTOP
181      RSQ = (((XP(M)*2.0) - XS(I))**2) +
182      1      (((YP(M)*2.0) - YS(J))**2)
183      IF(RSQ.GT.(RP*RP)) GOTO 300
184      PCHI = PUFCHI * EXP(HSGSQ * RSQ)
185      CHI(I,J) = CHI(I,J) + PCHI
186      300      CONTINUE
187      310      CONTINUE
188      320      CONTINUE
189      330      CONTINUE
190      340      CONTINUE
191      C

```

CNTRL Computer Code (contd)


```

192         IF(NRCPT.LT.1) GOTO 350
193         ONOFF = 0
194         IF(PREVHR.EQ.ONTIM) CALL RCPTR(ONOFF)
195         ONOFF = 1
196         IF(DHR.EQ.OFFTIM) CALL RCPTR(ONOFF)
197     C
198     350 DO 650 I = 1, 16
199           DO 640 J = 1, 16
200             U(I,J) = UU(I,J)
201             V(I,J) = VV(I,J)
202     640 CONTINUE
203     650 CONTINUE
204         PREVDY = DUAY
205         PREVHR = DHR
206     C
207     C COUNT THE ACTIVE PUFFS
208         IPSUM = 0
209         DO 670 M = 1, TPUFFS
210           IPSUM = IPSUM + MF(M)
211     670 CONTINUE
212     C
213         IEXIT = 0
214         CALL PRINTE(IPSUM,IEXIT)
215     C
216     C ** WRITE MATRIX TO UNIT 7 FOR LATER USE BY NEWCONTUR
217         WRITE(7) CHI, DHR
218         IF(IEXIT.EQ.1) GOTO 390
219     C
220     100 CONTINUE
221     C
222     390 WRITE(6,400)
223     400 FORMAT(5X,'END OF SIMULATION',///)
224         IF(IEXIT.NE.1) THEN
225             WRITE(6,420)
226     420 FORMAT(5X,'MESO TERMINATED NORMALLY',///)
227         ELSE
228             WRITE(6,430)
229     430 FORMAT(5X,'MESO TERMINATED BY USER PRIOR TO 48 HOUR MAX',///)
230         END IF
231     C
232         GOTO 515
233     C
234     500 WRITE(6,510) SHR
235     510 FORMAT(5X,'DATA EOF ENCOUNTERED DURING HOUR ',I2,
236           1 ' OF THE SIMULATION')
237     515 WRITE(6,520)
238     520 FORMAT(5X,'DO YOU WISH TO RESTART? Y OR N')
239     READ(5,530,END=515,ERR=515) SELECT
240     530 FORMAT(A1)
241     IF(SELECT.NE.'Y') STOP 'END MESOI EXECUTION -- ADD END FILE'
242     REWIND 10
243     REWIND 11
244     C
245     535 WRITE(6,540)
246     540 FORMAT(5X,'DO YOU WISH TO REINITIALIZE THE GRID? Y OR N')
247     READ(5,530,END=535,ERR=535) SELECT
248     IF(SELECT.EQ.'Y') GOTO 10
249     GOTO 20
250     C
251     600 WRITE(6,610) SHR
252     610 FORMAT(5X,'DATA READ ERROR DURING HOUR ',I2,
253           1 ' OF THE SIMULATION --> STOP')
254     STOP
255     END

```

CNTRL Computer Code (contd)

ADATE

ADATE is a UNIVAC system subroutine that provides the user with the calendar date and time of the subroutine call. In MESOI it is used to establish the date and time of program execution. This information is provided to assist the user in run identification; it does not enter into the model simulation.

GRIDIN

GRIDIN is the subroutine that initializes the wind grid and establishes the stations for which wind data are available. MESOI is currently configured to accept wind data from 30 locations. The names and locations for 22 of these stations are predefined for Hanford in the data statements at the beginning of GRIDIN. The wind grid dimensions and grid spacing are also predefined.

In the section of GRIDIN from line 50 through line 57, the user is given the opportunity to expand or contract the wind grid by changing DELXY. Once DELXY is set, the positions of the wind stations, given in distance east or west of the Hanford Meteorology Station (grid center), are converted to grid positions and the status of the stations is reviewed. The status flags can be changed by the user and new wind stations can be added in the section of the code from line 84 through line 146. This section of code is repeated until no further changes are desired.

When the initialization of the wind stations is complete, REARNG is called, if necessary, to delete those stations that are not operational (status flag = 1). Then STRAY is called to identify the 10 wind stations closest to each point in the wind grid. ASCND is called from STRAY to arrange these stations in order of increasing distance from the grid points.

```

1      C      ** GRIDIN
2      C
3      C      ** INITIALIZATION OF THE GRID AND SET UP OF STATIONS
4      C
5      SUBROUTINE GRIDIN(DELXY,NUMSTA)
6      C
7      REAL XSTA(30),YSTA(30)
8      REAL XDIST(30),YDIST(30),USTA(30),VSTA(30)
9      C
10     INTEGER STATUS(30),ACTSTA,STANUM(30)
11     C
12     CHARACTER*1 SEL
13     CHARACTER NAMST*4(30)
14     C
15     COMMON/STATN/XSTA,YSTA,NAMST,STATUS,RCH,ACTSTA,USTA,VSTA
16     C
17     PARAMETER NCOLS=16, NROWS=16
18     C
19     DATA NAMST/'PROS','EUC ','ARMY','RSPG','EDNA','200E',
20     1          '200W','WAHI ','FFTF','YAKR','300A','WYFR',
21     2          '100N','WPPS','FRNK','GABL','RING','RICH',
22     3          'SAGE','RMTN','HMS ','PASC','8* '  '/'
23     C
24     DATA XDIST/ 11.5,  6.0,  4.0, -6.5, 13.0,  5.5,
25     1          -1.5,-13.0, 11.0, -7.5, 19.0, 12.0,
26     2          2.0, 18.0, 23.0,  7.5, 20.5, 18.5,
27     3          18.0,  1.0,  0.0, 31.5, 8*0.0/
28     C
29     DATA YDIST/-15.5,-14.5, -7.5, -3.5,  2.0,  0.0,
30     1          -1.5, 18.0,-11.5,  2.0,-16.5, -8.0,
31     2          10.0, -9.5,-12.5,  3.5, -2.0,-22.0,
32     3          8.5,-19.5,  0.0,-27.0,8*0.0/
33     C
34     DATA STATUS/30*0/
35     DATA RCH/5.0/
36     DATA CLH/0033073000000/
37     WRITE(6,90) CLR
38     90 FORMAT(1X,A4)
39     WRITE(12,92)
40     92 FORMAT(1H1)
41     C
42     DELXY = 5000.0
43     WRITE(6,100)
44     WRITE(12,100)
45     100 FORMAT(5X,'MESO ---> GRID INITIALIZATION',/)
46     WRITE(6,110) NCOLS, NROWS, DELXY
47     110 FORMAT(5X,'THE CURRENT WIND GRID IS:',/,8X,I3,' ROWS',5X,
48     1          I3,' COLUMNS',/,8X,'DELXY = ',F10.2,' METERS'/)
49     115 WRITE(6,120)
50     120 FORMAT(/5X,'DO YOU WANT A DIFFERENT GRID SPACING? Y OR N')
51     READ(5,130,END=115,ERR=115) SEL
52     130 FORMAT(A1)
53     IF(SEL.EQ.'Y') GOTO 300
54     C
55     135 WRITE(6,140)
56     140 FORMAT(/5X,'SPECIFY NEW DELTA XY (IN METERS)')

```

Subroutine GRIDIN

```

57      HEAD(5,*,END=135,ERR=135) DELXY
58      C
59      300 WRITE(6,90) CLR
60      WRITE(6,310)
61      310 FORMAT(5X,'MESO ---> STATION INITIALIZATION',/)
62      315 NUMSTA = 0
63      NSTAT = 0
64      C
65      DO 320 I = 1, 30
66          XSTA(I) = (XDIST(I) * 1000. / DELXY) + 7.5
67          YSTA(I) = (YDIST(I) * 1000. / DELXY) + 7.5
68          IF(NAMST(I).EQ.' ') GOTO 330
69          NUMSTA = NUMSTA + 1
70          IF(STATUS(I).EQ.1) NSTAT = NSTAT + 1
71      320 CONTINUE
72      C
73      330 WRITE(6,340) NUMSTA, NSTAT
74      340 FORMAT(5X,'THERE ARE CURRENTLY ',I2,' STATIONS WITH ',
75      1 I2,' DISABLED',/)
76      WRITE(6,350)
77      350 FORMAT(6X,'STA NAME',3X,'GRIDX',3X,'GRIDY',5X,'STATUS')
78      C
79      DO 370 I = 1, NUMSTA
80          WRITE(6,360) I,NAMST(I),XSTA(I),YSTA(I),STATUS(I)
81      360 FORMAT(6X,I2,2X,A4,3X,F6.2,2X,F6.2,6X,I1)
82      370 CONTINUE
83      C
84      375 WRITE(6,380)
85      380 FORMAT(/,5X,'ANY CHANGES TO STATUS FLAGS?',
86      1 ' Y OR N')
87      READ(5,390,END=375,ERR=375) SEL
88      390 FORMAT(A1)
89      IF(SEL.NE.'Y') GOTO 446
90      C
91      400 WRITE(6,410)
92      410 FORMAT(/5X,'HOW MANY STATIONS TO BE CHANGED?')
93      READ(5,*,END=400,ERR=400) ICHG
94      IF(ICHG.EQ.0) GOTO 450
95      IF(ICHG.LE.NUMSTA) GOTO 425
96      WRITE(6,422)
97      422 FORMAT(/5X,'VALUE EXCEEDS NUMBER OF CURRENT STATIONS',/)
98      GOTO 400
99      C
100     425 WRITE(6,430)
101     430 FORMAT(/5X,'ENTER STATION NUMBERS TO BE CHANGED --> N,N,N...')
102     READ(5,*,END=425,ERR=425) (STANUM(I),I=1,ICHG)
103     DO 445 I = 1, ICHG
104         J = STANUM(I)
105         IF(STATUS(J).EQ.0) THEN
106             STATUS(J) = 1
107         ELSE
108             STATUS(J) = 0
109         END IF
110     445 CONTINUE
111     GOTO 315
112     C
113     446 WRITE(6,447)

```

Subroutine GRIDIN (contd)

```

114      447 FORMAT(/5X,'ANY STATIONS TO BE ADDED? Y OR N')
115      READ(5,448,END=446,ERR=446) SEL
116      448 FORMAT(A1)
117      IF(SEL.NE.'Y') GOTO 600
118      450 WRITE(6,460)
119      460 FORMAT(/5X,'HOW MANY STATIONS TO BE ADDED?')
120      READ(5,*,END=450,ERR=450) IADD
121      IF(IADD.EQ.0) GOTO 600
122      IF(NUMSTA+IADD.LE.30) GOTO 490
123      WRITE(6,480)
124      480 FORMAT(5X,'ONLY 30 STATIONS ALLOWED')
125      GOTO 450
126
127      C
128      490 WRITE(6,500)
129      500 FORMAT(5X,'EACH STATION SPECIFICATION MUST INCLUDE:','/,
129      1 7X,'STATION ID -- 4 CHARACTERS','/,7X,
130      2 1X AND Y DISTANCES IN KILOMETERS FROM HMS',/,)
131
132      C
133      DO 550 I = 1, IADD
134      502 WRITE(6,504) NUMSTA+I
135      504 FORMAT(5X,'SPECIFY 4 CHARACTER NAME FOR STATION ',I2,/,)
136      READ(5,506,END=502,ERR=502) NAMST(NUMSTA+I)
137      506 FORMAT(A4)
138      510 WRITE(6,520) NUMSTA+I
139      520 FORMAT(5X,'SPECIFY X AND Y DISTANCES FOR STATION ',I2,/,)
140      READ(5,*,END=510,ERR=510)
141      1 XDIST(NUMSTA+I), YDIST(NUMSTA+I)
142      IF(ABS(XDIST(NUMSTA+I)).GT.(7.5*DELXY)) GOTO 800
143      IF(ABS(YDIST(NUMSTA+I)).GT.(7.5*DELXY)) GOTO 800
144      550 CONTINUE
145      GOTO 315
146
147      C
148      600 CONTINUE
149      ACTSTA = NUMSTA - NSTAT
150      IF(NSTAT.NE.0) CALL REARNG(NUMSTA)
151      CALL STRAY(ACTSTA)
152
153      C
154      DO 610 I = 1, 30
155      USTA(I) = 0.0
156      VSTA(I) = 0.0
157      610 CONTINUE
158
159      C
160      WRITE(6,630) RCH
161      630 FORMAT(5X,'INTERPOLATION RADIUS IS ',F7.3,' GRID UNITS',/,)
162      635 WRITE(6,640)
163      640 FORMAT(/5X,'DO YOU WANT TO CHANGE THE RADIUS? Y OR N')
164      READ(5,650,END=635,ERR=635) SEL
165      650 FORMAT(A1)
166      IF(SEL.NE.'Y') GOTO 680
167      655 WRITE(6,660)
168      660 FORMAT(5X,'ENTER NEW RADIUS')
169      READ(5,*,END=655,ERR=655) RCH
170      680 CONTINUE
171      WRITE(6,700)
172      700 FORMAT(/5X,'** END GRID INITIALIZATION **',/,)
173      PAUSE 'HIT RETURN TO CONTINUE'
174
175      C

```

Subroutine GRIDIN (contd)

```

171      C WRITE COMPLETED GRID INFORMATION TO OUTPUT FILE
172      WRITE(12,110) NCOLS,NROWS,DELXY
173      WRITE(12,340) NUMSTA, NSTAT
174      WRITE(12,350)
175      DO 750 I = 1, NUMSTA
176      WRITE(12,360) I,NAMST(I),XSTA(I),YSTA(I),STATUS(I)
177      750 CONTINUE
178      WRITE(12,630) RCH
179      WRITE(12,700)
180      RETURN
181      C
182      800 WRITE(6,810) NUMSTA+I
183      810 FORMAT(/5X,'NEW STATION NUMBER ',I2,' IS OFF THE GRID',/)
184      GOTO 446
185      C
186      END

```

Subroutine GRIDIN (contd)

REARNG

Subroutine REARNG deletes those wind stations that are identified as not operational by their status flags from the array of stations to be used in wind field interpolation. Both station names and positions are deleted.

STRAY

STRAY determines the 10 wind stations closest to each point in the wind grid. These are the wind stations that will be used in the wind field interpolation at the grid point.

ASCND

Subroutine ASCND takes the 10 wind stations closest to each grid point and arranges them in order of increasing distance from the point. As MESOI searches for data for use in the wind field interpolation at a point, it goes down these lists.

```

1      C      ** REARNG
2      C
3      C      ** REMOVES STATIONS WITH STATUS FLAG SET FROM THE
4      C      **      SET OF ACTIVE STATIONS TO BE USED IN WIND INTERPOLATION
5      C
6      C      SUBROUTINE REARNG(NUMSTA)
7      C
8      C      REAL    XSTA(30), YSTA(30)
9      C
10     C      INTEGER STATUS(30)
11     C
12     C      CHARACTER NAMST*4(30)
13     C
14     C      COMMON/STATN/XSTA,YSTA,NAMST,STATUS
15     C
16     C      I = 0
17     C      DO 100 K = 1, NUMSTA
18     C          IF(STATUS(K).EQ.1) GOTO 100
19     C          I = I + 1
20     C          XSTA(I) = XSTA(K)
21     C          YSTA(I) = YSTA(K)
22     C          NAMST(I) = NAMST(K)
23     C      100 CONTINUE
24     C
25     C
26     C      WRITE(6,200)
27     C      200 FORMAT(5X,'REARNG:  DISABLED STATIONS REMOVED FROM LIST',/)
28     C      RETURN
29     C      END

```

Subroutine REARNG


```

1      C  ** STRAY
2      C
3      C  ** SETS UP THE STATION ARRAY FOR EACH WIND GRID POINT
4      C
5          SUBROUTINE STRAY(NUMSTA)
6      C
7          REAL XSTA(30),YSTA(30)
8          REAL STDIST(10,16,16)
9          REAL U(16,16),V(16,16),UU(16,16),VV(16,16)
10         REAL RT(30)
11      C
12         INTEGER STATUS(30), STNUM(10,16,16), NSB(30)
13      C
14         CHARACTER NAMST*4(30)
15      C
16         COMMON/STATN/XSTA,YSTA,NAMST,STATUS
17         COMMON/WINDS/STDIST,STNUM,U,V,UU,VV
18      C
19         XG = 0.0
20         DO 300 I = 1, 16
21             YG = 0.0
22             DO 200 J = 1, 16
23                 DO 100 L = 1, NUMSTA
24                     NSB(L) = L
25                     RT(L) = (XSTA(L)-XG)**2 + (YSTA(L)-YG)**2
26             100 CONTINUE
27         C
28             CALL ASCND(RT,NSB,NUMSTA)
29             DO 150 L = 1, NUMSTA
30                 STDIST(L,I,J) = RT(L)
31                 STNUM(L,I,J) = NSB(L)
32                 IF(L.EQ.10) GOTU 160
33             150 CONTINUE
34             160 YG = YG + 1.0
35             200 CONTINUE
36                 XG = XG + 1.0
37             300 CONTINUE
38         C
39             WRITE(6,400) NUMSTA
40             400 FORMAT(5X,'STRAY: STATION ARRAY SET UP FOR EACH GRID ',
41             1 'POINT',/,15X,I3,' ACTIVE STATIONS',/)
42             RETURN
43         END

```

Subroutine STRAY

```

1      C      ** ASCND
2      C
3      C      ** FOR A GIVEN GRID POINT, STATIONS ARE ARRANGED
4      C      **      IN ASCENDING ORDER BY DISTANCE FROM THE POINT
5      C
6      C      **      X -- DISTANCE (X**2 + Y**2)
7      C      **      N -- STATION NUMBER
8      C      **      NP - TOTAL NUMBER OF STATIONS
9      C
10     C      SUBROUTINE ASCND(X,N,NP)
11     C
12     C      REAL X(30)
13     C      INTEGER N(30)
14     C
15     C      DO 110 I = 1,NP-1
16     C          J = 0
17     C          DO 100 K = 1, NP-1
18     C              IF(X(K+1).GT.X(K)) GOTO 100
19     C              J = K + 1
20     C              TMP = X(K)
21     C              NTMP = N(K)
22     C              X(K) = X(J)
23     C              N(K) = N(J)
24     C              X(J) = TMP
25     C              N(J) = NTMP
26     C      100 CONTINUE
27     C          IF(J.EQ.0) GOTO 120
28     C      110 CONTINUE
29     C
30     C      120 RETURN
31     C      END

```

Subroutine ASCND

INIT

Subroutine INIT is the primary initialization route for the portion of MESOI dealing with the frequency of puff releases and sampling. It also provides the user with the opportunity to enter a title for each simulation. The puff release rate, sampling interval and minimum puff concentration are defined in INIT and are used to compute several other constants that are important for program operation.

Following the setting of model parameters, INIT requests that the user specify the date and time for starting the simulation. This date and time are used as the beginning date and time for the wind field interpolation; they are not used to start the puff releases. INIT uses subroutines JULIAN and LOCATE. JULIAN converts calendar date to Julian day, and LOCATE positions the meteorological data input files at the proper records for starting the simulation.

JULIAN

JULIAN converts month, day and year to Julian day within the year. The Julian day returned by the subroutine is correct for both regular and leap years, except those years ending in 00. Variable names in JULIAN do not conform to the names used in the calling program elements. The subroutine call lists should be used to determine correspondence between names in Julian and in the calling element.

LOCATE

Subroutine LOCATE positions the observed and forecast meteorological data files to the proper records for the start of the simulation. The observed data file is positioned first when the starting day and time are defined for the simulation. If CONTRL determines that there are no observed data, LOCATE is called to position the forecast file. If the proper location cannot be found, the user is informed of the specific problem encountered.

WIND

Subroutine WIND is divided into two sections. The first prepares the wind data at each station for use in the wind field interpolation, and the second

performs the interpolation. In the first section the wind data are decoded, checked for reasonableness and transformed from direction and speed to u and v (east-west and north-south) components. The wind speed components are then converted from miles per hour to meters per second and stored in the arrays USTA and VSTA.

In performing the wind field interpolation, WIND uses all available wind data from stations within the interpolation radius. If there are fewer than 3 stations within this distance, WIND will include data from more distant stations until the data from three stations have been used. If data are available from fewer than 3 stations, the user will be informed of the limited data base.

BCWR46*MESOI(1).INIT

```

1      C  ** INIT
2      C
3      C  ** PRIMARY INITIALIZATIONS OF THE MODEL, INCLUDING:
4      C  **    IDENTIFICATION TITLE, CURRENT DATE AND TIME,
5      C  **    AND BASIC SIMULATION PARAMETERS
6      C
7      C      SUBROUTINE INIT(FAC,ADT,DELXY,XS,YS,NUMSTA)
8      C
9      C      REAL CHI(32,32), XS(31),YS(31)
10     C      REAL STDIST(10,16,16), U(16,16), V(16,16),
11     C      * UU(16,16), VV(16,16)
12     C
13     C      INTEGER SDAY,SHR,NPH,DT,NSI,DDAY,DHR,STHR,STDAY,DFLAG
14     C      INTEGER TITLE(50), DATA(30), STNUM(10,16,16)
15     C
16     C      CHARACTER*8 RDATE,RTIME.
17     C
18     C      COMMON/MASTER/RDATE,RTIME,TITLE,NPH,DT,CHIMIN,DDAY,DHR,NSI,
19     C      1 CHI,ACNST,SDAY,SHR
20     C      COMMON/WINDS/STDIST,STNUM,U,V,UU,VV
21     C
22     C      DATA CLR/0000033073000/
23     C      WRITE(6,80) CLR
24     C      80 FORMAT(1X,A4)
25     C      WRITE(6,90)
26     C      90 FORMAT(5X,'MESO ----> PRIMARY INITIALIZATION',/)
27     C
28     C      100 WRITE(6,110)
29     C      110 FORMAT(5X,'ENTER RUN IDENTIFICATION TITLE OF UP TO',
30     C      1 ' 50 CHARACTERS')
31     C      READ(5,120,END=100,ERR=100) TITLE
32     C      120 FORMAT(50A1)
33     C
34     C  ** SET MODEL PARAMETERS:
35     C  **    NPH ----- NUMBER OF PUFFS PER HOUR
36     C  **    DT ----- NUMBER OF MINUTES BETWEEN PUFF SAMPLINGS
37     C  **    CHIMIN -- INITIAL MINIMUM SIGNIFICANT CONCENTRATION??
38     C  **    NSI ----- NUMBER OF TIMES PUFF IS SAMPLED BETWEEN RELEASES
39     C
40     C      NPH = 6
41     C      DT = 2
42     C      CHIMIN = 1.0E-15 * (DT / 60.)
43     C      NSI = 60 / (DT * NPH)
44     C
45     C      IF((MOD(60,NPH)).NE.0) GOTO 800
46     C      IF(DT.GT.(60/NPH)) GOTO 800
47     C      IF(MOD((60/NPH),DT).NE.0) GOTO 800
48     C
49     C      DO 200 I = 1, 31
50     C        DO 200 J = 1, 31
51     C          XS(I) = I - 1
52     C          CHI(I,J) = 0.0
53     C          YS(J) = J - 1
54     C      200 CONTINUE
55     C
56     C      ADT = 1.0 / NPH
57     C      FAC = ADT * 3600 / DELXY
58     C      ACNST = 3.0 * (DT / 60.0) / (6.283185 ** 1.5)
59     C      205 WRITE(6,210)
60     C      210 FORMAT(//5X,'ENTER DATE FOR START OF SIMULATION --> MMDDYY')
61     C      READ(5,215,END=205,ERR=205) IMO, IDY, IYR
62     C      215 FORMAT(10I2)
63     C      CALL JULIAN(IYR,IMO,IDY,STDAY)
64     C

```

Subroutine INIT

```

65         IF (IMO.LT.1.OR.IMO.GT.12.OR.IDY.LT.1.OR.IDY.GT.31) THEN
66             WRITE(6,220) IMO, IDY
67         220 FORMAT(5X,'A DATE OF ',2I2,' IS IMPOSSIBLE ',
68             1      '--> TRY AGAIN',//)
69             GOTO 205
70         ELSE
71             WRITE(6,225) STDAY, IYR
72         225 FORMAT(/5X,'JULIAN DATE = ',I3,4X,'19',I2,/)
73         END IF
74     C
75         230 WRITE(6,240)
76         240 FORMAT(/5X,'ENTER HOUR FOR START OF SIMULATION',/)
77         HEAD(5,*,END=230,ERR=230) STHR
78         IF (STHR.LT.1.OR.STHR.GT.24) THEN
79             WRITE(6,250) STHR
80         250 FORMAT(5X,'A STARTING HOUR OF ',I3,' IS IMPOSSIBLE ',
81             1      '--> TRY AGAIN',//)
82             GOTO 230
83         END IF
84     C
85         DFLAG = 0
86         CALL LOCATE(STDAY,STHR,LERROR,DFLAG)
87         IF (LERROR.EQ.1) GOTO 205
88     C
89     C  ** LOAD FIRST HOURS WINDS INTO U AND V
90     C
91         READ(10,270,END=900,ERR=900) (DATA(I),I=1,10)
92         READ(10,270,END=900,ERR=900) (DATA(I),I=11,20)
93         READ(10,270,END=900,ERR=900) (DATA(I),I=21,30)
94         270 FORMAT(13X,10(1X,I5))
95     C
96         CALL WIND(STDAY,STHR,DATA,U,V,NUMSTA)
97         DDAY = STDAY
98         DHR = STHR
99     C
100        PAUSE 'HIT RETURN TO CONTINUE'
101        WRITE(12,300) TITLE,RDATE,RTIME
102        300 FORMAT(/5X,50A1,5X,A8,2X,A8)
103        WRITE(12,310) STHR, IMO, IDY
104        310 FORMAT(/5X,'SIMULATION STARTS AT HOUR ',I2,' ON DAY ',2I2,/)
105        RETURN
106    C
107        800 WRITE(6,810)
108        810 FORMAT(5X,'INCORRECT RELATIONSHIP OR BAD VALUES FOR ',
109            1      'VARIABLE NPH AND/OR DT',/,7X,'CHECK SPECIFICATIONS')
110        STOP
111    C
112        900 WRITE(6,910)
113        910 FORMAT(/5X,'EOF OR ERROR DURING READ TO INITIALIZE ',
114            +      'WIND FIELD (U AND V) ',//)
115        STOP
116        END

```

Subroutine INIT (contd)

```

1      SUBROUTINE JULIAN(IYR,MO,IDAY,JDATE)
2      C
3      C      JULIAN CONVERTS YEAR, MONTH AND DAY TO JULIAN DATE
4      C
5      C      CHECK FOR MONTH INDEX IN RANGE
6      C
7      IF(MO.LE.0.OR.MO.GE.13) GO TO 30
8      C
9      C      CONVERT TO JULIAN DATE
10     C
11     GO TO (1,2,3,4,5,6,7,8,9,10,11,12),MO
12     1 JDATE=IDAY
13     GO TO 40
14     2 JDATE=IDAY+31
15     GO TO 20
16     3 JDATE=IDAY+59
17     GO TO 20
18     4 JDATE=IDAY+90
19     GO TO 20
20     5 JDATE=IDAY+120
21     GO TO 20
22     6 JDATE=IDAY+151
23     GO TO 20
24     7 JDATE=IDAY+181
25     GO TO 20
26     8 JDATE=IDAY+212
27     GO TO 20
28     9 JDATE=IDAY+243
29     GO TO 20
30     10 JDATE=IDAY+273
31     GO TO 20
32     11 JDATE=IDAY+304
33     GO TO 20
34     12 JDATE=IDAY+334
35     20 CONTINUE
36     C
37     C      ADJUST FOR LEAP YEAR
38     C
39     A=FLOAT(IYR)/4-IYR/4
40     IF(A.EQ.0.AND.MO.GE.3) JDATE=JDATE+1
41     GO TO 40
42     30 CONTINUE
43     JDATE=0
44     40 CONTINUE
45     RETURN
46     END

```

Subroutine JULIAN

```

1      C  ** LOCATE
2      C
3      C  ** PROGRAM TO SEARCH THE DATA FILES FOR THE REQUIRED
4      C  ** STARTING RECORDS. THE OBSERVATION RECORDS ARE SEARCHED
5      C  ** FIRST FOR DAY, THEN HOUR AND RECORD NUMBER.
6      C
7      C      SUBROUTINE LOCATE(SDAY, SHR, LERROR,DFLAG)
8      C
9      C      INTEGER SDAY, SHR, DAY, HOUR, RECNO, DFLAG
10     C
11     C      IF(DFLAG.EQ.1) GOTO 300
12     C      WRITE(6,100)
13     C      100 FORMAT(/5X,'METEOROLOGICAL DATA FILE SEARCH -- ',/)
14     C
15     C      105 READ(10,110,END=600,ERR=800) DAY, HOUR, RECNO
16     C      110 FORMAT(1X,I3,I2,I1)
17     C      IF(DAY.EQ.888) GOTO 600
18     C      IF(RECNO.NE.1) GOTO 820
19     C      IF(DAY.GT.SDAY) GOTO 620
20     C      IF(DAY.EQ.SDAY) GOTO 120
21     C      READ(10,1) IDUM
22     C      READ(10,1) IDUM
23     C      1 FORMAT(A1)
24     C      GOTO 105
25     C
26     C  ** LOCATE PROPER HOUR
27     C
28     C      120 IF(HOUR.EQ.SHR) GOTO 150
29     C      READ(10,1) IDUM
30     C      READ(10,1) IDUM
31     C      GOTO 105
32     C
33     C      150 WRITE(6,200) DAY, HOUR, RECNO
34     C      200 FORMAT(7X,'OBSV FILE POSITIONED AT:  DAY ',I3,3X,' HOUR ',I2,
35     C      1 3X,' RECORD ',I1/)
36     C      BACKSPACE 10
37     C
38     C      READ(11,110,END=640,ERR=840) DAY,HOUR,RECNO
39     C      BACKSPACE 11
40     C      WRITE(6,210) DAY, HOUR, RECNO
41     C      210 FORMAT(7X,'FORECAST FILE STARTS AT:  DAY ',I3,3X,
42     C      * ' HOUR ',I2,3X,' RECORD ',I1,/)
43     C      DFLAG = 1
44     C      LERROR = 0
45     C      RETURN
46     C
47     C      300 WRITE(6,310)
48     C      310 FORMAT(/5X,'FORECAST DATA FILE SEARCH -- ',/)
49     C      315 READ(11,110,END=640,ERR=840) DAY, HOUR, RECNO
50     C      IF(RECNO.NE.1) GOTO 820
51     C      IF(DAY.EQ.SDAY) GOTO 320
52     C      READ(11,1) IDUM
53     C      READ(11,1) IDUM
54     C      GOTO 315
55     C
56     C      320 READ(11,1) IDUM

```

Subroutine LOCATE


```

57      READ(11,1) IDUM
58      IF(HOUR.NE.SHR) GOTO 315
59      READ(11,110,END=640,ERR=840) DAY, HOUR, RECNO
60      BACKSPACE 11
61      C
62      WRITE(6,340) DAY, HOUR, RECNO
63      340 FORMAT(7X,'FORECAST DATA FILE POSITIONED AT:  DAY ',I3,
64      * 3X,' HOUR ',I2,3X,' RECORD ',I1,/)
65      IERROR = 0
66      RETURN
67      C
68      C
69      600 WRITE(6,610) SDAY, SHR
70      610 FORMAT(/5X,'EOF ENCOUNTERED IN OBSERVATION DATA FILE DURING
71      1'SEARCH',/,7X,'FOR DAY ',I3,' HOUR ',I2,/,7X,
72      2'SIMULATION WITH SPECIFIED DATE AND TIME IS IMPOSSIBLE',/)
73      IERROR = 1
74      REWIND(UNIT=10)
75      REWIND(UNIT=11)
76      RETURN
77      C
78      620 WRITE(6,630) DAY, SDAY
79      630 FORMAT(/5X,'DATA FILE STARTS ON DAY ',I3,5X,
80      1'CANNOT SIMULATE DAY ',I3,/)
81      IERROR = 1
82      REWIND(UNIT=10)
83      REWIND(UNIT=11)
84      RETURN
85      C
86      640 WRITE(6,650)
87      650 FORMAT(/5X,'EOF ENCOUNTERED IN FORECAST DATA FILE DURING SKIP',
88      1' TO STARTING POSITION',/,7X,'FILE DOES NOT MATCH OBS FILE',
89      2' --> STOP',/)
90      STOP
91      C
92      800 WRITE(6,810)
93      810 FORMAT(/5X,'READ ERROR IN OBSERVATION DATA FILE --> STOP',/)
94      STOP
95      820 WRITE(6,830) DAY, HOUR, RECNO
96      830 FORMAT(/5X,'INCOMPLETE DATA RECORD --> STOP ',/,
97      17X,'DAY ',I3,' HOUR ',I2,' RECORD ',I1)
98      STOP
99      840 WRITE(6,850)
100     850 FORMAT(/5X,'READ ERROR IN FORECAST DATA FILE -->',
101     * ' STOP',/)
102     STOP
103     END

```

Subroutine LOCATE (contd)

```

1      C      ** WIND
2      C
3      C      ** PROGRAM TO DECODE WIND DATA ELEMENTS INTO DIRECTION
4      C      **      AND SPEEDS THEN INTERPOLATE TO EACH GRID LOCATION
5      C
6      SUBROUTINE WIND(JDAY,HOUR,IData,UG,VG,NUMSTA)
7      C
8      REAL DIR(30), SPD(30), USTA(30), VSTA(30), UG(16,16),
9      1    VG(16,16), XSTA(30), YSTA(30)
10     REAL STDIST(10,16,16), U(16,16), V(16,16), UU(16,16), VV(16,16)
11     C
12     INTEGER IDATA(30), STATUS(30), LFLAG(30)
13     INTEGER STNUM(10,16,16), JDAY, HOUR, ACTSTA
14     C
15     CHARACTER NAMST*4(30)
16     C
17     COMMON/STATN/XSTA,YSTA,NAMST,STATUS,RCH,ACTSTA,USTA,VSTA
18     COMMON/WINDS/STDIST,STNUM,U,V,UU,VV
19     C
20     C      ** DECODE WIND DIRECTION AND SPEED FOR EACH ACTIVE STATION
21     C      **      CHECK FOR MISSING DATA (999'S)
22     C
23     M = 0
24     DO 100 J = 1, NUMSTA
25         IF(STATUS(J).EQ.1) GOTO 100
26         M = M + 1
27         DIR(M) = IDATA(J) / 100
28         SPD(M) = IDATA(J) - DIR(M) * 100
29     C
30     IF(DIR(M).EQ.999.AND.SPD(M).EQ.99) GOTO 90
31     IF(DIR(M).EQ.0.AND.SPD(M).EQ.0) GOTO 90
32     C
33     LFLAG(M) = 0
34     C
35     IF(DIR(M).LT.0.0.OR.DIR(M).GT.360.0)
36     1    WRITE(5,500) J, DIR(M), JDAY, HOUR
37     IF(SPD(M).LT.0.0.OR.SPD(M).GT.45.0)
38     1    WRITE(6,510) J, SPD(M), JDAY, HOUR
39     C
40     C      ** CALCULATE U AND V COMPONENTS AND CONVERT TO METERS/SEC
41     C
42     ANG = (270. - DIR(M)) * (3.1415927 / 180.)
43     USTA(M) = (SPD(M) * COS(ANG)) * 0.44704
44     VSTA(M) = (SPD(M) * SIN(ANG)) * 0.44704
45     GOTO 100
46     C
47     90    LFLAG(M) = 1
48         IF(M.GE.ACTSTA) GOTO 200
49     100    CONTINUE
50     C
51     500    FORMAT(5X,'WARNING -- STATION NUMBER ',I2,'/,7X,
52     1    'DIRECTION OUT OF NORMAL RANGE --> ',F6.1,'/,
53     2    'DAY ',I3,2X,'HOOR ',I2,'//)
54     510    FORMAT(5X,'WARNING -- STATION NUMBER ',I2,'/,7X,
55     1    'SPEED OUT OF NORMAL RANGE --> ',F6.1,'/,7X,
56     2    'DAY ',I3,2X,'HOOR ',I2,'//)

```

Subroutine WIND

```

57      C
58      C  ** WIND INTERPOLATION SECTION
59      C
60      200 DO 280 I = 1, 16
61          DO 270 J = 1, 16
62              SNU = 0.0
63              SNV = 0.0
64              SNO = 0.0
65              NS = 0
66      C
67          DO 220 L = 1, 10
68              LS = STNUM(L,I,J)
69              IF (LFLAG(L,I).EQ.1) GOTO 220
70              IF (STDIST(L,I,J).LE.1.0E-15) GOTO 250
71              IF (NS.LT.3) GOTO 210
72              IF (STDIST(L,I,J).GT.RCH) GOTO 260
73      C
74      210      SNU = SNU + USTA(LS) / STDIST(L,I,J)
75              SNV = SNV + VSTA(LS) / STDIST(L,I,J)
76              SNO = SNO + (1.0 / STDIST(L,I,J))
77              NS = NS + 1
78              IF (L.GT.ACTSTA) GOTO 230
79      220      CONTINUE
80      230      IF (NS.LT.3) WRITE(6,240) NS, I, J, JDAY, HOUR
81      240      FORMAT(5X,'WARNING -- ONLY ',I2,' STATIONS AT ',
82              1      'WIND GRID POINT ',I2,', ',I2,'//7X,'DAY ',I3,
83              2      '5X,'HOUR ',I2, '//)
84              GOTO 260
85      C
86      250      UG(I,J) = USTA(LS)
87              VG(I,J) = VSTA(LS)
88              GOTO 270
89      260      UG(I,J) = SNU / SNO
90              VG(I,J) = SNV / SNO
91      270      CONTINUE
92      280      CONTINUE
93      C
94      RETURN
95      END

```

Subroutine WIND (contd)

RCPTIN

Subroutine RCPTIN is used to initialize the off-grid receptors; if the off-grid receptor option is not desired, an immediate exit from the subroutine is made. If the user elects to make use of the off-grid receptor option, positions for a maximum of 10 receptor locations can be specified.

Exposures are computed for each off-grid receptor for a specified period of time. The duration of the period is selectable, and can range from 1 to 23 hours. Within this limitation, the period can start on one day and end on the next. In RCPTIN the user is requested to specify the hour that the off-grid receptors begin to accumulate their exposure (ONTIM), and the hour that their exposure ends (OFFTIM). All off-grid receptors are activated and deactivated simultaneously.

Finally, RCPTIN determines the weights to be used in the interpolation of exposures at the off-grid positions. These weights are proportional to the inverse square of the distance between the position of the off-grid receptor and the four surrounding grid points.

RELEAS

Subroutine RELEAS is used to initialize the source characteristics. This initialization includes determination of the source position relative to the Hanford Meteorology Station, the date and time of the release, the duration of the release and the rate of release. If the rate of release is known, it must be specified in terms of mass or activity released per minute. If it is not known, a default release rate of one mass or activity unit per hour is assumed.

After the release date and time are entered by the user, RELEAS compares them with the date and time for the start of the simulation. If the release takes place before or more than 48 hours after the start of the simulation, the subroutine writes an error message and requests a revised release date and time.

```

1  C  ** RCPTIN
2  C
3  C  ** INITIALIZATION ROUTINE FOR THE RECEPTORS
4  C  **   SETS UP NUMBER OF RECEPTORS, LOCATIONS, AND ON/OFF TIMES
5  C
6      SUBROUTINE RCPTIN(DELXY)
7  C
8      REAL RPOS(2,10), RWT(4,10), WT(10), RDOSE(10), RDISX(10),
9      1  RDISY(10)
10 C
11     CHARACTER SELECT*1
12 C
13     INTEGER ONTIM, OFFTIM, IP(2,10)
14 C
15     COMMON/RCPT/IP,RWT,WT,ONTIM,OFFTIM,NRCPT,RDOSE
16 C
17     DATA CLR/0033073000000/
18     WRITE(6,5) CLR
19     5  FORMAT(1X,A4)
20     WRITE(6,7)
21     7  FORMAT(5X,'MESO ----> RECEPTOR INITIALIZATION',//)
22     NRCPT = 0
23 C
24     10 WRITE(6,20)
25     20 FORMAT(5X,'DO YOU WISH TO SET UP RECEPTORS? Y OR N')
26     READ(5,30,END=10,ERR=10) SELECT
27     30 FORMAT(A1)
28     IF(SELECT.EQ.'Y') GOTO 105
29 C
30     35 WRITE(6,40)
31     WRITE(12,40)
32     40 FORMAT(//5X,'NO RECEPTORS INITIALIZED',//)
33     GOTO 350
34 C
35     105 WRITE(6,110) NRCPT + 1
36     110 FORMAT(5X,'SPECIFY X AND Y COORDINATES OF RECEPTOR ',12,
37     1  /,'X','IN KILOMETERS FROM HMS',5X,
38     2  'HIT A TO END INPUT MODE',/)
39     READ(5,*,END=130,ERR=130) RDISX(NRCPT+1),RDISY(NRCPT+1)
40     RPOS(1,NRCPT+1) = (RDISX(NRCPT+1) * 1000. / (DELXY/2.0)) + 16.0
41     RPOS(2,NRCPT+1) = (RDISY(NRCPT+1) * 1000. / (DELXY/2.0)) + 16.0
42     NRCPT = NRCPT + 1
43 C
44     IF(NRCPT.GE.10) THEN
45         WRITE(6,120)
46     120  FORMAT(5X,'A MAXIMUM OF 10 RECEPTORS IS ALLOWED',//)
47     ELSE
48         GOTO 105
49     END IF
50 C
51     130 IF(NRCPT.EQ.0) GOTO 35
52 C
53     DO 150 I = 1, NRCPT
54         WRITE(6,140) I, RDISX(I), RDISY(I)
55     140  FORMAT(5X,12,3X,2(2X,F10.2))
56     150 CONTINUE

```

Subroutine RCPTIN

```

57      155 WRITE(6,160)
58      160 FORMAT(5X,'ARE RECEPTOR NUMBER AND COORDINATES CORRECT?')
59      1   ' Y OR N',/)
60      READ(5,30,END=155,ERR=155) SELECT
61      IF(SELECT.EQ.'N') GOTO 10
62
63      C
64      175 WRITE(6,180)
65      180 FORMAT(5X,'ENTER RECEPTOR ON AND OFF TIMES IN HOURS (01-24)')
66      READ(5,9,END=175,ERR=175) UNTIM,OFFTIM
67      IF(UNTIM.LT.1.OR.UNTIM.GT.24) GOTO 400
68      IF(OFFTIM.LT.1.OR.OFFTIM.GT.24) GOTO 400
69      WRITE(6,200) UNTIM, OFFTIM
70      200 FORMAT(5X,'RECEPTORS ON AT ',I2,' AND OFF AT ',I2,/)
71
72      C
73      DO 300 I = 1, NRCPT
74      IX = RPOS(1,I)
75      IY = RPOS(2,I)
76      IP(1,I) = IX
77      IP(2,I) = IY
78      DX = RPOS(1,I) - IX
79      DY = RPOS(2,I) - IY
80      DX1 = 1.0 - DX
81      DY1 = 1.0 - DY
82
83      C
84      IF(DX.LE.0.05.AND.(DY.LE.0.05.OR.DY1.LE.0.05)) GOTO 220
85      IF(DX1.LE.0.05.AND.(DY.LE.0.05.OR.DY1.LE.0.05)) GOTO 230
86
87      C
88      RWT(1,I) = 1.0 / (DX*DX + DY*DY)
89      RWT(2,I) = 1.0 / (DX*DX + DY1*DY1)
90      RWT(3,I) = 1.0 / (DX1*DX1 + DY1*DY1)
91      RWT(4,I) = 1.0 / (DX1*DX1 + DY*DY)
92      WT(I) = RWT(1,I)+RWT(2,I)+RWT(3,I)+RWT(4,I)
93      GOTO 300
94
95      C
96      220 IF(DY.LE.0.05) GOTO 240
97      IP(2,I) = IP(2,I) + 1
98      GOTO 240
99
100      230 IP(1,I) = IP(1,I) + 1
101      IF(DY1.LE.0.05) IP(2,I) = IP(2,I) + 1
102
103      240 RWT(1,I) = 1.0
104      300 CONTINUE
105
106      C
107      WRITE(6,310)
108      310 FORMAT(5X,'END RECEPTOR INITIALIZATION',/)
109      WRITE(12,320) NRCPT
110      320 FORMAT(1H1,5X,'RECEPTOR INITIALIZATION',5X,I2,
111      1   ' RECEPTORS',/)
112      WRITE(12,330)
113      330 FORMAT(5X,'NO.',9X,'CHIX',7X,'CHIY')
114      DO 340 I = 1, NRCPT
115      WRITE(12,140) I, RPOS(1,I), RPOS(2,I)
116      340 CONTINUE
117      WRITE(12,200) UNTIM, OFFTIM
118      350 PAUSE 'HIT RETURN TO CONTINUE'
119      RETURN
120
121      C
122      400 WRITE(6,410)
123      410 FORMAT(5X,'TIME SPECIFIED IS IMPOSSIBLE -- TRY AGAIN',/)
124      GOTO 175
125
126      C
127      END

```

Subroutine RCPTIN (contd)

```

1      C      ** RELEAS
2      C
3      C      ** DEFINITION OF THE RELEASE PARAMETERS AND SOURCE LOCATION
4      C
5          SUBROUTINE RELEAS(NPH,DELXY)
6      C
7          REAL XSOURC,YSOURC,0
8      C
9          CHARACTER SELECT*1
10     C
11         INTEGER RELDAY, STRTD, RELHR, RELMIN, PARTHR,
12         1 DURHR, DURMIN, MAXPUF, STRTH
13     C
14         COMMON/REL/XSOURC,YSOURC,RELDAY,RELHR,
15         1 PARTHR,MAXPUF,0
16     C
17         DATA CLR/0033073000000/
18         WRITE(6,90) CLR
19     90 FORMAT(1X,A4)
20     C
21         WRITE(6,110)
22     110 FORMAT(5X,'MESO ---> RELEASE INITIALIZATION',//)
23     115 WRITE(6,120)
24     120 FORMAT(/5X,'SPECIFY COORDINATES (X,Y) OF SOURCE',
25     * ' IN KILOMETERS FROM HMS',/)
26     C
27         READ(5,*,END=115,ERR=115) XDIST, YDIST
28         XSOURC = XDIST * 1000. / DELAY * 7.5
29         YSOURC = YDIST * 1000. / DELAY * 7.5
30     C
31         IF(XSOURC.LT.0.0.OR.XSOURC.GT.15.0) GOTO 800
32         IF(YSOURC.LT.0.0.OR.YSOURC.GT.15.0) GOTO 800
33     C
34     140 WRITE(6,150)
35     150 FORMAT(/5X,'ENTER DATE OF RELEASE --> MMDDYY')
36         READ(5,155,END=140,ERR=140) IMO, IDY, IYR
37     155 FORMAT(10I2)
38     C
39         IF(IMO.LT.1.OR.IMO.GT.12) GOTO 820
40         IF(IDY.LT.1.OR.IDY.GT.31) GOTO 820
41         CALL JULIAN(IYR,IMO,IDY,RELDAY)
42     C
43         READ(10,170,END=920,ERR=920) STRTD, STRTH
44     170 FORMAT(1X,13,12)
45         BACKSPACE 10
46         IF(RELDAY.LT.STRTD.OR.RELDAY.GT.(STRTD+2)) GOTO 840
47     C
48     175 WRITE(6,180)
49     180 FORMAT(/5X,'HOUR OF RELEASE? 1 - 24 ')
50         READ(5,*,END=175,ERR=175) RELHR
51         IF(RELHR.LT.1.OR.RELHR.GT.24) GOTO 860
52         IF(RELHR.LT.STRTH) GOTO 840
53     C
54     185 WRITE(6,190)
55     190 FORMAT(/5X,'MINUTE OF RELEASE? 0 - 59')
56         READ(5,*,END=185,ERR=185) RELMIN

```

Subroutine RELEAS

```

57      IF (RELMIN.LT.0.OR.RELMIN.GT.59) GOTO 880
58      PARTHR = RELMIN / (60/NPH) + 1
59
60      C
61      195 WRITE(6,200)
62      200 FORMAT(/5X,'DURATION OF RELEASE? HOURS,MINUTES',/,
63      1 7X,'IF CONTINUOUS, ENTER C ')
64      READ(5,*,END=230,ERR=230) DURHR, DURMIN
65
66      C
67      IF (DURHR.LT.0.OR.DURMIN.LT.0) GOTO 900
68      MAXPUF = (DURHR * NPH) + (DURMIN / (60/NPH))
69      WRITE(6,220) MAXPUF
70      220 FORMAT(5X,I4,' PUFFS WILL BE RELEASED')
71      GOTO 300
72      230 DURHR = 0
73      DURMIN = 0
74      MAXPUF = 1000
75      WRITE(6,240) NPH
76      240 FORMAT(5X,'RELEASE WILL BE CONTINUOUS AT ',I3,
77      1  ' PUFFS PER HOUR')
78
79      C
80      300 WRITE(6,310)
81      310 FORMAT(/5X,'IS THE SOURCE TERM KNOWN? Y OR N')
82      READ(5,320,END=300,ERR=300) SELECT
83      320 FORMAT(A1)
84
85      C
86      IF (SELECT.EQ.'Y') THEN
87      330 WRITE(6,340)
88      340 FORMAT(/5X,'INPUT A RELEASE RATE IN MCI PER MINUTE',/)
89      READ(5,*,END=330,ERR=330) Q
90      Q = Q * 60 / NPH
91      ELSE
92      Q = 1.0 / NPH
93      END IF
94
95      C
96      WRITE(12,400) XSOURC, YSOURC
97      400 FORMAT(/5X,'SOURCE IS LOCATED AT WIND GRID ',F4.1,1X,F4.1)
98      WRITE(12,410) RELHR,RELMIN, IMO, IDY, MAXPUF, Q
99      410 FORMAT(/5X,'RELEASE WILL OCCUR AT ',I2,' ON DAY ',
100      1  '212',/,7X,I4,' PUFFS AT ',F6.3,' MCI',/)
101      RETURN
102
103      C
104      800 WRITE(6,810) XSOURC, YSOURC
105      810 FORMAT(/5X,'SOURCE IS OFF GRID -- X = ',F10.2,5X,'Y = ',
106      1  F10.2,/)
107      GOTO 115
108      820 WRITE(6,830) IMO, IDY
109      830 FORMAT(/5X,'A DATE OF ',I2,' IS NOT VALID')
110      GOTO 140
111      840 WRITE(6,850) STRTD,STRTH, RELDAY,RELHR
112      850 FORMAT(/5X,'DATA STARTS ON DAY ',I3,' AT HOUR ',I2,/,5X,
113      1  'A RELEASE ON DAY ',I3,' AT HOUR ',I2,' CANNOT BE SIMULATED')
114      GOTO 140
115      860 WRITE(6,870) RELHR
116      870 FORMAT(/5X,'SPECIFIED HOUR OF RELEASE IS NOT POSSIBLE --> ',
117      1  I5)
118      GOTO 175
119      880 WRITE(6,890) RELMIN

```

Subroutine RELEAS (contd)


```

114      890 FORMAT(/5X,'SPECIFIED MINUTES OF RELEASE NOT POSSIBLE --> ',
115      1      15)
116      GOTO 175
117      900 WRITE(6,910) DURHR.,DURMIN
118      910 FORMAT(/5X,'NEGATIVE VALUES OF DURATION NOT ALLOWED --> ',2I5,/)
119      GOTO 195
120      920 WRITE(6,930)
121      930 FORMAT(/5X,'EOF OR ERROR ENCOUNTERED DURING READ OF DATA',
122      1      ' STARTING DATE')
123      STOP
124      END

```

Subroutine RELEAS (contd)

CLEAN

Subroutine CLEAN is used to delete puffs that are no longer considered in the exposure computations. It is called only when there are more than 200 puffs on the grid. A status flag associated with each puff is stored in the array MF and is initially set to 1. When a puff's concentration drops below the minimum significant concentration defined in INIT, or if the puff leaves the grid, the puff status flag is set to 0. CLEAN checks puff status flags and deletes those puffs with MF = 0. The remaining puffs are renumbered and the number of active puffs is corrected for the deleted puffs.

PUFFR

Subroutine PUFFR is used to assign the initial puff attributes including position, dimensions and mass or activity. The puff is given initial dimensions (SIGMAY and SIGMAZ) greater than zero to avoid numerical problems. The dimensions assigned are sufficiently small that they do not affect the exposure computations at grid point. After the puff attributes have been assigned, the puff counters NPUFFS and TPUFFS are incremented.

PUFFM

Puff displacement during an advection period is computed in subroutine PUFFM. The displacement is based on interpolated winds at the puff center at the beginning and end of the advection period. Advection winds are computed at each time using spatial interpolation between the puff center and the surrounding grid points and temporal interpolation between winds at the last and next observation times. An initial estimate of the puff position at the end of the advection period is made using the displacement estimate made with the winds at the beginning of the advection period. The final displacement estimate is the average of the displacement estimates made for the beginning and end of the period.

If the displacement during the advection period moves the puff off the grid, the off-grid flag MOFG is set to 1. When this flag is set to 1 the puff continues to move with its last speed and direction until it no longer contributes to the exposure at any grid point. The puff status flag MF is then set to 0 in CNTRL.

```

1      C ** CLEAN
2      C
3      C ** ROUTINE TO ELIMINATE PUFFS WHICH HAVE LEFT THE GRID
4      C
5      SUBROUTINE CLEAN
6      C
7      REAL SIGMAY(500), SIGMAZ(500), Q(500), STOTAL(500), XP(500),
8      1    YP(500), DXS(500), DYS(500)
9      C
10     INTEGER MF(500), TPUFFS
11     C
12     COMMON/PUFFS/MF,SIGMAY,SIGMAZ,Q,STOTAL,XP,YP,TPUFFS,NPUFFS,
13     1    DXS,DYS,FAC,ADT
14     C
15     I = 1
16     J = 1
17     100 IF(MF(I).EQ.0) GOTO 120
18     MF(J) = MF(I)
19     SIGMAY(J) = SIGMAY(I)
20     Q(J) = Q(I)
21     STOTAL(J) = STOTAL(I)
22     SIGMAZ(J) = SIGMAZ(I)
23     XP(J) = XP(I)
24     YP(J) = YP(I)
25     DXS(J) = DXS(I)
26     DYS(J) = DYS(I)
27     J = J + 1
28     C
29     120 I = I + 1
30     IF(I.LE.TPUFFS) GOTO 100
31     C
32     WRITE(6,140) TPUFFS-(J-1),J-1
33     140 FORMAT(5X,'CLEAN CALLED --> ',I4,' PUFFS DROPPED',
34     1    4X,I4,' PUFFS REMAIN ON THE GRID',/)
35     TPUFFS = J - 1
36     RETURN
37     END

```

Subroutine CLEAN

```

1      C      ** PUFFR
2      C
3      C      ** PUFF RELEASE SUBROUTINE SPECIFIES INITIAL ATTRIBUTES
4      C
5      C      SUBROUTINE PUFFR(ACNST)
6      C
7      REAL XP(500), YP(500), STOTAL(500), QP(500), SIGMAZ(500),
8      1  SIGMAY(500), DXS(500), DYS(500)
9      REAL XSOURC,YSOURC,QSOURC
10     C
11     INTEGER MF(500),TPUFFS,NPUFFS
12     INTEGER RELDAY,RELTIM,RELHR,PARTHR,MAXPUF
13     C
14     COMMON/PUFFS/MF,SIGMAY,SIGMAZ,QP,STOTAL,XP,YP,TPUFFS,
15     1  NPUFFS,DXS,DYS,FAC,ADT
16     COMMON/REL/XSOURC,YSOURC,RELDAY,RELHR,PARTHR,
17     1  MAXPUF,QSOURC
18     C
19     NPUFFS = NPUFFS + 1
20     TPUFFS = TPUFFS + 1
21     MF(TPUFFS) = 1
22     XP(TPUFFS) = XSOURC
23     YP(TPUFFS) = YSOURC
24     QP(TPUFFS) = QSOURC * ACNST
25     STOTAL(TPUFFS) = 1.0
26     SIGMAZ(TPUFFS) = 0.1
27     SIGMAY(TPUFFS) = 1.0
28     C
29     RETURN
30     END

```

Subroutine PUFFR

```

BCW846* MESOI(1).PUFFM
1      C ** PUFFM
2      C
3      C ** CALCULATES MOVEMENT OF THE PUFF
4      C
5      SUBROUTINE PUFFM(M,DXM,DYM,TINC,MOFG)
6      C
7      REAL XP(500),YP(500),STOTAL(500),SIGMAZ(500),
8      1 SIGMAY(500),OP(500),DXS(500),DYS(500)
9      REAL STUIST(10,16,16),U(16,16),V(16,16),UU(16,16),
10     1 VV(16,16), XG(2), YG(2), DX(2), DY(2)
11     C
12     INTEGER MF(500),TPUFFS,NPUFFS,STNUM(10,16,16)
13     C
14     COMMON/PUFFS/MF,SIGMAY,SIGMAZ,OP,STOTAL,XP,YP,TPUFFS,
15     1 NPUFFS,DXS,DYS,FAC,ADT
16     COMMON/WINDS/STUIST,STNUM,U,V,UU,VV
17     C
18     XG(1) = XP(M)
19     YG(1) = YP(M)
20     C
21     DO 100 K = 1, 2
22         C2 = TINC + (FLOAT(K) - 1.0) * ADT
23         C1 = 1.0 - C2
24         I = XG(K) + 1.0
25         IF(I.LT.1.0.OR.I.GE.16) GOTO 110
26         J = YG(K) + 1.0
27         IF(J.LT.1.0.OR.J.GE.16) GOTO 110
28         RX = XG(K) - (I-1)
29         RY = YG(K) - (J-1)
30         RX1 = 1.0 - RX
31         RY1 = 1.0 - RY
32     C
33         CST = (RX1*RY1) * (C1*U(I,J) + C2*UU(I,J))
34         CST = CST + (RY*RX1) * (C1*U(I,J+1) + C2*UU(I,J+1))
35         CST = CST + (RX*RY) * (C1*U(I+1,J+1) + C2*UU(I+1,J+1))
36         CST = CST + (RX*RY1) * (C1*U(I+1,J) + C2*UU(I+1,J))
37         DX(K) = CST * FAC
38     C
39         CST = (RX1*RY1) * (C1*V(I,J) + C2*VV(I,J))
40         CST = CST + (RY*RX1) * (C1 * V(I,J+1) + C2*VV(I,J+1))
41         CST = CST + (RX*RY) * (C1*V(I+1,J+1) + C2*VV(I+1,J+1))
42         CST = CST + (RX*RY1) * (C1*V(I+1,J) + C2*VV(I+1,J))
43         DY(K) = CST * FAC
44     C
45         IF(K.EQ.2) GOTO 100
46         XG(K+1) = XG(K) + DX(K)
47         YG(K+1) = YG(K) + DY(K)
48     100 CONTINUE
49     C
50     DXM = 0.5 * (DX(1) + DX(2))
51     DYM = 0.5 * (DY(1) + DY(2))
52     RETURN
53     C
54     110 MOFG = 1
55     RETURN
56     END

```

Subroutine PUFFM

SIGMA

The SIGMA subroutine computes the diffusion parameters used in making the exposure estimates. It is called each sampling interval for each puff. The increases in diffusion parameters from one interval to the next are based on the effective distance from the source, atmospheric stability and the thickness of the atmospheric mixing layer.

EFDIST is the effective distance that the puff has traveled from the source. It is computed at the beginning of each interval from the magnitude of the diffusion parameter in the previous interval and is a function of the current atmospheric stability and mixing depth. It is not likely that EFDIST will be the same for both horizontal and vertical diffusion parameter estimates. ENDIST is the effective puff travel distance at the end of the current interval.

The effective travel distances at the mid-points of the sampling interval or sub-interval are given names HDIST, HDIST1 and HDIST2. These variables are used in the evaluation of the derivatives needed to compute the diffusion parameter increments.

RCPTR

Subroutine RCPTR is used to compute the exposure to off-grid receptors. It is called twice for each set of receptor exposure estimates. The initial call is made when the receptors are turned on, and the second call is made when they are turned off.

When the initial call is made to RCPTR, the flag ONOFF is equal to zero. This results in RCPTR computing a residual exposure estimate for each off-grid receptor location. These estimates are made by interpolating between the current exposures at surrounding grid points. When RCPTR is called at the time the off-grid receptors are turned off, the flag ONOFF is equal to 1. This causes RCPTR to compute an exposure increment for each location. The exposure increment is the difference between the exposure estimate at the receptor based on exposures at the surrounding grid points at the off time and the residual exposures.

```

1      C  ** SIGMA
2      C
3      C  ** CALCULATES VALUES FOR SIGMA Z AND SIGMA Y
4      C
5      SUBROUTINE SIGMA(DSMTR,M,TPUFFS,STAB,LDEPTH,
6      1  JN,SIGMAZ,SIGMAY,STOTLM)
7      C
8      REAL CONST(6,4)
9      C
10     INTEGER STAB, TPUFFS
11     C
12     PARAMETER SYX=20000.0
13     C
14     DATA CONST/0.718,0.425,0.349,0.267,0.299,0.401,
15     1          0.100,0.105,0.128,0.146,0.331,0.812,
16     2          1.033,0.975,0.891,0.824,0.567,0.307,
17     3          0.960,1.026,1.122,1.214,1.764,3.267/
18     C
19     IF (JN.EQ.1) THEN
20         A = CONST(STAB,1)
21         A1 = A * SYX ** 0.35
22         H = CONST(STAB,2)
23         QG = CONST(STAB,3)
24         QGI = CONST(STAB,4)
25     C
26         CCHGPT = 0.335 * LDEPTH
27         SZSMAX = 0.465 * LDEPTH
28         SMAX = (SZSMAX/H) ** QGI
29         SZMAX = 0.8 * LDEPTH
30         IFLAG = 1
31         IF (STOTLM.LT.SYX) IFLAG = 0
32     END IF
33     C
34     STOTLM = STOTLM + DSMTR
35     C
36     C  ** CALCULATE SIGMA Z (IF NECESSARY) USING LINEAR OR POWER FORMULA
37     C
38     IF (SIGMAZ.LT.SZMAX) THEN
39         IF (SIGMAZ.GE.SZSMAX) THEN
40             DELTA = (CCHGPT / SMAX) * DSMTR
41             DELTA = MIN(DELTA,SZMAX-SIGMAZ)
42         ELSE
43             EFDIST = (SIGMAZ/H) ** QGI
44             ENDIST = EFDIST + DSMTR
45             IF (ENDIST.LE.SMAX) THEN
46                 HDIST = EFDIST + DSMTR / 2
47                 DELTA = B * QG * HDIST ** (QG-1) * DSMTR
48             ELSE
49                 F1 = (SMAX - EFDIST) / DSMTR
50                 HDIST1 = (EFDIST + SMAX) / 2.0
51                 DELTA = (F1 * B * QG * HDIST1 ** (QG-1) +
52                 (1.0-F1) * (CCHGPT/SMAX)) * DSMTR
53             ENDIF
54         END IF
55         SIGMAZ = SIGMAZ + DELTA
56         IF (SIGMAZ.GT.SZMAX) THEN

```

Subroutine SIGMA

```

57         SIGMAZ = SZMAX
58     END IF
59 END IF
60 C
61 C ** CALCULATE SIGMA Y
62 C
63     IF (SIGMAY.LT.1.0) THEN
64         EFDIST = 0.0
65     ELSE
66         EFDIST = (SIGMAY / A) ** (1.0 / 0.85)
67     ENDIF
68     IF (EFDIST.LE.SYX) THEN
69         IF (EFDIST.DSMTR.LE.SYX) THEN
70             HDIST = EFDIST * (DSMTR / 2.0)
71             SIGMAY = SIGMAY + (0.85 * A) * DSMTR / HDIST ** 0.15
72         ELSE
73             DS1 = (SYX - EFDIST) / DSMTR
74             DS2 = 1.0 - DS1
75             HDIST1 = EFDIST + DS1 * DSMTR
76             HDIST2 = SYX + DS2 * DSMTR
77             SIGMAY = SIGMAY + 0.85 * DS1 * DSMTR * A / HDIST1 ** 0.15
78             + 0.5 * A1 * DS2 * DSMTR / HDIST2 ** 0.5
79         END IF
80     ELSE
81         EFDIST = (SIGMAY / A1) ** 2.0
82         HDIST = EFDIST + DSMTR / 2
83         SIGMAY = SIGMAY + 0.5 * A1 * DSMTR / HDIST ** 0.5
84     ENDIF
85 RETURN
86 END

```

Subroutine SIGMA (contd)


```

1      C  ** RCPTR
2      C
3      C  ** ROUTINE TO CALCULATE DOSE AT THE RECEPTORS
4      C
5      C  SUBROUTINE RCPTR(ONOFF)
6      C
7      REAL RPOS(2,10), RWT(4,10), WT(10), RDOSE(10)
8      REAL CHI(32,32)
9      C
10     INTEGER ONTIM, OFFTIM, IP(2,10), ONOFF
11     INTEGER SDAY,SHR,NPH,DT,NSI,DDAY,DHR
12     INTEGER TITLE(50)
13     C
14     CHARACTER*8 RDATE,RTIME
15     C
16     COMMON/RCPT/ IP,RWT,WT,ONTIM,OFFTIM,NRCPT,RDOSE
17     COMMON/MASTER/RDATE,RTIME,TITLE,NPH,DT,CHIMIN,DDAY,DHR,NSI,
18     1 CHI,ACNST,SDAY,SHR
19     C
20     IF(ONOFF.EQ.1) GOTO 125
21     DO 120 I = 1, 10
22         RDOSE(I) = 0.0
23     120 CONTINUE
24     C
25     125 DO 140 I = 1, NRCPT
26         IX = IP(1,I)
27         IY = IP(2,I)
28         IF(RWT(1,I).NE.1.0) GOTO 130
29         RDOSE(I) = CHI(IX,IY) - RDOSE(I)
30         GOTO 140
31     130 CONTINUE
32         RDOSE(I) = ((CHI(IX,IY)*RWT(1,I)+CHI(IX,IY+1)*RWT(2,I)
33     1 +CHI(IX+1,IY+1)*RWT(3,I)+CHI(IX+1,IY)*RWT(4,I))
34     2 /WT(I)) - RDOSE(I)
35     140 CONTINUE
36     C
37     RETURN
38     END

```

Subroutine RCPTR

PRINTE

Subroutine PRINTE provides the user with output options at the end of each hour simulated. The options include no output, displaying current results on the VDT screen, sending them to the print file, and stopping the simulation without further output. If selected, VDT output occurs in lines 60 through 114, and output to the print file occurs in lines 115 through 139.

```

1      C  ** PRINTE
2      C
3      C  ** HANDLES SELECTION OF OUTPUT -- GRID AND RECEPTOR DOSES
4      C  **   ROUTED TO SCREEN AND/OR PRINT FILE
5      C
6      C      SUBROUTINE PRINTE(IPSUM,IEXIT)
7      C
8      C      REAL CHI(32,32), VALUE(11)
9      C      REAL RWT(4,10),WT(10),RDOSE(10)
10     C
11     C      INTEGER SHR,SELECT,SDAY,DT,DDAY,DHR
12     C      INTEGER ONTIM, OFFTIM,IP(2,10)
13     C      INTEGER TITLE(50)
14     C
15     C      CHARACTER*8 RDATE,RTIME
16     C      CHARACTER*1 SYMBOL(10)
17     C      CHARACTER*1 DISPL(50)
18     C      CHARACTER*3 BORDER(16)
19     C
20     C      COMMON/MASTER/RDATE,RTIME,TITLE,NPH,DT,CHIMIN,
21     C      1 DDAY,DHR,NSI,CHI,ACNST,SDAY,SHR
22     C      COMMON/RCPT/IP,RWT,WT,ONTIM,OFFTIM,NRCPT,RDOSE
23     C      COMMON/REL/XSOURC,YSOURC
24     C
25     C      DATA BORDER/16*3H * /
26     C      DATA SYMBOL/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
27     C      DATA VALUE/1.0E-17,1.0E-16,1.0E-15,1.0E-14,1.0E-13,1.0E-12,
28     C      1 1.0E-11,1.0E-10,1.0E-09,1.0E-08,1.0E-07/
29     C
30     C  ** DEFINE SCREEN CONTROL STRINGS FOR TVI-912C
31     C
32     C      DATA CLR/00330730000000/
33     C      DATA XYMOVE/0033075047126/
34     C      DATA SETAR/00330610000000/
35     C      DATA TAB/00110000000000/
36     C      DATA BOTTOM/0033075065040/
37     C      WRITE(6,90) CLR
38     C      90 FORMAT(1X,A4)
39     C
40     C      WRITE(6,100) SHR,DDAY,DHR,IPSUM
41     C      100 FORMAT(5X,'END OF SIMULATION HOUR ',I3,5X,
42     C      1 'DATA: DAY ',I3,' HOUR ',I2,'/,7X,I3,' PUFFS ACTIVE',/)
43     C      105 WRITE(6,110)
44     C      110 FORMAT(5X,'SELECT OUTPUT OPTION FOR THIS HOUR -->',/,
45     C      1 7X,'0 = NO OUTPUT',/,
46     C      2 7X,'1 = SCREEN ONLY',/,
47     C      3 7X,'2 = PRINT FILE ONLY',/,
48     C      4 7X,'3 = SCREEN AND PRINT FILE',/,
49     C      5 7X,'4 = TERMINATE CURRENT SIMULATION',/)
50     C
51     C      READ(5,*,END=400,ERR=105) SELECT
52     C
53     C      WRITE(6,90) CLR
54     C      IF(SELECT.GT.3) THEN
55     C          IEXIT = 1
56     C          RETURN
57     C      END IF
58     C      IF(SELECT.LT.1) RETURN
59     C      IF(SELECT.EQ.2) GOTO 300
60     C
61     C  ** SCREEN DISPLAY OF HOURLY OUTPUT
62     C      WRITE(6,200) TITLE,RDATE,RTIME
63     C      200 FORMAT(5X,50A1,/,60X,A8,2X,A8,/)

```

Subroutine PRINTE

```

64      WRITE(6,210) SHR,DDAY,DHR,IPSUM
65      210 FORMAT(5X,'SIMULATION HOUR ',I2,15X,'DAY ',I3,3X,
66      1 'HOUR ',I2,/,7X,I4, ' PUFFS ACTIVE',/)
67
68      C      WRITE(6,500) BORDER
69      500 FORMAT(2X,16A3)
70      DISPL(1) = 1H*
71      DISPL(50) = 1H*
72
73      C      DO 600 N = 1, 16
74      DO 510 I = 2, 49
75      DISPL(I) = 1H
76      510 CONTINUE
77
78      C      DO 580 I = 1, 16
79      IF (CHI(I*2-1,33-(N*2)).LT.VALUE(1)) GOTO 580
80      DO 570 K = 2, 11
81      IF (CHI(I*2-1,33-(N*2)).LT.VALUE(K)) THEN
82      DISPL(I*3) = SYMBOL(K-1)
83      GOTO 580
84      END IF
85      570 CONTINUE
86
87      C      DISPL(I*3) = 1H+
88      580 CONTINUE
89
90      C      PUT CHARACTER 'X' AT RELEASE POINT
91      C      PUT CHARACTER 'M' AT GRID CENTER (MET TOWER)
92
93      C      IF (INT(YSOURC).EQ.16-N) DISPL(INT((XSOURC+1.0)*3+0.5)) = 1HX
94      IF (N.EQ.9) DISPL(26) = 1HM
95      WRITE(6,590) DISPL
96      590 FORMAT(1X,50A1)
97
98      C      600 CONTINUE
99      WRITE(6,610) BORDER
100     610 FORMAT(2X,16A3)
101
102     C      IF (NRCPT.EQ.0.OR.OFFTIM.NE.DHR) GOTO 230
103     WRITE(6,240) XMOVE, SETAB
104     240 FORMAT(1X,2A4)
105     WRITE(6,245) TAB
106     245 FORMAT(1X,A4,'RECEPTORS OFF',/)
107     WRITE(6,250) TAB
108     250 FORMAT(1X,A4,'RECEPTOR',5X,'DOSE',/)
109     DO 270 I = 1, NRCPT
110     WRITE(6,260) TAB, I, ROOSE(I)
111     260 FORMAT(1X,A4,5X,I2,3X,1PE10.2)
112     270 CONTINUE
113     230 IF (SELECT.NE.3) GOTO 400
114
115     C      300 IPLUS = 0
116     WRITE(12,200) TITLE, RDATE, RTIME
117     WRITE(12,210) SHR, DDAY, DHR, IPSUM
118     DO 350 L = 1, 3
119     WRITE(12,310) (I+IPLUS,I=1,11)
120     310 FORMAT(1H0, ' Y COORDINATE OF',25X, ' X COORDINATE ',
121     1 ' OF THE GRID POINTS',/,2X, ' THE GRID POINTS',I4,11110/)
122
123     C

```

Subroutine PRINTE (contd)

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123      DO 340 J = 1, 31
124          WRITE(12,330) 32-J, (CHI(I,32-J), I=1+IPLUS, 11+IPLUS)
125      330      FORMAT(11,5X,1P11E10.2)
126      340      CONTINUE
127          IPLUS = IPLUS + 11
128      350      CONTINUE
129      C
130          IF (NRCPT.EQ.0.OR.OFFTIM.NE.DHR) GOTO 400
131          WRITE(12,360)
132      360      FORMAT(4X,'RECEPTOR NO.',7X,'DOSE',/)
133          DO 380 I = 1, NRCPT
134              WRITE(12,370) I, RDOSE(I)
135      370      FORMAT(12X,12,6X,1PE10.2)
136      380      CONTINUE
137      C
138      400      WRITE(6,410) BOTTOM
139      410      FORMAT(1X,A4)
140          PAUSE 'HIT RETURN TO CONTINUE'
141          RETURN
142      END

```

Subroutine PRINTE (contd)

REFERENCES

- Athey, G. F., K. J. Allwine and J. V. Ramsdell. 1981. User's Guide to the MESOI Diffusion Model and to the Utility Programs UPDATE and LOGRVU, PNL-3999, Pacific Northwest Laboratory, Richland, Washington.
- Gifford, F. A. 1968. "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere." in Meteorology and Atomic Energy - 1968, ed. D. Slade. TID 24190. U.S. Atomic Energy Commission.
- Gifford, F. A. 1976. "Turbulent Diffusion Typing Schemes: A Review," Nuclear Safety, 17, 68-86.
- Hilsmeier, W. F. and F. A. Gifford. 1962. Graphs for Estimating Atmospheric Dispersion. USAEC Report ORO-545, Weather Bureau, Oak Ridge, Tennessee.
- Horst, T. W., J. C. Doran and P. W. Nickola. 1979. Evaluation of Empirical Diffusion Data. NUREG/CR-0798, Pacific Northwest Laboratory, Richland, Washington.
- Pasquill, F. 1961. "The Estimation of the Dispersion of Windborne Material," Meteorol. Mag., 90, 33-49.
- Sedefian, L. and E. Bennett. 1980. "A Comparison of Turbulence Classification Schemes," Atmospheric Environment, 14, 741-750.
- Slade, D. ed. 1968. Meteorology and Atomic Energy - 1968, TID 24190. U.S. Atomic Energy Commission.
- Start, G. E. and L. L. Wendell. 1974. Regional Effluent Dispersion Calculations Considering Spatial and Temporal Meteorological Variations, NOAA Tech. Memo., ERL ARL-44, 63p.
- Turner, D. B. 1970. Workbook of Atmospheric Dispersion Estimates. USEPA, AP-26.
- U.S. Nuclear Regulatory Commission. 1979. "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." Regulatory Guide 1.145, USNRC, Washington, D.C.
- Wendell, L. L. 1972. "Mesoscale Wind Fields and Transport Estimates Determined from a Network of Wind Towers." Mon. Wea. Rev., 100, 565-578.
- Yanskey, G. R., E. H. Markee and A. P. Richter. 1966. Climatology of the National Reactor Testing Station. IDO-12048.

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