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DEVELOPMENT OF MESOSCALE AIR QUALITY SIMULATION MODELS

VOLUME 3. USER'S GUIDE TO MESOPUFF (MESOSCALE PUFF) MODEL

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1. INTRODUCTION

1.1 Background

In response to a growing national commitment to the use of indigenous coal reserves to meet energy generation demands, several regions of the country will see greatly expanded use of coal and oil shale resources for steam electric power plants and other coal-based energy resource development. But, mandated by federal National Ambient Air Quality Standards, and by the PSD major source review procedures, additional coal-based energy resource development (ERD) will only be permitted where consistent with the maintenance of human health, welfare, and environmental quality. Accordingly, the siting and generation capacity of such ERD facilities will be constrained by their potential impacts on regional ambient air quality.

Various plans have been proposed for regional development of multiple major new facilities and suitable air quality simulation tools are needed to assess the impacts of different energy development scenarios on regional-scale air quality. To meet this need in the public interest, the National Oceanic and Atmospheric Administration (NOAA) has sponsored a study by Environmental Research & Technology, Inc. (ERT) to develop, compare, evaluate, and exercise a number of alternative approaches to regional-scale ambient air quality modeling. A major objective of this study is to provide a suite of air quality simulation models that are both technically sound and computationally practical for assessing regional-scale impacts of energy development scenarios.

As described in the companion report, Volume 1 (Bass et al. 1979) three different air quality transport-diffusion modeling approaches have been developed, implemented and compared for simulation of point-source plume dispersion on the mesoscale [e.g., dispersion at ranges of 100 to 1,000 kilometers (km)].

The models are optimized for regional-scale impacts; in Volume 1, the ambient air concentrations calculated by MESOPUFF in the near field of sources, that is, less than 100 km, are not realistic. The current version of MESOPUFF (presented in this volume) has been augmented to handle near-field impacts in a more realistic manner - see Section 2.1. Both worst-case and average dispersion situations are treated, with meteorological inputs constructed from rawinsonde data that is readily available for the region. The models are computationally practical for simulating the impact of multiple point sources over periods of several days to several weeks, and are easy to use for a variety of decision-making and regulatory applications. Finally, the models are intended to serve as flexible testbeds for further research, development and simulation tasks.

The three new models are, respectively:

- MESOPLUME, a mesoscale variable-trajectory Gaussian "plume-segment" model (Benkley and Bass 1979a), adapted by ERT from the plume segment approach taken in the STRAM model (Hales et al. 1977),

- MESOPUFF, a mesoscale variable-trajectory Gaussian "puff" superposition model, adapted by ERT from the puff approach taken in the MESODIF model (Start and Wendell 1974); and

- MESOGRID, a mesoscale numerical grid model (Morris et al. 1979), adapted from the method of moments approach taken in the SULFA3D model (Egan et al. 1976).

This report, the third in a series entitled "Development of Mesoscale Air Quality Simulation Models", describes the MESOPUFF model in technical detail; illustrates its application; and provides a User's Guide to the model. However, to obtain a fuller understanding of the model's capabilities, limitations and recommended usage, the user should be familiar with the relevant materials contained in the following related reports:

- the companion report (Volume 1) describing the extensive series of comparison and model sensitivity analyses performed with these models (Bass et al. 1979);

- the companion report (Volume 6) describing the specially designed MESOSCALE meteorological preprocessor program, MESOPAC (Benkley and Bass 1979b);

- the companion report (Volume 5) describing the specially designed model postprocessing and analysis system, MESOFILE (Scire et al. 1979).

1.2 The Mesoscale Puff Element Model (MESOPUFF)

MESOPUFF is a regional-scale variable-trajectory Gaussian puff model. The MESOPUFF modeling algorithm has been adapted from that described by Start and Wendell (1974). It differs from the conventional Guassian plume approach in that MESOPUFF simulates the deformation of a continuous plume by a temporally-varying, vertically-uniform horizontal wind field. MESOPUFF simulates a continuous point source by superposing discrete puffs. Each puff is advected in a Lagrangian sense--its time history is independent of preceding or succeeding puffs. The dimensions of an individual puff are proportional to its travel distance (or travel time). The representation of a continuous plume by the discrete puff approach is depicted schematically in Figure 1-1.

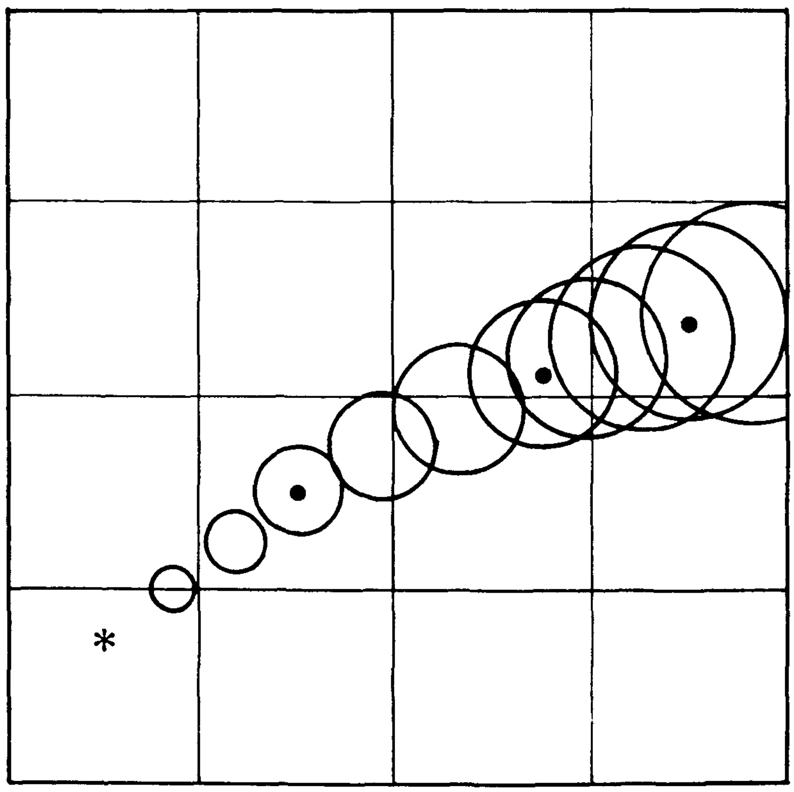

Figure 1-1 Schematic Representation of Puff Superposition Approach

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MESOPUFF accommodates multiple point sources and includes modules for plume rise, plume growth, fumigation, linear conversion of sulfur dioxide (SO_2) to sulfate ($SO_4^=$) and dry deposition of SO_2 and $SO_4^=$.

With suitable choices of input parameters, MESOPUFF can reproduce the results of a conventional Gaussian plume model in the near field of a source (as close as 5 km).

1.3 Integrated Mesoscale Modeling System

The MESOPUFF model has been incorporated as an independent model element within an efficient, easy to use integrated mesoscale modeling system. This integrated system, depicted in Figure 1-2, comprises components for meteorological preprocessing, mesoscale transport-diffusion, and post-processing. Standardizing model input/output functions in this system permits easy combination of results from two or more model runs, or direct and cost-effective comparison of simulations performed with two or more different models (see, for example, Bass et al. 1979). The meteorology preprocessor MESOPAC drives identically any of the three mesoscale transport-diffusion models. In turn, each of these models in turn identically communicates its results to the MESOFILE postprocessing system - responsible for file management, display, and statistical analysis of all model output fields.

1.4 Organization of the Report

Section 2 of this report contains a detailed technical description of the MESOPUFF model; specific user instructions are described in Section 3; a test case for the MESOPUFF model is presented in Section 4.

A complete Fortran microfiche listing of the MESOPUFF model is appended.

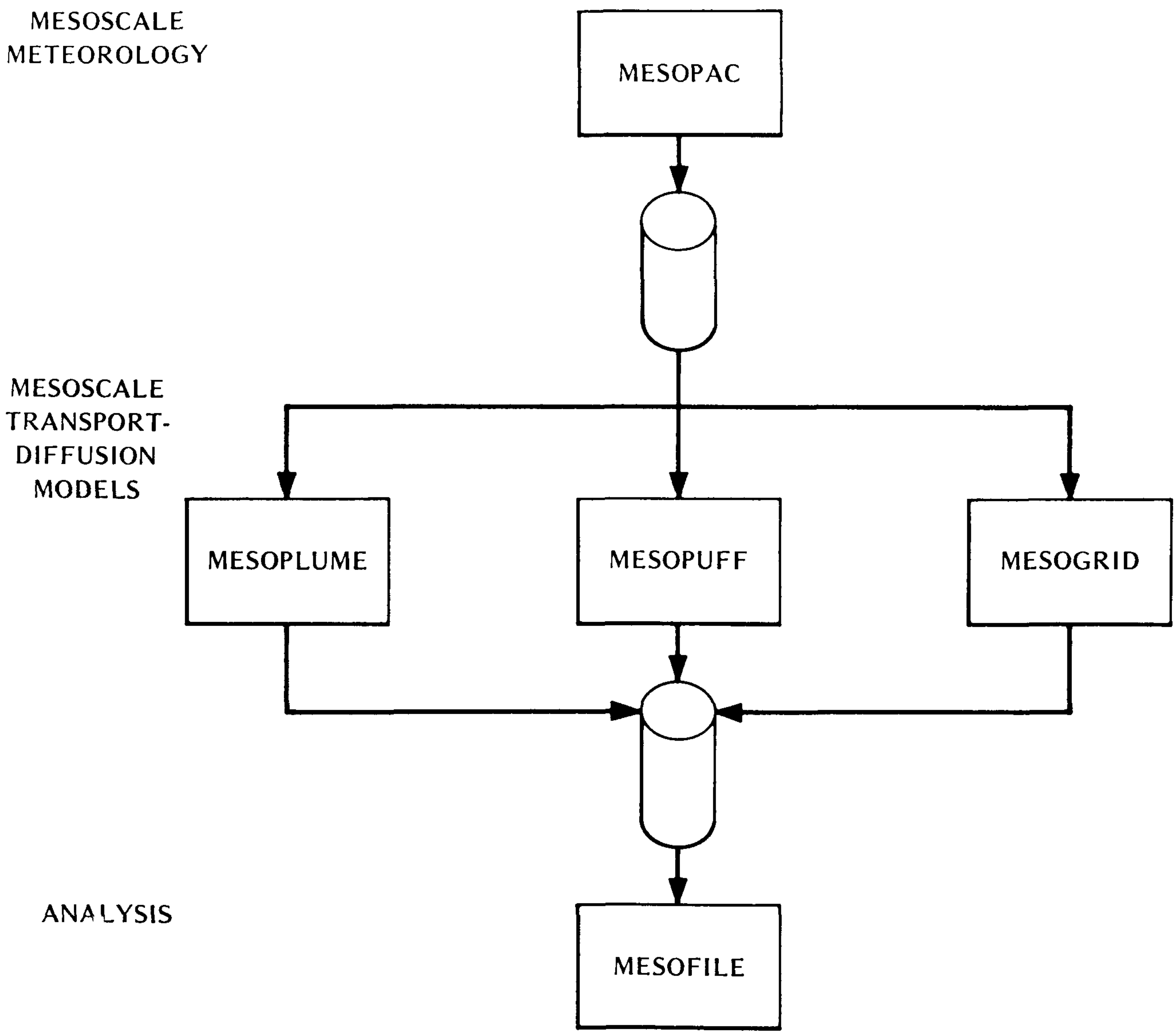

Figure 1-2 Integrated Modeling System

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2. MESOPUFF TECHNICAL DISCUSSION

2.1 Basic Mass Conservation Equations

MESOPUFF, a discretized variable-trajectory version of the conventional straight-line Gaussian plume model, is designed to take into account the spatial and temporal variations in the advection, diffusion, transformation, and removal mechanisms governing plume dispersion on regional transport scales. In MESOPUFF, a continuous plume is modeled by subdivision into a sufficient number of discrete "puffs" of circular horizontal cross section. The conservation of pollutant mass in a puff transported a distance Δs is expressed by the mass balance equation:

$$\Delta Q = \int_{o}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} G(r,\ \theta,\ z)\ dr\ d\theta\ dz \tag{2-1}$$

$$= \frac{u}{\Delta s} \int_{o}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} C\ dr\ d\theta\ dz \Bigg|_{s+\Delta s} - \frac{u}{\Delta s} \int_{o}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} C\ dr\ d\theta\ dz \Bigg|_{s}$$

where r, θ, z define points relative to the puff center in cylindrical coordinates, $G(r,\theta,z)$ ($g\ m^{-3}\ s^{-1}$) is the rate of change (gain-loss) of pollutant concentration $C(r,\theta,z;s)$ ($g\ m^{-3}$), ΔQ ($g\ s^{-1}$) is the resultant rate of change of pollutant mass, and u($m\ s^{-1}$) is the wind speed. In the MESOPUFF model u is constant from s to Δs, where s is defined as the total distance a puff has traveled since it was emitted.*

For a discrete puff lying below the mixing height H, the circularly symmetric ground-level puff concentration C(r,0,0;s) is defined as

$$C(r,0,0;s) = \frac{Q(s)}{2\pi\ \sigma_y^{\,2}(s)\ g_1(z)} \exp\left(\frac{-r^2}{2\ \sigma_y^{\,2}(s)}\right) g_2(z) \tag{2-2}$$

where Q(s) is the pollutant mass flux, and $\sigma_y(s)$ the "radial" Gaussian plume dispersion coefficient at distance s. The use of a "radial" Gaussian dispersion coefficient is a convenient computational device, nothing more. The functions $g_1(z)$ and $g_2(z)$ are dependent upon the

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*By contrast in the MESOPLUME (plume segment) model, s is the current distance of a plume segment endpoint from the emitting source, measured along the plume axis; for temporally varying flows, the two definitions can yield significantly different values of s.

vertical distribution of concentration in the puff. Replacing H by H_m, the maximum mixing depth encountered by a puff (see Section 2.8), MESOPUFF permits the user to specify one of two possible algorithms for the distribution function g(z), namely

1) a uniform vertical distribution algorithm within H_m, such that $g_1(z) = H_m$ and $g_2(z) = 1.0$, and

2) a Gaussian, multiple reflection algorithm where

- for $\sigma_z < 2H$ $g_1(z) = \sqrt{2\pi}\ \sigma_z$ and $g_2(z)$ is a function that accounts for multiple reflection effects ($g(2) > 1$), and

- for $\sigma_z \geq 2H_m$, $g_1(z) = H_m$, and $g_2(z) = 1.0$.

For regional-scale transport, e.g., at distances from 100 to 1,000 km from a source, either algorithm will produce substantially similar results, as a rule, because at travel distances $\gtrsim$100 km σ_z is likely to be greater than $2H_m$.

Using the uniform vertical distribution function (1), the ground level puff concentration C(r,0,0;s) at distance s is

$$C(r,0,0;s) = \frac{Q(s)}{2\pi\ \sigma_y^2(s)\ H_m} \exp\left(\frac{-r^2}{2\ \sigma_y^2(s)}\right) \qquad (2\text{-}3)$$

At distance s+Δs, the ground level concentration becomes

$$C(r,0,0;s+\Delta s) = \frac{Q(s+\Delta s)}{2\pi\ \sigma_y^2(s+\Delta s)\ H_m} \exp\left(\frac{-r^2}{2\ \sigma_y^2(s+\Delta s)}\right) \qquad (2\text{-}4)$$

To ensure that a series of discrete puffs overlap along the variable plume axis with sufficient density to approximate a continuous plume, an individual puff (as described by Equation 2-2), should not travel a distance Δs any larger than σ_y in one time step Δt. Where wind speeds are large enough that this condition would be violated it is necessary to subdivide further the time step used to interpolate puff concentrations to grid points.

The MESOPUFF model solves the mass balance equation (2-1) independently for both sulfur dioxide (SO_2) and sulfate ($SO_4^=$). The "gain" functions for each species include terms for the loss (gain) of SO_2

($SO_4^=$) by linear decay of SO_2 to $SO_4^=$, and also include terms for dry deposition of either species - see Sections 2.5 and 2.6.

2.2 The Grid System

To facilitate the interaction of the MESOPUFF model with a number of input and output routines and pre- and postprocessors, a simple Cartesian coordinate system has been adopted for MESOPUFF. All spatial model input data (emission source inventories and meteorological fields) are referenced to the same grid, called the "basic computational" grid. To improve the resolution of the plume sampling function (see Section 2.4.3), MESOPUFF uses a sampling grid that is a subset of the basic computational grid. The origin of the sampling grid may be placed anywhere on the basic computational grid (other than on the northern or eastern grid boundaries). The resolution of the sampling grid is a multiple of the resolution of the basic computational grid. Currently, the maximum allowable size of both the basic computational and sampling grids is 40 by 40 horizontal grid indices. Figure 2-1 illustrates one possible arrangement of basic computational and sampling grids. [More detailed instructions for defining the dimensions and resolutions of the two grids are contained in Section 3.2.] Note that the grid index of the origin (1,1) is assigned Cartesian coordinates x = 0, y = 0. The sampling grid in this example originates at (i = 2, j = 2) or (x = 1, y = 1) on the basic computational grid, and a spatial resolution four times finer than the basic computational grid.

2.3 Specification of Model Inputs

MESOPUFF is, at present, driven by the meteorological fields produced by the MESOPAC MESOscale meteorology PACkage (Benkley and Bass 1979b), but an alternative meteorological preprocessing system with appropriate grid resolution could be substituted by the user. MESOPUFF requires the following fields (usually at hourly intervals) interpolated to each model grid point:

- horizontal (u,v) wind components,
- mixing depth, and
- Pasquill-Gifford-Turner (PGT) stability class.

Examples of the MESOPAC meteorological input used by MESOPUFF are shown in Appendix A. Use of MESOPAC model output by the MESOPUFF model is straightforward - the Cartesian coordinate system is identical in both models. Note that the horizontal (u,v) wind components are considered invariant with height. Vertical wind components are not used. The fields of PGT stability class are used by MESOPUFF in doing plume rise and plume growth calculations.

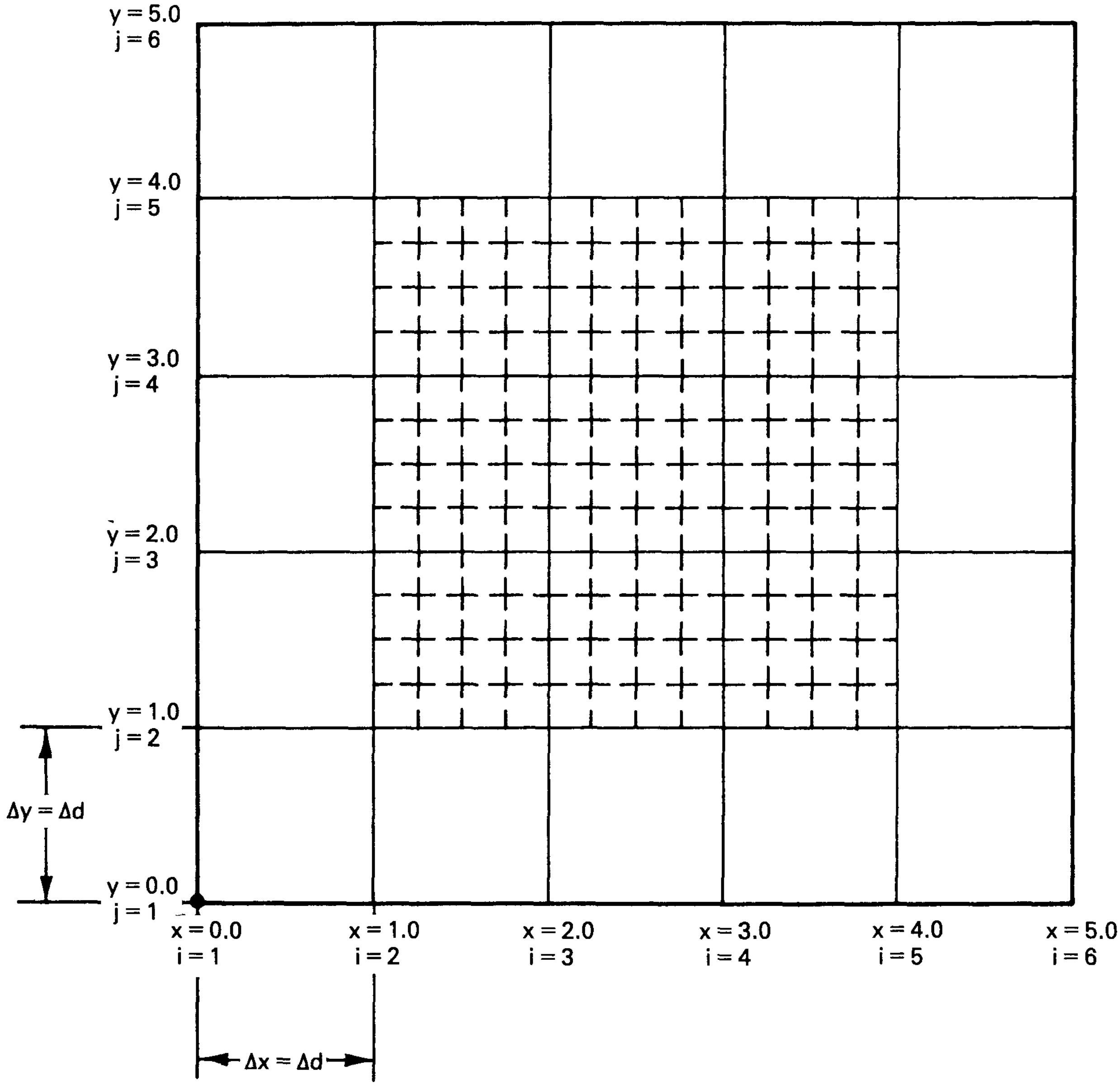

Figure 2-1 One Possible Arrangement of Sampling and Basic Computational Grids

2.4 Puff Trajectory, Dispersion and Sampling Algorithms

The computational scheme of the MESOPUFF model has three distinct functional elements: (1) a Lagrangian puff trajectory function, (2) a puff dispersion function, and (3) a puff sampling function. The Lagrangian trajectory function is used to advect the centerpoint of each puff during a basic time step. The radius of each puff is determined by the puff dispersion function. Given the size and location of each puff, the puff sampling function computes the concentration exposure received during the time interval at each grid point by summing up the individual puff contributions at each grid point.

2.4.1 Lagrangian Trajectory Function

This section describes how the centerpoint of a puff is advected during a time step, it has been adapted (but largely verbatim) from Hales et al. (1977, pages 15-18).

Let the components of the wind in the x and y grid directions along the trajectory be designated by $u[t;x(t),y(t)]$ and $v[t;x(t),y(t)]$, respectively,

where

$$x(t) = \frac{1}{\Delta d} \int_o^t u[t';x(t'),y(t')]dt'$$

$$y(t) = \frac{1}{\Delta d} \int_o^t v[t';x(t'),y(t')]dt'$$

$$x(0) = x_0 \; ; \; y(0) = y_0$$

$$u(0;x(0),y(0)) = u(x_0,y_0)$$

$$v(0;x(0),y(0)) = v(x_0,y_0)$$

and x_0,y_0 are the initial coordinates (origin) of a trajectory of total length s. (The grid space unit Δd is used in the program to convert to nondimensional spatial units on the computational grid.) The vectors u(t;...) and v(t;...) provide a Lagrangian description of the velocity field. Increments of advection over a further time interval Δt are therefore given by

$$\Delta x = \frac{1}{\Delta d} \int_t^{t+\Delta t} u[t';x(t'),y(t')]\; dt' \; ; \qquad (2\text{-}5a)$$

$$\Delta y = \frac{1}{\Delta d} \int_{t}^{t+\Delta t} v[t';x(t'),y(t')]\, dt' . \qquad (2\text{-}5b)$$

After the new coordinates $x(t+\Delta t)$ and $y(t+\Delta t)$ are calculated for each incremented puff centerpoint, a check is made to see if any of these values are off the grid. If so, the affected puff is deleted from further consideration.

The integration of the wind components over the trajectory is approximated by a two-step iteration method involving bilinear interpolation in space and in time (see Figure 2-2).

The various positions in Figure 2-2 are best defined by equations:

$$x_1 = x(t) + u[t;x(t),y(t)]\, \Delta t ; \qquad (2\text{-}6a)$$

$$y_1 = y(t) + v[t;x(t),y(t)]\, \Delta t ; \qquad (2\text{-}6b)$$

$$x_2 = x_1 + u[t+\Delta t;x_1,y_1]\, \Delta t ; \qquad (2\text{-}6c)$$

$$y_2 = y_1 + v[t+\Delta t;x_1,y_1]\, \Delta t ; \qquad (2\text{-}6d)$$

$$x(t+\Delta t) = 0.5[x(t) + x_2] ; \qquad (2\text{-}6e)$$

$$y(t+\Delta t) = 0.5[y(t) + y_2] . \qquad (2\text{-}6f)$$

Thus, the new position $(x(t+\Delta t),y(t+\Delta t))$ is found by adding the vector average of two advection increments to the former position $(x(t),y(t))$. The first advection increment is calculated by advecting the plume increment for the entire interval Δt using the wind effective at $[x(t),y(t)]$ at time t. The addition of this increment to the position $[x(t),y(t)]$ yields the position (x_1,y_1). However, (x_1,y_1) is not assumed to be the actual end of the advection increment because the wind may change along the trajectory. A second advection increment is calculated using (x_1,y_1) as the starting point and the wind at that point effective at the end of the time increment. The addition of this advection increment to position (x_1,y_1) yields position (x_2,y_2). Then the new puff position $(x(t+\Delta t),y(t+\Delta t))$ is taken to be the point halfway along the line from $(x(t),y(t))$ to (x_2,y_2).

The bilinear interpolation by which the effective wind components $u(t)$, and $v(t)$ are calculated works as follows. Let t_n and t_{n+1} be the effective times of the two gridded wind fields closest to time t. Time interpolation weights t_1 and t_2 are defined by:

$$t_2 = \frac{t - t_n}{t_{n+1} - t_n} \qquad t_n \leq t < t_{n+1} ; \qquad (2\text{-}7a)$$

$$t_1 = 1 - t_2 \, . \tag{2-7b}$$

Next, the location of (x(t),y(t)) is noted on Figure 2-2. The coordinate values are between 3 and 4 for x(t) and between 2 and 3 for y(t). Accordingly:

$$X_q = x(t) - 3 \, ; \tag{2-8a}$$

$$X_p = 1 - X_q \, ; \tag{2-8b}$$

$$Y_q = y(t) - 2 \, ; \tag{2-8c}$$

$$Y_p = 1 - Y_q \, . \tag{2-8d}$$

This yields

$$\begin{aligned} u(t) = \; & t_1 X_p Y_p u(t_n;3,2) + t_2 X_p Y_p u(t_{n+1};3,2) \\ & + t_1 X_q Y_p u(t_n;4,2) + t_2 X_q Y_p u(t_{n+1};4,2) \\ & + t_1 X_p Y_q u(t_n;3,3) + t_2 X_p Y_q u(t_{n+1};3,3) \\ & + t_1 X_q Y_q u(t_n;4,3) + t_2 X_q Y_q u(t_{n+1};4,3) \, . \end{aligned} \tag{2-9}$$

Similar equations hold for v(t), u(t+Δt), and v(t+Δt). Therefore, the advection Equation 2-5 is calculated from

$$\Delta x = \frac{1}{2\Delta d} \{u(t) + u(t+\Delta t)\}\Delta t; \tag{2-10a}$$

$$\Delta y = \frac{1}{2\Delta d} \{v(t) + v(t+\Delta t)\}\Delta t. \tag{2-10b}$$

The subsequent positions are given by

$$x(t+\Delta t) = x(t) + \Delta x \, ; \tag{2-11a}$$

$$y(t+\Delta t) = y(t) + \Delta y \, . \tag{2-11b}$$

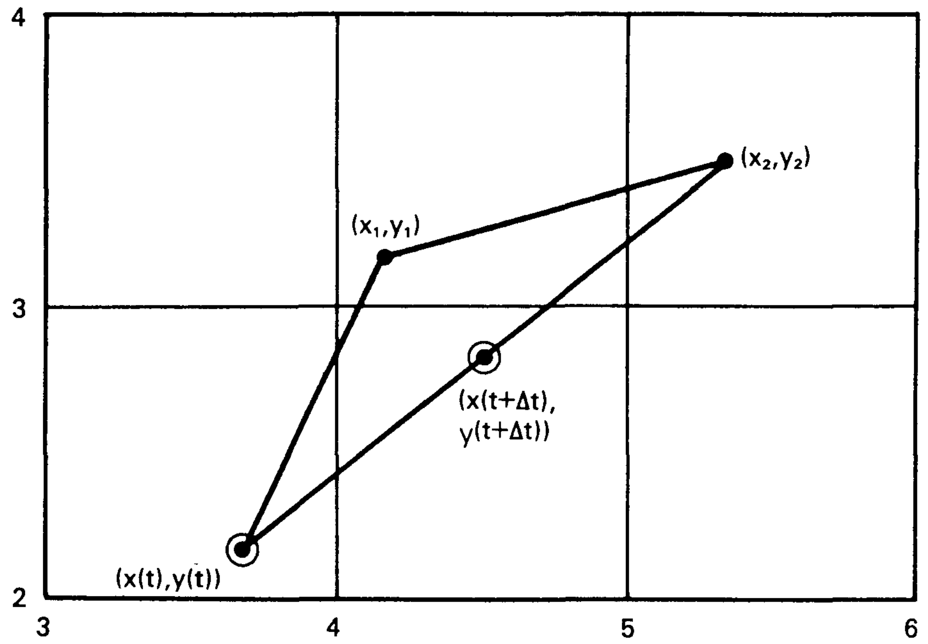

Figure 2-2 Calculation of the Trajectory of a Puff Centerpoint

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2.4.2 The Puff Dispersion Function

This section, describing the evaluation of the puff dispersion parameters, has been taken largely verbatim, with modifications, from Hales et al. (1977, pp. 23-24). The puff dispersion parameters σ_y and σ_z are calculated for distances out to 100 km using plume growth formulas fitted to the curves of Turner (1970). For distances greater than 100 km the plume growth rates given by Heffter (1965) are used. The growth of a puff with travel time t or along the plume trajectory distance s from the source is represented by

$$\sigma_y(s+\Delta s) = \sigma_y(s) + \Delta s \left.\frac{d\sigma_y}{ds}\right|_{s+\Delta s/2} ; \qquad (2\text{-}12)$$

$$\sigma_y(t+\Delta t) = \sigma_y(t) + \Delta t \left.\frac{d\sigma_y}{dt}\right|_{t+\Delta t/2} . \qquad (2\text{-}13)$$

Similar equations for σ_z are used. These terms allow for spatial and temporal changes in stability class to be included, without violating the entropy principle (puff centerpoint concentrations cannot increase with downwind distance).

The integral formulas for σ_y and σ_z for travel distances less than 100 km are of the following forms

$$\sigma_y(s,\alpha) = Y_\alpha \, s^{0.9} \text{ (meters)}; \qquad (2\text{-}14)$$

$$\sigma_z(s,\alpha) = Z_\alpha \, s^{b_\alpha} \text{ (meters)}. \qquad (2\text{-}15)$$

Here α is a stability index designated as A, B, C, D, E, or F corresponding to the PGT stability categories. The coefficients Y_α, Z_α, and b_α are given in Table 2-1 as a function of stability index α and yield values of σ_y and σ_z in meters when s is specified in meters. Because the integral formulas are not valid if the stability class changes over the travel distance s, the differentiated forms of 2-14 and 2-15 are actually used to carry out the computations in 2-12.

$$\frac{d\sigma_y}{ds} = 0.9 \; Y_\alpha \, s^{-0.1} ; \qquad (2\text{-}16)$$

TABLE 2-1

COEFFICIENTS FOR DISPERSION PARAMETER FORMULAS

Stability Index α	Puff Growth Coefficients		
	Y_α	Z_α	b_α
A	0.36	0.00023	2.10
B	0.25	0.058	1.09
C	0.19	0.11	0.91
D	0.13	0.57	0.58
E	0.096	0.85	0.47
F	0.063	0.77	0.42

$$\frac{d\sigma_z}{ds} = b_\alpha Z_\alpha s^{(b_\alpha - 1)} \quad . \tag{2-17}$$

MESOPUFF assumes that σ_y, $\sigma_z = 0$ at the origin (s = 0).

The derivative formulas used to grow σ_y and σ_z for travel distances greater than 100 km are those given by Heffter (1965):

$$\frac{d\sigma_y}{dt} (m\ s^{-1}) = 0.5 \tag{2-18}$$

$$\frac{d\sigma_z}{dt} (m\ s^{-1}) = 0.5\ (2K_z)^{1/2}\ t^{-1/2} \tag{2-19}$$

2.4.3 The Plume Sampling Function

Each puff resident on the grid is sampled, using the plume sampling function, to evaluate the average concentration experienced at each sampling grid intersection during the previous time step. For example, consider the hypothetical puff depicted in Figure 2-3. The puff center-point is at (x,y) and the puff radius is truncated at 3 σ_y. This is a reasonable simplification - much less than 1% of the area under a Gaussian distribution function lies beyond 3 σ_y from the peak value. During the time step considered, the grid point intersections (21,12), (22,12), and (22,13) are each impacted by the hypothetical puff; each grid point is assigned a certain average concentration resulting from the presence of the puff during the time step Δt. The grid point concentration C(i,j) calculated at (22,12) is computed by Equation 2-2:

$$C(22,12) = \frac{Q(x,y)}{2\pi\ \sigma_y^2(x,y)\ g_1(z)} \exp\left[\frac{-r^2}{2\ \sigma_y^2(x,y)}\right] g_2(z) \tag{2-20}$$

If a continuous plume has been properly simulated, a grid point impacted by the plume will receive individual doses from more than one puff (as was previously depicted in Figure 1-1). It is also possible that two plumes overlap; in this case, puffs from both plumes can impact a grid point. The total concentration, $C_T(i,j)$ at each grid point is therefore computed as the sum of individual puff contributions:

$$C_T(i,j) = \sum_{M=1}^{M_T} C_M(i,j) \tag{2-21}$$

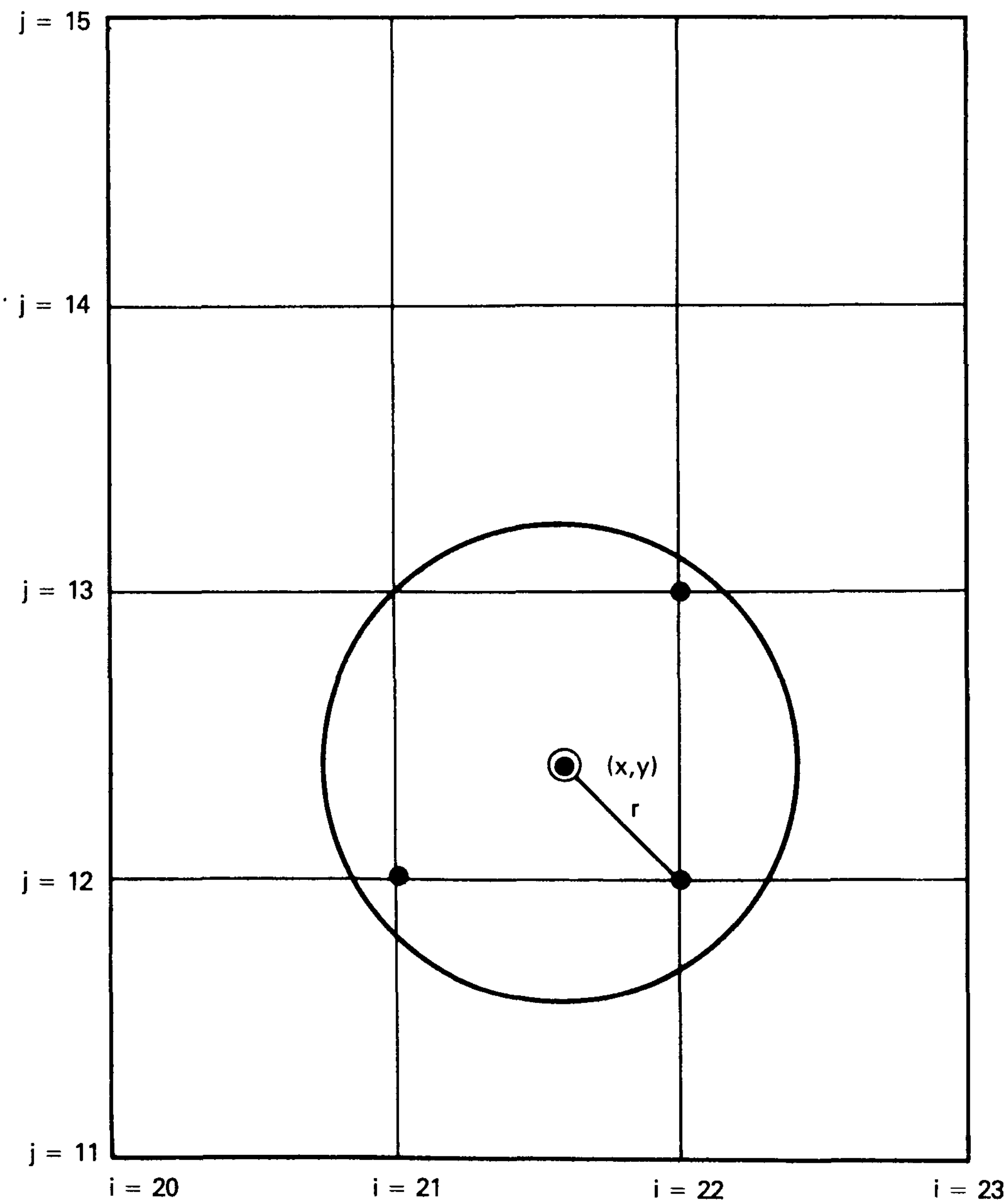

Figure 2-3 Calculation of the Concentration C(i,j) by the Sampling Function

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where M_T is the total number of puffs impacting the grid intersection (i,j) during the time step of interest.

2.5 Conversion of Sulfur Dioxide to Sulfate

MESOPUFF represents the conversion of SO_2 to $SO_4^=$ as a simple linear rate function--the changes in mass of each pollutant in one time step Δt are given by the time-discretized equations:

$$\Delta Q^n(SO_2) = k_1 Q^n(SO_2) \Delta t \tag{2-22a}$$

$$\Delta Q^n(SO_4^=) = -1.5 k_1 Q^n(SO_2) \Delta t \tag{2-22b}$$

where $Q^n(SO_2)$ is the mass of SO_2 at the beginning of the nth time step and $k_1(s^{-1})$ is the conversion rate constant. MESOPUFF uses the nominal value $k_1 = -5.56 \times 10^{-6}$ (that is, 2% per hour) - suggested by Hales et al. (1977), unless otherwise specified by the user.

Note that the conversion of SO_2 to $SO_4^=$ represented by Equation 2-22 is (1) independent of the vertical or horizontal distribution of SO_2 within a plume and (2) independent of whether a plume lies above or below the mixing height.

For the solutions to be adequate representations of the continuous exponential equations (e.g., $\dot{Q}(SO_2) = k_1 Q(SO_2)$), Q should not change appreciably over the time interval Δt. Since this is frequently not the case, the time interval Δt is optionally subdivided into as many subintervals $\Delta t'$ as are required to ensure that no more than a specified fraction ΔQ_f of the mass Q is removed by decay during a subinterval $\Delta t'$. This process is described further in the next section.

2.6 Dry Deposition of Sulfur Dioxide and Sulfate

The changes of mass $\Delta Q^n(g)$ of each pollutant resulting from dry deposition are given by:

$$\Delta Q^n(SO_2) = -(v_d(SO_2)\ Q^n(SO_2)\ \Delta t)\ /\ H_m \tag{2-23a}$$

$$\Delta Q^n(SO_4^=) = -(v_d(SO_4^=)\ Q^n(SO_4^=)\ \Delta t)\ /\ H_m \tag{2-23b}$$

where $Q^n(SO_2)$ and $Q^n(SO_4^=)$ are the masses of SO_2 and $SO_4^=$, respectively, in the puff at the beginning of the nth time step, $v_d(SO_2)$ and $v_d(SO_4^=)$ are the deposition velocities of each pollutant, and H_m is the vertical depth of the puff element (see Section 2.8). MESOPUFF uses the nominal values $v_d(SO_2) = 0.01$ (m/s) and $v_d(SO_4^=) = 0.001$ (m/s), as suggested by Hales et al. (1977), unless otherwise specified by the user.

As described before, MESOPUFF can optionally ensure that the mass Q does not change within one subinterval $\Delta t'$ by more than a user-specified fraction ΔQ_f. Taking into account both SO_2 removal mechanisms (decay and deposition), the expression used by MESOPUFF to specify the subinterval $\Delta t'$ is

$$\Delta t' = \text{MIN} \left\{ \frac{\Delta Q_f(SO_2)}{-k_1} \, , \, \frac{\Delta Q_f(SO_2) \; H_m}{v_d(SO_2)} \right\} \quad (2\text{-}24)$$

In other words, the subinterval size $\Delta t'$ can optionally be chosen by MESOPUFF at the beginning of each basic interval Δt such that no more than a specified fraction ΔQ_f of SO_2 mass is removed by either mechanism (or, no more than $2\Delta Q_f$ by both mechanisms combined) within $\Delta t'$. It should be emphasized that the conversion and removal rates are not affected by this restriction. Further discussion of the optional sampling mechanism is contained in Section 2.9.

2.7 Plume Rise

The effective emission height h_e of each plume segment is computed as $h_e = h_s + h_p$, where h_s is the stack height (m) and h_p is the plume rise (m). The plume rise equations used by the MESOPUFF model are those described by Briggs (1975) for equilibrium (final) plume rise. For unstable and neutral conditions with $h' \leq H$ (i.e., the plume does not rise into an elevated stable layer)

$$h_p = h' = 1.6 \; F^{1/3} \; (3.5 \; x^*)^{2/3} \; u^{-1} \; ; \quad (2\text{-}25a)$$

For unstable and neutral conditions with $h' > H$ (i.e., the plume penetrates into an elevated stable layer)

$$h_p = \text{MIN} \; \{h' \, , \, (1.8 \; z_b^3 + 18.75 \; F \; u_m^{-1} \; S^{-1})^{1/3} \}; \quad (2\text{-}25b)$$

for stable conditions when $u \geq 1.37$ m/s

$$h_p = 2.6 \; F^{1/3} \; S^{-1/3} \; u^{-1/3} \; ; \quad (2\text{-}25c)$$

for stable conditions when $u < 1.37$ m/s

$$h_p = 5.0 \; F^{1/4} \; S^{-3/8} \; . \quad (2\text{-}25d)$$

where:

F = buoyancy flux (m^4/s^3)

x^* = $34.49\ F^{0.4}$ for $F > 55$

= $14.0\ F^{0.625}$ for $F \leq 55$

S = $(g/T)(\partial\theta/\partial z)$

g = $9.8\ m\ s^{-2}$

T = $290°K$

$\partial\theta/\partial z$ = $0.0137°K\ m^{-1}$

H = mixing depth (m)

z_b = $H - h_s$ (m)

u = wind speed ($m\ s^{-1}$)

u_m = MAX {u, 1.37}

2.8 Treatment of Plume Fumigation

When the "uniform vertical distribution" option is elected, MESOPUFF takes the spatial and temporal variations in the mixing height into consideration to determine the extent of ground level impact.

(a) For a puff element emitted at an effective stack height which is less than the mixing height, MESOPUFF assigns the element a height of zero and immediately mixes the entire mass of the puff uniformly through the mixing depth (the mixing lid acts as a perfect reflector). Equations 2-3 and 2-4 are then applied to compute ground level concentrations.

(b) For a puff element which is emitted at an effective stack height greater than the mixing height, no effect of the puff is felt at ground. However, if subsequently the mixing height becomes greater than the height of the puff centerpoint, the entire puff element is immediately mixed uniformly through the mixing depth, the puff height is set equal to zero, and Equations 2-3 and 2-4 again apply. The mixing depth encountered by a puff element is likely to change over time and space. MESOPUFF assumes that a puff element residing in the mixed layer is mixed through the maximum mixing depth H_m encountered by the puff in its progression through the computational space-time grid.

The restriction of a uniform puff through a characteristic depth such as H_m is imperative for a one-layer model such as MESOPUFF - so that parcels of material, once entrained, are not bifurcated in the vertical when the height of the mixing lid changes (as sensed by a parcel in transport). Therefore, in the MESOPUFF model a puff, once entrained, is uniformly mixed through a realistic height, consistent with the following assumptions:

(a) When convection ceases in the late afternoon, turbulent energy in the afternoon mixed layer dissipates. Once the energy of the large convective cells is completely damped, the remaining small scale energy is not sufficient to yield a vertical entrainment rate comparable to the daytime entrainment rate produced by large convective eddies.

(b) The stable lid capping the convective layer most likely maintains some integrity after convection ceases, and acts to prohibit any additional vertical entrainment of plume material.

(c) A modeling approach that redistributes mass into a shallower layer when the mixing depth decreases will violate the second law of thermodynamics.

Since no mechanism remains for turbulent transfer of pollutant material either upwards or downwards once the mixing depth decreases, it is asserted that the height most appropriate to define the extent of vertical mixing of a puff is the maximum mixing height that the puff encounters during any portion of its travel.

To schematically illustrate the interaction of the MESOPUFF vertical distribution algorithm and the mixing depth progression algorithm used by MESOPAC (Benkley and Bass (1979b), Benkley and Schulman 1979)) a hypothetical example is given in Figure 2-4.

Here, consider two puffs of material released at different times from a source with an effective stack height of 250 m; the first puff release is made at 0300 GMT on the first day, the second puff release at 0300 GMT on the second day. Assume that the hypothetical source is located in the western United States so that 0000 GMT corresponds to late afternoon--the usual time of maximum mixing depth.

The first puff is entrained at 0600 GMT on Day 1 as the nocturnal boundary layer oscillates slightly upward in height. MESOPUFF immediately mixes the puff uniformly throughout this mixing depth.

This puff is mixed uniformly through 900 m by 0000 GMT on Day 2, and remains mixed through 900 m subsequent to that time, even though the height of the mixed layer collapses. The second puff, emitted at 0300 GMT on Day 2 is fumigated at 1500 GMT and is mixed uniformly through 700 m by the end of the afternoon. Therefore, the first puff, emitted at 0300 GMT on Day 1, remains uniformly mixed through a deeper vertical layer than the second puff; this is consistent with the greater extent of mixing on the first day as compared to the second day.

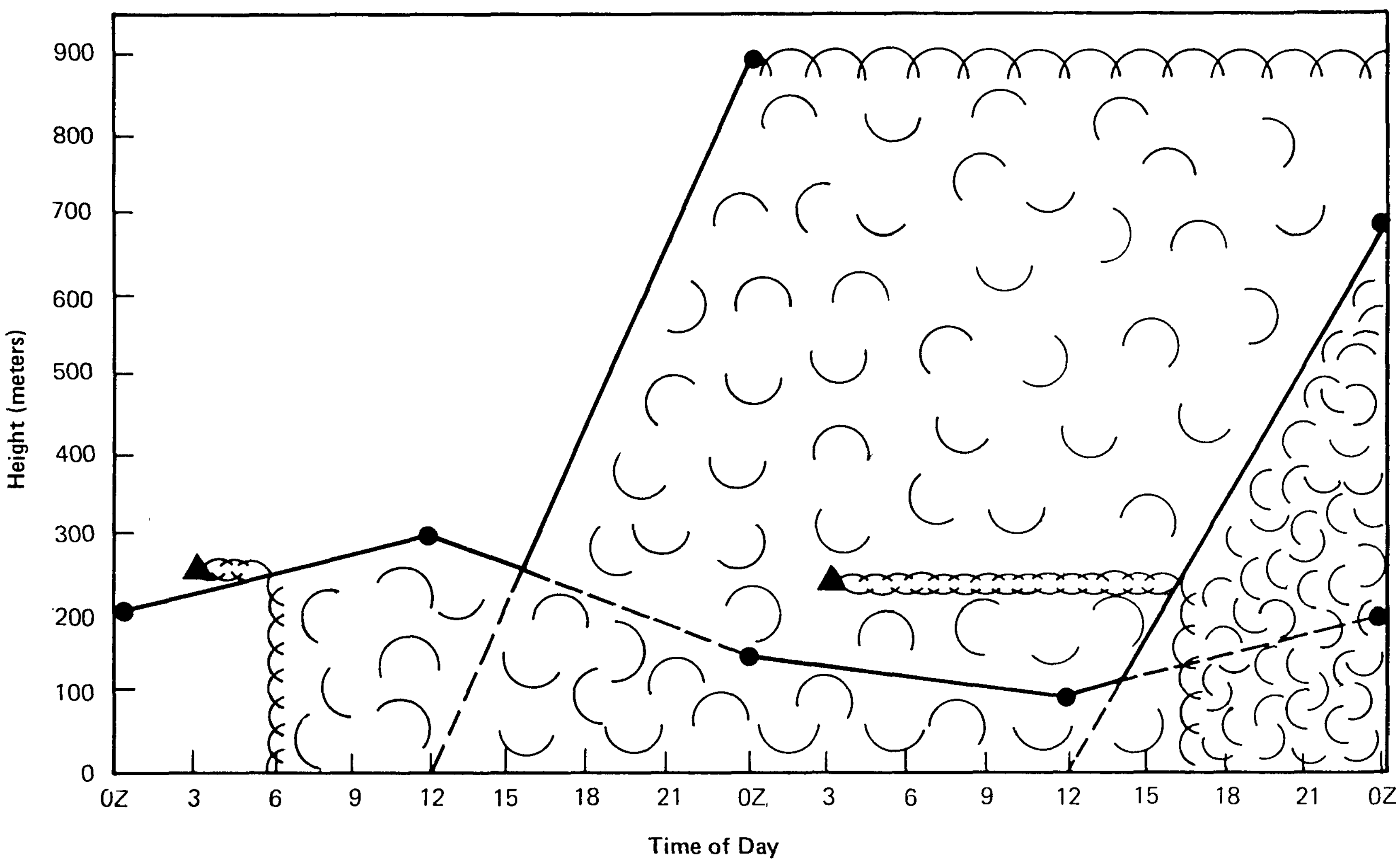

Figure 2-4 Response of Two Plume Elements to Changes in Mixing Depth

Both options can be exercised jointly; however, the larger of (n_p, n_s) should be an even multiple of the smaller. As an example, suppose the basic time step is 1 hour, with $n_p = 2$ and $n_s = 4$; puffs will be released every half-hour from each source, puff trajectories will also be updated every half-hour, and puffs will be sampled every quarter-hour, or twice per puff release step.

If the dynamic sampling step option is invoked in MESOPUFF (see Section 2.6) the actual sampling frequency n_p used by MESOPUFF during any basic model time step will be taken as the larger of (a) the user-specified n_p and (b) the dynamically-computed n_p.

Some guidance in selecting the appropriate puff release and sampling rates for a MESOPUFF simulation is provided by Figure 2-5, which depicts the strong effect of increasing the distance between adjacent puff centerpoints upon the ability of MESOPUFF to recreate a continuous plume. It is seen that when adjacent puff centerpoints are separated by 2 σ_y, concentrations computed by MESOPUFF will differ by no more than about ± 2% from concentrations as computed by MESOPUFF in the limit as puff separation distances go to zero; by contrast, if the centerpoint of adjacent puffs are separated by about 4 σ_y, deviations can be as large as 50% or more.

Because puffs are assigned zero width when released, it follows that for a given combination of puff release rate, sampling rate, and wind speed, a certain amount of time must elapse before adjacent puffs have grown wide enough to provide the degree of overlap necessary to simulate a continuous plume. But, because high rates of puff release and puff sampling quickly becomes cost-prohibitive (see Section 3.5), some near-field inaccuracies must be tolerated if long-distance transport is to be modeled in a cost-effective manner. Therefore, if one wishes to model plume impact at distances greater than 100 km, for example, the puff release rate and puff sampling rate should be chosen so that, for the maximum expected wind speeds, adjacent puffs will overlap sufficiently within say, a downwind range of 50-100 km.

2.10 Comparison to the Conventional Gaussian Plume Model

From the point of view of possible regulatory applications, one of the most attractive features of MESOPUFF is its ability to recreate the results of the conventional Turner Workbook plume model (using PGT coefficients). When MESOPUFF is run with appropriate uniform meteorology and fine steady-state spatial resolution, it can reproduce the Turner Workbook results to a high degree. This can be demonstrated, for example, under the following test conditions:

- The horizontal grid spacing of the model is reduced, e.g., to 5 km.

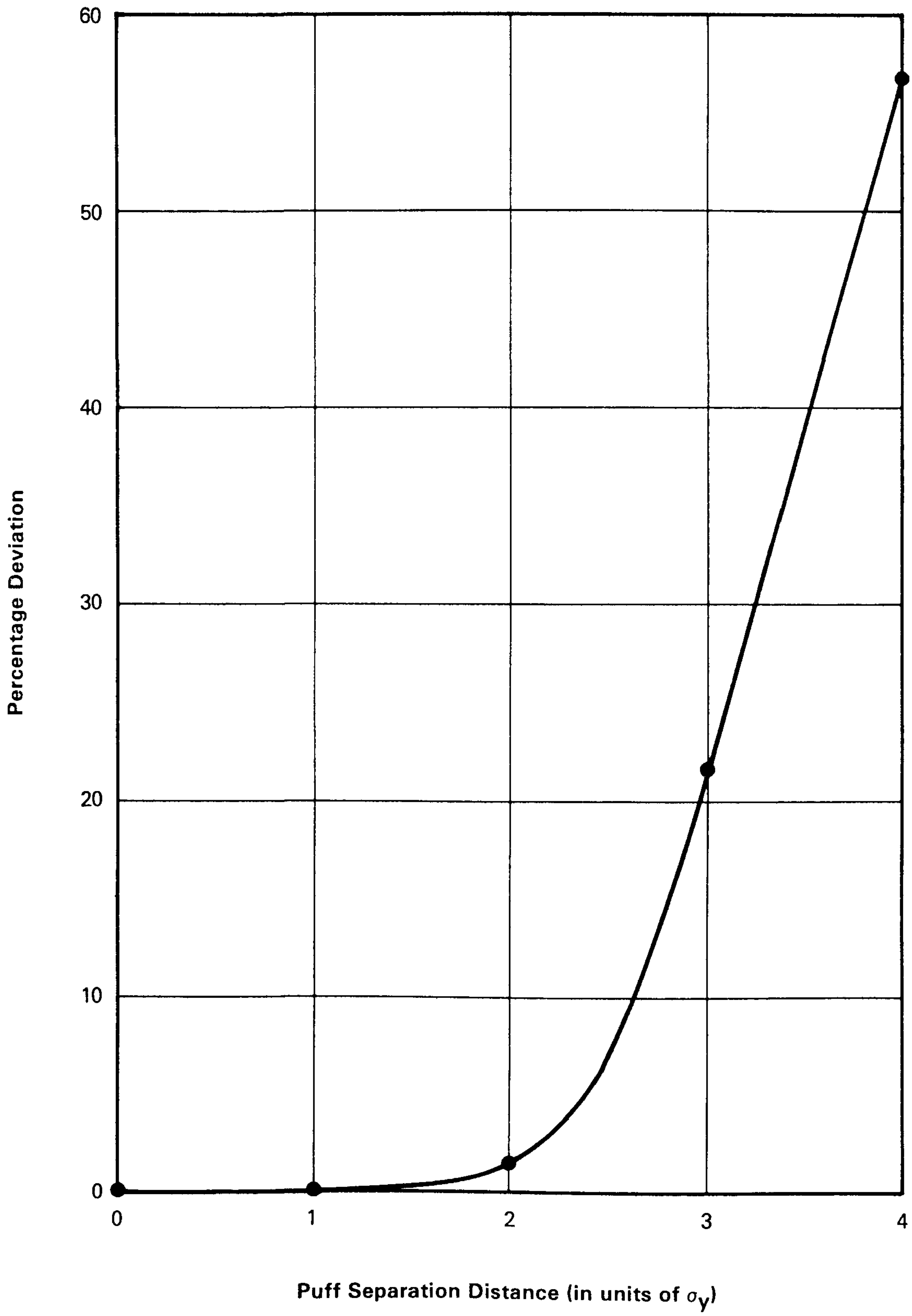

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Figure 2-5 MESOPUFF Model: Percentage Deviation with Puff Separation Distance

- The meteorological fields (wind direction, wind speed, mixing height and PGT stability class) used to drive MESOPUFF are taken to be spatially uniform and constant in time.

- MESOPUFF is run with one source until quasi-steady-state conditions are well established; that is, puffs are created at the same uniform rate at which they disappear off the edge of the grid.

- Consecutive puffs are emitted (or sampled) with sufficient frequency to simulate a continuous plume (see Section 2-9).

Under these special test conditions, MESOPUFF simulates very well the Turner Workbook plume concentrations out to distances of 100 km from an emission source. (The PGT σ_y and σ_z curves, represented in the model by piecewise linear power law fits, are only defined to 100 km.) Table 2-2 and Figure 2-6 provide a representative illustration of how closely MESOPUFF results compare to those obtained for the conventional Gaussian plume model using the PGT "D" curve for σ_y, and a uniform vertical distribution. Overall, the comparison is excellent--the very small fractional differences (typically less than 2%) are attributable mostly to inexact fitting of the PGT curves by the power law functions used in MESOPUFF.

MESOPUFF includes the option for a Gaussian distribution in the vertical with multiple reflections (see Section 2.1). MESOPUFF is therefore applicable both in the near field of a source (where a vertical Gaussian profile is appropriate and in the far-field of a source (where a uniform vertical distribution can normally be assumed). The current version of MESOPUFF does not include a transitional plume rise algorithm but transitional plume rise is not important beyond 5 km, even for the largest power plants.

In sum, if input parameters are chosen appropriately, MESOPUFF can be used for dispersion calculations even as close as, say, 5 km from a source; and, importantly, MESOPUFF can reproduce a conventional Gaussian model.

2.11 The MESOPUFF Computer Program

MESOPUFF is a highly modular computer program which shares with MESOPLUME and MESOGRID standarized input/output features and, where possible, identical program modules. The computer program flow chart (Figure 2-7) outlines the order of execution of the individual modules described at length in the 'MESOPUFF Technical Discussion'.

TABLE 2-2

COMPARISON OF Cu/Q VALUES FOR MESOPUFF AND TURNER WORKBOOK-COMPUTED VALUES
($u = 2.78\ m\ s^{-1}$, PGT Class = D, H = 1000 m, uniform vertical distribution)

Distance (km)	PGT σ_y (m)	Turner Workbook ($C\ u\ Q^{-1}$)	MESOPUFF ($C\ u\ Q^{-1}$)	Fractional Deviation
5	300	11.80×10^{-7}	12.01×10^{-7}	0.02
10	550	7.25	7.47	0.03
15	780	5.11	5.18	0.01
20	1,000	3.99	4.02	0.01
25	1,220	3.27	3.28	0.00
30	1,420	2.80	2.80	0.00
35	1,620	2.46	2.43	-0.01
40	1,820	2.19	2.15	-0.02
45	2,020	1.97	1.94	-0.02
50	2,200	1.81	1.77	-0.02
55	2,400	1.66	1.62	-0.02
60	2,600	1.53	1.49	-0.03
65	2,775	1.44	1.39	-0.03
70	2,975	1.34	1.30	-0.03
75	3,200	1.25	1.22	-0.02
80	3,375	1.18	1.15	-0.03
85	3,550	1.12	1.09	-0.03
90	3,700	1.08	1.04	-0.04
95	3,850	1.04	1.00	-0.04
100	4,000	1.00	0.96	-0.04

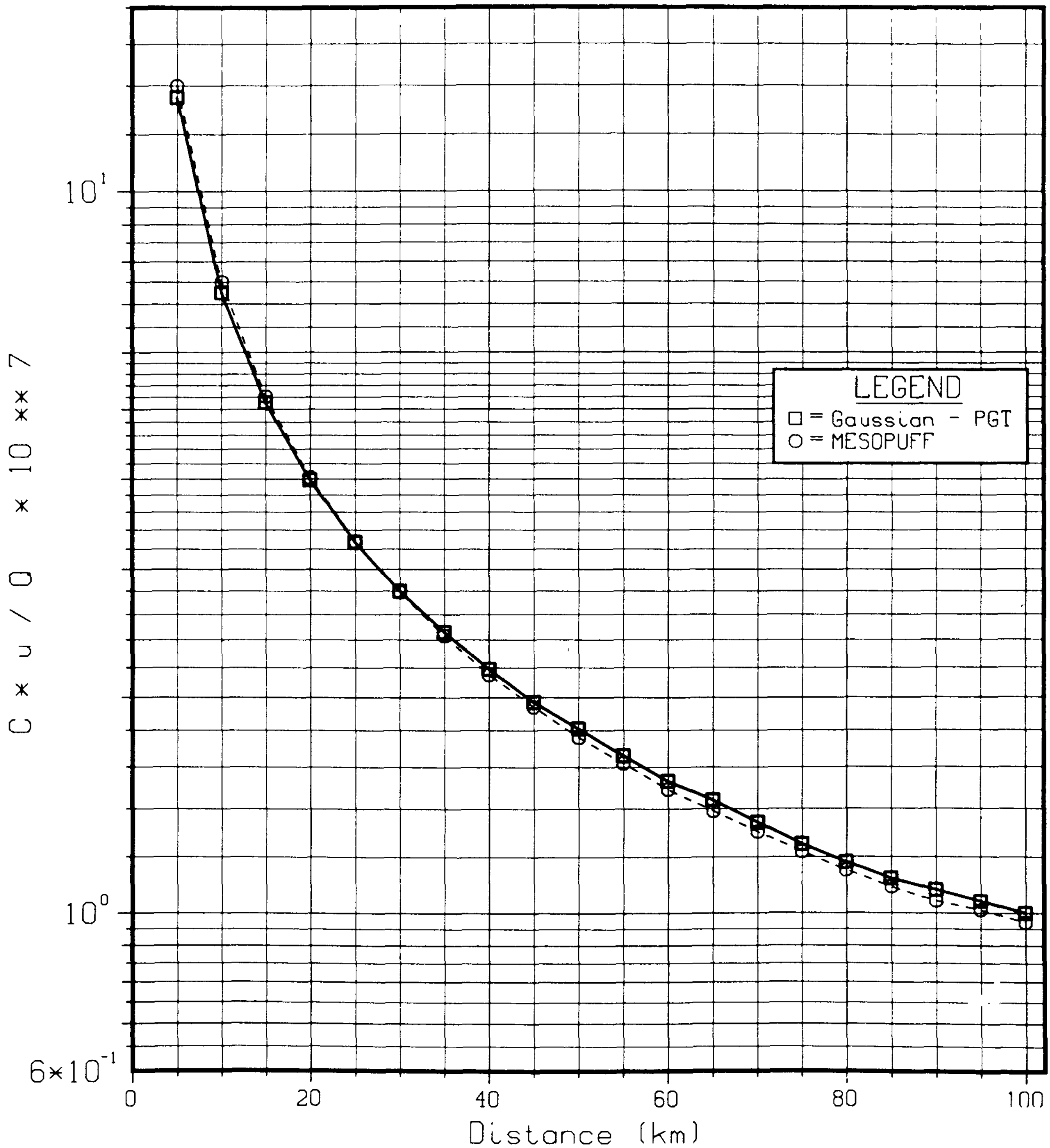

Figure 2-6 MESOPUFF vs. the Conventional Gaussian Plume

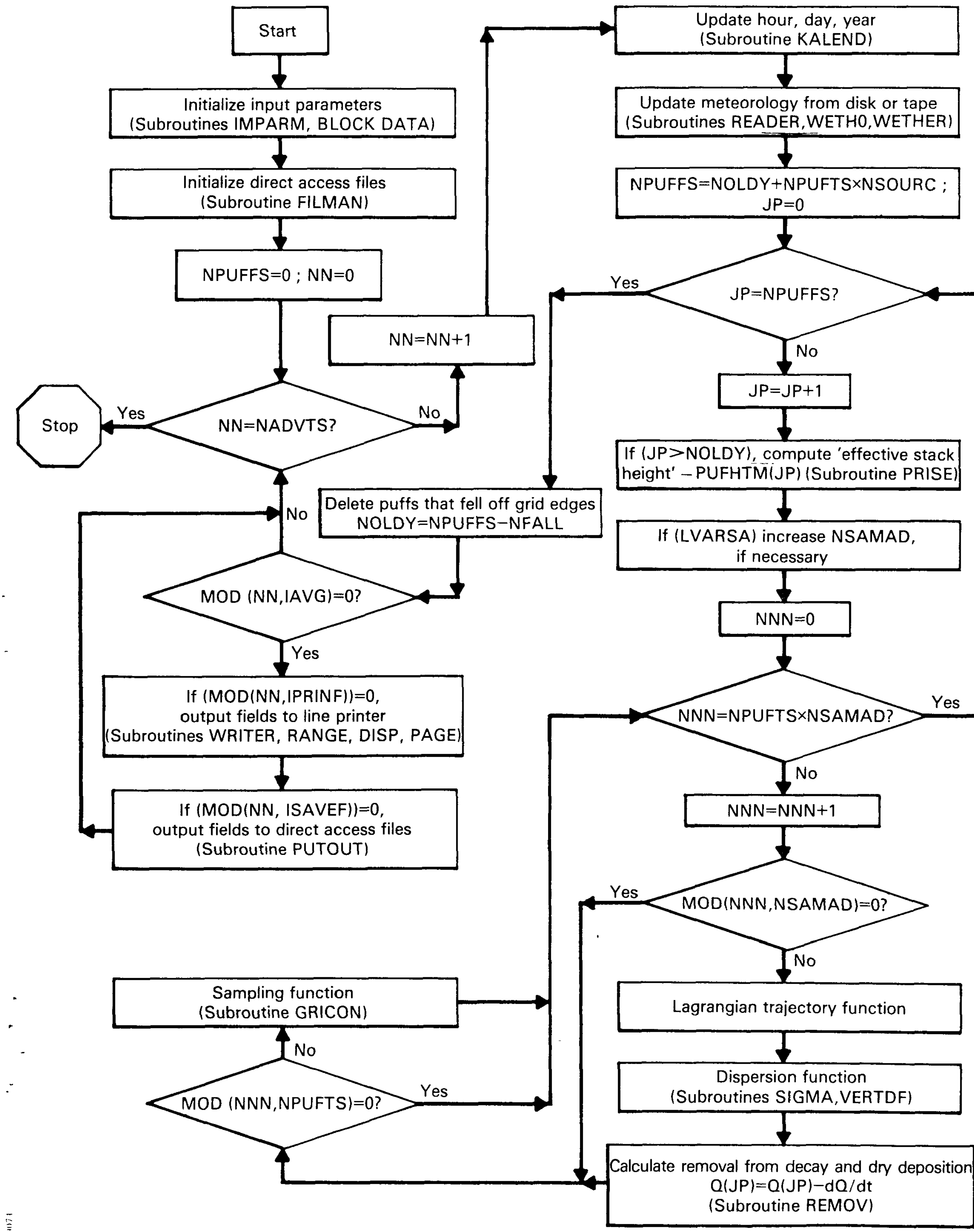

Figure 2-7 MESOPUFF Computer Program Flow Chart

3. MESOPUFF USER INSTRUCTIONS

3.1 General

A MESOPUFF model simulation requires the following two input data sets:

- meteorological fields from MESOPAC (unformatted disk or tape input via logical unit 2) and
- model simulation control parameters and emission source inventory (cards or card-image disk input via logical unit 5)

A complete description of model simulation control parameter and emission source inventory input is contained in Section 3.2.

For most convenient operation, MESOPUFF should interface with the output of the MESOPAC meteorological preprocessor (see Section 3.3). Output of a MESOPUFF simulation can be routed to either (or both) of the following:

- line printer (logical unit 6) and
- direct-access disk storage system (logical units 13, 15, 21, 22, 23, and 24).

The direct access storage system allows for automatic storage, cataloging, and easy retrieval of all output data files from MESOPUFF. Availability of on-line direct-access disk storage enables the user to invoke the powerful MESOFILE file-management system, designed especially for interface with the regional-scale models. The MESOFILE system has file management components that can produce a record of the date of the run, the run characteristics, the disk file locations of all the concentration data output, and the values of all the input parameters for the run. The MESOFILE program allows this information to be retrieved for all the previous runs made on a particular set of disk files. The MESOPUFF program contains a file management subroutine (FILMAN) which determines without further user input the proper locations for all of the various MESOPUFF disk output files. MESOFILE can then be used for flexible time averaging of any set of fields, summation of different model simulations (particularly useful when more than 10 sources are to be simulated), statistical comparison of model results, and graphical contour display.

3.2 Description of Card-Image Input

This section provides a detailed description of all the card-image input requirements of the MESOPUFF model, model simulation control parameters, and emission inventory. The input package has been designed for use in common by all three mesoscale models (MESOPLUME, MESOPUFF, and MESOGRID) especially to facilitate intermodel comparison tests. The common input subroutine (INPARM) reads in all model simulation control parameters in Fortran NAMELIST format so that input parameters common to all three models can be included in standardized NAMELIST blocks. A few model-specific NAMELIST sets, however, are required because of certain features peculiar to each model algorithm. There are thirteen NAMELIST blocks included within the INPARM subroutine package, as follows: (1) MODEL, (2) CONTR, (3) GRID, (4) SIGMA, (5) METD, (6) PUFF1, (7) PUFF2, (8) PLUM1, (9) PLUM2, (10) GRIDY, (11) REMOV, (12) OUTPT, and (13) SOURC. NAMELIST blocks PLUM1, PLUM2, and GRIDY are not used by MESOPUFF and must be omitted from the input data runstream.

The remainder of this section provides detailed descriptions of the parameters in each NAMELIST set.* These NAMELIST sets are to be included in the input run stream in the identical sequence described above.

NAMELIST TITLE--MODEL

MODEL defines which model is to be run. Initialize LPLUME = .TRUE. for a MESOPLUME run.

Parameter	Type	Definition	Default
LPLUME	LOGICAL	If .TRUE., MESOPLUME is to be run	.FALSE.
LPUFF	LOGICAL	If .TRUE., MESOPUFF is to be run	.FALSE.
LGRID	LOGICAL	If .TRUE., MESOGRID is to be run	.FALSE.

NAMELIST TITLE--CONTR

CONTR initializes computational control variables.

Parameter	Type	Definition	Default
DTIME	REAL	Length of the basic time step (hours)	1.0
NADVTS	INTEGER	Length of the simulation in terms of basic time steps	24

*The description of certain parameters that were retained from an earlier version of MESOPUFF but not otherwise used or that were included only to perform various model sensitivity tests, are omitted from this discussion--these parameters would not be activated by the average user. However, for a complete list of possible input parameters, the interested reader should consult the documentation included as comment cards directly in subroutine INPARM.

Parameter	Type	Definition	Default
MTFREQ	INTEGER	Rate (in terms of 'DTIME') with which wind, mixing depth, and stability fields are updated, in terms of the basic time step. 'MTFREQ'*'DTIME' must be equal to or an even multiple of the MESOPAC time step 'ISTEP' (hours)	1
IAVG	INTEGER	Number of basic time steps over which output concentration arrays are to be averaged	24

NAMELIST TITLE--GRID

GRID initializes parameters defining the three major grids: meteorological, basic computational, and sampling. The basic computational grid must be a subset of the meteorological grid and also must have the same grid spacing. The sampling grid must be a subset of the basic computational grid; it may have a grid spacing that is the same as the basic computation grid or denser by an integer multiple. Currently, the maximum allowable size of both the basic computational and sampling grids is 40 by 40 horizontal grid elements.

Parameter	Type	Definition	Default
IELMET	INTEGER	Number of elements in the x-direction of the meteorological grid--must be the same as 'IMAX' used by MESOPAC (must be $\leq$ 40).	26
JELMET	INTEGER	Number of elements in the y-direction of the meteorological grid--must be the same as 'JMAX' used by MESOPAC (must be $\leq$ 40).	26
DELTMT	REAL	Basic computational grid spacing (meters)--must be equal to the grid spacing, DX, used by the MESOPAC meteorological grid	40,000.
IASTAR	INTEGER	Element number of the meteorological grid where the basic computational grid starts (x-direction).	1
IASTOP	INTEGER	Element number of the meteorological grid where the basic computational grid stops (x-direction).	26

Parameter	Type	Definition	Default
JASTAR	INTEGER	Element number of the meteorological grid where the basic computational grid starts (y-direction).	1
JASTOP	INTEGER	Element number of the meteorological grid where the basic computational grid stops (y-direction).	26
ISASTR	INTEGER	Element number of the meteorological grid where the sampling grid starts (x-direction)--make sure that 'ISASTR' ≥ 'IASTAR'.	1
ISASTP	INTEGER	Element number of the meteorological grid where the sampling grid stops (x-direction)--make sure that 'ISASTP' ≤ 'IASTOP'.	26
JSASTR	INTEGER	Element number of the meteorological grid where the sampling grid starts (y-direction)--make sure that 'JSASTR' ≥ 'JASTAR'.	1
JSASTP	INTEGER	Element number of the meteorological grid where the sampling grid stops (y-direction)--make sure that 'JSASTP' ≤ 'JASTOP'.	26
MESHDN	INTEGER	A factor by which the basic computational grid spacing 'DELTMT' is divided to produce the sampling grid spacing.	1

NAMELIST TITLE--SIGMA

SIGMA initializes PGT stability-class-dependent coefficients that describe the differential forms of σ_y and σ_z. (σ_z is not applicable when 'LLID' = .TRUE.)

$$\sigma_y(s + \Delta s) = \sigma_y(s) + \frac{\partial \sigma_y}{\partial s} \Delta s$$

$$\text{where} \quad \frac{\partial \sigma_y}{\partial s} = a_y(s + \Delta s/2)^{b_y}$$

$$\sigma_z(s + \Delta s) = \sigma_z(s) + \frac{\partial \sigma_z}{\partial s} \Delta s$$

$$\text{where} \quad \frac{\partial \sigma_z}{\partial s} = a_z(s + \Delta s/2)^{b_z}$$

Parameter	Type	Definition	Defaults
AY(6)	REAL ARRAY	a_y for PGT classes A-F, respectively	(.33, .22, .17, .12, .086, .057)
BY(6)	REAL ARRAY	b_y for PGT classes A-F, respectively	(-.1, -.1, -.1, -.1, -.1, -.1)
AZ(6)	REAL ARRAY	a_z for PGT classes A-F, respectively	(.00048, .063, .1, .33, .41, .32)
BZ(6)	REAL ARRAY	b_z for PGT classes A-F, respectively	(1.10, .09, -.09, -.42, -.53, -.58)

NAMELIST TITLE--METD

METD initializes parameters that identify the input meteorological data base.

Parameter	Type	Definition	Default
METSRT	INTEGER	Year (2 digits), Julian day (3 digits), and hour (2 digits) in the MESOPAC output data file at which the MESOPUFF run begins.	7700101
METCOD	INTEGER	4-digit serial number to identify the meteorological data used (previously assigned by the user to the MESOPAC simulation run that generated the input meteorology fields).	1001

NAMELIST TITLE--PUFF1

For MESOPUFF only, PUFF1 initializes control parameters.

Parameter	Type	Definition	Default
NPUFTS	INTEGER	Number of puffs released per basic model time step 'DTIME' for each source.	1

Parameter	Type	Definition	Default
NSAMAD	INTEGER	Minimum number of times per basic time step 'DTIME' that puffs will be sampled by sampling grid.	1
LVARSA	LOGICAL	If .TRUE. program will dynamically increase sampling rate at any basic time step if necessary so that no more than a fraction 'CONVFR' (see NAMELIST REMOV) is removed from any puff in any sampling step.	.TRUE.
MAXSAM	INTEGER	If 'LVARSA' = .TRUE., this is the maximum number of sampling steps allowed in any basic time step.	100

NAMELIST TITLE--PUFF2

For MESOPUFF only, PUFF2 initializes computational parameters.

Parameter	Type	Definition	Default
NSIGMA	INTEGER	Puffs do not impact grid points further than 'NSIGMA' σ_y from the puff centerpoint.	3
LUFORM	LOGICAL	If .TRUE. fumigated puffs immediately assume a uniform vertical concentration distribution. If .FALSE. plume reflection terms are considered when appropriate.	.TRUE.

NAMELIST TITLE--REMOV

REMOV assigns values to the removal rate parameters.

Parameter	Type	Definition	Default
CONVFR	REAL	Maximum fractional amount of conversion or removal of SO_2 by either decay or dry deposition in any one sampling step (limits the sampling step size, not the conversion rate).	.02
LDCAY	LOGICAL	If .TRUE., exponential decay of SO_2 to $SO_4^=$ is simulated; If .FALSE., no decay is simulated.	.TRUE.

Parameter	Type	Definition	Default
EXTNCT	REAL	If 'LDCAY' is .TRUE., conversion rate of SO_2 to $SO_4^=$ (negative, for loss of SO_2).	-5.56×10^{-6}
LDEPOT	LOGICAL	If .TRUE. dry deposition is simulated for both species. If .FALSE., dry deposition is not simulated for either specie.	.TRUE.
DEPVEL(2)	REAL ARRAY	If 'LDEPOT' is .TRUE., 'DEPVEL(1)' and, 'DEPVEL(2)' are deposition velocities ($m\ s^{-1}$) for SO_2 and $SO_4^=$, respectively.	(.01,.001)

NAMELIST TITLE--OUTPT

OUTPT initializes the output control parameters.

Parameter	Type	Definition	Default
LPRINT	LOGICAL	Is .TRUE. if line printer output of gridded concentration arrays is desired.	.TRUE.
IPRINF	INTEGER	If 'LPRINT' is .TRUE., specifies the rate (in terms of 'DTIME') of gridded concentration array output (to line printer) in terms of the basic time step. Must be equal to or an even multiple of 'IAVG' (see NAMELIST CONTR).	24
LSAVE	LOGICAL	If .TRUE., concentration arrays are to be saved on disk or tape.	.FALSE.
ISAVEF	INTEGER	If 'LSAVE' is .TRUE., rate (in terms of 'DTIME') of concentration array output to tape or disk. Must be an even multiple of 'IAVG' (see NAMELIST CONTR).	24

NAMELIST TITLE--SOURC

SOURC assigns values to the parameters associated with source characteristics.

Parameter	Type	Definition	Default
NSOURC	INTEGER	Number of sources (up to 10)	1
LMISS	LOGICAL	If .TRUE., a 24 hour cycle of emission rate multipliers is to be read in. If .FALSE., temporally constant emission rates are assumed.	.FALSE.
LFLUX	LOGICAL	If .TRUE., a 24 hour cycle of buoyancy flux multipliers is to be read in. If .FALSE., temporally constant buoyancy fluxes are assumed.	.FALSE.

The following formatted (non-NAMELISTED) input follows the NAMELISTED input described above: For each source (there are a total of 'NSOURC' sources) the formatted input consists of the following sequence of cards.

STACK PARAMETERS (1 card per source)

Columns	Format	Parameter	Definition
1-10	F10.2	STAKHT	Stack height (m) above ground
11-20	F10.2	XXSTAK	x-coordinate of source (meteorological grid units)
21-30	F10.2	YYSTAK	y-coordinate of source (meteorological grid units)
31-40	F10.2	EMISS(1)	Emission rate (g s^{-1}) for SO_2
41-50	F10.2	EMISS(2)	Emission rate (g s^{-1}) for $SO_4^=$
51-60	F10.2	BFLUX	Buoyancy flux (m^4 s^{-3}) for plume rise

EMISSION CYCLE (2 cards per source; needed only if LMISS = .TRUE.)

The emission rate $Q_h(P,I)$ for hour h, source I, and pollutant P (1 = SO_2, 2 = $SO_4^=$) is computed as $Q_h(P,I)$ = '¯CYCLE(h,I)' * 'EMISS(P,I)'. Two emission cycle input cards are required for each source; the multipliers for hours 1-12 are specified on Card #1 and hours 13-24 are on Card #2. Card #1 is for each source set up as follows.

Columns	Format	Parameter	Definition
1-6	F6.2	ECYCLE (1,N)	Emission multiplier for hour 1, source N
7-12	F6.2	ECYCLE (2,N)	Emission multiplier for hour 2, source N
13-18	F6.2	ECYCLE (3,N)	Emission multiplier for hour 3, source N
19-24	F6.2	ECYCLE (4,N)	Emission multiplier for hour 4, source N
25-30	F6.2	ECYCLE (5,N)	Emission multiplier for hour 5, source N
31-36	F6.2	ECYCLE (6,N)	Emission multiplier for hour 6, source N
37-42	F6.2	ECYCLE (7,N)	Emission multiplier for hour 7, source N
43-48	F6.2	ECYCLE (8,N)	Emission multiplier for hour 8, source N
49-54	F6.2	ECYCLE (9,N)	Emission multiplier for hour 9, source N
55-60	F6.2	ECYCLE (10,N)	Emission multiplier for hour 10, source N
61-66	F6.2	ECYCLE (11,N)	Emission multiplier for hour 11, source N
67-72	F6.2	ECYCLE (12,N)	Emission multiplier for hour 12, source N

The format for Card #2 (hours 13-24) is identical.

BUOYANCY FLUX CYCLE (2 cards per source, needed only if LFLUX = .TRUE.).

The buoyancy flux $F_h(P,I)$ for hour h, source I, and pollutant P (1 = SO_2, 2 = $SO_4^=$) is computed as $F_h(P,I)$ = 'BCYCLE(h,I)' * 'BFLUX(P,I)'. Two emission cycle input cards are required for each source; the multipliers for hours 1-12 are on Card #1, and hours 13-24 are on Card #2. Card #1 is for each source is set up as follows.

Columns	Format	Parameter	Definition
1-6	F6.2	BCYCLE (1,N)	Buoyancy flux multiplier for hour 1, source N
7-12	F6.2	BCYCLE (2,N)	Buoyancy flux multiplier for hour 2, source N
13-18	F6.2	BCYCLE (3,N)	Buoyancy flux multiplier for hour 3, source N
19-24	F6.2	BCYCLE (4,N)	Buoyancy flux multiplier for hour 4, source N
25-30	F6.2	BCYCLE (5,N)	Buoyancy flux multiplier for hour 5, source N
31-36	F6.2	BCYCLE (6,N)	Buoyancy flux multiplier for hour 6, source N
37-42	F6.2	BCYCLE (7,N)	Buoyancy flux multiplier for hour 7, source N
43-48	F6.2	BCYCLE (8,N)	Buoyancy flux multiplier for hour 8, source N
49-54	F6.2	BCYCLE (9,N)	Buoyancy flux multiplier for hour 9, source N
55-60	F6.2	BCYCLE (10,N)	Buoyancy flux multiplier for hour 10, source N
61-66	F6.2	BCYCLE (11,N)	Buoyancy flux multiplier for hour 11, source N
67-72	F6.2	BCYCLE (12,N)	Buoyancy flux multiplier for hour 12, source N

The format for Card #2 (hours 13-24) is identical.

3.3 Other Considerations

3.3.1 Meteorological Considerations and MESOPAC Input

The meteorological input for the MESOPUFF model is specified as a time sequence of spatially variable, gridded fields of horizontal (u,v) wind components, mixing depth, and PGT stability class. These fields are generated and written to off-line storage (disk or tape) by the MESOPAC* Meteorological Preprocessing Program (see Benkley and Bass 1979b). As mentioned in Section 3.1, MESOPUFF retrieves the meteorological data set from logical unit 2.

Direct compatibility of MESOPUFF input with MESOPAC output is ensured if the successive runs of MESOPAC and MESOPUFF jointly satisfy the following constraints on respective run parameters.

- The four-digit serial number 'METCOD' used to identify the meteorological data sets requested by MESOPUFF must match the 'METCOD' assigned when MESOPAC created and tagged its output meteorological data set.
- The grid spacing 'DELTMT' used by MESOPUFF must be identical to the grid spacing 'DX' used by MESOPAC; of course, the number of horizontal grid elements 'IELMET' and 'JELMET' used to specify the met data array sizes in both models must be identical.
- The geographical area covered by the MESOPUFF basic computational grid must be identical to, or a subset of the area covered by the MESOPAC meteorological grid.
- The chronological time period over which the MESOPUFF simulation run is performed must be a subset of the time period used by MESOPAC to define the meteorological fields.
- The interval at which the meteorological fields are updated by MESOPUFF is specified by the product 'DTIME' * 'MTFREQ' (hours). This time interval must be equal to or an even multiple of the time interval 'ISTEP' (hours) used by MESOPAC to generate and output successive sets of meteorological fields.

3.3.2 Array Size Considerations

Currently, MESOPUFF allows for the basic computational grid to be as large as 40 elements in each horizontal direction. However, since most of the large arrays in MESOPUFF are related to the total number of puffs from all sources combined, the size of the grid could be increased without a substantial increase in the core required by MESOPUFF. The user can specify up to 10 sources; if a larger source inventory is needed, the user can run MESOPUFF with up to 10 sources at a time and

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*If desired, another meteorological preprocessing routine can be substituted to drive the MESOPUFF model.

then aggregate results with MESOFILE. MESOPUFF allows for up to 500 puffs (from all sources combined) to be resident on the grid at any time; thus, for example, for a 1-hour puff emission interval ('DTIME'/'NPUFTS' = 1.0), the MESOPUFF simulation is prematurely terminated if the average puff residence time becomes greater than 50 hours.

3.4 MESOPUFF Model Output

MESOPUFF output can be specified in either (or both) of two media depending on further user needs. The results can be output directly to the line printer, and/or routed for storage on the direct-access disk storage system for subsequent postprocessing. This section describes the types of output data that can be routed through each system. In most cases, the user may specify whether a certain type of output data will be received.

3.4.1 Line Printer Output

The following is a complete list of the line printer output options available from a MESOPUFF simulation:

- a table that lists the values of all input parameters used in the run (this output is always generated);

- arrays of ground-level concentrations for SO_2 and $SO_4^=$ block averaged over time intervals of 'IAVG' * 'DTIME' hours and output at intervals of 'IPRINF' * 'DTIME' hours during the run (these fields are printed only if 'LPRINT' = .TRUE.); and

- if, at any time, data for more than 400 puffs are being held in the puff arrays, MESOPUFF will delete all data in core for puffs that have previously fallen off the edge of the basic computational grid. A message will be output informing the user how many puffs have been deleted and how many puffs remain on the grid.

3.4.2 Direct Access Disk Output

Table 3-1 describes the logical unit file structure of the direct access disk storage system expected by MESOPUFF. (Model outputs are only directed to direct access disk storage when 'LSAVE' = .TRUE.) As indicated, six distinct direct access files are used, each with independent size characteristics; these file characteristics are currently frozen within the MESOPUFF code itself via Fortran "Define File" statements and may require specific modification for adaptation to the user's host system.

TABLE 3-1

LOGICAL UNIT FILE STRUCTURE

Device Logical Unit Number	File Name	Record Structure
13	Library	25 records, 14 words/record
15	NAMELIST	25 records, 800 words/record
21	SO_2 Concentration	1,800 records, 1,610 words/record
22	$SO_4^=$ Concentration	1,800 records, 1,610 words/record
23	Run Number	1 record, 2 words
24	Pointer	1 record, 4 words

Concentration Files 21 and 22 contain the SO_2 and $SO_4^=$ concentration fields for each output time step. An identifying header record identical to the format used for File 15 (see File 15 description below) precedes the concentration fields. Files 21 and 22 can accommodate a maximum of 1,800 records each; therefore, for example, the results of 10 independent model simulations, each of 179 hours duration with hourly output, will fit exactly within the 1,800 records allotted.

The library file (13) contains a single-record descriptor for each model run; File 13 can accommodate a maximum of 25 independent model runs. A hard copy printout of the library file produced by MESOFILE is shown in Figure 4-2 in the next section. The parameters defining each model simulation run are as follows:

INUMB	-	A model run number which is automatically assigned by the direct access disk output subroutine.
DATFLD	-	The date of execution (day, month, and year) of the model run [<u>not</u> the day (or days) simulated].
MODEL	-	The particular mesoscale dispersion model chosen from the integrated modeling mesoscale system--in this case, MESOPUFF.
YR/DAY/HR	-	The year, Julian day, and hour on which the model simulation begins (Note that the first gridded concentration field is not output until 'ISAVEF'*'DTIME' hours subsequently, where 'DTIME' is the basic MESOPUFF time step (hours) and 'ISAVEF' is defined below).
NGRIDS	-	The total number of concentration arrays output for each pollutant during the model simulation ('NGRIDS' = 'NADVTS'/'ISAVEF' where 'NADVTS' is the total number of time steps in the model simulation.)
IAVG	-	The concentration array averaging frequency in terms of the basic time step, 'DTIME'.
ISAVEF	-	The concentration array direct-access disk output frequency in terms of the basic model time step, 'DTIME'.
ISAFE	-	The direct access address of the duplicate File 15 record.
IBEGIN	-	The direct access address of the first of the 'NGRIDS' number of arrays output to File 21 for SO_2 and File 22 for $SO_4^=$.
ISTOP	-	The direct access address of the last of the 'NGRIDS' number of arrays to File 21 for SO_2 and File 22 for $SO_4^=$.

ICHECK - The run termination status indicator 'ICHECK' = 1 indicates the model simulation terminated normally; 'ICHECK' = 0 indicates it terminated abnormally. In the latter case, the results of this run must be deleted from the file management system using the program BACKUPØ1 (see Scire et al. 1979) before another run is made.

NAMELIST File 15 contains a one-record detailed description of the parameters used for each model run. Each record in File 15 contains: (1) a duplicate of the corresponding FILE 13 record for the run and (2) the NAMELIST parameters used to make the run (also output to the line printer).

Finally, the Run Number and Pointer Files (23 and 24) preserve information between runs necessary to maintain proper archival sequencing of run outputs--they are invisible to the user.

3.5 Execution Time and Core Requirements

The time required for a MESOPUFF simulation depends on:

- the number of time steps N,
- the number of puff releases n_p per source per time step,
- the number of puff samples n_s per time step,
- the number of sources S, and
- various meteorological factors that control the average number of puffs resident on the grid.

For a single source, the following relationship for MESOPUFF execution time was found useful for estimating run time for typical meteorological conditions in the Four Corners area:

$$t(sec) = 20 + 0.5N + 0.003\,(n_p-1)\,N^2 + 0.002\,(n_s-1)\,N^2 \qquad (3\text{-}1)$$

Note that while both n_p and n_s can be varied to simulate a continuous plume, frequent sampling is often less costly than frequent puff releases. For one puff release per time step (n_p = 1) and sampling frequency dynamically determined, a useful relationship describing the execution time (on an IBM 370/158) of MESOPUFF with multiple sources and the computational grid and typical meteorological conditions used is given by:

$$t(sec) = 0.38\,(S)\,(N) + 0.43\,(N) \qquad (3\text{-}2)$$

For runs with more than a few sources (so that the second term on the right hand side of (3-2) is negligible), the MESOPUFF model is about twice as expensive to run as MESOPLUME.

On the same computer installation, MESOPUFF required 230k bytes of core during execution.

4. TEST CASE FOR MESOPUFF

A test case is provided in this section to familiarize the user with the operation of the MESOPUFF model and to verify that the model is running properly on the host system. The test case included here is a 3-day sequence of MESOPUFF model output for the time period 0000 Greenwich Mean Time (GMT) June 14, 1978 through 0000 GMT June 17, 1978 in the Four Corners area of the southwestern United States see Bass et al. (1979)]. A 10-source partial emission inventory was selected from the full set of energy-related major point sources of SO_2 in the Four Corners area.

Figure 4-1 contains the run control parameters and emission source inventory (input on logical unit 5) for this test case. Note that most of the model input variables assume their default values. Appendix A contains the entire input data set used by the MESOPAC preprocessor to generate the meteorological fields that were subsequently read in by MESOPUFF (on logical unit 2). Appendix A also contains a very small portion of the MESOPAC model output--included to aid the user in verifying the full test case.

The full set of line printer output for this MESOPUFF test case is included in Appendix B. Descriptions of the model output fields assigned to the direct access disk storage system (as echoed in hard copy form by the MESOFILE system) are shown in Figure 4-2 (the library file) and in Appendix C (the NAMELIST file). In this example, the results from the MESOPUFF test case are stored together with the results from the MESOPLUME and MESOGRID test cases as discussed in the MESOPLUME user's manual (Benkley and Bass 1979) and the MESOGRID user's manual (Morris et al. 1979). Appendix C also shows the NAMELIST file; there, the library record NAMELIST input parameters and emission source data are stored for future reference.

The MESOFILE postprocessing system (Scire et al. 1979) operates on the direct access disk output files produced by MESOPUFF, to produce various forms of result analyses. Figure 4-3 illustrates one such option--a Calcomp contour plot of the 24-hour average ground-level SO_2 concentration field for June 16, 1978 as obtained from the test case. (Concentration isopleth values are not printed directly on the contour plot, but the user can generate an equivalent line printer plot, as illustrated in Figure 4-4, which does include the actual isopleth values.) Figure 4-5 illustrates the bulk statistical descriptors (described by Bass et al. 1979) used to compare, for example, two time sequences of model result fields. In this example, the base case 24-hour average ground-level SO_2 concentration fields for June 16 computed by the MESOGRID model are compared to those computed by the MESOPUFF model.

```
 &MODEL LPUFF=.TRUE. &END
 &CONTR NADVTS=72 &END
 &GRID &END
 &SIGMA &END
 &METD METSRT=7816500,METCOD=1003 &END
 &PUFF1 &END
 &PUFF2 &END
 &REMOV &END
 &OUTPT LSAVE=.TRUE. &END
 &SOURC NSOURC=10 &END
236.       8.8       8.8       2560.      0.        6397.
152.       23.4      14.0      343.8      0.        1503.
152.       17.2      18.9      633.4      0.        2847.
152.       23.7      13.0      488.       0.        3353.
163.       13.5      1.2       53.7       0.        3016.
229.       10.0      13.1      320.       0.        6222.
76.2       8.0       19.5      146.9      0.        240.
183.       9.7       15.2      1310.8     0.        3016.
175.       0.9       8.0       268.8      0.        1047.
152.       1.5       4.1       1011.      0.        11144.
```

Figure 4-1 MESOPUFF Test Case Parameter and Emission Source Inventory Input

INUMB	DATFLD	MODEL	YR/DAY/HR	NGRIDS	IAVG	ISAVEF	ISAFE	IBEGIN	ISTOP	ICHECK
1	12 FEB 1979	MESOPLUM	78/165/ 0	3	24	24	1	2	4	1
2	12 FEB 1979	MESOPUFF	78/165/ 0	3	24	24	5	6	8	1
3	12 FEB 1979	MESOGRID	78/165/ 0	3	24	24	9	10	12	1

Figure 4-2 Test Case Library File (MESOFILE)

Day 167 MESOPUFF

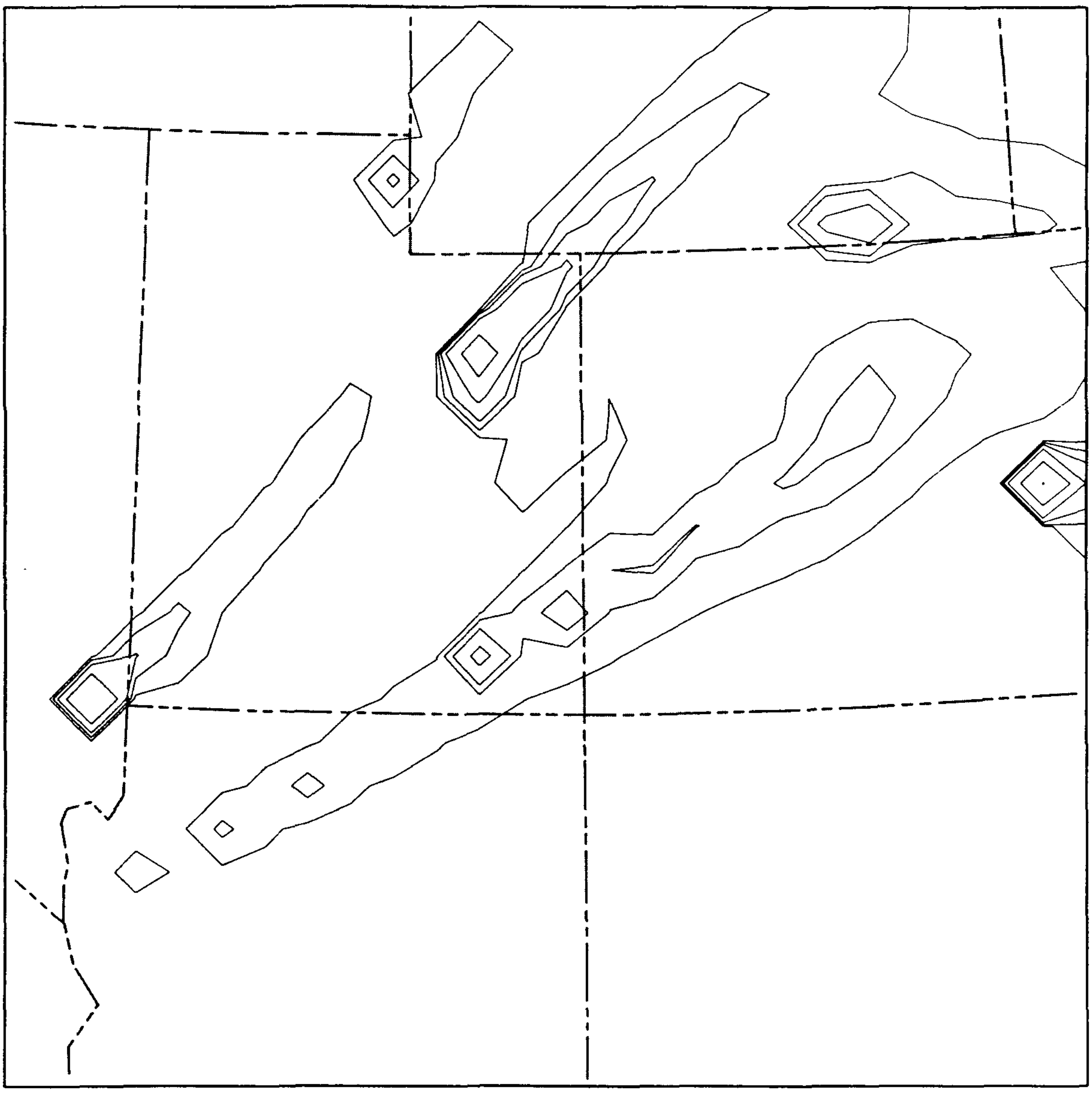
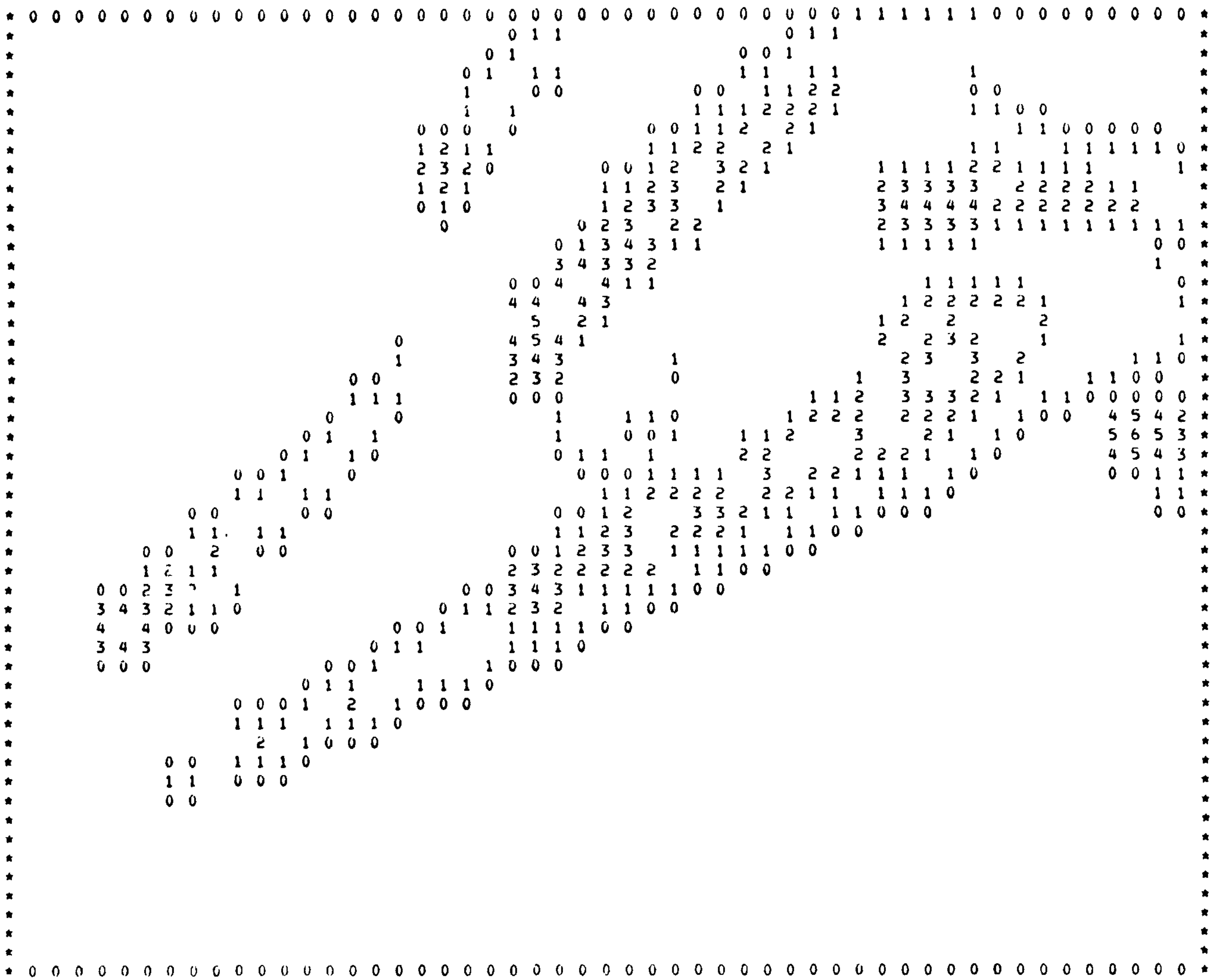


Figure 4-3 MESOPUFF 24-Hour Average SO_2 Concentratic.ı Calcomp Plot, 16 June, 1978 (from MESOFILE)

7901344



PLOT NUMBER: 6

VALUE	THRESHOLD (MICROGRAMS)
0	-0.00 LE X LT 0.10
1	0.10 LE X LT 0.50
2	0.50 LE X LT 1.00
3	1.00 LE X LT 2.00
4	2.00 LE X LT 5.00
5	5.00 LE X LT 10.00
6	10.00 LE X LT 25.00
7	25.00 LE X LT 50.00
8	50.00 LE X

Figure 4-4 MESOPUFF 24-Hour Average SO_2 Concentration Line Printer Plot, 16 June 1978 (from MESOFILE)

```
THE FOLLOWING RECORDS WERE USED AS THE BASE FIELD:
FIRST RECORD =     31      LAST RECORD =     31

THE FOLLOWING RECORDS WERE USED AS THE PERTURBED FIELD:
FIRST RECORD =     34      LAST RECORD =     34


STATISTICS FOR THE SET OF ALL GRID POINTS:


AVERAGE BASE FIELD VALUE (AVEB) =  0.16300E-06
AVERAGE PERTURBED FIELD VALUE (AVEP) =  0.19558E-06
AVERAGE DEVIATION (AD) = -0.32577E-07
AVERAGE ABSOLUTE DEVIATION (AAD) =  0.19679E-06
MAXIMUM LOCAL DEVIATION (XMLD) =  0.84354E-05
DIFFERENCE OF MAXIMA (DLM) B-P =  0.59659E-05
FRACTIONAL DIFFERENCE OF MAXIMA (FDLM) B-P =  0.58229E+00
MAXIMUM BASE FIELD VALUE (XMBF) =  0.10246E-04
MAXIMUM PERTURBED FIELD VALUE (XMPF) =  0.42797E-05


STATISTICS FOR THE SET OF POINTS WITHIN THE UNION OF THE TWO PLUMES:

AVERAGE DEVIATION (AD1) = -0.54241E-07
AVERAGE ABSOLUTE DEVIATION (AAD1) =  0.32767E-06
CORRELATION COEFFICIENT (RBA) =  0.27


STATISTICS FOR THE SET OF POINTS WITHIN THE INTERSECTION OF THE TWO PLUMES:

AVERAGE DEVIATION (AD0) = -0.11859E-06
AVERAGE ABSOLUTE DEVIATION (AAD0) =  0.38715E-06
AVERAGE FRACTIONAL DEVIATION (AFD0) = -0.44175E+01
AVERAGE ABSOLUTE FRACTIONAL DEVIATION (AAFD0) =  0.47745E+01
MAXIMUM ABSOLUTE FRACTIONAL DEVIATION (XMLFD0) =  0.11390E+03


PLUME CHARACTERISTICS


TOTAL NUMBER OF GRID POINTS =        676
NUMBER OF GRID POINTS CONTAINED IN THE INTERSECTION OF THE BASE AND PERTURBED PLUMES =        288
NUMBER OF NON-ZERO CONCENTRATIONS (BASE OR PERTURBED) =        406
NUMBER OF GRID POINTS IN THE BASE PLUME =        356
NUMBER OF GRID POINTS IN THE PERTURBED PLUME =        338
AVERAGE BASE PLUME VALUE (AVEB0) =  0.30952E-06
AVERAGE PERTURBED PLUME VALUE (AVEP0) =  0.39116E-06
FRACTIONAL DEVIATION OF THE MEANS (FDM) = -0.26376E+00
```

Figure 4-5 Bulk Statistical Comparison of MESOGRID to MESOPUFF, 16 June, 1978 (from MESOFILE)

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APPENDIX A

TEST CASE MESOPAC INPUT AND OUTPUT

```
MESOPAC TEST CASE -- DAYS 165 THROUGH 167, 1978                    1003
   26   26   18    1    1
0016578    0016878
40000.     0.0001            1.0              50
.TRUE.      .TRUE.     .TRUE.
.TRUE.      .TRUE.       12     0
 INW 10.0 3.7
 UCC -0.7 8.3
 ABQ 19.1 3.7
 GJT 14.5 14.7
 TUS 9.6  -4.0
 DEN 22.9 16.9
 LND 15.1 25.9
 SLC 7.8  19.8
 ELY 1.5  15.7
 BOI -0.4 27.7
 WMC -4.2 20.8
 RAP 26.0 28.8
 LBF 31.4 21.3
 DDC 34.8 12.3
 AMA 30.8 5.0
 MAF 29.2 -4.3
 ELP 19.6 -5.2
 SAN -5.2 -2.8
016578      18
BOI            26.0                    6.5  3.0
RAP            32.2                    5.8  5.8
WMC            27.8                    3.9  6.7
LND            30.2                    6.3  5.3
SLC            32.8                    5.0 10.7
LBF            28.2                    5.0 -1.3
ELY            28.2                    2.8  4.9
GJT            33.2                    5.1  3.5
DEN            29.4                    0.2  2.0
DDC            29.4                    5.3  1.9
UCC           999.0                  999.0999.0
INW            34.4                    6.7  4.7
ABQ            28.2                    5.6  1.0
AMA            27.8                    8.0  4.6
SAN            30.0                    9.9  8.3
TUS            39.4                    3.6  0.3
ELP            35.0                    2.3  1.1
MAF            31.6                    0.4  4.6
1216578      18
 BOI       914. 10.6 12.8  3.2-14.1  6.9  8.3
 RAP       903. 18.8 21.8 10.4-11.9 14.7-10.3
 WMC       869.  8.2 13.4  3.8-12.3 12.6  8.9
 LND       830. 11.6999.0 11.0-11.5  7.1  4.1
 SLC       896. 21.6 23.6 11.4 -9.5  9.9  8.3
 LBF       916. 18.2 26.2 13.0-10.9  7.5  6.3
 ELY       809. 10.2999.0 10.0 -9.5  7.2 12.5
 GJT       853. 18.2 19.4 12.4 -7.7  7.5  3.5
 DEN       839. 13.2999.0 12.8 -8.3  9.4 -2.5
 DDC       927. 18.2 22.0 10.0-10.3  4.6  8.0
 UCC      9999.999.0999.0999.0999.0999.0999.0
```

```
INW       855. 16.0 17.4 11.6 -7.1  5.9  5.0
ABQ       842. 18.8999.0 13.8-11.1  6.5 -3.0
AMA       895. 18.2 19.8 11.0 -8.1  7.1 -1.3
SAN      1000. 17.0 15.8 11.2 -7.3 14.0  6.5
TUS       924. 23.0 27.2 14.2 -6.5  5.5  5.5
ELP       884. 21.2 22.2 13.2 -9.7999.0999.0
MAF       918. 18.8 21.4 12.4 -8.5  2.6 -0.2
016678      18
BOI            23.8                10.4  2.8
RAP            29.4                 4.8 10.3
WMC            25.0                 8.3  6.9
LND           999.0               999.0999.0
SLC            30.6                 2.4 13.7
LBF            33.2                 3.3  5.8
ELY            28.0                 4.6  9.8
GJT            31.0                 3.3  5.8
DEN            32.2                -2.9  2.9
DDC            33.8                 6.6 -1.2
UCC           999.0               999.0999.0
INW            35.0                 7.3  7.3
ABQ            35.0                 3.2  2.6
AMA            31.0                 7.6  4.4
SAN            23.8                19.3  7.0
TUS            40.0                 8.6  1.5
ELP            36.6                -1.1  2.9
MAF           999.0               999.0999.0
1216678     18
BOI       917.  8.2  9.0  3.5-19.1  8.2 -0.7
RAP      9999.999.0999.0999.0999.0999.0999.0
WMC       870.  6.6  7.6  2.3-17.1  5.1  0.9
LND       825. 10.6999.0 11.4-10.1  8.7  3.2
SLC       868. 15.6 17.4  8.2-12.1  4.6 12.6
LBF       911. 17.8 23.2 15.6 -9.9  1.9  7.0
ELY       807.  8.4999.0  8.4-12.3  3.5  5.1
GJT       851. 20.6 22.4 10.8 -9.9  7.6  5.3
DEN       836. 18.8999.0 13.2 -9.1  9.9  2.7
DDC       921. 21.6 25.8 14.2 -7.1 14.7  7.5
UCC      9999.999.0999.0999.0999.0999.0999.0
INW       853. 20.0 19.8 13.0 -8.3 12.6 10.6
ABQ       840. 17.2999.0 13.4 -5.9999.0999.0
AMA       891. 20.0 22.8 14.6 -7.3  6.1  0.5
SAN      1002. 16.0 17.6 11.6 -7.7  3.4  7.7
TUS       924. 23.2 24.4 13.6 -7.5   .8  5.7
ELP       882. 24.8 27.0 15.4 -5.9  6.7  0.6
MAF       917. 20.6 22.0 13.8 -7.1 -2.5  0.7
016778      18
BOI            19.4                11.4  3.1
RAP            29.4                10.6  3.9
WMC            22.8                 5.0  7.2
LND            27.2                 7.3  7.3
SLC            26.6                 4.7  6.7
LBF           999.0                 9.2  0.8
ELY            23.8                 8.6 10.2
GJT            33.2                 6.5  6.5
DEN            34.0                 9.7 -0.9
```

```
DDC           36.0                   12.9  7.5
UCC          999.0                  999.0999.0
INW           33.2                   10.3  4.8
ABQ           35.6                   10.6  1.9
AMA           35.0                    9.7  6.8
SAN           22.0                   15.2  2.7
TUS          999.0                  999.0999.0
ELP          999.0                  999.0999.0
MAF           33.2                    2.3 -4.0
1216778     18
BOI        918.  6.6 10.8  3.5-20.5  7.6 -5.3
RAP        904. 13.8 13.4  6.8-11.9  5.5 -1.5
WMC        870.  6.6  8.0 -0.9-23.5  1.4  3.9
LND       9999.999.0999.0999.0999.0999.0999.0
SLC        870. 13.8 13.8  5.4-12.7  2.6  7.3
LBF        910. 18.8 21.8 15.0 -9.1  4.7 -4.0
ELY       9999.999.0999.0999.0999.0999.0999.0
GJT       9999.999.0999.0999.0999.0999.0999.0
DEN       9999.999.0999.0999.0999.0999.0999.0
DDC        920. 23.2 26.6 15.6 -6.9 11.6  4.2
UCC       9999.999.0999.0999.0999.0999.0999.0
INW       9999.999.0999.0999.0999.0999.0999.0
ABQ       9999.999.0999.0999.0999.0999.0999.0
AMA        890. 21.6 27.4 16.2 -7.7  8.5  4.9
SAN       9999.999.0999.0999.0999.09 ?.0999.0
TUS       9999.999.0999.0999.0999.09  ,0999.0
ELP       9999.999.0999.0999.0999.0999.0999.0
MAF        916. 21.0 25.2 14.6 -6.3 -1.5 -0.3
016878      18
BOI           20.6                    9.1 -1.6
RAP           22.2                    4.3  5.1
WMC           21.6                    3.6 -0.3
LND          999.0                  999.0999.0
SLC           25.6                   10.8  0.9
LBF           28.8                    6.2  3.6
ELY           21.6                    8.0  5.6
GJT           31.6                   12.5  7.2
DEN           31.6                    0.2 -1.0
DDC           36.6                   10.5 10.5
UCC          999.0                  999.0999.0
INW           32.8                    9.8  5.7
ABQ           34.4                   11.8 -0.0
AMA           34.4                    5.5  3.8
SAN           23.4                   18.4  1.6
TUS           38.4                    3.8 -2.7
ELP           38.0                    4.5 -1.2
MAF           34.4                    2.9 -2.1
```

** MESOPAC **

STATION DATA FOR 0 166 78 (HOUR,DAY,YEAR)

STATION	U	V	DEPTH	STAB
INW	7.3	7.3	130.	3
UCC	999.0	999.0	9999.	9
ABQ	3.2	2.6	4265.	1
GJT	3.3	5.8	2656.	2
TUS	8.6	1.5	3534.	2
DEN	-2.9	2.9	3861.	1
LND	7.1	4.1	9999.	9
SLC	2.4	13.7	1578.	3
ELY	4.6	9.8	3743.	3
BOI	10.4	2.8	1982.	3
WMC	8.3	6.9	2815.	3
RAP	4.8	10.3	1442.	3
LBF	3.3	5.8	1019.	2
DDC	6.6	-1.2	2612.	2
AMA	7.6	4.4	2029.	2
MAF	2.6	-0.2	9999.	9
ELP	-1.1	2.9	5264.	1
SAN	19.3	7.0	1088.	4

ONLY NON-MISSING DATA IS USED TO CONSTRUCT ALL FIELDS AT EACH TIME STEP

** MESOPAC **
U-FIELD FOR 0 166 78 (HOUR,DAY,YEAR) 2 ITERATIONS SCAN RADIUS= 9.8 GRID SPACES FIELD IN UNITS OF 10** -1

78 +	85 +	82 +	78 +	71 +	65 +	59 +	56 +	53 +	55 +	53 +	58 +	61 +	66 +	68 +	70 +	68 +	65 +	62 +	55 +	49 +	44 +
64 +	71 +	69 +	70 +	64 +	59 +	54 +	51 +	49 +	51 +	50 +	52 +	56 +	60 +	63 +	64 +	62 +	59 +	55 +	51 +	46 +	42 +
51 +	62 +	64 +	63 +	57 +	52 +	47 +	43 +	42 +	40 +	43 +	44 +	50 +	54 +	57 +	55 +	55 +	52 +	47 +	41 +	39 +	34 +
48 +	57 +	59 +	58 +	53 +	45 +	42 +	38 +	37 +	35 +	37 +	39 +	42 +	46 +	45 +	45 +	44 +	41 +	39 +	35 +	29 +	26 +
47 +	55 +	56 +	54 +	48 +	41 +	37 +	33 +	31 +	32 +	32 +	33 +	36 +	40 +	38 +	37 +	35 +	30 +	28 +	25 +	19 +	14 +
45 +	53 +	53 +	52 +	47 +	40 +	35 +	31 +	29 +	28 +	29 +	31 +	33 +	34 +	31 +	31 +	26 +	23 +	18 +	14 +	8 +	5 +
43 +	51 +	51 +	50 +	46 +	41 +	34 +	32 +	29 +	28 +	28 +	29 +	30 +	28 +	27 +	26 +	21 +	17 +	11 +	3 +	1 -	6 -
40 +	48 +	48 +	49 +	45 +	42 +	36 +	32 +	29 +	29 +	29 +	29 +	29 +	26 +	27 +	24 +	19 +	15 +	7 +	1 -	6 -	13 -
38 +	45 +	45 +	47 +	45 +	42 +	39 +	34 +	31 +	29 +	29 +	29 +	29 +	28 +	28 +	24 +	20 +	14 +	7 +	1 -	9 -	16 -
39 +	44 +	45 +	46 +	45 +	43 +	40 +	36 +	33 +	29 +	27 +	28 +	28 +	29 +	29 +	27 +	22 +	15 +	4 +	4 -	12 -	17 -
39 +	44 +	44 +	46 +	46 +	43 +	40 +	37 +	33 +	31 +	29 +	28 +	29 +	29 +	31 +	29 +	25 +	17 +	8 +	1 -	10 -	14 -
40 +	43 +	44 +	46 +	45 +	44 +	41 +	37 +	34 +	31 +	31 +	29 +	30 +	31 +	32 +	31 +	25 +	19 +	11 +	3 +	6 -	10 -
42 +	44 +	44 +	46 +	45 +	43 +	43 +	40 +	39 +	36 +	35 +	35 +	34 +	34 +	32 +	31 +	26 +	20 +	14 +	8 +	1 +	3 -
42 +	48 +	45 +	46 +	46 +	45 +	44 +	42 +	41 +	40 +	38 +	38 +	36 +	36 +	33 +	29 +	26 +	21 +	16 +	10 +	7 +	3 +
40 +	48 +	47 +	47 +	45 +	44 +	47 +	45 +	44 +	43 +	43 +	43 +	40 +	37 +	35 +	31 +	28 +	24 +	18 +	15 +	11 +	11 +
44 +	49 +	52 +	54 +	53 +	51 +	50 +	49 +	48 +	46 +	47 +	43 +	43 +	41 +	39 +	38 +	32 +	28 +	25 +	20 +	18 +	17 +
48 +	49 +	51 +	56 +	59 +	59 +	57 +	57 +	56 +	56 +	54 +	48 +	49 +	48 +	45 +	42 +	39 +	31 +	29 +	23 +	24 +	22 +
49 +	59 +	55 +	58 +	59 +	60 +	61 +	61 +	61 +	60 +	57 +	56 +	55 +	53 +	49 +	46 +	42 +	39 +	32 +	32 +	28 +	32 +
50 +	54 +	61 +	63 +	62 +	64 +	64 +	66 +	65 +	63 +	61 +	61 +	59 +	56 +	52 +	48 +	44 +	41 +	38 +	36 +	35 +	35 +
87 +	69 +	68 +	69 +	69 +	65 +	67 +	67 +	68 +	67 +	67 +	66 +	65 +	60 +	53 +	48 +	45 +	41 +	38 +	36 +	37 +	39 +

** MESOPAC **

119	117	86	89	78	74	69	68	69	69	69	69	68	64	57	49	44	39	35	34	34	36
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
120	122	119	94	87	74	73	70	71	71	71	70	69	65	58	49	43	37	36	34	34	35
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
121	130	129	110	89	85	76	73	72	71	71	69	67	63	52	47	42	38	35	35	34	36
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
127	136	115	112	93	88	80	76	74	72	71	68	65	57	51	46	41	38	34	34	34	34
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
157	138	123	115	109	90	86	81	77	75	71	67	60	55	50	45	40	36	34	31	29	27
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
168	140	127	113	107	87	84	80	80	78	74	67	62	57	51	45	39	34	30	27	21	20
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPAC **

40 +	39 +	38 +	37 +
37 +	36 +	31 +	27 +
30 +	29 +	23 +	20 +
21 +	20 +	15 +	11 +
12 +	10 +	6 +	3 +
0 -	1 -	7 -	7 -
11 -	12 -	15 -	15 -
18 -	18 -	20 -	19 -
20 -	20 -	21 -	19 -
20 -	19 -	20 -	18 -
18 -	17 -	15 -	13 -
14 -	13 -	14 -	10 -
7 -	6 -	8 -	0 +
1 +	3 +	9 +	14 +
8 +	18 +	18 +	23 +
20 +	25 +	22 +	31 +
26 +	28 +	27 +	34 +
30 +	33 +	33 +	37 +
32 +	36 +	36 +	42 +
40 +	47 +	49 +	52 +

** MESOPAC **

40	46	47	49
+	+	+	+
36	41	39	44
+	+	+	+
35	37	36	39
+	+	+	+
32	36	35	37
+	+	+	+
28	31	31	31
+	+	+	+
23	26	28	31
+	+	+	+

*** MESOPAC ***
V-FIELD FOR 0 166 78 (HOUR,DAY,YEAR) 2 ITERATIONS SCAN RADIUS= 9.8 GRID SPACES FIELD IN UNITS OF 10** -1

59	70	86	97	105	111	115	116	113	108	101	84	70	62	58	57	60	62	63	67	69	71
60	69	77	87	96	101	107	110	109	104	99	84	71	60	55	53	53	55	53	56	59	61
67	73	77	84	94	102	109	112	113	110	102	90	77	67	60	53	52	53	52	52	55	56
71	74	78	85	95	103	110	116	115	112	108	95	82	72	60	54	54	52	45	47	49	50
77	78	82	88	97	108	117	121	122	119	111	100	87	76	65	58	55	54	52	44	46	46
81	83	87	92	101	111	119	125	127	123	115	103	91	78	65	61	56	56	50	44	42	44
86	87	90	95	102	112	122	126	128	124	115	103	91	75	66	62	58	56	52	42	41	39
90	91	92	96	104	111	119	126	127	122	113	101	87	73	65	62	60	57	47	42	39	36
94	94	96	98	104	109	117	122	123	119	108	96	81	69	64	61	60	57	49	41	37	32
96	96	97	99	104	107	113	117	116	112	103	91	77	65	62	60	59	56	46	40	34	31
97	98	99	100	103	104	108	110	109	104	96	86	73	64	61	59	58	52	44	40	35	32
98	98	99	100	103	102	103	105	104	99	91	82	71	64	61	58	56	51	44	37	33	32
96	99	99	99	102	100	98	98	96	93	86	78	69	64	60	57	54	49	43	37	33	31
93	93	97	99	97	96	95	94	91	87	82	76	67	62	59	56	54	50	46	40	36	34
96	93	91	97	97	93	90	88	85	82	79	72	65	62	56	55	53	48	45	39	35	32
97	91	90	89	89	93	89	84	83	80	79	71	61	60	57	53	52	47	43	38	34	31
97	94	89	87	87	84	81	81	78	78	73	67	64	61	56	53	47	46	39	35	32	31
92	93	89	85	84	83	80	79	77	75	70	66	63	60	56	52	45	40	36	33	31	32
106	97	88	85	79	76	75	74	73	73	69	67	65	61	56	51	45	38	33	30	28	30
88	100	96	85	80	75	73	73	72	71	69	67	64	61	56	49	42	36	32	29	28	27

** MESOPAC **

72	78	92	87	76	68	66	69	70	69	69	68	64	59	54	48	41	34	30	28	28	29
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
76	75	73	85	70	66	65	65	67	68	68	67	63	59	51	42	37	33	30	29	29	29
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
71	75	68	63	68	59	61	61	64	66	67	65	62	56	46	40	35	32	30	29	29	28
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
84	68	57	54	52	58	54	57	57	60	60	59	55	48	41	35	31	28	27	27	26	24
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
72	54	47	43	48	50	50	53	54	56	57	54	48	43	37	32	28	26	25	26	24	22
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
37	30	29	30	30	34	44	46	49	49	46	43	38	32	26	22	19	18	18	17	15	19
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPAC **

71	73	72	80
63	66	68	73
59	61	63	67
51	53	54	57
46	48	48	49
43	42	42	43
38	37	37	40
34	33	34	34
31	31	32	32
30	30	31	29
30	30	30	27
30	32	31	25
31	30	31	26
30	29	32	28
30	35	34	26
33	35	32	29
34	32	33	33
34	30	32	33
29	29	31	33
28	29	31	35

```
************************************************************ MESOPAC ************************************************************
   28    31    31    30
    +     +     +     +

   30    30    29    29
    +     +     +     +

   28    28    30    29
    +     +     +     +

   24    25    25    25
    +     +     +     +

   24    24    26    23
    +     +     +     +

   22    21    25    20
    +     +     +     +
```

** MESOPAC **

MIXING DEPTH FIELD FOR 0 166 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

2192	2197	2215	2223	2209	2172	1734	1703	1683	1671	1578	1578	1578	1578	1989	2037	1578	2621	2571	2506	2422	2320
2349	2325	2310	2281	2229	2153	1988	1928	1648	1642	1578	1816	1875	1939	2001	2057	2644	2463	2720	2708	2654	2581
2501	2457	2409	2341	2242	2119	1924	1845	1806	1692	1734	1795	1870	1949	2023	2526	2664	2798	2842	2852	2850	2868
2633	2584	2515	2409	2257	2075	1905	1749	1754	1774	1704	1780	1874	1971	2394	2543	2687	2831	3339	2997	3037	3062
2754	2719	2642	2502	2294	2045	1818	1679	1641	1688	1791	1776	1894	2014	2417	2567	2712	2861	3019	3441	3204	3272
2892	2887	2815	2650	2388	2069	1807	1616	1578	1646	1773	1797	1944	2086	2457	2597	2733	2883	3053	3452	3577	3452
3073	3109	3054	2875	2570	2191	1849	1660	1617	1684	1823	1999	2036	2367	2511	2627	2744	2889	3071	3456	3610	3720
3295	3373	3340	3161	2882	2456	2054	1834	1769	1820	1949	2120	2170	2459	2570	2651	2740	2873	3232	3445	3633	3761
3542	3632	3618	3464	3150	2726	2335	2094	2000	2020	2122	2268	2320	2547	2618	2661	2721	2838	3164	3411	3630	3776
3632	3743	3743	3593	3324	2947	2593	2350	2234	2222	2289	2399	2442	2608	2646	2661	2696	2795	3089	3352	3591	3751
3633	3710	3706	3598	3381	3070	2770	2546	2421	2384	2416	2489	2510	2634	2656	2656	2681	2826	3028	3282	3519	3685
3574	3628	3618	3529	3398	3109	2867	2674	2551	2498	2659	2541	2530	2609	2655	2659	2683	2818	2996	3318	3435	3596
3643	3524	3509	3481	3348	3100	3059	2940	2855	2801	2766	2740	2651	2659	2697	2713	2818	2953	3132	3320	3483	3604
3610	3634	3465	3398	3400	3222	3125	3043	2978	2927	2883	2839	2720	2813	2857	2946	3020	3062	3213	3364	3495	3594
3743	3743	3743	3451	3408	3254	3197	3148	3106	3067	3023	2873	2996	2969	3076	3152	3212	3306	3332	3451	3551	3626
3743	3743	3836	3852	3874	3430	3285	3268	3252	3230	3195	3225	3400	3342	3309	3313	3417	3488	3568	3578	3649	3699
3743	3743	3870	3890	3915	3944	3709	3708	3698	3676	3617	3662	3608	3562	3537	3543	3582	3670	3731	3735	3780	3804
3743	3888	3905	3928	3954	3984	4013	3801	3815	3826	3861	3830	3788	3748	3727	3737	3777	3836	3890	3928	3925	3695
3743	3918	3938	3962	3989	4018	4045	4069	3941	3957	3981	3960	3924	3887	3869	3883	3928	3989	4044	4076	4079	3837
2899	3945	3966	3990	4017	4044	4130	4130	4080	4018	4040	4023	3986	3982	3966	3984	4035	4099	4152	4178	4175	4077

MESOPAC

2324	2600	4130	4130	4130	4006	4035	4065	4092	4114	4120	4083	4042	4000	3982	4048	4103	4168	4218	4278	4284	4198
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2186	2483	2799	4130	3966	3994	4027	4062	4095	4121	4130	4122	4109	4101	4112	4233	4262	4297	4276	4265	4274	4225
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2031	2343	2682	3157	3944	3971	4004	4043	4082	4114	4130	4116	4098	4087	4194	4237	4269	4280	4284	4271	4282	4235
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
1865	2187	2813	3086	3912	3934	3964	4000	4039	4078	4091	4084	4067	4149	4194	4244	4283	4299	4324	4311	4324	4250
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
917	2402	2722	3011	3255	3885	3903	3928	3957	3983	4012	4012	4094	4134	4192	4256	4309	4341	4354	4404	4438	4477
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
914	2296	2636	2939	3189	3826	3828	3832	3839	3848	3886	3991	4038	4104	4187	4275	4354	4413	4453	4481	4612	4638
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPAC **

2001	1898	1800	1717
+	+	+	+
2212	2108	1994	1881
+	+	+	+
2469	2368	2237	2082
+	+	+	+
2764	2674	2528	2329
+	+	+	+
3028	3010	2861	2625
+	+	+	+
3308	3292	3207	2954
+	+	+	+
3646	3577	3512	3267
+	+	+	+
3772	3803	3735	3583
+	+	+	+
3845	3861	3800	3664
+	+	+	+
3828	3825	3770	3661
+	+	+	+
3773	3804	3672	3539
+	+	+	+
3693	3736	3746	3428
+	+	+	+
3682	3725	3680	3418
+	+	+	+
3662	3704	3478	3397
+	+	+	+
3678	3447	3402	3299
+	+	+	+
3472	3426	3475	3221
+	+	+	+
3522	3439	3436	3263
+	+	+	+
3606	3609	3423	3208
+	+	+	+
3840	3661	3436	3177
+	+	+	+
3932	3708	3409	3065
+	+	+	+

** MESOPAC **

```
4007  3779  3466  3101
   +     +     +     +

4141  3984  3743  3143
   +     +     +     +

4165  4027  3809  3513
   +     +     +     +

4192  4074  3883  3621
   +     +     +     +

4251  4147  3979  3749
   +     +     +     +

4366  4262  4106  3898
   +     +     +     +
```

*** MESOPAC ***

STABILITY FIELD FOR 0 166 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	2	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	2	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	2	3	3	3	[illegible]	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1
+	+	+	+	+	[illegible]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

```
************************************************ MESOPAC ****************************************************
 3   3   3   3   3   3   2   2   3   3   3   2   2   2   2   2   2   1   1   1   1   1
 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

 3   3   3   3   3   3   2   2   2   3   3   2   2   2   2   2   2   1   1   1   1   1
 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

 3   3   3   3   3   3   2   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1
 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

 3   3   3   3   3   3   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1
 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

 4   3   3   3   3   3   3   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1
 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +

 4   3   3   3   3   2   2   2   2   2   2   2   2   2   2   1   1   1   1   1   1   1
 +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +
```

```
*************************************************************** MESOPAC ***************************************************************
 2   2   2   2
 +   +   +   +

 2   2   2   2
 +   +   +   +

 2   2   2   2
 +   +   +   +

 2   2   2   2
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   1   1   1
 +   +   +   +

 1   2   2   2
 +   +   +   +
```

```
****************************************************************** MESOPAC ******************************************************************
     1      2      2      2
     +      +      +      +

     1      1      1      1
     +      +      +      +

     1      1      1      1
     +      +      +      +

     1      1      1      1
     +      +      +      +

     1      1      1      1
     +      +      +      +

     1      1      1      1
     +      +      +      +
```

APPENDIX B

TEST CASE MESOPUFF OUTPUT

```
&MODEL
LPLUME=F,LPUFF=T,LGRID=F,LPAC=F,LFILE=F
&END
&CONTR
DTIME=  1.00000000    ,MTFREQ=          1,IAVG=          24,NADVTS=          72
&END
&PUFF1
NPUFTS=          1,NSAMAD=          1,LVARSA=T,MAXSAM=         100
&END
&GRID
IELMET=          26,JELMET=          26,DELTMT=  40000.0000    ,IASTAR=           1,IASTOP=          26,JASTAR=           1,JASTOP=
          26,ISASTR=           1,JSASTR=           1,ISASTP=          26,JSASTP=          26,MESHDN=           1
&END
&SIGMA
AY=  .329999983    ,  .220000029    ,  .170000017    ,  .120000005    ,  .860000253E-01,  .570000000E-01,BY= -.100000024    ,
 -.100000024    , -.100000024    , -.100000024    , -.100000024    , -.100000024    ,AZ=  .479999930E-03,  .630000234E-01,
  .100000024    ,  .329999983    ,  .410000026    ,  .319999993    ,BZ=  1.10000038    ,  .899999738E-01, -.899999738E-01,
 -.420000017    , -.529999971    , -.579999983
&END
&METD
METSRT=    7816500,METCOD=       1003,LSENSE=F
&END
&PUFF2
IPFLIM=        400,CHIMIN=  .0            ,  .0            ,NSIGMA=           3,LANUAL=F,LUFORM=T
&END
&REMOV
CONVFR=  .199999996E-01,LDCAY=T,EXTNCT= -.556000032E-05,LDEPOT=T,DEPVEL=  .100000016E-01,  .999999931E-03,LWASH=F,WASHOT=
  .0            ,  .0
&END
&OUTPT
LECHO=T,LPRINT=T,IPRINF=          24,LEXACT=F,LSAVE=T,ISAVEF=          24
&END
&SOURC
NSOURC=         10,LMISS=F,LFLUX=F,STAKHT=  236.000000    ,  152.000000    ,  152.000000    ,  152.000000    ,  183.000000    ,
  229.000000    ,  76.1999969    ,  183.000000    ,  175.000000    ,  152.000000    ,XXSTAK=  8.80000019    ,  23.3999939    ,
  17.1999969    ,  23.6999969    ,  13.5000000    ,  10.0000000    ,  8.00000000    ,  9.69999981    ,  .899999976    ,
  1.50000000    ,YYSTAK=  8.80000019    ,  14.0000000    ,  18.8999939    ,  13.0000000    ,  1.19999981    ,  13.1000004    ,
  19.5000000    ,  15.1999998    ,  8.00000000    ,  4.10000038    ,EMISS=  2560.00000    ,  .0            ,  343.800049    ,
  .0            ,  633.399902    ,  .0            ,  488.000000    ,  .0            ,  53.6999969    ,  .0            ,
  320.000000    ,  .0            ,  146.899994    ,  .0            ,  1310.80005    ,  .0            ,  268.800049    ,
  .0            ,  1011.00000    ,  .0            ,ECYCLE=  1.00000000    ,  1.00000000    ,  1.00000000    ,  1.00000000    ,
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2847.00000   , 3353.00000   , 3016.00000   , 6222.00000   , 240.000000   , 3016.00000   , 1047.00000   ,
11144.0000   ,BCYCLE=  1.00000000    , 1.00000000    , 1.00000000    , 1.00000000    , 1.00000000    , 1.00000000    ,
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1.00000000   , 1.00000000   , .00000000
&END
```

```
************************************************************ MESOPUFF ***************************************************************

    24.0-HOUR CONCENTRATION (GRAMS/CUBIC METER) ENDING     0  166   78 (HOUR,DAY,YEAR) FOR
   POLLUTANT 1: SULFUR DIOXIDE



  THERE FOLLOWS 1 TABLE(S):

     1) A 4 PAGE GRID OF CONCENTRATIONS, EXPRESSED IN INTEGER UNITS OF AN APPROPRIATE EXPONENT
        PAGE 1: NW CORNER, PAGE 2: SW CORNER, PAGE 3: NE CORNER, PAGE 4: SE CORNER
```

** MESOPUFF **

TABLE 1 POLLUTANT 1 24.0 HOUR AVERAGE ENDING 0 166 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** -8

0	0	0	0	0	0	0	0	0	0	0	1	3	4	5	2	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	1	7	11	14	6	1	0	0	0	0	1	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	1	8	16	18	2	0	0	0	1	2	3	5	4
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	7	25	16	1	1	1	2	4	9	14	14	12	7
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	1	42	6	2	1	6	8	13	28	42	35	24	14	8
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	1	2	3	3	2	12	12	29	64	79	45	28	23	17	66
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	2	3	5	3	10	20	75	119	124	32	5	6	8	7	10
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	1	3	6	5	1	15	155	197	63	6	5	11	14	8	3	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	2	7	7	1	6	245	125	7	6	9	19	11	5	4	2	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	1	7	11	1	1	333	7	12	13	20	17	6	9	13	14	8	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	5	17	2	0	3	6	15	25	28	8	12	20	32	41	33	14	3
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	2	24	3	0	1	7	11	22	14	22	26	32	57	91	72	31	9	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	17	7	0	0	6	14	16	15	38	40	51	106	115	62	22	6	1	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	2	31	0	0	3	16	18	11	54	62	117	135	42	9	1	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	90	0	0	1	17	22	7	37	127	175	9	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	10	0	0	0	10	34	5	0	309	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	2	42	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	43	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	41	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

```
************************************************************ MESOPUFF ************************************************************************
   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     1     1     1     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     9     7     6     4     3     2     1
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     1     1     1
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +
```

** MESOPUFF **

0 +	0 +	0 +	0 +
2 +	1 +	0 +	0 +
3 +	1 +	0 +	0 +
3 +	1 +	0 +	0 +
13 +	15 +	9 +	4 +
58 +	47 +	39 +	18 +
16 +	19 +	16 +	6 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	6 +	3 +
0 +	0 +	101 +	31 +
0 +	0 +	580 +	24 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +
0 +	0 +	0 +	0 +

** MESOPUFF **

0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
1	0	0	0
+	+	+	+
1	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+

```
*************************************************************** MESOPUFF ******************************************************************
                    24.0-HOUR CONCENTRATION (GRAMS/CUBIC METER) ENDING     0  166    78 (HOUR,DAY,YEAR) FOR
                   POLLUTANT 2: SULFATES



                  THERE FOLLOWS 1 TABLE(S):

                     1) A 4 PAGE GRID OF CONCENTRATIONS, EXPRESSED IN INTEGER UNITS OF AN APPROPRIATE EXPONENT
                        PAGE 1: NW CORNER, PAGE 2: SW CORNER, PAGE 3: NE CORNER, PAGE 4: SE CORNER
```

** MESOPUFF **

TABLE 1 POLLUTANT 2 24.0 HOUR AVERAGE ENDING 0 166 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** -9

0	0	0	0	0	0	0	0	0	0	0	3	10	15	21	9	0	0	0	0	1	4
0	0	0	0	0	0	0	0	0	0	4	18	33	43	22	3	0	0	0	2	9	19
0	0	0	0	0	0	0	0	0	3	17	36	46	13	4	1	1	3	11	27	48	51
0	0	0	0	0	0	0	0	2	12	38	35	13	7	4	7	18	52	101	119	106	64
0	0	0	0	0	0	0	1	6	34	21	18	10	17	29	53	146	255	231	136	73	40
0	0	0	0	0	0	0	4	11	19	24	14	28	30	100	261	365	243	93	53	46	159
0	0	0	0	0	0	1	7	18	31	22	17	35	189	351	409	129	29	33	44	37	33
0	0	0	0	0	0	3	13	34	31	7	19	265	393	152	22	21	51	70	49	22	7
0	0	0	0	0	1	8	33	40	9	8	245	166	34	29	32	67	50	34	31	20	6
0	0	0	0	0	3	27	50	8	4	122	40	56	59	64	54	32	64	107	120	73	19
0	0	0	0	0	14	64	8	1	15	42	66	84	82	45	62	115	204	290	257	121	26
0	0	0	0	3	72	10	0	8	39	65	83	79	92	104	144	286	497	446	223	70	12
0	0	0	0	38	20	0	2	28	71	88	77	114	122	178	413	504	314	128	38	9	1
0	0	0	3	67	0	0	14	70	86	55	105	131	296	402	147	36	6	0	0	0	0
0	0	0	133	0	0	3	60	87	31	41	167	302	20	0	0	0	0	0	0	0	0
0	0	6	0	0	0	29	110	20	1	198	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	5	108	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	85	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	55	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

** MESOPUFF **

0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	2	2
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	13	14	13	11	10	8
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	7
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPUFF **

7	6	2	0
+	+	+	+
22	14	4	1
+	+	+	+
34	14	3	0
+	+	+	+
27	9	3	2
+	+	+	+
50	64	47	23
+	+	+	+
179	181	188	96
+	+	+	+
48	68	72	33
+	+	+	+
1	0	0	0
+	+	+	+
1	0	0	0
+	+	+	+
2	0	0	0
+	+	+	+
2	0	13	6
+	+	+	+
1	0	50	34
+	+	+	+
0	0	97	19
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+

** MESOPUFF **

```
  0      0      0      0
  +      +      +      +

  0      0      0      0
  +      +      +      +

  2      1      1      0
  +      +      +      +

  5      3      1      0
  +      +      +      +

  4      2      1      0
  +      +      +      +

  0      0      0      0
  +      +      +      +
```

211 PUFFS DROPPED   189 PUFFS LEFT

```
*************************************************************** MESOPUFF *********************************************************************
 24.0-HOUR CONCENTRATION (GRAMS/CUBIC METER) ENDING    0  167   78 (HOUR,DAY,YEAR) FOR
POLLUTANT 1: SULFUR DIOXIDE



THERE FOLLOWS 1 TABLE(S):

   1) A 4 PAGE GRID OF CONCENTRATIONS, EXPRESSED IN INTEGER UNITS OF AN APPROPRIATE EXPONENT
      PAGE 1: NW CORNER, PAGE 2: SW CORNER, PAGE 3: NE CORNER, PAGE 4: SE CORNER
```

*** MESOPUFF ***

TABLE 1 POLLUTANT 1 24.0 HOUR AVERAGE ENDING 0 167 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** -8

0	0	0	0	0	0	0	0	1	2	6	10	2	1	2	5	14	31	36	24	15	10
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	1	2	3	25	9	2	3	12	25	48	64	50	30	20	18
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	1	3	17	15	2	4	19	34	52	69	51	31	22	21	37
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	3	4	48	3	3	17	34	46	69	44	26	20	21	33	75
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	1	4	3	15	2	7	35	29	71	35	20	18	19	25	113	75
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	2	4	3	2	4	27	18	78	34	16	22	24	28	204	77	44
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	3	4	2	2	6	49	43	51	13	26	33	38	45	48	45	39
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	1	5	4	2	3	9	11	96	12	21	40	46	60	64	58	46	33
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	3	7	4	3	6	16	193	13	17	46	50	61	80	72	52	32	18
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	8	8	4	3	9	12	13	14	49	57	50	80	74	39	21	11	5
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	2	14	7	3	4	12	11	14	47	66	40	73	69	19	5	4	2	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	12	15	6	1	7	13	12	37	66	32	66	65	8	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	1	28	12	2	2	11	11	18	41	34	72	68	4	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	15	30	5	0	5	13	13	26	47	77	49	1	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	64	11	0	1	12	11	27	51	88	72	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	30	23	0	0	5	13	25	19	115	2	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	30	0	0	1	13	22	21	5	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	14	39	19	3	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	2	76	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	149	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPUFF **

0	0	0	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	2	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	2	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	2	2	2	1	1
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPUFF **

11	13	11	4
+	+	+	+
26	32	19	7
+	+	+	+
56	35	20	9
+	+	+	+
54	33	25	13
+	+	+	+
57	43	31	15
+	+	+	+
35	29	22	12
+	+	+	+
31	23	15	8
+	+	+	+
22	13	7	3
+	+	+	+
10	5	3	5
+	+	+	+
2	1	17	3
+	+	+	+
0	4	20	4
+	+	+	+
0	0	2	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
1	1	1	0
+	+	+	+
1	1	1	0
+	+	+	+

** MESOPUFF ***

```
1   1   1   0
+   +   +   +

1   1   1   0
+   +   +   +

0   0   0   0
+   +   +   +

0   0   0   0
+   +   +   +

0   0   0   0
+   +   +   +

0   0   0   0
+   +   +   +
```

** MESOPUFF **

24.0-HOUR CONCENTRATION (GRAMS/CUBIC METER) ENDING 0 167 78 (HOUR,DAY,YEAR) FOR
POLLUTANT 2: SULFATES

THERE FOLLOWS 1 TABLE(S):

1) A 4 PAGE GRID OF CONCENTRATIONS, EXPRESSED IN INTEGER UNITS OF AN APPROPRIATE EXPONENT
PAGE 1: NW CORNER, PAGE 2: SW CORNER, PAGE 3: NE CORNER, PAGE 4: SE CORNER

MESOPUFF

TABLE 1 POLLUTANT 2 24.0 HOUR AVERAGE ENDING 0 167 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** -9

0	0	0	0	0	0	0	1	6	13	21	28	11	13	27	53	111	213	249	189	136	116
0	0	0	0	0	0	0	4	16	25	57	27	17	35	86	167	292	392	341	244	194	179
0	0	0	0	0	0	1	9	24	40	33	15	35	110	189	283	379	324	241	201	187	236
0	0	0	0	0	0	2	16	26	54	15	28	93	171	226	331	262	197	168	164	206	343
0	0	0	0	0	0	5	22	23	23	18	53	149	151	281	193	149	145	156	194	403	389
0	0	0	0	0	0	10	27	21	14	31	104	110	249	162	121	153	184	239	465	416	410
0	0	0	0	0	1	18	28	18	18	48	137	147	176	103	160	216	286	374	437	450	419
0	0	0	0	0	4	29	27	17	25	68	91	203	91	133	232	306	414	491	498	436	339
0	0	0	0	0	13	39	23	16	37	84	227	77	103	224	288	358	489	498	417	300	187
0	0	0	0	1	33	40	19	15	54	78	69	77	194	274	254	390	396	264	181	119	62
0	0	0	0	8	58	32	13	20	67	65	75	147	259	173	275	276	95	44	39	29	13
0	0	0	0	36	59	21	5	34	65	59	109	218	114	186	198	28	1	2	4	3	1
0	0	0	2	78	37	6	7	51	51	77	135	99	150	163	10	0	0	0	0	0	0
0	0	0	28	72	10	0	20	52	49	97	108	119	89	2	0	0	0	0	0	0	0
0	0	0	101	16	0	2	40	36	85	88	93	94	0	0	0	0	0	0	0	0	0
0	0	25	24	0	0	14	37	64	56	68	2	0	0	0	0	0	0	0	0	0	0
0	0	16	0	0	2	31	46	50	13	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	23	65	37	7	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	3	90	18	2	0	0	0	0	0	0	0	0	0	0	0	1	2	3
0	0	0	0	116	4	0	0	0	0	0	0	0	0	0	0	0	0	1	6	8	8

** MESOPUFF **

0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	16	11	9
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	11	7	6	6
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	4	4	4	3	3
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

** MESOPUFF **

116	116	94	42
+	+	+	+
205	227	150	67
+	+	+	+
315	243	168	91
+	+	+	+
324	274	240	149
+	+	+	+
390	375	314	192
+	+	+	+
402	366	287	174
+	+	+	+
360	287	201	111
+	+	+	+
242	163	98	48
+	+	+	+
107	59	33	32
+	+	+	+
28	13	56	12
+	+	+	+
4	6	55	15
+	+	+	+
0	0	4	1
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
1	2	2	1
+	+	+	+
4	5	5	3
+	+	+	+
8	8	7	4
+	+	+	+

```
**************************************************************** MESOPUFF ***********************************************************************
     8      7      6      3
     +      +      +      +

     6      6      4      2
     +      +      +      +

     3      3      3      2
     +      +      +      +

     1      1      1      1
     +      +      +      +

     0      0      0      0
     +      +      +      +

     0      0      0      0
     +      +      +      +

  243 PUFFS DROPPED     166 PUFFS LEFT
```

** MESOPUFF **

24.0-HOUR CONCENTRATION (GRAMS/CUBIC METER) ENDING 0 168 78 (HOUR,DAY,YEAR) FOR
POLLUTANT 1: SULFUR DIOXIDE

THERE FOLLOWS 1 TABLE(S):

1) A 4 PAGE GRID OF CONCENTRATIONS, EXPRESSED IN INTEGER UNITS OF AN APPROPRIATE EXPONENT
PAGE 1: NW CORNER, PAGE 2: SW CORNER, PAGE 3: NE CORNER, PAGE 4: SE CORNER

*** MESOPUFF ***

TABLE 1 POLLUTANT 1 24.0 HOUR AVERAGE ENDING 0 168 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** -7

0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	2	2	1
0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	2	4	4	2	1
0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	3	6	5	2	1	1
0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	5	8	4	2	2	1	1
0	0	0	0	0	0	0	0	0	12	1	1	1	0	6	11	3	2	3	2	5	6
0	0	0	0	0	0	0	0	0	1	1	0	0	6	14	3	2	4	3	24	34	8
0	0	0	0	0	0	0	0	0	0	1	0	1	23	3	3	5	3	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	0	49	3	5	5	2	1	2	2	3	4
0	0	0	0	0	0	0	0	0	1	0	84	6	3	3	1	2	2	3	6	9	9
0	0	0	0	0	0	0	0	1	1	0	24	1	2	1	2	1	3	5	9	12	9
0	0	0	0	0	0	0	1	1	0	0	0	1	3	1	1	4	3	5	12	10	4
0	0	0	0	0	0	1	2	0	0	0	0	2	0	1	4	3	7	11	8	4	1
0	0	0	0	0	0	3	1	0	0	0	0	0	1	4	4	10	8	4	2	1	0
0	0	0	0	0	4	1	0	0	0	0	0	1	5	10	11	3	2	1	1	0	0
0	0	0	0	6	1	1	0	0	0	0	1	7	15	5	2	1	0	0	0	0	0
0	0	0	10	3	0	0	0	0	0	1	25	4	2	1	0	0	0	0	0	0	0
0	0	48	0	0	0	0	0	0	1	3	3	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	3	4	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	2	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

** MESOPUFF **

0+	0+	0+	2+	1+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+

** MESOPUFF **

0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
1	0	0	0
+	+	+	+
1	1	1	0
+	+	+	+
4	3	3	1
+	+	+	+
7	7	6	3
+	+	+	+
1	1	1	1
+	+	+	+
3	2	2	1
+	+	+	+
6	4	2	1
+	+	+	+
4	2	1	1
+	+	+	+
1	1	0	0
+	+	+	+
0	0	102	19
+	+	+	+
0	0	0	4
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+

```
************************************************************ MESOPUFF ****************************************************************
     0     0     0     0
     +     +     +     +

     0     0     0     0
     +     +     +     +

     0     0     0     0
     +     +     +     +

     0     0     0     0
     +     +     +     +

     0     0     0     0
     +     +     +     +

     0     0     0     0
     +     +     +     +
```

```
************************************************************ MESOPUFF ************************************************************

     24.0-HOUR CONCENTRATION (GRAMS/CUBIC METER) ENDING    0  168   78 (HOUR,DAY,YEAR) FOR
    POLLUTANT 2: SULFATES


    THERE FOLLOWS 1 TABLE(S):

       1) A 4 PAGE GRID OF CONCENTRATIONS, EXPRESSED IN INTEGER UNITS OF AN APPROPRIATE EXPONENT
          PAGE 1: NW CORNER, PAGE 2: SW CORNER, PAGE 3: NE CORNER, PAGE 4: SE CORNER
```

```
************************************************************ MESOPUFF *****************************************************************
TABLE 1     POLLUTANT 2     24.0 HOUR AVERAGE ENDING    0  168    78 (HOUR,DAY,YEAR)       FIELD IN UNITS OF 10** -9
   0     0     0     0     0     0     0     0     0     0     1    10    38    14    13    10     7    19    98   205   183    86
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     0     3    82    30    24    21    16    26   147   332   343   196    84
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0     1    66    28    28    27    22    27   201   415   346   198   106    77
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0           0     0     0     2    31    28    31    25    21   236   448   248   151   129   135   130
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0   100    23    35    30    19   258   466   160   119   171   181   229   294
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     0    14    29    34    22   188   482    98    99   167   163   394   592   288
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     2    18    39    30    34   558    67    95   165   125   103   106   123   147
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     0     6    37    42    20   804    60    93   138    83    81   100   159   293   371
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     1    23    53    28   796    65    48    80    55    72    95   171   388   701   739
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     8    55    38    14   122    14    45    34    64    79   172   260   551   866   695
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     1    44    49    15     8     6    20    38    37    65   164   161   267   628   651   344
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0    24    61    16     8     7     5    22    24    51   151   132   262   468   433   256   107
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     8    72    16    10     8     3     3    16    41   132   125   316   302   206   148    95    44
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0    79    16    13     6     1     1     9    34   140   232   289   151   115    86    56    31    13
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0    88    18    11     2     0     0     5    29   125   277   158   104    63    30    13     6     3     1
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0    93    36     2     0     0     0     3    29   247   125   107    59    21     5     1     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0   205     1     0     0     0     0     3    41   107   104    43    12     2     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0     0     5    74   123    39     5     0     0     0     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0     0    29   141    40     2     0     0     0     0     0     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +

   0     0     0     0     0    76    26     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0
   +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +     +
```

MESOPUFF

```
****************************************************************** MESOPUFF *******************************************************************
     0      0      0      9      6      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
     +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +

     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
     +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +

     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      1      2      2
     +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +

     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      1      2      4      6      7      7
     +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +

     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      1      1
     +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +

     0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0      0
     +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +      +
```

** MESOPUFF **

33	18	15	11
+	+	+	+
42	32	28	20
+	+	+	+
66	60	51	34
+	+	+	+
117	100	80	52
+	+	+	+
247	222	192	104
+	+	+	+
327	381	379	205
+	+	+	+
146	134	123	83
+	+	+	+
322	249	185	106
+	+	+	+
521	349	239	128
+	+	+	+
380	229	155	84
+	+	+	+
139	77	54	31
+	+	+	+
38	18	301	125
+	+	+	+
14	4	2	21
+	+	+	+
4	1	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+
0	0	0	0
+	+	+	+

```
****************************************************************** MESOPUFF ******************************************************************
     0      0      1      0
     +      +      +      +

     1      2      3      2
     +      +      +      +

     3      4      5      3
     +      +      +      +

     8      7      6      2
     +      +      +      +

     1      1      1      0
     +      +      +      +

     0      0      0      0
     +      +      +      +
```

APPENDIX C

TEST CASE NAMELIST FILE

```
INUMB    DATFLD        MODEL       YR/DAY/HR     NGRIDS      IAVG      ISAVEF     ISAFE      IBEGIN     ISTUP      ICHECK
-----------------------------------------------------------------------------------------------------------------------
  1    12 FEB 1979    MESOPLUM    78/165/ 0         3          24         24         1          2          4          1

*************************************************************************************************************************

&MODEL
LPLUME=T,LPUFF=F,LGRID=F,LPAC=F
&END
&CONTR
DTIME=  1.00000000    ,MTFREQ=          1,IAVG=         24,NADVTS=         72
&END
&GRID
IELMET=          26,JELMET=          26,DELTMT=  40000.0000    ,IASTAR=           1,IASTOP=          26,JASTAR=           1,JASTOP=
        26,ISASTR=           1,JSASTR=           1,ISASTP=          26,JSASTP=          26,MESHDN=           1
&END
&SIGMA
AY=  .329999983    ,  .220000029    ,  .170000017    ,  .120000005    ,  .860000253E-01,  .570000000E-01,BY= -.100000024    ,
 -.100000024    , -.100000024    , -.100000024    , -.100000024    , -.100000024    ,AZ=  .479999930E-03,  .630000234E-01,
  .100000024    ,  .329999983    ,  .410000026    ,  .319999993    ,BZ=  1.10000038    ,  .899999738E-01, -.899999738E-01,
 -.420000017    , -.529999971    , -.579999983
&END
&METD
METSRT=    7816500,METCOD=        1003,LSENSE=F
&END
&PLUM1
MAXSEG=         100,LLID=T,LSTAB=T,LDEPTH=T,MSTABV=          4,          4,          4,          4,          4,          4,
          4,          4,          4,          4,          4,          4,          4,          4,          4,          4,          4,
          4,          4,          4,          4,          4,          4,          4,HHMV=  1000.00000    ,  1000.00000    ,
  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,
  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,
  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,  1000.00000    ,
  1000.00000
&END
&PLUM2
NRE=           0,XRES=  .0            ,  .0            ,  .0            ,  .0            ,  .0            ,  .0            ,
  .0            ,  .0            ,  .0            ,  .0            ,YRES=  .0            ,  .0            ,  .0            ,
  .0            ,  .0            ,  .0            ,  .0            ,  .0            ,  .0            ,  .0
&END
&REMOV
CONVFR=  .199999996E-01,LDCAY=T,EXTNCI= -.556000032E-05,LDEPOT=T,DEPVEL=  .100000016E-01,  .999999931E-03,LWASH=F,WASHOT=
  .0            ,  .0
&END
&OUTPT
LECHO=T,LPRINT=T,IPRINF=          24,LEXACT=F,LSAVE=T,ISAVEF=          24
&END
&SOURC
NSOURC=          10,STAKHT=  236.000000    ,  152.000000    ,  152.000000    ,  152.000000    ,  183.000000    ,  229.000000    ,
  76.1999969    ,  183.000000    ,  175.000000    ,  152.000000    ,XXSTAK=  8.80000019    ,  23.3999939    ,  17.1999969    ,
  23.6999969    ,  13.5000000    ,  10.0000000    ,  8.00000000    ,  9.69999981    ,  .899999976    ,  1.50000000    ,YYSTAK=
  8.80000019    ,  14.0000000    ,  18.8999939    ,  13.0000000    ,  1.19999981    ,  13.1000004    ,  19.5000000    ,
  15.1999998    ,  8.00000000    ,  4.10000038    ,EMISS=  2560.00000    ,  .0            ,  343.800049    ,  .0            ,
  633.399902    ,  .0            ,  488.000000    ,  .0            ,  53.6999969    ,  .0            ,  320.000000    ,
  .0            ,  146.899994    ,  .0            ,  1310.80005    ,  .0            ,  268.800049    ,  .0            ,
  1011.00000    ,  .0            ,LMISS=F,ECYCLE=  1.00000000    ,  1.00000000    ,  1.00000000    ,  1.00000000    ,
  1.00000000    ,  1.00000000    ,  1.00000000    ,  1.00000000    ,  1.00000000    ,  1.00000000    ,  1.00000000    ,
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INUMB	DATFLD	MODEL	YR/DAY/HR	NGRIDS	IAVG	ISAVEF	ISAFE	IBEGIN	ISTOP	ICHECK
2	12 FEB 1979	MESOPUFF	78/165/ 0	3	24	24	5	6	8	1

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LPLUME=F,LPUFF=T,LGRID=F,LPAC=F
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&CONTR
DTIME=  1.00000000     ,MTFREQ=             1,IAVG=             24,NADVTS=            72
&END
&GRID
IELMET=          26,JELMET=            26,DELTMT=  40000.0000     ,IASTAR=             1,IASTOP=            26,JASTAR=             1,JASTOP=
        26,ISASTR=             1,JSASTR=             1,ISASTP=            26,JSASTP=            26,MESHDN=             1
&END
&SIGMA
AY=  .329999983     ,  .220000029     ,  .170000017     ,  .120000005     ,  .860000253E-01,  .570000000E-01,BY= -.100000024     ,
 -.100000024     , -.100000024     , -.100000024     , -.100000024     , -.100000024     ,AZ=  .479999930E-03,  .630000234E-01,
  .100000024     ,  .329999983     ,  .410000026     ,  .319999993     ,BZ=  1.10000038     ,  .899999738E-01, -.899999738E-01,
 -.420000017     , -.529999971     , -.579999983
&END
&METD
METSRT=     7816500,METCOD=          1003,LSENSE=F
&END
&PUFF1
NPUFTS=            0,NSAMAD=             1,LVARSA=T,MAXSAM=           100
&END
&PUFF2
IPFLIM=          400,CHIMIN=  .0              ,  .0              ,NSIGMA=             3,LANUAL=F,LUFORM=T
&END
&REMOV
CONVFR=  .199999996E-01,LDCAY=T,EXTNCT= -.556000032E-05,LDEPOT=T,DEPVEL=  .100000016E-01,  .999999931E-03,LWASH=F,WASHUT=
  .0             ,  .0
&END
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LECHO=T,LPRINT=T,IPRINF=            24,LEXACT=F,LSAVE=T,ISAVEF=            24
&END
&SOURC
NSOURC=           10,STAKHT=  236.000000     ,  152.000000     ,  152.000000     ,  152.000000     ,  183.000000     ,  229.000000     ,
  76.1999969     ,  183.000000     ,  175.000000     ,  152.000000     ,XXSTAK=  8.80000019     ,  23.3999939     ,  17.1999969     ,
  23.6999969     ,  13.5000000     ,  10.0000000     ,  8.00000000     ,  9.69999981     ,  .899999976     ,  1.50000000     ,YYSTAK=
  8.80000019     ,  14.0000000     ,  18.8999939     ,  13.0000000     ,  1.19999981     ,  13.1000004     ,  19.5000000     ,
  15.1999998     ,  8.00000000     ,  4.10000038     ,EMISS=  2560.00000     ,  .0              ,  343.800049     ,  .0              ,
  633.399902     ,  .0              ,  488.000000     ,  .0              ,  53.6999969     ,  .0              ,  320.000000     ,
  .0              ,  146.899994     ,  .0              ,  1310.80005     ,  .0              ,  268.800049     ,  .0              ,
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2847.00000    , 3353.00000    , 3016.00000    , 6222.00000    , 240.000000    , 3016.00000    , 1047.00000    ,
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&END

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INUMB	DATFLD	MODEL	YR/DAY/HR	NGRIDS	IAVG	ISAVEF	ISAFE	IBEGIN	ISTOP	ICHECK
3	12 FEB 1979	MESOGRID	78/165/ 0	3	24	24	9	10	12	1

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&MODEL
LPLUME=F,LPUFF=F,LGRID=T,LPAC=F
&END
&CONTR
DTIME=  1.00000000    ,MTFREQ=          1,IAVG=         24,NADVTS=          72
&END
&GRID
IELMET=         26,JELMET=         26,DELTMT=  40000.0000   ,IASTAR=          1,IASTOP=         26,JASTAR=          1,JASTOP=
        26,ISASTR=          1,JSASTR=          1,ISASTP=         26,JSASTP=         26,MESHDN=          1
&END
&METD
METSRI=    7816500,METCOD=       1003,LSENSE=F
&END
&GRIDY
INVL=          3,CREFLT=  1.00000000    ,CREFLB=  1.00000000    ,CEPSC=  .999999944E-10,CBOUND=  .0           ,  .0           ,
  .0           ,  .0           ,  .0           ,  .0           ,  .0           ,  .0           ,  .0           ,
  .0           ,  .0           ,  .0           ,  .0           ,  .0           ,  .0           ,  .0           ,
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  .0           ,CZ=  .0           ,  500.000000   ,  1500.00000   ,  4000.00000   ,NPTS=       9999,LREFLB=          0,MODRFL=
       2,NOSPEC=          1,LBACK=F,BACK2=  .0           ,BACK4=  .0           ,NPKZ=       9999
&END
&REMOV
CONVFR=  .199999996E-01,LDCAY=T,EXTNCT= -.556000032E-05,LDEPOT=T,DEPVEL=  .100000016E-01,  .999999931E-03,LWASH=F,WASHUT=
  .0           ,  .0
&END
&OUTPT
LECHO=T,LPRINT=T,IPRINF=         24,LEXACT=F,LSAVE=T,ISAVEF=         24
&END
&SOURC
NSOURC=         10,STAKHT=  236.000000   ,  152.000000   ,  152.000000   ,  152.000000   ,  183.000000   ,  229.000000   ,
  76.1999969   ,  183.000000   ,  175.000000   ,  152.000000   ,XXSTAK=  8.80000019   ,  23.3999939   ,  17.1999969   ,
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  8.80000019   ,  14.0000000   ,  18.8999939   ,  13.0000000   ,  1.19999981   ,  13.1000004   ,  19.5000000   ,
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  633.399902   ,  .0           ,  488.000000   ,  .0           ,  53.6999969   ,  .0           ,  320.000000   ,
  .0           ,  146.899994   ,  .0           ,  1310.80005   ,  .0           ,  268.800049   ,  .0           ,
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TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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7. AUTHOR(S) Carl W. Benkley Arthur Bass		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Research & Technology, Inc. 696 Virginia Road Concord, MA 01742		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 03-6-022-35254/NOAA Contract
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16. ABSTRACT

MESOPUFF is a variable-trajectory regional-scale Gaussian puff model especially designed to simulate the air quality impacts of multiple point sources at long transport distances. It has been developed to answer the need for a simple, computationally practical, easy to use and flexible mesoscale point source model - suitable for decision-making and regulatory applications - particularly at transport distances beyond the range of applicability of the conventional (Turner Workbook) straight-line Gaussian plume model. MESOPUFF is a natural generalization of the conventional Gaussian model to situations in which transport and diffusion may be dominated by spatial and temporal variations in mesoscale meteorology.

Highly user-oriented, MESOPUFF provides a range of flexible options, and its clean, modular structure permits further modifications with ease. It is designed to be driven by user-specified meteorological scenarios, of arbitrary duration, constructed by a suitable meteorological preprocessor model (e.g., MESOPAC). It outputs spatially-gridded concentration arrays averaged over arbitrary time intervals of one hour or more and is designed to be coupled to a postprocessor model (e.g., MESOFILE) to provide additional graphical and statistical analyses. Routines are provided for: plume rise; plume growth; fumigation; linear conversion of SO_2 to $SO_4^=$; and dry deposition of SO_2 and $SO_4^=$.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
* Air Pollution		13B
* Algorithms		12A
* Atmospheric Models		04A
* Atmospheric Diffusion		07D
* Transport Properties		14B

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