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User's Guide to the CG-MATHEW/ADPIC Models Version 5.0

C. Foster, Editor

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USER'S GUIDE TO THE CG-MATHEW/ADPIC MODELS Version 5.0

February 1997

Atmospheric Release Advisory Capability

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Acknowledgments

Because of the dynamic and evolutionary nature of the MATHEW/ADPIC models, and because their use needs to be well-documented for the Atmospheric Release Advisory Capability (ARAC) operations team, this manual has undergone numerous revisions of varying magnitude over the years. The table below indicates the authors (in alphabetic order) that contributed to the changes for this revision, as well as the accumulation of authors for the existing content of the manual:

Topic	Accumulation of Authors for Existing Material	Authors Contributing to Changes for Rev. 5
Word processing & document preparation	Raylene Cooper, Jodi Greenfield, Doris Gresho	Jodi Greenfield
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Chapters 1 & 2 regarding MEDIC	Connee Foster, John Pace, Dan Rodriguez, Hoyt Walker	Connee Foster, John Pace
Chapters 1 & 2 regarding MATHEW	Gayle Sugiyama	
Chapters 1 & 2 regarding ADPIC	Ron Baskett, Gordon Duckworth, Don Ermak, Connee Foster, Kevin Foster, Robert Freis, George Greenly, Rolf Lange, John Nasstrom, Brenda Pobanz, Allan Taylor	Ron Baskett, Connee Foster, Kevin Foster, Allan Taylor
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Appendix F	Hoyt Walker, Connee Foster	Connee Foster
Appendix G	Connee Foster	Connee Foster

This manual was originally released in 1982 with the following authors: Daniel J. Rodriguez, George D. Greenly, Philip M. Gresho, Rolf Lange, Bryan S. Lawver, Leonard A. Lawson, and Hoyt

Walker, with Dan Rodriguez also acting as the editor. Connee Foster assumed the editor/co-author role for subsequent unofficial versions of the manual. Connee was also the editor for the next official version (Rev. 1) of the this document released in December 1992. She was ably assisted in preparing that version by: Robert P. Freis, Kevin T. Foster, John S. Nasstrom, Ronald L. Baskett, Walter W. Schalk III, James S. Ellis, Brenda M. Pobanz, Philip J. Vogt, Leonard A. Lawson, Hoyt Walker, and John C. Pace. Special thanks go to Raylene Cooper for her work in preparing and editing the December 1992 version.

A major re-write by Allan Taylor, Gayle Sugiyama, and Hoyt Walker occurred during Summer 1993, Rev. 2, reflecting the initial implementation of the restructured models. This restructuring was basically a general housecleaning of the structure of the models required to facilitate easier maintenance and easier insertion of upcoming major model improvements. Subsequent informal versions have been edited by Connee Foster with input provided primarily by Allan, Gayle, and Hoyt. Rev. 2 reflects the current state of the models after the restructuring and prior to inclusion of major improvements (see following paragraphs). Special thanks go to Jodi Greenfield for help with scanning figures and editing.

Version Rev 3 includes Conjugate Gradient MATHEW, generalized map projection capability, and some other minor changes and additions. Primary authors are Connee Foster, Hoyt Walker, Gordon Duckworth, Allan Taylor, and Gayle Sugiyama. Special thanks go to Jodi Greenfield for word processing and document preparation for this revision.

Version Rev 4 includes the Random Displacement Method (RDM) for calculation diffusion in ADPIC using a random walk, Monte Carlo approach, hybrid particles, moving receptors, plus other minor changes and additions.

Version Rev. 5 includes the moving sources capability, dense gas capability, better use of multi-level tower data, additional metdata sources (including several new gridded data sources) for MEDIC, and Appendix G. The right hand column of the table above shows the authors contributing to this revision.

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Preface

This user's guide documents the CG-MATHEW and ADPIC transport and diffusion models and their supporting stream of codes. It includes a description of each code (Chapter I), its theoretical basis (Chapter II), and the preparation of input and output data (Chapter III).

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I. Introduction to the CG-MATHEW/ADPIC Transport and Diffusion Models

This user's guide provides both an operational and theoretical summary of the CG-MATHEW/ADPIC transport and diffusion models and supplemental codes needed to execute these models. The acronym CG-MATHEW comes from **C**onjugate-**G**radient **M**ass-**A**djusted **THrE**e-dimensional **W**ind field. ADPIC stands for **A**tmospheric **D**iffusion **P**article-**I**n-**C**ell model. These models calculate air concentration and ground deposition on a regional scale (up to 200 km) from continuous or instantaneous point sources.

CG-MATHEW is a three-dimensional meteorological data-adjustment model which supplies ADPIC with mean wind fields that are mass-consistent and representative of the available meteorological measurements (surface, tower, and upper air soundings). The bottom boundary in this model is determined by grid cell estimates of the actual topographic features of a given site and its environs, which can play a very important role in defining or modifying regional-scale flow patterns. ADPIC is a three-dimensional particle transport and diffusion code capable of calculating the time-dependent dispersion of inert or radioactive air pollutants.

In addition to CG-MATHEW/ADPIC, three supplemental codes are required to provide input/output support. These codes, which are also discussed in this user's guide, are TOPOG, MEDIC, PLCNT and TIMEHIS. TOPOG defines topographic features for MEDIC, CG-MATHEW, and ADPIC. MEDIC builds a realistic three-dimensional wind field from the observed meteorological conditions. This input is used by CG-MATHEW to compute the mass-consistent wind field required by ADPIC. PLCNT is a post-processing code that allows dose conversion from particle concentration to other units (e.g., Rem). PLCNT uses the resulting doses to generate products for shipment to ARAC site workstations.

An overview of CG-MATHEW/ADPIC and the support routines follows in this section. A complete technical formulation of each code is found in Section II. Section III provides a user's guide to each code.

I.A. CG-MATHEW

The Conjugate-Gradient Mass-Adjusted THrEe-dimensional Wind (CG-MATHEW) code generates mass-consistent winds by minimal adjustment of input fields derived from observational, analyzed, or model data. The adjustment is performed by a constrained variational minimization using finite-difference methods and a conjugate gradient solution. Generalized symmetric boundary conditions are implemented, which allow control of the relative amounts of normal and tangential adjustment at the lateral and terrain surfaces. Sugiyama et al. (1994) discuss the methodology in detail, give comparisons with potential flow solutions for simple geometries, and demonstrate the use of the new boundary conditions to create different kinds of flow fields, prevent speed reductions, and eliminate flow artifacts caused by complex terrain.

The underlying theoretical framework for the variational adjustment was developed by Sasaki (1958, 1970a, 1970b) and first applied in the Atmospheric Release Advisory Capability (ARAC) operational context by Sherman (1978). A functional is formulated which minimizes the variance between input and output winds subject to a non-divergence constraint, mass-flow boundary conditions on lateral and top faces, and the requirement of zero normal wind-field components at terrain surfaces. The requirement of minimal adjustment maintains consistency with available meteorological measurements (surface and upper air soundings), while atmospheric stability conditions govern the relative amounts of change in the vertical and horizontal wind components. The adjustment is irrotational and neither momentum balance nor energy conservation is imposed. Velocity components are defined on staggered grid faces so that the mass-consistency constraint is cell-flux rather than grid-point based. The problem then reduces to the solution of the Poisson equation in the Lagrange multiplier $\lambda(x, y, z)$, with the adjusted winds derived from the corresponding Euler-Lagrange equations.

The original ARAC MATHEW code discretized the Poisson equation using quadratic fits to generate the boundary conditions, which resulted in an asymmetric coefficient matrix. The equation was then solved by a successive overrelaxation (SOR) method. In order to implement a conjugate gradient algorithm, which is approximately twice as fast as the SOR approach, the problem has been reformulated with standard image point boundary conditions. This yields a symmetric matrix representation consistent with the symmetry of the continuous Poisson problem. The boundary conditions are generalized to include parameters for controlling the relative amounts of normal and tangential adjustment at the lateral and top edges (MIXED boundary condition, Gresho, 1978) and for fixing velocities at the inflow boundaries.

Input wind fields are generally derived by a combination of interpolation and extrapolation from sparse observational data and are typically assumed to be purely horizontal due to the lack of vertical velocity measurements. Such two-dimensional wind fields can be prepared for CG-MATHEW using the MEDIC code which incorporates surface, upper air, and analyzed wind data as available and appropriate. However, the mass-adjustment technique is applicable to input winds with a complete set of u, v, and w components and can be implemented using three-dimensional wind fields derived from assorted diagnostic and prognostic models.

I.B. ADPIC

ADPIC (Atmospheric Diffusion Particle-in-Cell) is a numerical, three-dimensional particle-diffusion code capable of calculating the time-dependent distribution of air pollutants under many conditions including strongly distorted wind fields, calm conditions, wet and dry deposition, radioactive decay, and space- and time-variable turbulence parameters.

ADPIC solves the three-dimensional advection-diffusion equation. This version of ADPIC includes a new option to use the Random Displacement Method (RDM) described by Ermak *et al*. (1995). The RDM is a random walk, Monte Carlo method of solving the advection-diffusion equation using Lagrangian marker particles to represent species mass. The original version of ADPIC solved the advection-diffusion equation using a Gradient Diffusion method that is a hybrid Eulerian-Lagrangian pseudo-velocity method developed by Lange (1973, 1978, and 1989), and described in earlier versions of this user's guide. This Gradient Diffusion method is retained as an option in this version of ADPIC. Mass-consistent mean wind fields supplied to ADPIC by CG-MATHEW.

The RDM diffusion calculation is a purely Lagrangian, grid-independent calculation. Some of the benefits of this approach compared to the previously used Gradient Diffusion method in ADPIC are (a) sub-grid diffusion approximation is no longer needed, (b) numerical accuracy of the diffusion calculation is improved because particle displacement does not depend on the resolution of the Eulerian grid used to calculate species concentration, and (c) future adaptation to other grid structures for the input wind field does not affect the diffusion calculation. In addition, the RDM incorporates a unique and accurate treatment of particle interaction with the surface.

I.C. CG-MATHEW and ADPIC Support Routines

I.C.1. TOPOG

TOPOG creates the underlying surface for the CG-MATHEW and ADPIC models. The surface is created by averaging terrain data from a regional terrain data base which has, as its source, high resolution elevation data supplied by the Defense Mapping Agency.

TOPOG has three main functions: (1) It verifies that the CG-MATHEW and ADPIC grids, as defined by the user, are oriented correctly with respect to each other and the regional terrain grid. (2) It averages terrain data from the regional data base to the newly defined model grid and then rounds these averaged heights to the nearest model level. This provides the appropriate block topography for the CG-MATHEW and ADPIC models. (3)

I.C.2. MEDIC

MEDIC extrapolates a three-dimensional gridded wind field from a combination of surface and upper air observations. The extrapolation is a complex process, controlled by a number of parameters specified by the user. The extrapolated wind field is sensitive to small changes in some of these parameters and, as a result, widely differing extrapolated fields can be produced, all of which are consistent with a given data set. CG-MATHEW adjusts the winds to achieve mass consistency and then passes them to ADPIC. Because CG-MATHEW makes the smallest necessary adjustments to the extrapolated field and because ADPIC assumes persistence over extended periods (typically one hour), any change in the extrapolated wind field will affect all the results of the ARAC models. Therefore, it is crucial for the user to provide the best extrapolated wind field that can be produced for a data set within the allowed range of the various parameter values. In turn, this means that the graphical output from MEDIC must be examined very carefully by the assessor to determine if the wind field is an acceptable model of the physical state of the atmosphere. If it is not, then MEDIC must be re-executed with revised parameter values until a reasonable representation is produced.

I.C.3. PLCNT

PLCNT uses as input two-dimensional gridded arrays of concentrations that are produced by ADPIC at user-selected heights in what are called "sampling bins". These 2-D sampling bin arrays are converted to "dose bin" arrays using a user-specified multiplicative "dose conversion factor", and then used individually or summed in to "final bin" arrays for subsequent processing. At user-defined times, PLCNT writes files with the final 2-D arrays of data for creating contour plots on the ARAC central system or transfer to ARAC site workstations. Up to five contours levels will selected by the code, each differing by an order of magnitude, as a function of the largest grid point concentration. The user has the option of overriding these contour level choices (see Section III.B.8). As an example of the usefulness of this latter option, an environmental standard may have been established for a

substance which has been accidentally released into the atmosphere. On entering this value, the code will plot a contour level, if present, which represents a threshold to this standard, thereby delineating the area of concern.

There are three types of model output data: total deposition, integrated air concentration, and instantaneous air concentration. Total deposition is cumulative mass or activity per unit area on the ground over the model domain since the beginning of the calculation. Integration air concentration is integrated in time over all horizontal grid points at selected heights. Instantaneous air concentration are calculated at specified times over all horizontal grid points at selected heights.

PLCNT also has a centerline concentration capability, which starts at a user-specified ADPIC source location and searches along arcs of increasing radius for the maximum along each radial arc. The result series of maxima, along with their locations are available in tabular format, and the locations are also plotted on each contour plot.

I.C.4. TIMEHIS

In addition to the ability to obtain contours from PLCNT, a companion code TIMEHIS (i.e., Time History) allows concentrations to be estimated using bilinear interpolation for point locations that can be arbitrarily positioned in the grid. The grid point concentrations are developed in exactly the same way as in PLCNT with interpolation to the final bins performed before any smoothing. The times at which the interpolations are made are also determined in the same way as the times of the plots in PLCNT. The series of concentrations are plotted as time series and printed in the TIMEHIS.LOG file. TIMEHIS will also read sampler measurement data, plotting these observations on the time series plots along with the computed values for the same locations. In addition, TIMEHIS generates statistics that compare the computed and measured values. These features have proved useful when comparing model concentrations against collections by actual samplers that have been placed in the field during a tracer experiment.

II. Technical Discussion of ARAC Models

II.A. CG-MATHEW+

II.A.1. Variational formulation

A variational problem may be solved by reduction to a set of differential equations known as the Euler equations, which represent necessary, though not sufficient, conditions for a minimum (Courant and Hilbert, 1962). In its simplest form, the CG-MATHEW functional required to minimize the variance between the observed input and adjusted output winds subject to the mass-consistency constraint is

$$J(u,v,w,\lambda) = \int_{\Omega} \frac{1}{2\sigma_H^2}\left(\left(u-u^o\right)^2+\left(v-v^o\right)^2\right) + \frac{1}{2\sigma_V^2}\left(w-w^o\right)^2 + \lambda\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial x}+\frac{\partial w}{\partial z}\right)dxdydz \qquad \text{(II.A.1)}$$

where (u, v, w) and $\left(u^o, v^o, w^o\right)$ are the output and input wind components, respectively, $\lambda(x, y, z)$ is the Lagrange multiplier for the mass-consistency constraint, Ω is the volume domain of the simulation, and σ_v and σ_H are parameters controlling the relative amounts of vertical and horizontal adjustment. The Euler-Lagrange equations associated with this functional are

$$\begin{aligned} u - u^o &= \sigma_H^2 \frac{\partial \lambda}{\partial x} \\ v - v^o &= \sigma_H^2 \frac{\partial \lambda}{\partial y} \\ w - w^o &= \sigma_V^2 \frac{\partial \lambda}{\partial z} \end{aligned} \qquad \text{(II.A.2)}$$

with boundary conditions

$$\begin{aligned} \lambda n_x \, \delta u\big|_s &= 0 \\ \lambda n_y \, \delta v\big|_s &= 0 \\ \lambda n_z \, \delta w\big|_s &= 0 \quad . \end{aligned} \qquad \text{(II.A.3)}$$

Taking appropriate derivatives of the Euler-Lagrange equations and substituting into the mass-consistency constraint, $\nabla \cdot \vec{u} = 0$, yields the Poisson equation

$$\sigma_H^2\left(\frac{\partial^2\lambda}{\partial x^2} + \frac{\partial^2\lambda}{\partial y^2}\right) + \sigma_V^2 \frac{\partial^2\lambda}{\partial z^2} = -\frac{\partial u^0}{\partial x} - \frac{\partial v^0}{\partial y} - \frac{\partial w^0}{\partial z} \qquad \text{(II.A.4)}$$

which may be solved for λ subject to the boundary conditions. The adjusted wind fields are then determined from Eqs. II.A.2.

+ Abstracted from Sugiyama et al., 1994.

II.A.2. Boundary Conditions

The boundary conditions of Eqs. II.A.3 can be satisfied if $\lambda\big|_S = 0$. The physical interpretation of this solution is revealed by examination of the Euler-Lagrange equations. If λ is a constant on S, the derivatives along the surface vanish, which fixes the tangential component of the velocity, while imposing no restrictions on the normal component. This is the ADJUST_NORMAL condition and is a kind of flow-through boundary. Eqs. II.A.3 are also satisfied if $\frac{\partial\lambda}{\partial n}\big|_S = 0$, which prevents changes in the normal velocity component, while allowing free adjustment of the tangential component. This is a FIXED_NORMAL or fixed-flow boundary and can be used to maintain zero normal velocities on terrain surfaces [1].

It is advantageous to incorporate a new surface integral term which provides more flexibility in the boundary conditions and to treat the FIXED_NORMAL case in a constraint formalism, so that input wind fields with non-zero normal components at terrain surfaces can be used. These considerations lead to a generalized CG-MATHEW functional

$$\begin{aligned} J(u, v, w, \lambda) = & \int_\Omega \left[\left(\vec{u} - \vec{u}^0\right) \cdot \mathbf{D}^{-1} \cdot \left(\vec{u} - \vec{u}^0\right) + \lambda \nabla \cdot \vec{u} \right] dxdydz \\ & - \int_{S_{terrain}} \lambda_{terrain}\, \vec{n} \cdot \vec{u}\, dS \\ & + \frac{1}{2} \int_{S_{flow}} f(S) \left(\vec{u} - \vec{u}^0\right)^2 dS \end{aligned} \tag{II.A.5}$$

where $f(S)$ is an arbitrary continuous function on the flow-through boundary S_{flow}, $S_{terrain}$ is the terrain surface, and $\mathbf{D}$ is a 3x3 diagonal matrix with non-zero components $\sigma_i^2\, \delta_{i,j}$ $\left(\delta_{i,j}\right.$ is the Kronecker delta and $\sigma_1 = \sigma_2 = \sigma_H$ and $\left.\sigma_3 = \sigma_V\right)$.

The Euler-Lagrange and Poisson equations are unchanged from the simple CG-MATHEW formulation (Eqs. II.A.2 and II.A.4)

$$\vec{u} - \vec{u}^0 = \mathbf{D} \cdot \nabla\lambda \tag{II.A.6}$$

$$\nabla \cdot \mathbf{D} \cdot \nabla\lambda = -\nabla \cdot \vec{u}^0 \quad , \tag{II.A.7}$$

but the boundary conditions now contain contributions from the new surface integrals as well as from the integration by parts

$$\begin{aligned} 0 &= \int_S \lambda \vec{n} \cdot \delta\vec{u}\, dS - \int_{S_{terrain}} \lambda_{terrain}\, \vec{n} \cdot \delta\vec{u}\, dS + \int_{S_{flow}} f(S)\left(\vec{u} - \vec{u}^0\right) \cdot \delta\vec{u}\, dS \\ &= \int_{S_{terrain}} \left(\lambda_{terrain} - \lambda\right)\vec{n} \cdot \delta\vec{u}\, dS + \int_{S_{flow}} \left[f(S)\left(\vec{u} - \vec{u}^0\right) + \lambda\vec{n} \right] \cdot \delta\vec{u}\, dS \quad . \end{aligned} \tag{II.A.8}$$

For the first integral to vanish, λ must be equal to $\lambda_{terrain}$ on $S_{terrain}$. The flow-through boundary condition and terrain surface constraint can then be written as

---

[1] The original MATHEW code had OPEN boundaries corresponding to the ADJUST_NORMAL condition and CLOSED boundaries equivalent to FIXED_NORMAL on terrain surfaces with $\vec{n} \cdot \vec{u}^0\big|_{S_{terrain}} = 0$.

$$\begin{aligned} &\lambda + f(S)\vec{n} \cdot \left(\vec{u} - \vec{u}^0\right) = \lambda + f(S)\vec{n} \cdot \mathbf{D} \cdot \nabla\lambda = 0 && S_{flow} \\ &\vec{n} \cdot \vec{u} = \vec{n} \cdot \vec{u}^0 + \vec{n} \cdot \mathbf{D} \cdot \nabla\lambda = 0 && S_{terrain} \end{aligned} \tag{II.A.9}$$

where the Euler-Lagrange equations have been used to substitute for $\vec{u}$. For a rectangular grid, these equations reduce to

$$\begin{aligned} &\lambda + \sigma_n^2 \; f(S) \frac{\partial\lambda}{\partial n} = 0 && S_{flow} \\ &\vec{n} \cdot \vec{u}^0 = -\sigma_n^2 \frac{\partial\lambda}{\partial n} && S_{terrain} \end{aligned} \tag{II.A.10}$$

where $\vec{n}$ is the *outward* normal to the face. Although in principle, $f(S)$ could be any continuous function, in practice, it is taken to be a constant $1/c_n$ governing the ratio of normal to tangential adjustment on each face, in order to limit the danger of overly constraining the problem. The ADJUST_NORMAL and FIXED_NORMAL boundary conditions are limiting cases of the MIXED boundary condition as $c_n \to \infty$ or $c_n \to 0$, respectively.

II.A.3. Derivation of the CG-MATHEW stencil

The CG-MATHEW grid is rectangular with regular spacings of Δx, Δy, and Δz, indexed by i, j, and k, which run from 1 to $i_{\max}$, $j_{\max}$, and $k_{\max}$, respectively. The wind field components are defined on staggered face centers, interpolated from input grid-point winds, and λ is defined at the cell center as shown in Figure II.A.1. Standard two- and three-point finite difference formulae then give the first derivatives of λ on the staggered face centers and both the second λ derivative and the wind component first derivatives at the cell centers. The topography is specified by cell-centered heights indexed by $\left(i + \frac{1}{2}, j + \frac{1}{2}\right)$.

For computational purposes, the Poisson equation II.A.7 is divided through by σ_H^2 and discretized, resulting in a set of linear equations in the components $\lambda_{i+\frac{1}{2}, j+\frac{1}{2}, k+\frac{1}{2}}$, which can be written in matrix form as $\mathbf{C}\vec{\lambda} = \vec{\mathbf{b}}$. $\vec{\lambda}$ and $\vec{\mathbf{b}} = -\left(\nabla \cdot \vec{u}_0\right)/\sigma_H^2$ are vectors of length $N = \left(i_{\max} - 1\right) \cdot \left(j_{\max} - 1\right) \cdot \left(k_{\max} - 1\right)$, and $\mathbf{C}$ is an $N \times N$ matrix containing the finite-difference coefficients for each cell, which depend upon the boundary condition. Since the upper boundary of a given cell is the lower boundary of the next higher index cell on that axis, $\mathbf{C}$ is symmetrical, and can be constructed to be positive definite $\left(\vec{a} \cdot \mathbf{C} \cdot \vec{a} \geq 0 \text{ for all vectors } \vec{a}\right)$ [2].

---

[2] The original MATHEW stencil was derived using quadratic differencing formulae leading to an asymmetric coefficient matrix.

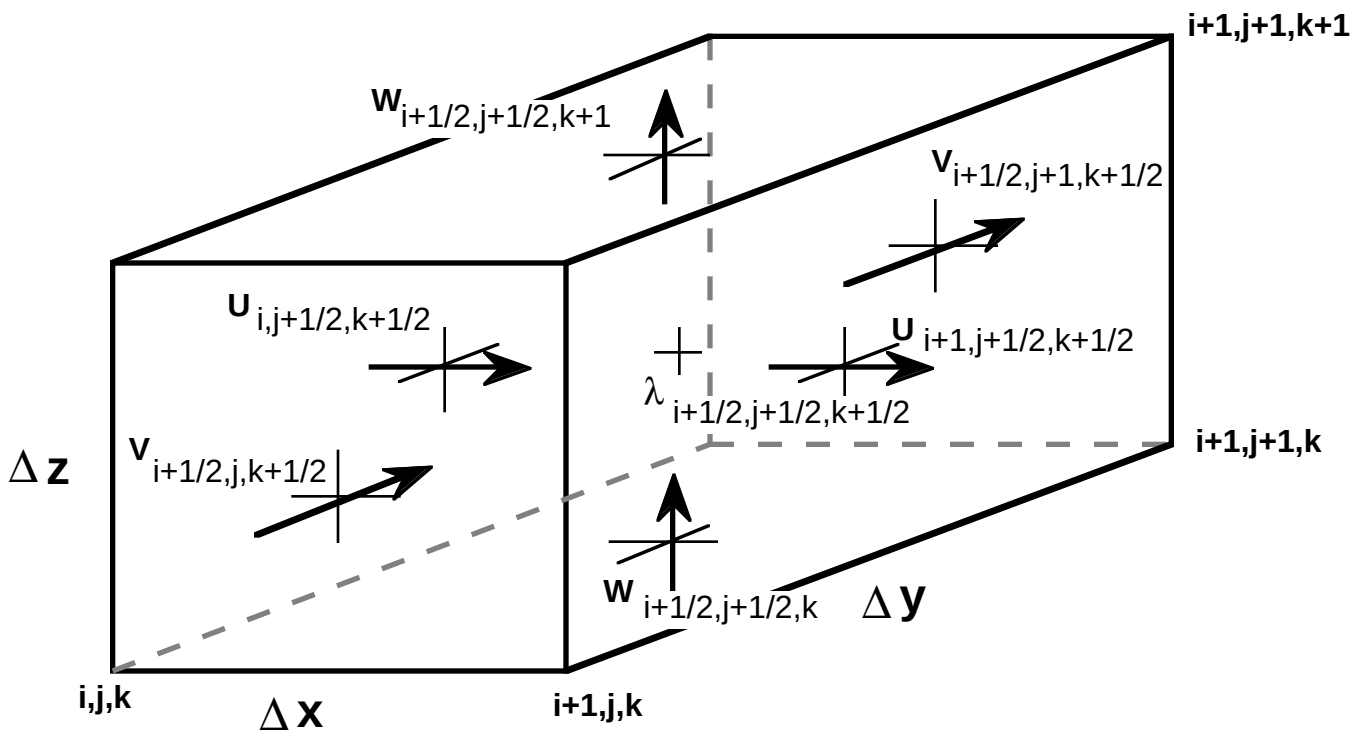

Figure II.A.1: Schematic representation of CG-MATHEW cell centered at point $(i + 1/2, j + 1/2, k + 1/2)$ showing staggered face-centered wind and cell-centered λ components.

The stencil for the coefficient matrix can be derived for any one of the three axis directions, with symmetry used to establish the other components. In the x direction, the boundary conditions on the i and $i + 1$ faces determine relationships between $\lambda_{i-1/2}$, $\lambda_{i+1/2}$, and $\lambda_{i+3/2}$, which are used in the discretized Poisson and Euler-Lagrange equations

$$\frac{\lambda_{i+3/2} - 2\lambda_{i+1/2} + \lambda_{i-1/2}}{(\Delta x)^2} = -\frac{1}{\sigma_H^2}\frac{u_{i+1}^0 - u_i^0}{\Delta x} \quad , \quad u_i = u_i^0 + \frac{\lambda_{i+1/2} - \lambda_{i-1/2}}{\Delta x} \quad . \qquad \text{(II.A.11)}$$

Terrain cells are decoupled by setting the diagonal $\lambda_{i+1/2}$ element to one and the off-diagonal elements of the matrix row to zero, so that the value of λ for a terrain cell is forced to be zero. Bordering interior cells impose no constraints on the λ values, while other boundary conditions restrict the allowed values as summarized in Table II.A.1. The opposite sign on the derivative for the i MIXED boundary condition reflects the reverse direction of the *outward* normal. It should be noted that for ADJUST_NORMAL boundary conditions, the tangential component is algebraically constrained but not fixed, due to the staggered face-centered representation of the wind components. Combinations of the boundary conditions can be treated by a straightforward extension.

CELL $i+\frac{1}{2}$	BOUNDARY i	BOUNDARY $i+1$		
terrain				$\lambda_{i+1/2} = 1$
interior	ADJUST_NORMAL			$\lambda_{i-1/2} = -\lambda_{i+1/2}$
		ADJUST_NORMAL		$\lambda_{i+3/2} = -\lambda_{i+1/2}$
	FIXED_NORMAL			$\lambda_{i-1/2} = \lambda_{i+1/2}$
		FIXED_NORMAL		$\lambda_{i+3/2} = \lambda_{i+1/2}$
	MIXED			$\lambda_{i-1/2} = \left(\frac{1-c_x^-\frac{\Delta x}{2}}{1+c_x^-\frac{\Delta x}{2}}\right)\lambda_{i+1/2}$
		MIXED		$\lambda_{i-3/2} = \left(\frac{1-c_x^+\frac{\Delta x}{2}}{1+c_x^+\frac{\Delta x}{2}}\right)\lambda_{i+1/2}$

Table II.A.1: Boundary condition restrictions on λ values. The constant $c_x^{\pm}$ controls the ratio of normal to horizontal adjustment for the MIXED condition.

Due to the symmetric sparse nature of the Poisson matrix, considerable memory savings are possible by storing only the diagonal and sub-diagonal elements. For the three-dimensional case, this can be generalized to storing the four possibly non-zero lower triangle components of **C** in a compact 4 x N form written schematically as

$$\mathbf{A} = \begin{vmatrix} \vdots & \vdots & \vdots & \vdots \\ C_{i,j,k-1} & C_{i,j-1,k} & C_{i-1,j,k} & C_{i,j,k} \\ \vdots & \vdots & \vdots & \vdots \end{vmatrix} \quad , \tag{II.A.12}$$

where N is the number of cells. The nth or $(i, j, k)^{th}$ element of the matrix multiply $\mathbf{C} \cdot \lambda$ then becomes

$$\begin{aligned} \left(\mathbf{C} \cdot \vec{\lambda}\right)_n &= \left(\mathbf{C} \cdot \vec{\lambda}\right)_{i,j,k} \\ &= A_{i,j,k,4}\,\lambda_{i,j,k} + A_{i,j,k,3}\,\lambda_{i-1,j,k} + A_{i,j,k,2}\,\lambda_{i,j-1,k} + A_{i,j,k,1}\,\lambda_{i,j,k-1} \\ &+ A_{i+1,j,k,3}\,\lambda_{i+1,j,k} + A_{i,j,+1,k,2}\,\lambda_{i,j+1,k} + A_{i,j,k+1,1}\,\lambda_{i,j,k+1} \\ &= A_{n,4}\,\lambda_n + A_{n,3}\,\lambda_{n-1} + A_{n,2}\,\lambda_{n-i_{\max}} + A_{n,1}\,\lambda_{n-i_{\max}\cdot j_{\max}} \\ &+ A_{n+1,3}\,\lambda_{n+1} + A_{n+i_{\max},2}\,\lambda_{n+i_{\max}} + A_{n+i_{\max}\cdot j_{\max},1}\,\lambda_{n+i_{\max}\cdot j_{\max}} \end{aligned} \tag{II.A.13}$$

since $\pm i_{\max}$ moves ± 1 in the j coefficient and $\pm(i_{\max} \cdot j_{\max})$ moves ± 1 in the k coefficient. We will also call this the matrix multiply $\mathbf{A} \cdot \lambda$.

The complete CG-MATHEW stencil in three-dimensions is given in terms of the components of **A** in Table II.A.2. The matrix elements are found by summing together the contributions in each column which match the appropriate boundary conditions. For example, if the cell $n = (i, j, k)$ is bordered by terrain cells at $i-1$ and $j+1$ and by interior cells on the remaining sides, $A_{n,1} = \left(\frac{\sigma_V}{\sigma_H}\right)^2 \frac{1}{(\Delta z)^2}$, $A_{n,2} = \frac{1}{(\Delta y)^2}$, $A_{n,3} = 0$, and $A_{n,4} = -\frac{1}{(\Delta x)^2} - \frac{1}{(\Delta y)^2} - \left(\frac{\sigma_V}{\sigma_H}\right)^2 \frac{2}{(\Delta z)^2}$.

II.A.4. Conjugate Gradient Algorithm

Conjugate gradient methods for solving an N x N linear system $\mathbf{A}\vec{x} = \vec{b}$ have several advantageous features. They require no parameter estimations and provide optimal error minimization. The algorithms have a finite termination after $M \leq N$ steps, where M is the number of distinct eigenvalues of **A**. Since they reference **A** only through vector multiplication, the codes are also highly vectorizable and allow concise storage for sparse systems.

Conjugate gradient algorithms (Varga, 1962) are based on the idea of minimizing a function $f(\vec{x}) = \frac{1}{2}\vec{x}^T \cdot \mathbf{A} \cdot \vec{x} - \vec{x}^T \cdot \vec{b}$ by finding the point where $\nabla f = \mathbf{A} \cdot \vec{x} - \vec{b} = 0$. The minimization is carried out by generating a succession of search directions $\vec{p}_k$ and a corresponding set of improved solutions $\vec{x}_{k+1}$ which minimize f in the space spanned by $\{\vec{p}_1, \vec{p}_2, \ldots, \vec{p}_k\}$. Convergence is monotonic, the generalized error function $(A\vec{x} - \vec{z})^T \cdot (\vec{x} - \vec{z})$ taking on its smallest value in the subspace spanned by the search when $\vec{z} = \vec{x}_{k+1}$ and decreasing in magnitude with each iteration.

For improved convergence, preconditioning is used to modify the matrix **A** to one that is very close to the identity matrix **I** except for a few extreme eigenvalues. This is done by multiplying **A** by a easily calculable sparse symmetric matrix $\tilde{\mathbf{A}}^{-1}$

$$\begin{aligned} &\tilde{\mathbf{A}}^{-1}\,\mathbf{A} \approx \mathbf{I} \\ &\tilde{\mathbf{A}}^{-1}\,\mathbf{A}\vec{x} = \tilde{\mathbf{A}}^{-1}\vec{b} \quad . \end{aligned} \tag{II.A.14}$$

As a first approximation, diagonal scaling

$$\tilde{\mathbf{A}}^{-1}_{i,j} = \frac{1}{\mathbf{A}_{i,j}} \tag{II.A.15}$$

is used for preconditioning.

The numerical algorithm (Press et al., 1993) uses an initial guess for $\vec{x}_1$, which is an arbitrary approximation to the solution vector and may be taken to be the zero vector. The first residual $\vec{r}_1$, the preconditioned residual $\vec{z}_1$, and an initial direction

CELL	BOUNDARY		$A_{n,1}$	$A_{n,2}$	$A_{n,3}$	$A_{n,4}$
terrain	all boundaries					1
interior	all boundaries					$-\frac{2}{(\Delta x)^2}-\frac{2}{(\Delta y)^2}-\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{2}{(\Delta z)^2}$
	x_{i-1}	interior			$\frac{1}{(\Delta x)^2}$	
		$\lambda = 0$				$-\frac{1}{(\Delta x)^2}$
		$\frac{\partial\lambda}{\partial x}=0$				$\frac{1}{(\Delta x)^2}$
		$c_x^-\lambda-\frac{\partial\lambda}{\partial x}=0$				$\frac{1-c_x^-\Delta x/2}{1+c_x^-\Delta x/2}\cdot\frac{1}{(\Delta x)^2}$
	x_{i+1}	interior				
		$\lambda = 0$				$-\frac{1}{(\Delta x)^2}$
		$\frac{\partial\lambda}{\partial x}=0$				$\frac{1}{(\Delta x)^2}$
		$c_x^+\lambda+\frac{\partial\lambda}{\partial x}=0$				$\frac{1-c_x^+\Delta x/2}{1+c_x^+\Delta x/2}\cdot\frac{1}{(\Delta x)^2}$
	y_{j-1}	interior		$\frac{1}{(\Delta y)^2}$		
		$\lambda = 0$				$-\frac{1}{(\Delta y)^2}$
		$\frac{\partial\lambda}{\partial y}=0$				$\frac{1}{(\Delta y)^2}$
		$c_y^-\lambda-\frac{\partial\lambda}{\partial y}=0$				$\frac{1-c_y^-\Delta y/2}{1+c_y^-\Delta y/2}\cdot\frac{1}{(\Delta y)^2}$
	y_{j+1}	interior				
		$\lambda = 0$				$-\frac{1}{(\Delta y)^2}$
		$\frac{\partial\lambda}{\partial y}=0$				$\frac{1}{(\Delta y)^2}$
		$c_y^+\lambda+\frac{\partial\lambda}{\partial y}=0$				$\frac{1-c_y^+\Delta y/2}{1+c_y^+\Delta y/2}\cdot\frac{1}{(\Delta y)^2}$
	z_{k-1}	interior	$\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$			
		$\lambda = 0$				$-\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$
		$\frac{\partial\lambda}{\partial z}=0$				$\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$
		$c_z^-\lambda-\frac{\partial\lambda}{\partial z}=0$				$\frac{1-c_z^-\Delta z/2}{1+c_z^-\Delta z/2}\cdot\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$
	z_{k+1}	interior				
		$\lambda = 0$				$-\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$
		$\frac{\partial\lambda}{\partial z}=0$				$\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$
		$c_z^+\lambda+\frac{\partial\lambda}{\partial z}=0$				$\frac{1-c_z^+\Delta z/2}{1+c_z^+\Delta z/2}\cdot\left(\frac{\sigma_V}{\sigma_H}\right)^2\frac{1}{(\Delta z)^2}$

Table II.A.2: CG-MATHEW stencil. The values of the stencil for any cell n are found by summing contributions from all applicable rows.

vector $\vec{p}_1$ are generated according to

$$\begin{aligned} \vec{r}_1 &= \left(\vec{b} - \mathbf{A}\vec{x}_1\right) \\ \vec{z}_1 &= \tilde{A}^{-1}\,\vec{r}_1 \\ \vec{p}_1 &= \vec{z}_1 \end{aligned} \qquad \text{(II.A.16)}$$

The minimization then proceeds for successive k by finding the α_k that minimize $f\left(\vec{x}_k + \alpha_k \vec{p}_k\right)$ and generating the next search direction vector by **A**-orthogonalization of the residuals according to the prescription

$$\begin{aligned} \alpha_k &= \tfrac{\vec{r}_k \cdot \vec{z}_k}{\vec{p}_k \cdot \mathbf{A} \cdot \vec{p}_k} \\ \vec{r}_{k+1} &= \vec{r}_k - \alpha_k \cdot \mathbf{A} \cdot \vec{p}_k \\ \vec{z}_{k+1} &= \tilde{\mathbf{A}}^{-1} \cdot \vec{r}_{k+1} \\ \vec{x}_{k+1} &= \vec{x}_k - \alpha_k \vec{p}_k \\ \beta_k &= \tfrac{\vec{r}_k \cdot \vec{z}_{k+1}}{\vec{r}_k \cdot \vec{z}_k} \\ \vec{p}_{k+1} &= \vec{z}_k - \beta_k \vec{p}_k \end{aligned} \qquad \text{(II.A.17)}$$

The residuals and direction vectors are mutually orthogonal and conjugate

$$\begin{aligned} \vec{r}_i \cdot \vec{r}_j &= 0 \quad j < i \\ \vec{r}_i \cdot \vec{p}_j &= 0 \quad j \le i \\ \vec{p}_i \cdot \mathbf{A} \cdot \vec{p}_j &= 0 \quad j < i \end{aligned} \qquad \text{(II.A.18)}$$

so that each iteration proceeds by making the residual orthogonal to one more independent conjugate direction vector. The residuals $\vec{r}_k$ are also linearly independent and give the direction of steepest descent $f(\vec{x})$ at each step. It should be noted that the conjugate direction vectors $\vec{p}_k$ are *not* determined beforehand. Instead, they are constructed as linear combinations of the $\vec{r}_k$ by calculation of the appropriate β_k at each iteration.

Any of several convergence criterion can be adopted depending on the application. We have chosen a combination of

$$\begin{aligned} \left|\mathbf{A}\vec{x}_k - \vec{b}\right| &< \Delta_{tolerance} \\ \tfrac{\left|\vec{x}_{k+1} - \vec{x}_k\right|}{\left|\vec{x}_{k+1}\right|} &< \Delta_{tolerance} \end{aligned} \qquad \text{(II.A.19)}$$

The first tolerance check is used to stop the iterations, whenever the second condition is satisfied. These criteria are not completely robust; the final field should only be trusted when the solution converges monotonically.

II.A.5. Output

The face-centered adjusted velocity components (u, v, w) are interpolated back to form grid-point winds using an averaging procedure which maintains mass-consistency. The grid-point velocities are then written to MATVEL files (see Section III.C.8) along with traceback block information which uniquely identifies the current problem. These files provide input for the pollutant transport and diffusion code ADPIC.

II.B. ADPIC

II.B.1. Advection-Diffusion Equation and its Lagrangian Equivalent

The Random Displacement Method (RDM), as well as the original particle-in-cell, gradient diffusion method used in ADPIC, is based upon the conservation of species principal expressed in the form of the 3-D, incompressible, Eulerian advection-diffusion equation:

$$\frac{\partial \overline{C}}{\partial t} = -\overline{u}\frac{\partial \overline{C}}{\partial x} - \overline{v}\frac{\partial \overline{C}}{\partial y} - \overline{w}\frac{\partial \overline{C}}{\partial z} + \frac{\partial}{\partial x}\left(K_x \frac{\partial \overline{C}}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y \frac{\partial \overline{C}}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z \frac{\partial \overline{C}}{\partial z}\right) \qquad \text{(II.B.1)}$$

where $\overline{C}$ is the mean air concentration of the species; $\overline{u}$, $\overline{v}$, and $\overline{w}$ are the mean wind components in the x, y, and z directions, respectively; t is time; and K_x, K_y, and K_z are the eddy diffusivities for the three coordinate directions (the eddy diffusivity tensor is assumed to be diagonal).

The RDM uses stochastic differential equations that describe the same process as the advection-diffusion equation (II.B.1), but in a Lagrangian instead of an Eulerian framework (Boughton *et al.*, 1987; Ermak, 1992; Rodean *et al*., 1992). The stochastic differential equations for the displacement of an idealized fluid element in the three coordinate directions are

$$dx = \overline{u}dt + (2K_x)^{1/2} dW_x, \qquad \text{(II.B.2a)}$$

$$dy = \overline{v}dt + (2K_y)^{1/2} dW_y, \text{ and} \qquad \text{(II.B.2b)}$$

$$dz = \overline{w}dt + \frac{\partial K_z}{\partial z}dt + (2K_z)^{1/2} dW_z, \qquad \text{(II.B.2c)}$$

where $dW_{x,y,z}$ are three independent random variates with zero mean and variance dt, i.e.,

$$\overline{dW} = 0,$$

$$\overline{dW^2} = dt.$$

In (II.B.2a-b) it has been assumed that turbulence is homogeneous in the horizontal, x and y, directions. Eqs. (II.B.2a-c) are integrated in time to calculate independent trajectories representing the movement of individual fluid elements. In a RDM calculation, the released species is represented by a large number of marker particles (fluid elements), each with a specified species mass. The ensemble-mean concentration at any time t can then be calculate from the particle locations at time t and the species mass associated with each particle.

The particle-in-cell, gradient diffusion method of solving the advection diffusion equation is a hybrid Eulerian-Lagrangian pseudo-velocity method developed by Lange (1973, 1978, and 1989), and described in earlier versions of this user's guide. The gradient diffusion method will *not* be described further in this chapter. The DIFF_METH parameter in the ADPIC_CONTROL namelist controls which diffusion method is used: RDM or gradient diffusion.

A fundamental assumption in both the Eulerian formulation (II.B.1) and the Lagrangian formulation (II.B.2a-c) is that time and space scales of the turbulence are small relative to the time and space scales of the diffusion calculation to be performed. From an Eulerian view, the length scale ("eddy size") of the turbulence, L, is assumed to be small relative to the length scale of the spatial gradients of the concentration to be calculated, e.g., $L << \overline{C}\Big/\left(\frac{\partial \overline{C}}{\partial z}\right)$. From a Lagrangian view, the time scale ("eddy lifetime") of the turbulence, τ, is assumed to be smaller than the time over which concentrations are to be calculated (i.e., $\tau << t$).

In the atmospheric boundary layer, turbulent time scales range from seconds to minutes. At the surface, they are typically assumed to be zero and to increase in a manner that is approximately linear with height. The rate of increase with height of the turbulent time scale near the surface is much higher under unstable, as opposed to stable, conditions. Therefore, for near-source diffusion from a point source the assumptions implicit in eqs. (1) and (2a-c) become more valid, in general, for source heights closer to the surface and for more stable conditions. Conversely, for more elevated source heights and more unstable conditions (when the time and space scales of turbulence are greater) the assumptions are only valid for times and distances farther from the source, when the concentration distribution is more dispersed.

II.B.2. RDM Numerical Solution

In the RDM, it is assumed that K_x and K_y are constant in space, and that K_z varies linearly with height, i.e.,

$$K_z(z) = K_z(z_i) + \left.\frac{\partial K}{\partial z}\right|_{z_i} \left(z - z_i\right). \tag{II.B.3}$$

Then, a numerical solution of eqs. (II.B.2a-c) can be constructed using the difference equations (Ermak, 1992)

$$\Delta x_i = \overline{u}\Delta t_i + \left[2K_{xi}\Delta t_i\right]^{1/2} \xi_{xi}, \tag{II.B.4a}$$

$$\Delta y_i = \overline{v}\Delta t_i + \left[2K_{yi}\Delta t_i\right]^{1/2} \xi_{yi}, \text{ and} \tag{II.B.4b}$$

$$\Delta z_i = \overline{w}\Delta t_i + \left(\frac{\partial K_z}{\partial z}\right)_i \Delta t_i + \left[2K_{zi}\Delta t_i + \left(\frac{\partial K_z}{\partial z}\right)_i^2 \Delta t_i^{\,2}\right]^{1/2} \xi_{zi}, \tag{II.B.4c}$$

where, for example, in the vertical direction,

$$\Delta z_i = z(t_{i+1}) - z(t_i),$$
$$K_{zi} = K_z(z_i, t_i),$$
$$\left(\frac{\partial K_z}{\partial z}\right)_i = \left.\frac{\partial K}{\partial z}\right|_{\substack{t=t_i \\ z=z_i}},$$
$$\Delta t_i = t_{i+1} - t_i, \text{and}$$
$$\xi_{zi} = \text{ a random number with zero mean } (\overline{\xi} = 0)$$
$$\text{and variance of one } (\overline{\xi^2} = 1).$$

The second-order term in (II.B.4c), $\left(\partial K/\partial z\right)^2 \Delta t^2$, is unique to our RDM. This term includes the effect of the linear variation of K during the finite time step, Δt, on the displacement variance, and is especially important close to the ground where K_z approaches zero in similarity theory parameterizations. Eddy diffusivity and the spatial derivative of the vertical eddy diffusivity are evaluated analytically at the particle position at each time step. Particle trajectories can be numerically calculated by successively using (II.B.4a-c) and incrementing the particle position using, for example,

$$z(t_{i+1}) = z(t_i) + \Delta z_i. \qquad \text{(II.B.5)}$$

Details on the implementation of (II.B.4-5) are given by Ermak *et al.* (1995).

In the ADPIC code, a gridded wind field is used for the mean wind components, $\overline{u}$, $\overline{v}$, and $\overline{w}$ in (II.B.4a-c). The time step used in the numerical solution is restricted to prevent a particle from moving more than a single mean wind grid cell in any time step due to mean wind advection plus diffusion. Furthermore, for accurate time integration of concentration in the concentration grid, the time step is also restricted to prevent any particle from moving through more than a single concentration grid cell in any time step (this results in conservatively small time steps when the concentration distribution spans many concentration sampling grid cells).

The *local time step* is determined separately for each particle. The local time steps for all particles are forced to synchronize at necessary times, such as when meteorological parameters change, source parameters change, wind input data changes, particle concentrations are to be saved, status messages are to be written, or graphics output is to be written. The *global time step* is the time interval between these events that affect all particles. The local time step cannot exceed the global time step. Time steps reported to the user through the status messages to the monitor or the log file are the global timesteps along with the average of the local particle time steps during each global time step.

II.B.3. Turbulence Parameterizations

As can be seen in the previous section, the RDM used in ADPIC requires parameterizations of atmospheric turbulence in the form of an eddy diffusivities, K. Several K parameterization options are available for use with the RDM. Turbulence parameterizations for the Gradient Diffusion

method are not described here, but are described in chapter III and in previous versions of this user's guide.

Tables II.B.3.a and II.B.3.b summarize the options available for both vertical and horizontal turbulence, respectively, in the RDM option in ADPIC. In the RDM option, two parameters, TURB_PARAM_VERT and TURB_PARAM_HORZ, control the vertical and horizontal turbulence parameterizations separately. These options are discussed in the following section II.B.3 and in section III.B.9 which describes the ADPIC namelist input parameters. Further information on these turbulence parameterizations is given by Nasstrom (1995).

In the Gradient Diffusion option, which is not described here, the parameter TURB_PARAM_TYPE, controls the turbulence parameterization in the vertical and horizontal simultaneously. See section III.B.9 for a description of TURB_PARAM_TYPE.

Table II.B.3.a. Vertical turbulence options in the RDM

TURB_PARAM_VERT=	**Description**
'KZ_SIMTHRY'	K_z as a function of z; calculated from boundary layer similarity theory as a function of u_*, h, z and L for $z < h$. Constant, K_z^{tropo}, used for $z > h$.
'KZ_SIMTHRY_USER'	K_z as a function of z; calculated from boundary layer similarity theory as function of u_*, h, z and L, but with *user-specified* coefficients a, b, c, c_2, c_3, and K_z^{tropo}
'SIGZ_PWRLAWX_PG'	K_z as a function of downwind distance, x; calculated from *Pasquill-Gifford* $\sigma_z(x)$ in a power law form ($\sigma_z = \gamma x^{\rho}$).
'SIGZ_PWRLAWX_USER'	K_z as a function of x; calculated from the power-law form of $\sigma_z = \gamma x^{\rho}$ and *user-specified* coefficients γ and ρ.
'KZ_LINEARZ'	K_z calculated from a linear function of height: $K_z = K_{z\mathrm{ref}}\left(z/z_{\mathrm{ref}}\right)$, where K_{zref} and z_{ref} are specified by the user.
'KZ_CONSTANTZ'	K_z fixed at constant value.

Table II.B.3.a. Horizontal turbulence options in the RDM

TURB_PARAM_HORZ=	Description
'SIGH_SIGTHETA'	K_H as a function of particle age (time) *t;* calculated from *Draxler's* $\sigma_y(t)$ using input σ_θ data and internal-default τ_H
'SIGH_SIGTHETA_USER'	K_H as a function of particle age (time) *t*; calculated from *Draxler's* $\sigma_y(t)$ using input σ_θ data and *user-specified* τ_H.
'SIGH_PWRLAWX_PG'	K_H as a function of downwind distance *x*; calculated from *Pasquill-Gifford* $\sigma_y(x)$ in a power law form ($\sigma_y = \alpha x^\beta$).
'SIGH_PWRLAWX_MESO'	K_H as a function of *x;* calculated from *MESODIF* $\sigma_y(x)$.
'SIGH_PWRLAWX_LONGRANGE'	K_H as a function of *x*; calculated from *Rodriguez's long-range* $\sigma_y(x)$.
'SIGH_PWRLAWX_USER'	K_H as function of *x*; calculated from power law form of $\sigma_y = \alpha x^\beta$ and *user-specified* coefficients α and β.

Preferred parameterizations are based on boundary layer turbulence scaling parameters and measured turbulent velocity statistics. Simpler parameterizations, based solely on Pasquill stability class, are also available. When eddy diffusivities are based on boundary layer turbulence scaling parameters (i.e., friction velocity, u_*; mixed layer height, *h*; height, *z*; and Obukhov length, *L*), "turbulence parameterization" is an appropriate term. In other cases, this term is used loosely to describe "sigma curves". These are semi-empirical relationships between the standard deviations, $\sigma_z(x)$ and $\sigma_y(x)$, of concentration from a point source and downwind distance. Separate sigma curves are used for each of six Pasquill stability classes, which are used to categorize the diffusive properties of the atmospheric surface layer. Consequently, sigma curves are more than parameterizations of turbulence since they also prescribe the final concentration distribution (for a point source) given a Pasquill stability class.

In the ADPIC model, sigma curves can be used to calculate the vertical and horizontal eddy diffusivities, K_z and K_H $(= K_x = K_y)$. Thus, they can be used to "back out" parameterizations for *K* which are consistent with the dispersion associated with the particular sigma curve. This results in

eddy diffusivities which are spatially homogeneous, but travel time dependent. A vertically homogeneous K_z is a poor assumption in the atmospheric boundary layer. A horizontally homogeneous K_H is a better assumption because quasi-horizontally-homogeneous turbulence is more common in the atmospheric boundary layer. The use of these time-dependent eddy diffusivities is an empirical approach to calculating diffusion at short times when the assumptions implicit in the advection-diffusion equation (on which the RDM is based) are less valid.

An improvement to the overly-broad, site-dependent stability class/sigma curve approach is the use of direct statistical measures of turbulent fluctuations (i.e., σ_θ) along with a horizontal turbulence time scale, τ_H, to determine a time-dependent horizontal concentration standard deviation, $\sigma_y(t)$. These are used in the RDM as a semi-empirical method of parameterizing a time-dependent, horizontally-homogeneous K_H.

II.B.3.a. Vertical Turbulence Parameterizations

TURB_PARAM_VERT = 'KZ_SIMTHRY' AND 'KZ_SIMTHRY_USER'

These options use K_z profiles based on surface layer and boundary layer scaling parameters (Lange, 1989). For the boundary layer ($z < h$), K_z^{bl} is a function of z, L, h, and u_* as follows:

$$K_z^{\mathrm{bl}}(z) = \frac{k u_* z}{\phi_z} e^{-cz/h}, \tag{II.B.6}$$

where

$$\phi_z = \left(1 + a\frac{z}{L}\right)^b, \tag{II.B.7}$$

$$a = \begin{cases} -15, & \text{if } 1/L < 0 \\ 0, & \text{if } 1/L = 0 \\ 4.5, & \text{if } 1/L > 0 \end{cases}$$

$$b = \begin{cases} -0.25, & \text{if } 1/L < 0 \\ 1, & \text{if } 1/L \geq 0 \end{cases}, \text{ and}$$

$$c = 4.$$

These default values for a, b, and c can be overridden by user input.

For the free troposphere ($z > h$), K_z is constant with height with a value of

$$K_z = K_z^{\mathrm{tropo}}. \tag{II.B.8}$$

In order to obtain a single K_z function for all z which is a smooth, differentiable function of z and which provides a quick transition from K_z^{bl} to K_z^{tropo} near $z=h$, a function $H(z)$ proposed by Ermak (1994, private communication) is used as follows:

$$K_z = H(z)K_z^{bl}(z) + [1 - H(z)]K_z^{tropo}, \tag{II.B.9}$$

where

$$H(z) = e^{-\left(z/c_2 h\right)^{c_3}}, \tag{II.B.10}$$

K_z^{tropo} may be larger or smaller than the value of K_z^{bl} at the mixed layer height, h. The current default values for the constants in Eqs. (II.B.9-10) are K_z^{tropo} = 0.01 m^2/s, $c_2 = 1.5$, and $c_3 = 8$. The user may specify values for all the constants in the K_z parameterization using the 'KZ_SIMTHRY_USER' option. Fig. II.B.1 shows an example K_z profile for a neutral stability case.

Since this turbulence parameterization uses fundamental boundary layer turbulence scaling parameters and accounts for vertical inhomogeneity of K_z, it is the preferred option for vertical turbulence parameterization.

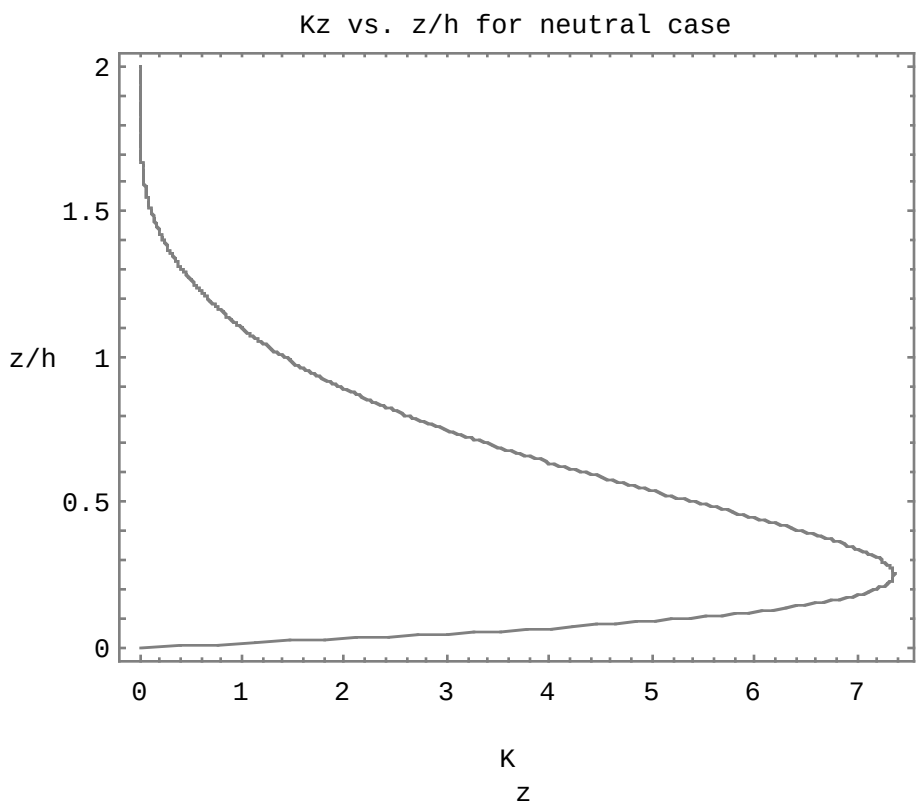

Fig. II.B.1 Example K_z profile for a neutral stability case (u_* = 0.4 m/s, h = 500 m, $1/L$ = 0, K_z^{tropo} = 0.01 m^2/s).

TURB_PARAM_VERT = 'SIGZ_PWRLAWX_PG'

In this option K_z is determined from Pasquill-Gifford $\sigma_z(x)$ using only stability class. K_z is calculated from $\sigma_z(x)$ in the following form:

$$\sigma_z = \gamma x^{\rho}. \tag{II.B.11}$$

There are different coefficients γ and ρ for each of six Pasquill stability classes, A, B, C, D, E, and F, corresponding in the ADPIC code to stab_class = 1, 2, 3, 4, 5 and 6, respectively. Values for these coefficients were determined by Lange (1993, private communication) by fitting sigma curves developed by Pasquill, adapted by Gifford, and published in Fig. 3.11 of *Meteorology and Atomic Energy* (Slade, 1968). These curves are based on data from experiments on surface releases with release durations and averaging times of 3-15 min. Therefore, it is recommended for calculations of near-surface sources with release durations, concentration averaging times and wind data temporal resolution close to this 3-15 min time period, and when only stability class is available.

Using the relationship between the variance of the concentration distribution and the eddy diffusivity*,

$$K = \frac{1}{2}\frac{d\sigma^2}{dt}, \tag{II.B.12}$$

and the relationship between mean wind speed (assumed to be constant) and downwind distance#,

$$x = \bar{u}\, t \tag{II.B.13}$$

a relationship for K_z can be obtained:

$$K_z = \gamma^2 \rho \bar{u} x^{(2\rho - 1)}. \tag{II.B.14}$$

Values of the γ and ρ coefficients were determined by Lange (1993, private communication) by fitting the close-in portions of the Pasquill-Gifford curves and are as follows:

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* This relationship assumes K is spatially homogeneous. However, this assumption is not generally valid in the vertical direction in the boundary layer, especially under unstable conditions. Correspondingly, vertical concentration distributions are not Gaussian in the vertical, as is assumed in this option.

\# In calculating K, the time t is the age of the particle since it was emitted from the source, and $\bar{u}$ is the mean wind at the particle location.

stab_class	γ	ρ
1	0.013	1.5
2	0.039	1.2
3	0.222	0.81
4	0.382	0.64
5	0.418	0.58
6	0.288	0.55

A new parameter, $x_{\max}$, specifies the downwind distance beyond which the value of K_z is held constant at its value at that maximum distance. The default values are as follows:

stab_class	$x_{\max}$ (m)
1	5.E+3
2-6	1.E+4

TURB_PARAM_VERT = 'KZ_LINEARZ'

This new option allows K_z to be calculated as a function of height from the linear equation:

$$K_z = K_{z_{\text{ref}}}\left(z/z_{\text{ref}}\right), \tag{II.B.15}$$

where $K_{z_{\text{ref}}}$ is the value of K_z at reference height z_{ref}. $K_{z_{\text{ref}}}$ and z_{ref} must be input by the user, and do *not* have any internal default values. When used with the wind speed power law option, this linear K_z option allows RDM calculations to be compared to analytical solutions to the advection-diffusion equation.

TURB_PARAM_VERT = 'KZ_CONSTANTZ'

This new option allows K_z to be fixed at a constant value, unchanging with height, time or downwind distance:

$$K_z = K_{z_{\text{constant}}}.$$

When used with the constant wind speed option, this constant K option allows RDM calculations to be compared to a Gaussian solution to the advection-diffusion equation.

II.B.3.b. Horizontal Turbulence Parameterizations

TURB_PARAM_HORZ='SIGH_SIGTHETA' AND 'SIGH_SIGTHETA_USER'

K_H for this option is based on Draxler's (1976) semi-empirical relationship for σ_y as a function of time and the standard deviation of cross-wind velocity component (σ_v). Draxler used an equation of the following form for σ_y:

$$\sigma_y = \sigma_v \, t \, f\left(t/\tau_H \right) \tag{II.B.16}$$

where

$$f\left(t/\tau_H \right) = \frac{1}{1 + d\left(t/\tau_H \right)^{1/2}}.$$

This formulation results in $\sigma_y \propto t$ for $t << \tau_H$ and $\sigma_y \propto t^{1/2}$ for $t >> \tau_H$. The constant d is a combination of constants used by Draxler. A value of d =0.36 resulted in Draxler's best fit to close-in diffusion data, and is similar to the value of 0.4 recommended by Hanna et al. (1982). Assuming d =0.36, Draxler recommended values of τ_H =50 sec for surface releases and 160 sec for elevated releases (note: Draxler's T_i is equal to 6.36τ_H). The default values in the RDM are

$$d = 0.36 \text{ and}$$

$$\tau_H = 50 \text{ sec.}$$

The value of τ_H can be overridden by user input. Using Eq. (II.B.12), assuming K_H=K_y, and using the approximation $\sigma_v \approx \sigma_\theta \bar{u}$, the following equation for K_H can be derived:

$$K_H = \frac{\bar{u}^2 \sigma_\theta^2 t \left[1 + \frac{d}{2} \left(\frac{t}{\tau_H} \right)^{1/2} \right]}{\left[1 + d \left(\frac{t}{\tau_H} \right)^{1/2} \right]^3}. \tag{II.B.17}$$

(Note: σ_θ is in radians).

Since this turbulence parameterization uses measured wind direction fluctuations, it is the preferred option for horizontal turbulence parameterization.

TURB_PARAM_HORZ = 'SIGH_PWRLAWX_PG', 'SIGH_PWRLAWX_MESO', 'SIGH_PWRLAWX_LONGRANGE', and 'SIGH_PWRLAWX_USER'

For these options, K_H is based only on stability class and is calculated using $\sigma_y(x)$ in the following form:

$$\sigma_y = \alpha x^{\beta}. \tag{II.B.18}$$

Using Eqs. (II.B.12) and (II.B.13), and assuming again that $K_H = K_y$, the following relationship for K_H can be obtained:

$$K_H = \alpha^2 \beta \bar{u} x^{(2\beta - 1)}. \tag{II.B.19}$$

For values of $x \geq x_{\max}$, the value of K_H is held constant at its value at that maximum distance.

The constants α and β depend on the turb_param_horz option used and are described below:

α and β for TURB_PARAM_HORZ = 'SIGH_PWRLAWX_PG':

The α and β coefficients for $\sigma_y(x)$ used in this option are based on a least-squares fit (Lange, 1993, private communication) to the sigma curves developed by Pasquill, adapted by Gifford, and published in Fig. 3.10 of *Meteorology and Atomic Energy* (Slade, 1968). These curves are based on data from experiments involving surface releases with release durations and averaging times of 3-15 min. Therefore, this turbulence parameterization option is recommended for calculations of near-surface releases with release durations, concentration averaging times and wind data temporal resolution close to this 3-15 min time period, and when only stability class is available.

There are separate curves for each of six Pasquill stability classes (A, B, C, D, E, and F, corresponding to stab_class = 1, 2, 3, 4, 5 and 6, respectively). The $\sigma_y(x)$ equation coefficients for this option are

$\beta = 0.92$ and

α, depending on stability class, as follows:

stab_class	α (Pasquill-Gifford)
1	0.42
2	0.30
3	0.22
4	0.15
5	0.09
6	0.06

Default value of x_{max} for this option is 2.E+4 m.

α and β for TURB_PARAM_HORZ = 'SIGH_PWRLAWX_MESO':

The equations for $\sigma_y(x)$ in this parameterization option are based on a fit to experimental data from near-surface releases from the Idaho National Reactor Testing Station (NRTS) (Yanskey et al., 1966) which were subsequently used in the MESODIF model (Start and Wendell, 1974) for the NRTS. These data show increased horizontal diffusion when compared to the Pasquill-Gifford values above, especially under stable conditions. This is due to both (a) the longer release durations (and, therefore, longer averaging times) used in the NRTS data (15-60 min) compared to the release durations in the Pasquill-Gifford data (3-15 min), and (b) the presence of meandering conditions during stable conditions. Therefore, this option is recommended for calculations of near-surface releases with release durations, concentration averaging times and wind data temporal resolution close to this 15-60 min time period, and when when only stability class is available. The $\sigma_y(x)$ equation coefficient values are

β = 0.85 and

α, depending on stability class, as follows:

stab_class	α (MESODIF)
1	0.72
2	0.42
3	0.35
4	0.27
5	0.30
6	0.40

Default value of x_{max} for this option is 2.E+4 m.

α and β for TURB_PARAM_HORZ = 'SIGH_PWRLAWX_LONGRANGE':

In this option, the equations for $\sigma_y(x)$ are based on a fit by Rodriguez *et al.* (1995) to long-range dispersion data. The $\sigma_y(x)$ equation coefficient values are

$$\beta = 1.0,$$

$$\alpha = 0.056, \text{ and}$$

$$x_{max} = 4.E+7 \text{ m}$$

The large default value of 40,000 km for x_{max} is used to assure that these α and β coefficients are, for practical purposes, always used, and, therefore, $\sigma_y \propto t$ essentially for all time. This parameterization reflects the effect of processes other than turbulent diffusion, i.e., spatial and temporal variation in the mean wind. Therefore, this parameterization is recommended for large-scale calculations using wind fields with low spatial resolution (in particular, low vertical resolution so that vertical wind shear in the lowest kilometer is unresolved) and/or low temporal resolution (e.g., 12 hour resolution).

II.B.4. Options in ADPIC

II.B.4.a. Source Parameters

Up to MAXSOURC separate pollutant source configurations (combinations of source type, rate, geometry, etc.) are allowed. The release rate and source center height of each pollutant source can vary with time. The effective times of the time-varying source parameters (SOURCE_RATE and CENTER_HGT) are controlled by the timing parameters SOURCE_START_DATE and SOURCE_START_TIME.

The default method used to create marker particles in a computational interval allocates marker particles proportional to the fraction of the total activity/mass of the total for this source to be released in the interval. An alternative method is also available which creates marker particles proportional to the fraction of the total time that the source is "on" (regardless of the source rate). The first method is especially useful for substantially varying source rates, such as an injection of a large mass of material within a short period of time followed by a relatively much smaller mass of material released over a relatively long period of time. Although the first method is generally recommended, the user should be aware that while the particle statistics will be improved during the peak release time, they will also be degraded during the non-peak release times. The input parameter PART_GEN_MODE is used to control which method is used.

The way in which ADPIC describes pollutants in terms of discrete mass (activity) particles makes the implementation of decay rate calculations straightforward. Such processes as radioactive decay of pollutants in conjunction with atmospheric dispersion under complex terrain conditions can be modeled.

II.B.4.b. Source Geometry

The initial position (x, y, and z coordinates) of each marker particle representing the pollutant material is computed by using a Gaussian or normal probability distribution function. The probability of the distance that each particle will be from each of the three orthogonal axes through the source center is determined by the shape of a Gaussian distribution. The number of particles to be generated for each source is specified by the user by the use of the TOTPART parameter. Several thousand particles per ADPIC source provide a fairly good representation of a sample population.

In all, ten parameters are used to control the representation of the initial stabilized source geometry. The first three are standard deviations of the Gaussian distribution, SIGX, SIGY and SIGZ, in the x, y, and z directions, respectively. These control how peaked or flat the source distribution will be along each axis, as shown in Fig. II.B.2. The Gaussian distributions are then truncated as shown in Fig. II.B.3 using six source cutoff parameters, XPOS_CUTOFF, XNEG_CUTOFF, YPOS_CUTOFF, YNEG_CUTOFF, ZPOS_CUTOFF, and ZNEG_CUTOFF, where POS is for right or top, NEG for left or bottom. The last source geometry parameter is the height above ground of the source center, CENTER_HGT.

If very little truncation of the Gaussian curves is desired, the radius of the entire source is typically used for the cutoff values and the radius divided by 2.5 to compute the standard deviations. This is based on the fact that about 99% of the area in the Gaussian distribution lies within 2.5 standard deviations of its center.

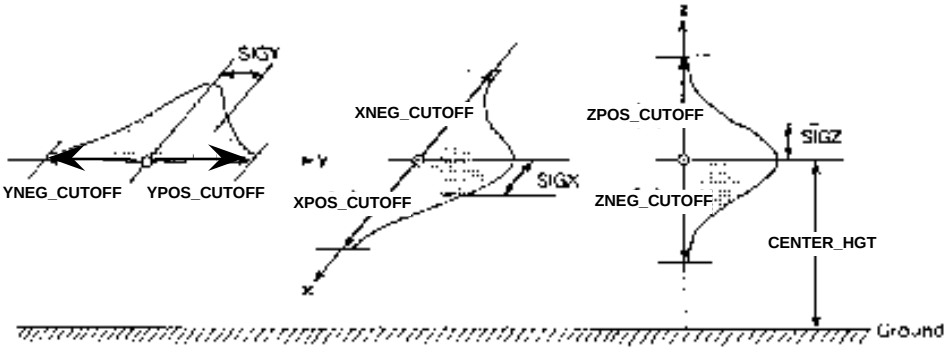


Fig. II.B.2. Gaussian source geometry parameters

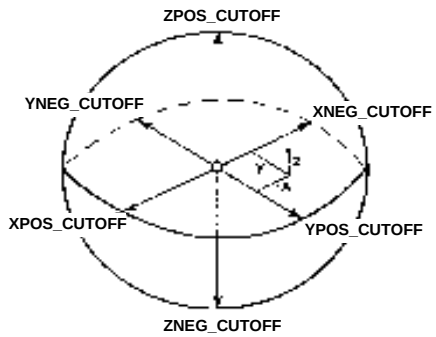


Fig. II.B.3. Cutoff parameters for a spherical-shaped source

The ten source parameters may be used to describe a wide variety of sources, with the three most common shown in Fig. II.B.4. Releases from stacks are usually assumed to be spherical (equal sigma and cutoff values in each direction). Puffs or clouds from fires or explosions are usually elongated in the vertical. If necessary an explosion may be described by two source terms, one for the lower stem and one for the upper cloud.

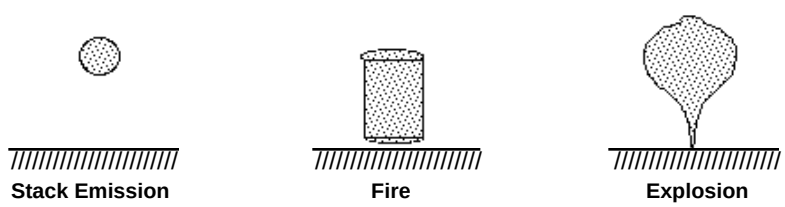
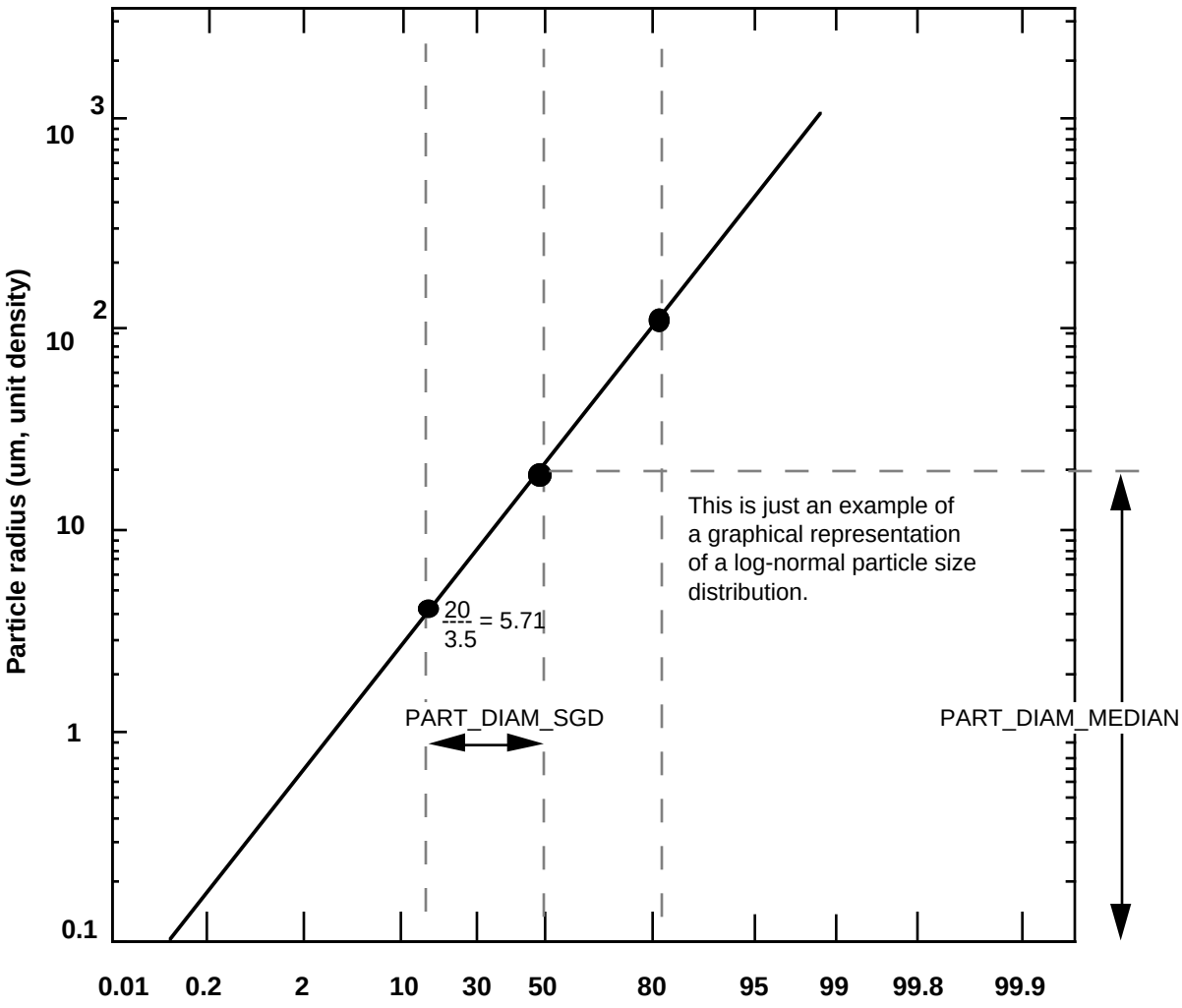


Fig. II.B.4. Example source geometries

II.B.4.c. Particle Size Distribution

The distribution of the particle size range as a log-normal distribution can be specified in ADPIC by using the parameters PART_DIAM_MIN, PART_DIAM_MAX, PART_DIAM_SGD, and PART_DIAM_MEDIAN. An example showing the graphical derivation of these values is shown in Fig. II.B.5. Usually particle sizes are normalized to a particle density of 1 g/cm3 (1000 kg/m3). If actual particle sizes are used, then the actual particle density (PART_DENSITY) must be specified.



Log-normal particle size parameters for ADPIC_SOURCE namelist

Percent less than stated size

Input parameters	Description
PART_DIAM_SGD	Standard geometric deviation: the ratio of $\frac{\text{radius } 50\%}{\text{radius } 16\%}$ or $\frac{\text{radius } 84\%}{\text{radius } 50\%}$
PART_DIAM_MEDIAN (μm)	Median diameter: diameter of 50% point
PART_DIAM_MAX (μm)	Maximum diameter of particles
PART_DIAM_MIN (μm)	Minimum diameter of particles

Fig. II.B.5. Log normal particle size distribution

II.B.4.d. Dry Deposition

The removal of material from the atmosphere through dry deposition is modeled separately by ADPIC via two processes: gravitational settling of material based on particle size, and flux of material from the surface layer to the ground surface based on a specified deposition velocity.

The settling velocity is modeled by ADPIC with either the Stokes law or the McDonald method (McDonald, 1960) based on particle size (PART_DIAM_MEDIAN), particle density (PART_DENSITY), and altitude. The McDonald method is used for cases when the Reynold's number is greater than 1 and the Stokes Law is invalid (e.g. particle diameters greater than approximately 3.5 um at standard ground-level conditions). The parameters PART_DIAM_MEDIAN and PART_DENSITY are used not only to specify the median particle size diameter and the particle density, respectively, but are also used as flags: if either PART_DIAM_MEDIAN or PART_DENSITY is zero, the ADPIC particles are treated as passive material with no gravitational settling velocity.

The surface deposition flux is modeled separately from gravitational settling. The deposition velocity is typically a function of effluent chemistry, particle size, atmospheric stability, and surface type (e.g. soil, vegetation, etc.). Fig. II.B.6 shows how deposition velocity varies with particle diameter in laboratory and field measurements made by McMahon and Dennison (1979).

The deposition velocity used by ADPIC is linearly weighted according to the distance from ground level, from zero at the height above ground level specified by SFC_DEP_HGT to the full value of SFC_DEP_VEL at ground level. A non-zero deposition velocity will cause an ADPIC particle to be deposited if it is at a height which is less than or equal to the weighted SFC_DEP_VEL (in m/sec) times the time step (in sec). A SFC_DEP_VEL value of zero will result in no removal of ADPIC particles via the deposition velocity mechanism.

If either PART_DIAM_MEDIAN or PART_DENSITY is zero, and if SFC_DEP_VEL are zero, the ADPIC particles are treated as passive material and no dry deposition will result. Although material can be moved into the surface layer from above via advection by the mean wind and by turbulent diffusion, material cannot be moved from the surface layer to the ground through either of these two methods as modeled by ADPIC. Any material that impacts the ground through advection will be reflected.

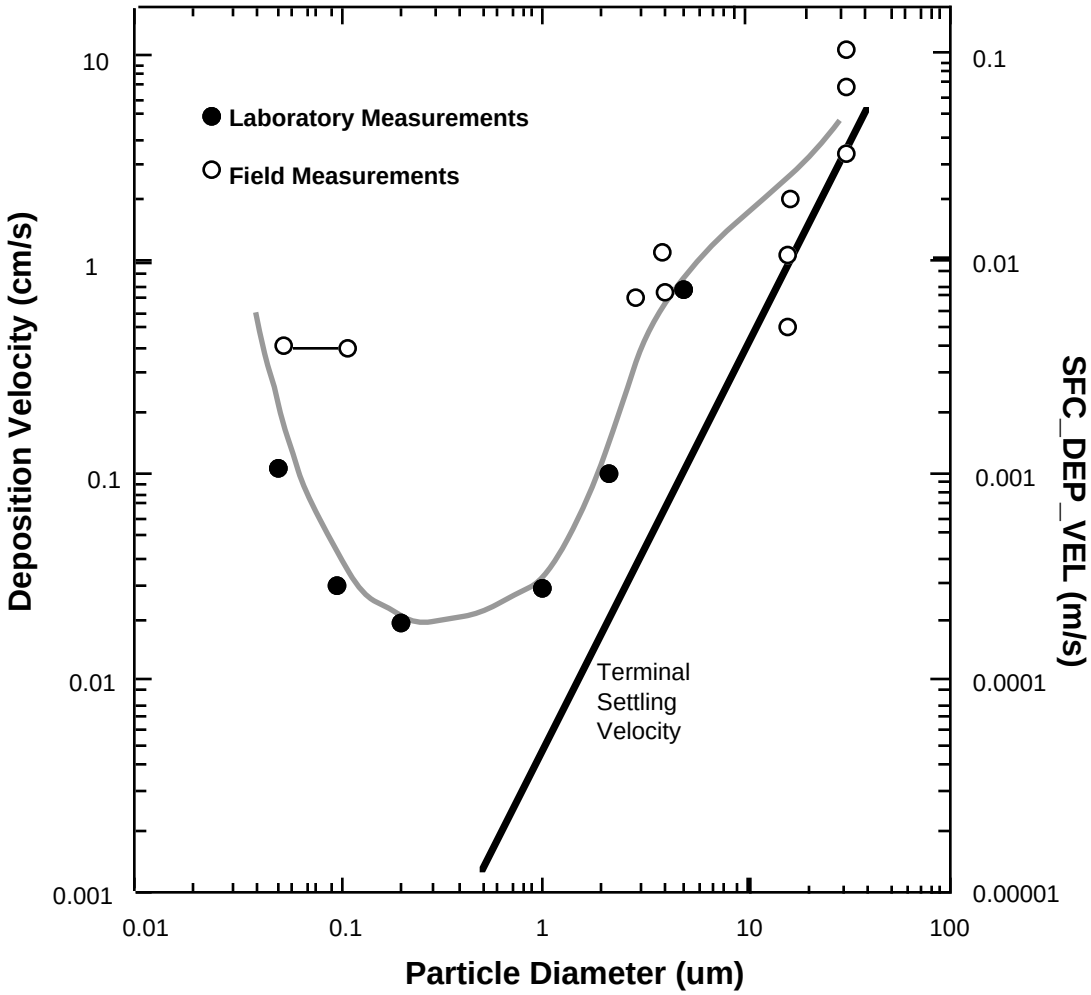


Fig. II.B.6. Laboratory and Field Measurements of Deposition Velocity to Grass vs. Particle Size (McMahon and Dennison, 1979)

II.B.4.e. Washout

At present, the basic assumption for model removal of debris particles in ADPIC is that the base of the rain cloud is above the debris cloud. For surface or near-surface pollutant releases, this seems to be a reasonable assumption to about 100 km downwind. Thus, ADPIC in its present form does not treat in-cloud rainout, but has provisions for below-cloud washout (Crandall et al, 1973).

Washout is treated in the following way in ADPIC. For a specified rain rate over a given surface area, a washout coefficient A (r) is assumed as a function of particles of radius r (see Figs. II.B.7 and II.B.8).

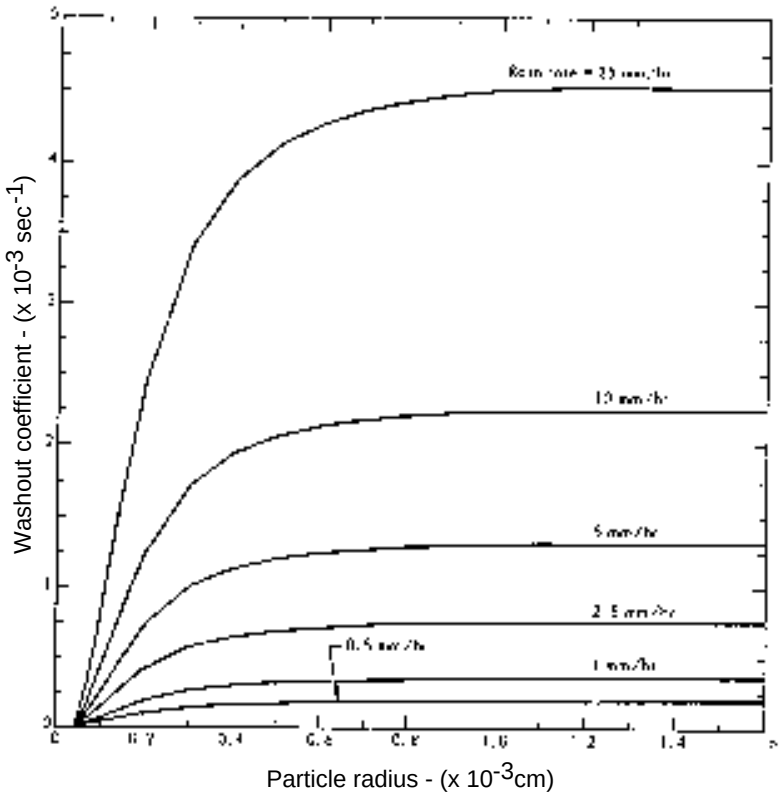


Fig. II.B.7. Washout coefficient versus particle radius for various rain rates. (Crandall *et al.*, 1973)

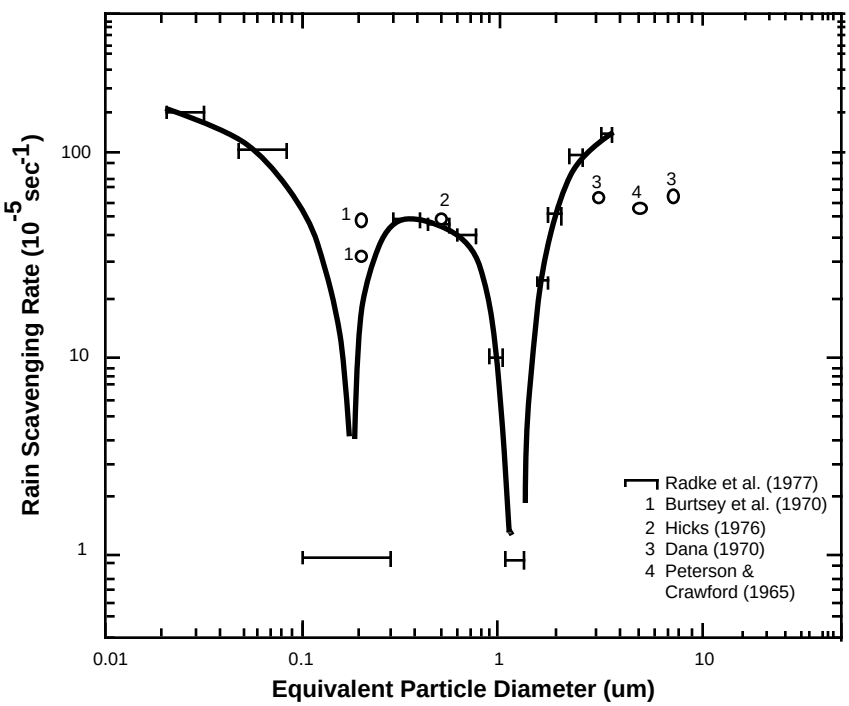


Fig. II.B.8. Measured Values of Scavenging Coefficient vs. Particle Size (McMahon and Dennison, 1979)}

Because of their limited number, each ADPIC particle is only a representation of a certain amount of an actual pollutant. Therefore, an ADPIC mass particle is initially considered to represent an integrated pollutant particle size distribution over sizes such that

$$M(0) = \int_{r=0}^{\infty} m(r,0)\,dr \quad , \tag{II.B.20}$$

where $M(0)$ is the initial mass of an ADPIC particle and $m(r,0)$ is the mass per unit radius of a pollutant particle of radius r at time 0. Constant density is assumed for the pollutant particles. $M(t)$, the mass of an ADPIC particle remaining after a time t in the rain for a given constant rain rate and raindrop size distribution, can be written as

$$\begin{aligned} M(t) &= \int_{r=0}^{\infty} m(r,t)\,dr \\ &= \int_{r=0}^{\infty} m(r,0)e^{-\Lambda(r)t}\,dr \quad . \end{aligned} \tag{II.B.21}$$

To account for the diffusion and transport of pollutants as calculated by ADPIC, this function $M(t)$ is obtained from a table at each ADPIC time step Δt. The fraction of mass $F(\Delta t)$ of an ADPIC particle washed out and deposited on the surface during one ADPIC time cycle then becomes

$$F(\Delta t) = \frac{M(t) - M(t+\Delta t)}{M(t)} = 1 - \frac{\int_{r=0}^{\infty} m(r,0)\varepsilon^{-\Lambda(r)(t-\Delta t)}\,dr}{\int_{r=0}^{\infty} m(r,0)e^{-\Lambda(r)t}\,dr} \quad . \tag{II.B.22}$$

This fraction of mass loss per cycle for each ADPIC particle is stored cumulatively each cycle in a two-dimensional, surface deposition array.

II.B.4.f. Plume Rise

Plume rise can significantly affect ground level concentrations from stack releases into the atmosphere. It becomes important and needs to be evaluated when the exit velocity and/or temperature are sufficiently higher than ambient. Generally, this problem is solved by calculating an effective stack height (physical stack height plus a final plume rise height increment). ADPIC, however, can calculate the time- dependent plume rise of a stack release given the stack emission and meteorological parameters. The parameterizations developed for ADPIC by Desiato and Lange (1986) are used. These parameterizations rely primarily on the work of Briggs (1975) except for the unstable cases where the work of Weil and Hoult (1973) is used. Separate plume rise equations are used for the various combinations of momentum and buoyancy plume rise, vertical and bent-over plumes, and stability class.

The plume rise calculations are controlled with two groups of parameters input via the ADPIC.NML file. The first group are stack parameters for each source: plume rise flag for each source (USE_PLUME_RISE), internal radius of stack (STACK_RADIUS), vertical exit velocity of gas (EXIT_VEL), temperature of gas emitted from stack (STACK_TEMP), and optional sensible heat emission rate (HEAT_EMISSION_RATE). The second group are time-varying meteorological parameters for each source: ambient air temperature (AMBIENT_TEMP), height of strong inversion

affecting plume rise (INV_HGT_AT_STACK) and vertical temperature gradient (VERT_TEMP_GRAD). If STACK_TEMP and AMBIENT_TEMP are specified, then HEAT_EMISSION_RATE should not be specified, and vice versa.

II.B.4.g. Explosive Cloud Rise

An explosive cloud rise module has been incorporated into ADPIC which simulates additional forces acting upon the ADPIC particles due to their proximity to the thermal environment resulting from the detonation of a chemical explosive. When employed, this module generates additional vertical and horizontal components of motion applied to each particle remaining within the calculated effects of the rising thermal cloud.

A full description of the explosive cloud rise integral model code is found in Boughton and Delaurentis (1987), with further discussion of its use in ADPIC discussed in Foster, *et. al.* (1990). Briefly, the code provides a time evolution of the physical and thermodynamic properties of a buoyant cloud formed when a chemical explosive is detonated. The model is based on integrating the three dimensional conservation equations of mass, momentum, and energy over the cloud's cross section. With some simplifying assumptions the integral equations reduce to a set of ordinary differential equations which can be solved for the cloud radius, centerline height, temperature, and velocity as a function of time. These solutions are sensitive to the input parameters describing the ambient atmospheric conditions, especially the atmospheric temperature profile. The initial size and conditions of the cloud are determined using these atmospheric conditions and amount of explosive mass.

Once the cloud's characteristics are determined at each cloud rise model time step (which may be shorter than ADPIC's advection time step), the influence of this buoyant volume must be coupled to the ADPIC particles. There are two considerations in coupling the marker particles to the cloud, the initial loading of the particles into the calculational grid and their subsequent motion while they remain within the buoyant environment. All of the marker particles are initially loaded into the spherical cloud volume at the specified source release time. They have a Gaussian distribution within this volume with radial cutoff values equal to the initial cloud radius as determined by the cloud model. The standard deviations of this distribution are scaled to the cloud radius and are controlled through a scaling factor (SIG_OVER_R used to adjust the “flatness” of the initial distribution. For surface explosions, this initial sphere is tangent to the surface (e.g. it is centered at a height equal to the cloud radius).

As the cloud rises with time it is assumed to contain an environment of enhanced turbulence with entrainment occurring along its surface. Particles remaining inside the sperical cloud volume are treated differently than those moving beyond the cloud radius. Specifically, diffusion is neglected while particles remain within the buoyant cloud. In addition, a fraction of the cloud's vertical motion is applied to each particle within radius, R, of the cloud center. The vertical motion imparted to each

particle due to its proximity to the rising cloud is a function of its distance, r, from the cloud center, and is given by:

$$w = W \exp\left(-c\left(r/R\right)^2\right)$$

where

w = the particle's vertical lift due to the rising cloud (in addition to the vertical advection velocity),
W = the cloud's vertical lift motion,
c = a velocity coupling coefficient (= 0.35),
r = the particle's distance from cloud center, and
R = the cloud's radius.

Another difference in the treatment of particles within the cloud is a radially outward adjustment to maintain the particle's relative position between the cloud center and cloud edge as the cloud increases in size. This adjustment “velocity” simulates the effects of a well-mixed cloud, as it grows through entrainment, by redistributing the particles throughout the entire cloud volume. This velocity due to the cloud's expansion is independent from the particle's movement relative to the cloud center due to gravitational fall, the particle's vertical motion w, and potential differences in advection of the cloud and particles due to the spatial variation in the winds.

Therefore, particles remaining within the extent of the cloud are moved by applying the appropriate advection, expansion, fall, and vertical lift velocities. Once a particle leaves the influence of the rising thermal (usually due to the particle's gravitational fall velocity moving the particle beyond the cloud radius), only advection, diffusion, and gravitational settling processes act on the particles.

The dynamics of the cloud are followed until its vertical velocity decreases below a predetermined limit. At this point all particles are treated as though the cloud no longer exists and the cloud calculation is bypassed for the remainder of the problem. A similar effect occurs if the cloud center rises above the top of the computational grid.

The use of the explosive cloud rise module is controlled by the ADPIC.NML parameter USE_EXPL_CLD_RISE; the remaining explosive cloud rise parameters are contained in the ADPIC_EXPL_CLD namelist in the ADPIC.NML file. Although multiple ADPIC sources may be put into a single explosive cloud (controlled by parameter SRC_EXPL_CLD), the capability for multiple explosive clouds does not yet exist. The model used in ADPIC assumes a high explosive device (HE). Other explosive cloud source parameters include heat of detonation (HEATDET), high explosive amount (HEAMT), velocity coupling coefficient (VEL_COUPL), and height of the center of the explosive cloud (ZINIT). Meteorological parameters required for the explosive cloud rise module include relative humidity at the surface (REL_HUM), atmospheric pressure at the source center height (SRC_PRESS), and the upper air temperature profile (TEMP_PROFILE). The content of the output text file is controlled by the parameters PRINT_EXPL_CLD and PRINT_TYPE_EXPL_CLD.

II.B.4.h. Hybrid Particles *

In the hybrid-particle model all the constituents of a pollutant that have similar transport properties can be treated as a single source. The number of sources typically carried can still be up to nine; however the number of parent nuclides followed can be up to 100. In many problems, one source will be sufficient. Although designed for radioactive sources, the hybrid model will properly handle non-radioactive sources, in which case release rates would be specified in units of mass. As in the simple-particle model, each source is represented by a collection of marker particles, typically a few thousand. Each marker particle represents the set of nuclides in the source, hence the name hybrid particle. As already stated, all the nuclides of the set must have similar transport and diffusion properties. Some examples of such sets are noble gasses, elemental halogens, refractory oxides, alkali metals, and noble metals.

The time dependence of the activity and toxicity for each source of hybrid particles is calculated in tables at the beginning of the problem and applied at times of interest during the calculation. The presence of radioactive decay products are included in the calculations. This requires the solution of a system of coupled ordinary differential rate equations, whose details are described below. Figure II.B.9 illustrates a schematic representation of the structure described above.

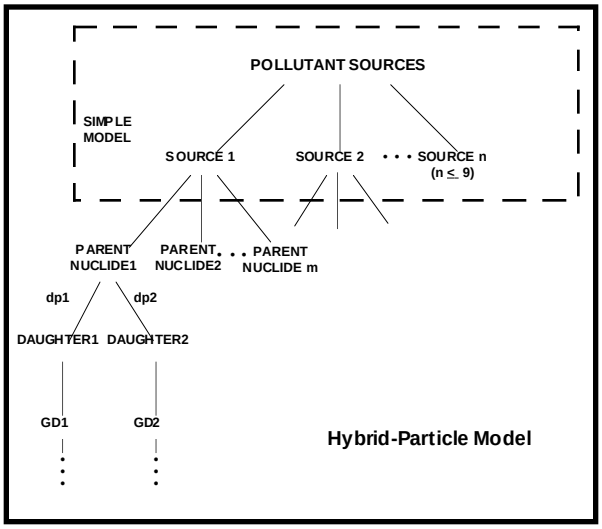


Fig. II.B.9. A schematic representation of the source structure. The dashed box defines the limits of the simple model. The complete box defines the hybrid-particle model. Only the first branch of the hybrid is depicted here. Parent nuclide 1 decays by decay path 1 to daughter 1 and by decay path 2 to daughter 2. Daughter 1 decays to granddaughter 1 and so on. More discussion on the chain decay process is given below.

---

* This section was taken from "A Description of the ADPIC Hybrid-Particle Model", Freis and Harvey, UASG95-4

HP Activity and Toxicity

Since each marker particle in a hybrid source can represent several nuclides, the set of initial nuclides in a source and their amounts must be determined at $t = 0$ from problem input. Changing this set of initial nuclides requires a new source. For a given marker particle the ratio of nuclides changes with time, depending on the nuclide half-lives and branching ratios. Chain-decay products add additional nuclides into the hybrid particle with time. The total hybrid-particle activity is the sum of the activity carried by each of the nuclides. We discuss this in detail here.

The activity for a single radionuclide is given by the expression

$$\dot{N}(t) = \lambda \; N(t) \qquad \text{(II.B.23)}$$

where N(t) is the number of atoms at time t and λ is $ln\ 2$ divided by the radionuclide half life. The next section discusses how N(t) is determined for all the nuclides in a decay chain starting with a single parent. In this section we assume this is known and use that information to determine the activity and toxicity.

The total activity at time t from one source released at time t_R is

$$C(t,t_R) = \sum_{j=1}^{jmax} \sum_{i=1}^{imax(j)} \lambda_{ij} N_{ij}(t - t_R) \qquad \text{(II.B.24)}$$

where we have summed over *jmax* parents and *imax(j)* daughters (note: each *imax* depends on *j*.)

We introduce the time dependent release rate; $\dot{R}(t) \; A_0$ where $\dot{R}(t)$ is normalized such that $\int_0^\infty \dot{R}(t) \; dt = 1$ and A_0 is the total activity released over all time by this source. Then the activity released in dt at $t = t_R$ is

$$C(t_R,t_R) = \dot{R}(t_R) \; A_0 \; dt \qquad \text{(II.B.25)}$$

In the Hybrid-Particle Model we normalize each parent nuclide so that its initial decay rate is one curie. Thus, suppressing subscripts, the normalized activity in curies of the parent nuclide is defined by

$$\widetilde{N}(0)\, \lambda = 1$$

and

$$N(t) = \kappa\, \widetilde{N}(t) \qquad \text{(II.B.26)}$$

where κ is a proportionality constant to be determined .

The relative amount of each parent nuclide present at $t = t_R$ is specified as F_j where

$$\sum_{j=1}^{jmax} F_j = 1$$

Then, in terrms of the normalized variables, the total activity at time *t* from one source realeased at time t_R is

$$C(t,t_R) = \sum_{j=1}^{jmax} F_j \sum_{i=1}^{imax(j)} \lambda_{i,j}\, \kappa\, \widetilde{N}_{i,j}(t - t_R) \qquad \text{(II.B.27)}$$

To determine κ, evaluate $C(t,t_R)$ at $t = t_R$, when no daughters have yet been produced. Then,

$$C(t_R,t_R) = \sum_{j=1}^{jmax} F_j\, \lambda_{1j}\, \kappa \widetilde{N}_{1j}(0)$$

and since

$$\sum_{j=1}^{jmax} F_j\, \lambda_{1j}\, \widetilde{N}_{1j}(0) = 1$$

then

$$C(t_R,t_R) = \kappa \quad .$$

From Eq. 25

$$\kappa = \dot{R}(t_R)\ A_0\ dt$$

The total activity at time *t* from one source realeased at time t_R (Eq. 27) becomes

$$C(t,t_R) = \dot{R}(t_R)\, A_0\, dt \sum_{j=1}^{jmax} F_j \sum_{i=1}^{imax(j)} \lambda_{ij}\ \widetilde{N}_{i,j}(t - t_R) \qquad \text{(II.B.28)}$$

The activity per marker particle is calculated by dividing Eq. 28 by the number of marker particles released during dt at $t = t_R$,

$N_p(t_R) = \dot{N}_p(t_R)\ dt$ where $\dot{N}_p(t_R)$ is the release rate of marker particles.

Then $C_p(t,t_R)$, the activity per marker particle is

$$C_p(t,t_R) = \frac{\dot{R}(t_R)\, A_0}{\dot{N}_p(t_R)} \sum_{j=1}^{jmax} F_j \sum_{i=1}^{imax(j)} \lambda_{ij}\ \widetilde{N}_{ij}(t - t_R) \qquad \text{(II.B.29)}$$

The toxicity (dose rate) for each nuclide is calculated by multiplying it's activity by an appropriate dose conversion factor which takes into account biological factors such as the organ exposed, the exposure pathway (e.g. inhalation, cloudshine) and exposure time. For a single radionuclide the dose rate is given by;

$$\dot{D}(t) = DCF_k \ \lambda \ N(t) \qquad \text{(II.B.30)}$$

where DCF_k is the appropriate dose conversion factor for the toxic effect *k*, for a particular pathway. Using the same steps as was done above for the activity, and replacing Eq. 23 with Eq. 30, the toxicity per marker particle, $T_{p,k}(t,t_R)$, at time t from particles released at t = tR is

$$T_{p,k}(t,t_R) = \frac{\dot{R}(t_R)\, A_0}{\dot{N}_p(t_R)} \sum_{j=1}^{jmax} F_j \sum_{i=1}^{imax(j)} DCF_k \ \lambda_{ij} \ \widetilde{N}_{ij}(t - t_R) \qquad \text{(II.B.31)}$$

Having determined the activity/toxicity per marker particle the calculation of distributing it over the Eulerian sampling grid is the same as in the simple model (i.e., bilinear interpolation to the neighboring grid points for surface deposition and trilinear interpolation to the nodes of the surrounding volume element for airborne samples)..The units of the DCF are $\left[\frac{rem\ m^3}{s\ \ Ci}\right]$ for airborne samples and $\left[\frac{rem\ m^2}{s\ \ Ci}\right]$ for deposited surface samples. The total dose rate from a fixed postiion on the Eulerian grid is the sum of the contributions from the marker particles. The total dose from a fixed position is the time integral of the dose rate over the time interval of exposure.

Nuclide Time Dependence Equations

Both the activity from Eq. 29 and the toxicity from Eq. 31 depend upon $N_{i,j}(t)$, the amount of each nuclide present at time t.* $N_{i,j}(t)$, is determined by solving a separate set of coupled ordinary differential rate equations for each nuclide initially present. These equations describe the parent-daughter chain decay process and require the branching ratio and half life for each nuclide in the chain. For all nuclides of practical interest this process has several special features :

At t = 0, only the parents are non-zero (i.e., $N_{ij}(0) = 0$ for all $i > 1$)

Each generation has at most two members. In many cases (but not all) the two members are the ground state and meta-stable state of the same element. In such cases there is a one to one correspondence between elements and generations.

The parent for any nuclide is in the immediately preceding generation or, in the case of meta-stable to ground transitions, is in the same generation.

---

* (In this section we supress the ~ but we are working with the normalized quantities. Also the release time, t_R, is in this section the initial time t = 0.)

The half life for each member is unique (i.e., no two memebers of the family have the identical half life to all significant figures. This feature is important for the solution method employed) .

The maximum number of generations is small (i.e., less than 20).

Utilizing these features, the set of equations has the following form in which each nuclide is uniquely identified by two indices, the first being its position within the generation (1 or 2), and the second being its generation number.

$$\dot{N}_{1,1} = -\lambda_{1,1} N_{1,1}$$
$$\dot{N}_{1,2} = a_{1,1,2}\lambda_{1,1} N_{1,1} - \lambda_{1,2} N_{1,2}$$
$$\dot{N}_{2,2} = a_{2,1,2}\lambda_{1,1} N_{1,1} + b_{2}\lambda_{1,2} N_{1,2} - \lambda_{2,2} N_{2,2} \qquad \text{(II.B.32)}$$
$$\dot{N}_{1,3} = a_{1,1,3}\lambda_{1,2} N_{1,2} + a_{1,2,3}\lambda_{2,2} N_{2,2} - \lambda_{1,3} N_{1,3}$$
$$\dot{N}_{2,3} = a_{2,1,3}\lambda_{1,2} N_{1,2} + a_{2,2,3}\lambda_{2,2} N_{2,2} + b_{3}\lambda_{1,3} N_{1,3} - \lambda_{2,3} N_{2,3}$$

$$\dot{N}_{i,g} = \sum_{j=1}^{2} a_{i,j,g}\lambda_{j,g-1} N_{j,g-1} + (i-1)\, b_{g}\lambda_{1,g} N_{1,g} - \lambda_{i,g} N_{i,g} \qquad \text{(II.B.33)}$$

where

i = nuclide position

g= nuclide generation

a, b = decay branching ratios. b is for gama decays to ground state (intragenerational), and a is for β decays to another element (intergenerational).

For convenience all meta-stable nuclides have position 1, hence nuclide $N_{1,g}$ can be a parent to nuclide $N_{2,g}$ in a given generation but the reverse is not allowed.

The Equation Solution

The analytic solution of the set of equations represented by Eq. II.B.33 is (See Appendix E for derivation)

For the first generation (g = 1)

$$N_{1,1}(t) = (1/\lambda_{1,1})\, e^{-\lambda_{1,1} t}, \qquad A(1,1,1) = 1/\lambda_{1,1}$$

and for subsequent generations (g > 1)

$$N_{i,g}(t) = \sum_{l=1}^{L_{max}-1} A(l,i,g) e^{-\lambda_{1,1} t}, \; g > 1$$

(note: $A(l,i,g)$ is defined below)

where

$$L_{max} = 2(g-1) + i - 1$$

$$\bar{\lambda}_1 = \lambda_{1,1}$$

$$\bar{\lambda}_l = \lambda_{\hat{i},\hat{g}}, \qquad l = 2(\hat{g}-1) + \hat{i} - 1, \quad \text{for } g \geq \hat{g} > 1 \qquad \text{(II.B.34)}$$

The $(\hat{i}, \hat{g})$ pair related to *l* is determined from Eq. II.B.34. Note $\hat{i}$ = 1 or 2 .

The coefficients $A(l,i,g)$ are solved for recursively as follows:

for $l = 1 \ldots L_{max} - 1$

$$A(l,i,g) = \sum_{j=1}^{2} \left[a_{i,j,g}\, \lambda_{j,g-1} A(l,j,g-1) + (i-1)\, b_g\, \lambda_{1,g} A(l,1,g) \right] \left(\bar{\lambda}_{L\,max} - \bar{\lambda}_l \right)^{-1},$$

and

$$A(L_{max}, i, g) = -\sum_{l=1}^{L_{max}-1} A(l,i,g)$$

Ground Deposition Accumulation

Particles reaching the ground are saved in a list that includes their age, deposition time, and deposition position for processing as needed. At sampling times they are assigned their appropriate activity and toxicity and distributed in sampling bins defined on an Eulerian grid. This permits

accurate decay in sampling bins that may contain multiple sources. This also enables total time integrated deposition dose to be calculated.

Rainout deposition, which removes a fraction of each active particle each time step, is treated differently since a deposited particle list would quickly grow to an unmanageable length. To avoid this the rainout particles are saved in Eulerian sampling bins with an additional index for particle age (or born time). This permits the sampling bins to be accurately decayed, but limits the bin to a single source. At deposition sampling times the rainout bins are added to the regular deposition bins, however they cannot be included in the total time integrated deposition calculation.

Implementation Comments

The use of the ADPIC_RADPARAMS module is controlled by the ADPIC.NML parameter DECAY_MODE being set to 'rad_decay'. The Hybrid source is created using NUCLIDE_NAME to specify the nuclides in a single source and NUCLIDE_MIX to specify the percentage that nuclide contributes to the total. The pathway a source uses is set using DOSE_PATH_DESCRIPTOR. From the NUCLIDE_NAME and DOSE_PATH_DESCRIPTOR, comes the DCF_NUCLIDE_NAME (the name of the parent or daughter nuclide), DCF_PATH_DESCRIPTOR (same as the DOSE_PATH_DESCRIPTOR but for each DCF_NUCLIDE_NAME), and the DCF (the dose conversion factor for each nuclide and it's specified pathway). Hybrid ADPIC applies the proper dose conversion factors to the parent nuclide and its daughters for the pathways specified for each source. Other required parameters are: NUMBER_OF_TOXIC_TIMES (the number of entries in the hybrid_toxicity_array), and DECAY_START_INTERVAL (which allows you to set when you wish the decay process to begin).

II.B.4.i. Moving Sources

ADPIC source locations may be specified as functions of x, y, z, and time. Whether a source is intended to change its location during the ADPIC run will be specified by the ADPIC_CONTROL variable USE_MOVING_SOURCE, which is singly dimensioned by MAXSOURC. The ADPIC_SOURCE variables XLOC and YLOC are doubly dimensioned by MAXTIM and MAXSOURC and can hold the x and y locations of moving sources as a function of times specified by SOURCE_START_TIME. CENTER_HGT remains doubly dimensioned and specifies the change in z as a function of time.

The source's location will change as a linear function between the endpoints specified by SOURCE_START_TIME, XLOC, YLOC, and CENTER_HGT quadruplets. (Note that this implies a slightly different placement in z, as specified by CENTER_HGT, for moving vs. non-moving sources. For non-moving sources the changes in z are stepwise functions as they have always been. Moving sources however will have smooth changes in z as linear interpolations between endpoints.)

CENTER_HGT values may be specified relative to sea level, grid bottom, or terrain with the new parameter CENTER_HEIGHT_REF. For example:

```
USE_MOVING_SOURCE = 'N'  'Y'  'Y'  'Y'

SOURCE_START_TIME = '15:00'  '15:10'  '15:20'  '16:00' '16:10'  '16:20'  '16:35'
SOURCE_RATE(1,1) =      0.0      1.0      0.0
SOURCE_RATE(1,2) =      1.0      1.0      0.0
SOURCE_RATE(1,3) =      0.0      0.0      0.0      1.0      0.0
SOURCE_RATE(1,4) =      0.0      0.0      0.0      0.0      0.0      1.0      0. 0
XLOC(1,1) =            280.0
YLOC(1,1) =           4130.0
XLOC(1,2) =            360.0   350.0   350.0
YLOC(1,2) =           4160.0  4150.0  4140.0
XLOC(1,3) =                 3*-99999.          310.0   340.0
YLOC(1,3) =                 3*-99999.         4201.0  4201.0
XLOC(1,4) =                 5*-99999.                          280.0    305.0
YLOC(1,4) =                 5*-99999.                         4211.0   4211.0
CENTER_HEIGHT(1,1) =  100.0
CENTER_HEIGHT(1,2) =  100.0   300.0   200.0
CENTER_HEIGHT(1,3) =        3*-99999.              1.0      1.0
CENTER_HEIGHT(1,4) =        5*-99999.                          300.0    300.0
CENTER_HEIGHT_REF = 'TERRAIN'  'GRID_BOTTOM'  'TERRAIN'  'GRID_BOTTOM'
```

In this example source 1 is non-moving and sources 2-4 are moving, and the interpretation of the above example is as follows:

<u>Source 1</u>: is on between 15:10 and 15:20 during which time it remains at location 280 and 4130, and is 100 meters above the terrain. If more than one xloc-yloc-center_height triplet is input for a non-moving source, only the first valid triplet will be used.

<u>Source 2</u>: is on between 15:00 and 15:20. From 15:00 to 15:10 the source moves from 360, 4160 to 350, 4150 and increases in height from 100 to 300 meters above the grid bottom. From 15:10 to 15:20 the source moves from 350, 4150 to 350, 4140 and decreases its height from 300 to 200 meters above the grid bottom.

<u>Source 3</u>: is on from 16:00 to 16:10 and moves from 310, 4201 to 340, 4201 while remaining at a constant height of 1 meter above terrain.

<u>Source 4:</u> is on from 16:20 to 16:35 during which time it moves from 280, 4211 to 305, 4211 while remaining at a constant height of 300 meters above grid bottom.

A pre-run test is done on all input quadruplets. If the user specifies an x, y, z combination for a particular SOURCE_START_TIME which would place any part of the source below ground *at that single instant in time*, he will be notified by a message to the screen and to the ADPIC log file. He will also be notified in a similar manner if at any time during the run particles are being generated under the terrain surface. Such particles will be regenerated until they are created above the

surface. If the number of attempts to generate particles above ground exceeds some maximum (e.g. the entire source is underground at all times) the user is also notified. If this maximum is exceeded, the code stops. The rest of the conditions however are non-fatal (i.e. the run will attempt to continue). CAUTION: This means that a user can define a source which moves entirely underground at some point during the run. As long as some part of the source extends above the surface at some time along its path the run will continue. The user will be notified however with messages to the screen and log file that a certain number of particles for the source have been "discarded".

The user must note that the orientation of the x and y axes have been modified for the purposes of specifying the parameters SIGX, SIGY, XPOS_CUTOFF, XNEG_CUTOFF, YPOS_CUTOFF, and YNEG_CUTOFF for a moving source. The positive x axis is always aligned with the current horizontal direction of source movement, with the positive y axis pointed perpendicularly to the left. For example, a source moving to the northeast will have its XPOS_CUTOFF measured from its current location to a point northeast of its location, its XNEG_CUTOFF to a point southwest of its location, its YPOS_CUTOFF to a point northwest of its location, and its YNEG_CUTOFF to a point southeast of its location. This orientation will change as the direction of horizontal source movement changes. The SIGX and SIGY parameters are then defined as to be consistent with the current x and y axis orientation. If a moving source stops horizontal movement, the orientation of the horizontal axes will remain as it was when it was last moving. Prior to a moving source beginning any horizontal movement, the x and y axes are oriented as for a non-moving source.

II.B.4.j. Moving Receptors

Background

As part of a Bio Sensor Architecture Study, a "moving receptor" capability has been implemented in ADPIC. This capability allows users to move one or more receptors (samplers) through the ADPIC domain and accumulate a quantitative integrated exposure from the ADPIC cloud to each of these receptor(s). Note that only an integrated and interval averaged exposure from the airborne cloud is computed. The capability to determine the time-dependent instantaneous air exposure or exposure from deposited material is not currently implemented, since it is significantly different from that needed for integrated air.

The current implementation is based on the user specifying one or more 3-dimensional (x,y,z) tracks (trajectories) through the ADPIC domain as a function of time. One or more receptors are then associated with a particular track. If more than one receptor is associated with a track, then the user may also need to specify the receptor's x, y, z offset from the track. This allows a 1-, 2-, or 3-dimensional grid of receptors to move in unison throughout the domain. Possible uses of this capability include being able to determine the exposure received by an airplane flying on a particular

course within the model grid, or a vehicle traveling a specified course within the model grid, or a person walking along a specified course within the model grid.

Note that having a few receptors for an ADPIC run does not seriously add to the wall-clock-time require for the model run; however, a few tens (or more) of receptors will significantly slow the execution time.

Time step control in ADPIC when using the moving receptors option is applied at two levels. First, global time step is altered downward if necessary so that a rcptr_interval time is not overshot. Second, the local time step used in moving individual particles is constrained so that the fastest moving receptor will not move more than one cell's distance in the horizontal or the vertical during that time step. For the case of rcptr_hgt_ref = 'terrain", this means that the implied vertical velocity including the velocity due to traversing terrain blocks is used. Also, the most constraining horizontal sampling grid dimension (including nested grids) at the particle's location is used in the horizontal.

Note that additional local time step restriction may be needed for accurate sampling of the ADPIC particle field by the receptor. This may be especially true if a receptor has a significant component of its motion counter to the mean flow of particles. To improve particle sampling, it is suggested the user set one of the ADPIC timing parameters (e.g., STATUS_INTERVAL) to a relatively small time period, thus restricting the maximum local time step. (This will however tend to lengthen the model's run time.)

Assigning Receptors to Sampling Bins

The user may specify identifier strings to the receptors via the RCPTR_ID parameter. To specify the combination of ADPIC sources to be sampled by the receptors, use the RCPTR_SBIN parameter to match each receptor with the desired sampling bin. For example:

```
SOURCE_TO_SAMPLING_BIN(1,1)      = 1  2  3
SOURCE_TO_SAMPLING_BIN(1,2)      = 2  3  4
SOURCE_TO_SAMPLING_BIN(1,3)      = 1
    .
    .
    .
RCPTR_ID(1) = 'one' 'two' 'three'
RCPTR_SBIN(1) = 2    1    3
```

This assigns receptor 'one' to integrate air concentrations from sampling bin 2 (i.e., ADPIC sources 2, 3, and 4). Sampler 'two' integrates sampling bin 1 (i.e., ADPIC sources 1, 2, and 3. Sampler 'three' integrates sampling bin 3 (i.e., only the concentrations from ADPIC source 1). NOTE: the SAMPLING_TYPE of the sources assigned to the receptors must not be 'INTDEP' or

'TOTDEP'. (Even though any "air" concentration SAMPLING_TYPE is okay, remember only integrated and interval averaged concentrations are calculated for the receptors).

Receptor Height Reference

The z coordinates used for the receptor trajectories may be referenced (via the RCPTR_HGT_REF parameter) as height above terrain, height above sea level, or height above grid bottom. Locations specified in the TRAJ_X/Y/Z arrays are checked to make sure that none are below the surface. The user should also be especially careful in specifying the trajectories (and offsets) when using a RCPTR_HGT_REF set to other than 'TERRAIN', since it will not be obvious by just looking at the model namelist input file that the receptor may pass through terrain when going from one set of coordinates to another. If the receptor passes through the terrain at any time, the user will be warned, and the receptor will cease to accumulate exposure until such time as it reappears above the surface.

Defining Base Trajectories, Optional Offsets, and Assigning to Each Receptor

The time-varying trajectory coordinates are specified using the TRAJ_X, TRAJ_Y, and TRAJ_Z arrays, with TRAJ_TIME and TRAJ_DATE defining the times for which each of the sets of coordinates is valid. Specify all the dates and times at which any of the trajectories need to have their beginning/intermediate/final locations set. Trajectories move in a linear fashion between these locations (except when RCPTR_HGT_REF = 'TERRAIN', the movement in the z-direction follows the terrain) at a rate dictated by the associated dates/times. For example (in this case only trajectory numbers 2 and 4 are being used by the current set of input):

TRAJ_DATE	=	6*'01JAN96'					
TRAJ_TIME	=	'01:00'	'02:00'	'02:05'	'02:30'	'03:00'	'04:00'
TRAJ_X(1,2)	=	295.2	300.1	300.1	296.2	290.5	-99999.0
TRAJ_X(1,4)	=	-99999.0	-99999.0	-99999.0	325.9	330.2	-99999.0
TRAJ_Y(1,2)	=	4201.0	4206.2	4206.2	4220.2	4221.0	-99999.0
TRAJ_Y(1,4)	=	-99999.0	-99999.0	-99999.0	4150.3	4150.5	-99999.0
TRAJ_Z(1,2)	=	50.0	-99999.0	-99999.0	-99999.0	-99999.0	40.0
TRAJ_Z(1,4)	=	-99999.0	-99999.0	-99999.0	20.0	-99999.0	-99999.0

The RCPTR_TRAJ parameter is used to associate receptor(s) to particular trajectories. For example:

RCPTR_TRAJ = 2 2 4

assigns receptors 'one' and 'two' to follow trajectory number 2, and receptor 'three' to follow trajectory number 4.

The user may also define receptor offsets from their associated trajectory. For example, if you wanted receptors 'one' and 'two' to move together but maintain a constant 5 km offset in the x direction, a 10 km offset in the y direction, and a 15 m offset in the z direction, and if you also wanted the two receptors to be symmetrically centered on their associated trajectory, you would specify:

```
RCPTR_DELX    =  -2.5    2.5
RCPTR_DELY    =  -5.0    5.0
RCPTR_DELZ    =  -7.5    7.5
```

Since we wanted receptor 'three' to follow the originally specified trajectory, you can just leave out the 3rd position of the RCPTR_DELX/Y/Z arrays, since the default is 0.0.

In summary, for the example trajectories (with the example offset specifications) and associated receptor assignments, the following will happen:

1) Receptor 'one' will move
   from location x=292.7 (295.2-2.5), y=4196.0 (4201.0-5.0), z=42.5 (50.0-7.5) at 01:00
   to location x=297.6, y=4201.2, z=39.167((50-7.5) - ((50-40)/(4-1))) at 02:00.
2) Receptor 'two' will move in a similar manner, only offset in the x, y, and z directions as indicated earlier.
3) Between 02:00 and 02:05 both 'one' and 'two' will remain stationary in the x and y dimensions, but will continue movement downward. They will then begin to move in all three dimensions once again at 02:05.
4) Receptor 'three' is relatively simple, moving only between 02:30 and 03:00 and remaining at a constant elevation of 20 m above terrain.

Note that receptors will not accumulate any exposure prior to the first time, or after the last time, a valid location coordinate is listed for its associated trajectory (in either the x, y, or z direction). In this example, 'one' and 'two' accumulate exposure from 01:00 up until 04:00. Receptor 'three' only "exists" and accumulates exposure between 02:30 and 03:00. In other words, a receptor is removed from the calculations as soon as it has no where else to go during the remainder of the run.

Range of Influence of Particles to Receptors

A receptor's integrated exposure concentration increases whenever an ADPIC particle moves within a user-controllable range of the receptor. A test is made after each local time step for each particle to see if the particle is within the specified range of any receptor. If so, it contributes a portion of its mass/activity to the receptor based on the "tent-function" method normally used for the sampling process to grid points . The range which is used for the particle-to-receptor proximity test is controlled by RCPTR_INFL_X_FRACT, RCPTR_INFL_Y_FRACT, and RCPTR_INFL_Z_FRACT. The values (defaults = 1) assigned to these parameters are the fractions of the extent of the advection grid cell over which the tent function reaches, in the respective directions. For example:

```
RCPTR_INFL_X_FRACT = 0.5
RCPTR_INFL_Y_FRACT = 0.25
```

would create a sampling reach of 1 delta Z, 0.5 delta X, and 0.25 delta Y.

Receptor Concentration Multipliers

For purposes of converting ADPIC concentration units to desired output units when using the moving receptors option, three hierarchical input parameters can be used as multiplier values. RCPTR_MULT_GLOBAL is used to assign a single multiplier to every receptor output value; RCPTR_MULT_GROUP is used to assign a multiplier to one or more "groups" of receptors (a "group" of receptors are those associated with a particular trajectory); RCPTR_MULT_IND is used to assign a multiplier to one or more specific receptors. RCPTR_MULT_GROUP assignments override RCPTR_MULT_GLOBAL assignments, and RCPTR_MULT_IND assignments override both RCPTR_MULT_GLOBAL and RCPTR_MULT_GROUP. For example:

```
RCPTR_MULT_GLOBAL  =  2.5
RCPTR_MULT_GROUP   =  -99999.9    4.2    (index is trajectory number)
RCPTR_MULT_IND     =  -99999.9    3.0    (index is receptor number)
```

will assign a global multiplier to all three receptors of 2.5, then this value is overridden for those associated with trajectory number 2 (receptors 'one' and 'two', as specified by the RCPTR_TRAJ parameter) by assigning a multiplier of 4.2, and finally receptor 'two' again is reassigned a different value of 3.0. So in this example the integrated exposure concentrations of receptor 'one' are multiplied by 4.2, 'two' are multiplied by 3.0, and 'three' are multiplied by 2.5.

Output

The frequency of output of the receptor concentrations is controlled by the RCPTR_INTERVAL parameter. All output generated during ADPIC is stored in memory and output at the end of the model run into a file named RECEPTOR.DAT in the dispersion run directory. For example:

```
RCPTR_INTERVAL = '00::00:10'
```

will output integrated exposure (multiplied by any stated multiplier values specified by RCPTR_MULT_GLOBAL, RCPTR_MULT_GROUP, and RCPTR_MULT_IND) for each receptor every 10 minutes of model run time. Note that the list of concentrations for a particular receptor does not start until a non-zero concentration is found for the receptor, and the list stops when all remaining integrated values are constant.

II.B.4k. Decay Mode

Through the use of the DECAY_MODE parameter in the ADPIC_SOURCE namelist, the user is able to specify if and how the source material will decrease in activity or amount, or change its form, state, or other characteristics. The decay method used for the hybrid particles option is discussed in more detail in section II.B.4.h.

Simple radioactive decay and chemical or biological decay are simpler decay modes discussed in this section. The following equation specifies the decrease in time (t) of the amount or activity of material (N) using a decay constant, .

$$\frac{dN}{dt} = -\lambda N \tag{II.B.35}$$

which can also be expressed as:

$$\lambda = \frac{-\ln\left(\frac{N}{N_o}\right)}{t} \tag{II.B.36}$$

For simple radioactive decay, the decay constant is expressed in terms of a half-life ($T_{1/2}$), which is the time it takes for the material to decay to half of its original amount (No):

$$\text{at t=} \quad T_{1/2}, \quad N = \frac{N_o}{2}$$

Substituting into Eq. II.B.36 :

$$\lambda = \frac{\ln 2}{T_{1/2}} \tag{II.B.37}$$

For chemical or biological decomposition, the decay constant is expressed in terms of τ , which is the time it takes for the material to decompose to 1/e of the initial amount:

$$\text{at t=} \ \tau, \quad N = \frac{No}{e}$$

substituting into Eq. II.B.36:

$$\lambda = \frac{1}{\tau} \tag{II.B.38}$$

However, since it is usually the decay rate (not the decay constant) that is know for biological decomposition, we need an expression for τ as a function of the decay rate. Equation II.B.35 can also be expressed as:

$$N_t = N_o e^{-7t} \tag{II.B.39}$$

At time t = t+1, the amount of material (or organisms) left at t+1 is:

$$N_{t+1} = N_o e^{-\lambda(t+1)} \tag{II.B.40}$$

Therefore, the decrease in material expressed in %/min from time t to time t+1 is given by:

$$100 \frac{N_t - N_{t+1}}{N_t} = 100 \frac{N_o e^{-7t} - N_o e^{-\lambda(t+1)}}{N_o e^{-\lambda t}} \tag{II.B.41}$$

Upon simplification, this becomes:

$$Decayrate = 100\left(1 - e^{-\frac{1}{\tau}}\right) \tag{II.B.42}$$

Rearranging to express ?? in terms of decay rate, this becomes:

$$\tau = \frac{1}{-\left[\ln\left(1 - \frac{DR}{100}\right)\right]\frac{60\,\min}{hr}} \tag{II.B.43}$$

II.B.4.l. Dense Gas Capability

As is commonly thought, a release is not denser-than-air simply if the molecular weight of the released gas is greater than air (>28.6 kg). A release is denser-than-air if the density of the release cloud-air mixture exceeds the ambient air density (approx. 1.2 g/cm3) enough to overcome the surface shear stress caused by the ambient wind. In the Questionnaire, the ALOHA source model internally calculates a release friction Richardson number, Ri_f, which determines whether or not the source will produce a denser-than-air cloud.

The dense gas capability consists of a combination of source modeling in the interactive Questionnaire application, use of the SLAB model, and use of the SLAB results by ADPIC to create sampling bins for denser-than-air chemicals. Please refer to Section III.C.12 "SLAB_INPUT.DAT" and Section III.C.13 "SLAB_TO_ADPIC.DAT" for descriptions of these two files, as well as to the "Assessor Training Manual" for more details regarding Questionnaire documentation, and to the "User's Manual For SLAB" for more details regarding the SLAB model. This section focuses primarily on the use of SLAB results by the ADPIC model.

Below are listed some of the basic features of the ARAC SLAB implementation:

- Source modeling in the Questionnaire determines if a CHEM TANK or CHEM POOL release is neutrally-buoyant or denser-than-air
- Only a single denser-than-air source is treated by SLAB
- The SLAB code accepts time-varying meteorology and source rates
- SLAB outputs a file of dispersion parameter arrays (SLAB_TO_ADPIC.DAT) which is read by ADPIC; ADPIC converts these to CONC*.BIF format
- A denser-than-air source can only produce average air and composite peak air plots (i.e., no integrated air or deposition plots)
- The denser-than-air average air and peak air sampling bins can be combined with like sampling bins from other neutrally-buoyant sources

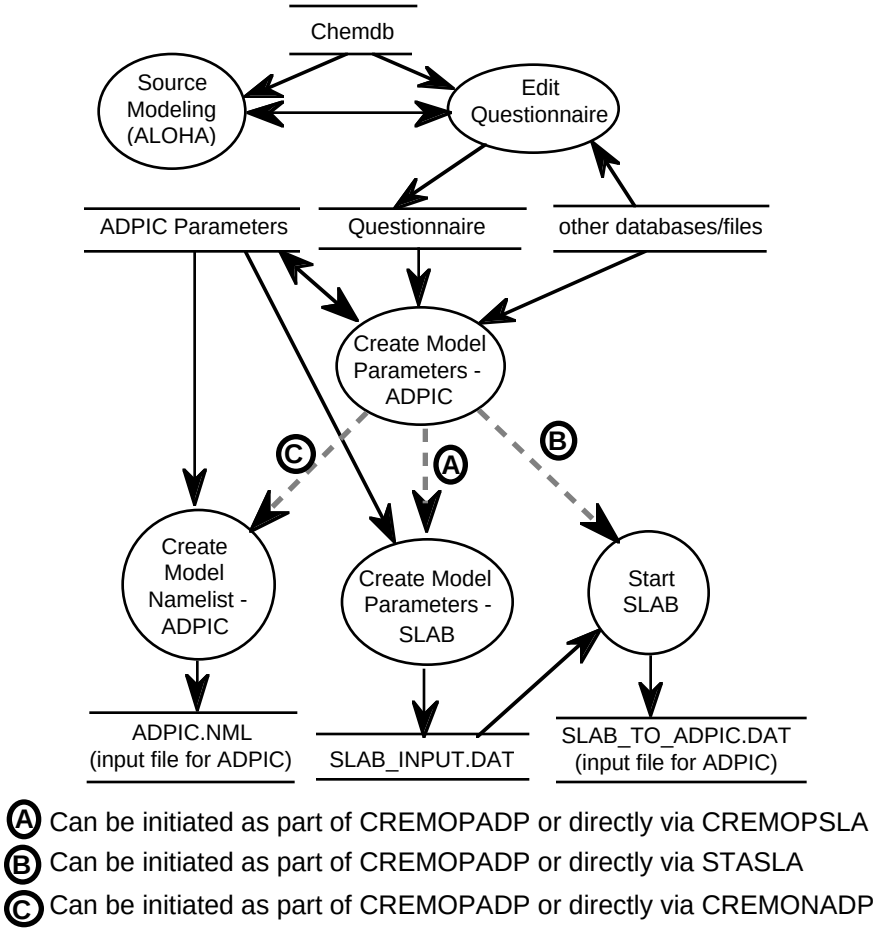


Fig. II.B.10. Incorporation of Dense Gas Parameters

As shown in Figure II.B.10, source modeling based on the ALOHA code is performed by the interactive Questionnaire application for CHEM TANK and CHEM POOL release types, and time-varying release rates are computed. If the release is denser-than-air, the user is also queried if he wishes to model it as a heavy gas (i.e., use SLAB). If SLAB is to be used, the Create_Model_Parameters-ADPIC (CREMOPADP) will:

1) create the adpic model parameter file (also contains heavy gas source parameters and cumulative average source rates)

2) run the Create_Model_Parameters-SLAB command file (reads the adpic parameter file and info from the questionnaire and creates a slab_input.dat file)

3) run the SLAB model (input = slab_input.dat, output = slab_to_adpic.dat, plus the other normal SLAB output files)

4) create the adpic namelist (will use info in adpic parameter file {including some slab parameters} to create an adpic.nml file with the following new namelist file parameters:

a) adpic_control namelist: USE_SLAB_CONC
b) adpic_source namelist: SLAB_SPECIES
SLAB_SOURCE
SLAB_START_INDEX
SLAB_SAMPLING_BINS
SLAB_SOURCE_RATE

As shown in Fig. II.B.10, steps 2, 3, and 4 described above can either be initiated as part of the Create_Model_Parameters-ADPIC command or they can be initiated directly via separate commands.

ADPIC uses the SLAB_TO_ADPIC.DAT file to produce ADPIC sampling information for the CONC*.BIF files for dense gas sources. At each metdata time interval the wind vector (from the appropriate MATVEL/MEDVEL file) closest to the dense gas source location is used to pick (based on wind speed) the appropriate UA-QA "dispersion parameter" array from SLAB_TO_ADPIC.DAT file, and to orient (based on wind direction) the array in space. The appropriate UA-QA "dispersion parameter" arrays are used to calculate a concentration and are combined to produce each AVGAIR and PKAIR sampling bin output data that are written to the CONC*.BIF files.

Note that ADPIC does not simulate the dense gas release by releasing marker particules into the wind field, and therefore there is no "ADPIC source" that represents the dense gas release; it simply uses the spatially- and time-varying concentration information in the SLAB_TO_ADPIC.DAT file, adjusts it according to the MEDIC/MATHEW wind field, and writes out the concentration arrays to the CONC*.BIF files.

II.B.4.m. Meteorological Parameters

Several time-varying meteorological or meteorology-related parameters that affect the diffusion and/or deposition of pollutant sources in ADPIC can be input via the ADPIC.NML namelist file. These time-varying met parameters (TURB_PARAM_TYPE, STAB_CLASS, INV_OBUKHOV_LEN_ML, INV_OBUKHOV_LEN_SL, ML_HGT, SIGMA_THETA_FACT, and PRECIP_SCAVENG_COEF) may have up to 50 values, with the MET_START_DATE and MET_START_TIME parameters controlling the start date and time that each value will become effective.

II.B.4.n. Nested Grid Sampling

A system of nested concentration sampling grids has been devised to improve the near-source resolution of the concentration values calculated from particle positions. The largest grid in Fig. II.B.11. represents ADPIC's standard advection and outermost concentration sampling grids, (i.e., the R41 grid, see Appendix F) dimensioned 40 x 40 cells. All interior, nested grids represent

concentration sampling grids of diminishing size, each having half the number of cells as the main grid, i.e., 20x20 in the figure, at half the resolution of the next outer grid. In all cases, the vertical dimensions of the advection and sampling cells are identical. The source maintains the same relative position in each of the five grids. To demonstrate how these grids are situated in relation to one another, assume that the Model x coordinate and northing coordinates of the source are 410.5 km and 4011.3 km, respectively, and that the assessor selects an advection grid for ADPIC whose lower-left coordinates are 400 km and 4000 km in the easting and northing directions. (Skewing the grid in this fashion would be appropriate when the prevailing winds and the winds in the foreseeable future are from the southwest.) Assuming a standard ADPIC grid having 40 x 40 cells in the horizontal with Δx and Δy equal to 2 km, the source would then occupy the advection cell whose index location is $i = 6$ and $j = 6$. Since the nested grids have 20 x 20 cells, the source should reside on or within the $i = 6$, $j = 6$ cell of all nested grids. (The word "should" is used here since a nested grid, if necessary, is shifted to the east and south so that its boundary falls on the nearest mesh lines of the next largest grid.) After receiving this coordinate information from the TOPOG*.GRID file (see Section III.C.1.), ADPIC correctly positions each of the four nested grids.

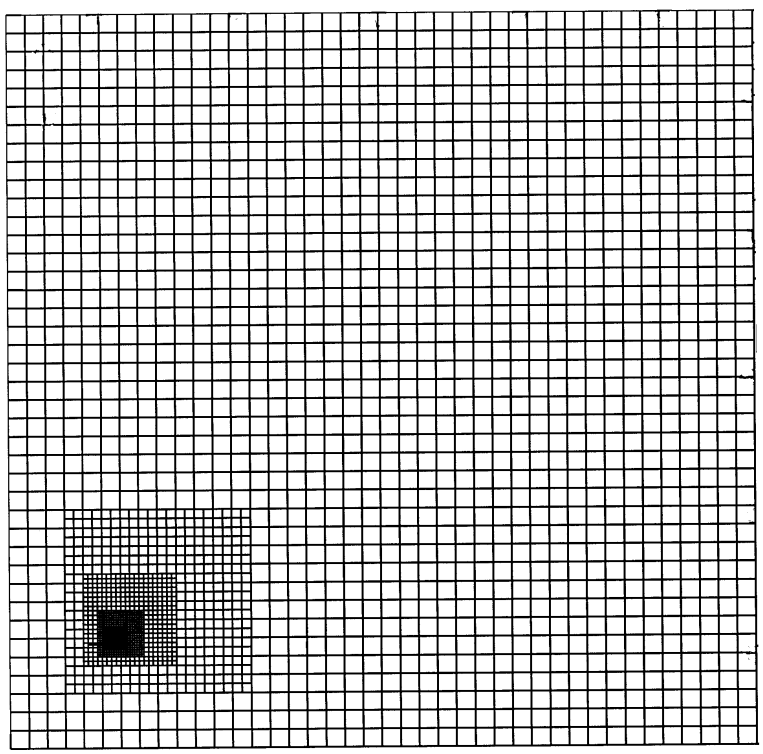


Fig. II.B.11. Nested grids for improving near-source sampling

ADPIC produces a set of five two-dimensional arrays of concentration at each of 1 to 10 vertical levels. These arrays are used by the plotting code, PLCNT, to generate isopleths of concentrations. It should be clear from the previous discussion that several arrays can share a common space. When this occurs, PLCNT will always choose, in a spatial sense, the more highly resolved values of concentration. Use of the nested grid approach does, however, create complications; immediately

beyond the extremity of any nested grid, the cell volume increases by a factor of four. This causes discontinuities in a contour when it spans two or more nested grids because of an abrupt drop in concentration. To improve the presentation, a routine has been developed that smooths the concentrations at the interface of two nested grids. However, use of this routine places a constraint on the ADPIC grid definition: the source must never be within two cells of the advection grid boundary. Returning to our example, a UTM source location of 402 km east and 4010 km north would violate the two-cell condition, assuming that all grid selections remained the same.

There are four nested grids that are used along with each of these arrays. Each of the nested grids has a Δx and Δy one-half that of its next larger neighbor. These nested grids are only used for sampling concentrations. The standard, outermost computational grid is the same as that for the input gridded wind fields, and is the only one used for the advection calculation. These nested grids are fixed in that there are always four of them and their cell size is determined by the size of the computational cells.

The placement of the nested grid is determined by the placement of the source in the computational grid. The nested grid is automatically placed such that the source is in the same relation to the nested grid as the source has with the computational grid. The only restriction is that when the grid is originally set up, the source must be at least two grid cells away from the computational boundary. If the source has been placed too close to the outside, a warning message will be printed out in ADPIC with the option to continue or start over.

These concentration arrays are used by PLCNT to plot contours of the concentrations. In addition to these concentrations, ADPIC can also print tabular output of such things as particle coordinates, advection velocities, concentrations, and friction velocities.

II.B.4.o. Output

The contents of up to MAXSBINS (currently 30) ADPIC output bins may be specified using the parameters SOURCES_TO_SAMPLING_BIN (specifies the concentration contributions of which ADPIC sources are to be placed in which sampling bins), SAMPLING_TYPE (specifies what type of integration is to be done), and SAMPLING_HGT (specifies at what height the concentrations are to sampled from). Any particular ADPIC source may be entered more than once. Also, combinations of ADPIC source numbers may be entered to sum the contributions from more than one ADPIC source. The table below lists the six sampling types and their descriptions.

Sampling Types (SAMPLING_TYPE)	**Description**
Instantaneous (INSAIR)	"Snapshots" of concentration at a given point in time
Time-integrated (INTAIR)	Total amount of pollutant passing a given point during a specified time interval; integration may either be over discrete time intervals (i.e., "interval") or it may be cumulative.

Time-averaged (AVGAIR)	Total amount of pollutant passing a given point during a specified time interval divided by the time interval -- i.e., same as interval integrated air concentration divided by the time interval.
Peak air (PKAIR)	Maximum x-min-averaged air concentration occuring from the beginning of the run to the time of output for each individual sampling cell.
Total deposition (TOTDEP)	Total amount of material deposited (and remaining) from the beginning of the release to the time of output.
Integrated deposition (INTDEP)	(Available only in hybrid particle mode.) Total (dose) effect from material deposited on the ground, integrated for a specified time interval.

A TOTDEP bin differs from INTDEP in that it is a snapshot of what is on the ground at any particular time. Another difference is that the contents of a TOTDEP sampling bin is decayed according to the longest half-life of the various materials that may have been combined in this bin, whereas an INTDEP bin decays the individual nuclides. For additional background, refer to the description for SAMPLING_TYPE in section III.B.9.a "ADPIC_CONTROL namelist".

The sampling bins for dense gas (SLAB) sources are specified by the SLAB_SAMPLING_BINS and SAMPLING_TYPE parameters. There is no entry in the SOURCES_TO_SAMPLING_BIN array for a SLAB source, since there is no ADPIC source that represents a SLAB source. The only values of SAMPLING_TYPE applicable for SLAB sources are AVGAIR and PKAIR.

II.B.5. Precision of ADPIC Calculations

Inasmuch as the ADPIC particles represent statistical sample of fluid elements marked with species mass, it is desirable to have as many particles per concentration sampling cell as possible. The upper limit of this number is obviously dictated by computer storage. ADPIC assigns to each particle a fictitious cell volume of the same size and shape as the basic concentration sampling grid cell. Thereby, in calculating the concentration field from the particles, each particle will contribute some fractional part of its mass to eight nearest-neighbor cells in proportion to the overlap of its “volume” with the cell volumes of the neighbor cells. This procedure smooths out the concentration field. From many prior calculations, we find that, due to the smoothing technique as few as one particle per cell on the average will yield meaningful results. The statistical significance of the calculated concentrations is obviously dependent on particle count; the fractional error of the concentration is inversely proportional to the square root of the particle count.

II.C. Support Routines

II.C.1. TOPOG

The construction of a solid bottom boundary for the CG-MATHEW and ADPIC models is accomplished through TOPOG. The boundary can be viewed as a system of blocks which approximate the shape of the actual terrain. Therefore the results of subsequent CG-MATHEW and ADPIC runs will reflect the major topographic features in the area of interest. The system of blocks is derived by averaging data from a problem elevation data base (see Section III.B.3.) to a grid volume defined by the user (see Section III.B.1.). Because of the large amount of averaging that has been applied to the original digitized terrain data in the generation of the system of blocks, the model terrain produced automatically by TOPOG may not be the best representation of terrain possible for a given grid resolution. ARAC's in-house version of TOPOG allows a user to selectively and interactively raise or lower individual boundary cells so as to more closely conform to the actual surface. Appendix B provides a description of this interactive capability.

The definitions of the CG-MATHEW and ADPIC grid volumes produced by TOPOG are made up of grid parameters and terrain heights for each horizontal grid cell. The user selects a grid by assigning values to certain grid parameters in the TOPOG.NML file (see Section III.B.1.). The ADPIC and CG-MATHEW grids are subject to a number of constraints in order to ensure proper averaging. TOPOG checks the grid parameters and if they define an illegal grid, TOPOG either halts with diagnostic errors or makes minor adjustments to some of the parameters in an attempt to create a legitimate grid.

In a typical ARAC problem, the user specifies the center of the ADPIC grid in the x and y coordinates of the map projection selected for the problem (optionally the user can specify the coordinates of the lower left corner of the ADPIC grid). Currently, most regional problems are run on the Universal Transverse Mercator (UTM) projection. The user also specifies the x, y and z ranges of the grid (or optionally the x, y, and z dimensions of an individual cell). Since the number of grid points in each dimension is normally left constant, choosing the cell size is equivalent to specifying the range of the ADPIC grid (e.g., an ADPIC grid having 41 by 41 by 15 points with a cell size of 1 km by 1 km by 50 m defines a grid volume of 40 km by 40 km by 700 m). The CG-MATHEW grid is defined on the basis of the user's ADPIC grid. They have the same grid cell sizes, but the number of points in CG-MATHEW's grid system (in any direction) must, at a minimum, be as great as the number in ADPIC's grid system. The CG-MATHEW grid surrounds the ADPIC grid so that a band of cells borders on all sides of the ADPIC grid. This has a buffering effect that protects ADPIC from possibly poor adjustments of the winds near CG-MATHEW's boundaries. For the standard ARAC model grid dimensions (CG-MATHEW: 51 by 51 by 15 grid points, ADPIC: 41 by 41 by 15 grid points, i.e., the R41 grid, see Appendix F), the band surrounding the ADPIC grid is usually five grid cells wide.

The terrain averaging requires that the boundaries and origins of both the CG-MATHEW and ADPIC grids lie on top of grid points in the elevation data base grid The current averaging procedure also requires that both of the horizontal grid cell lengths (DELX, DELY) be integer multiples of one-quarter the resolution of the terrain data base. Since standard regional elevation grids have grid cells which are 500m by 500m, legitimate values for DELX and DELY are integer multiples of 125 m. For hemispheric problems the grid cells must be 381 km by 381 km. The constraints on the cell size are absolute. TOPOG will halt if illegal values for DELX and DELY are specified; however, TOPOG will shift the CG-MATHEW and ADPIC grids as much as DELX (or DELY, as appropriate) to ensure the overlaying of the proper points. The origins will be shifted as little as possible from the positions given in TOPOG.NML. The other constraint on the grids is that no part of the CG-MATHEW grid may lie outside of the terrain database grid, and that no part of the ADPIC grid may lie outside of the CG-MATHEW grid. If the ADPIC grid, as specified, lies within the terrain data base grid and the default CG-MATHEW grid does not, then TOPOG will attempt to shift the CG-MATHEW grid to create a legal system of grids (See Fig.II.C.1.).

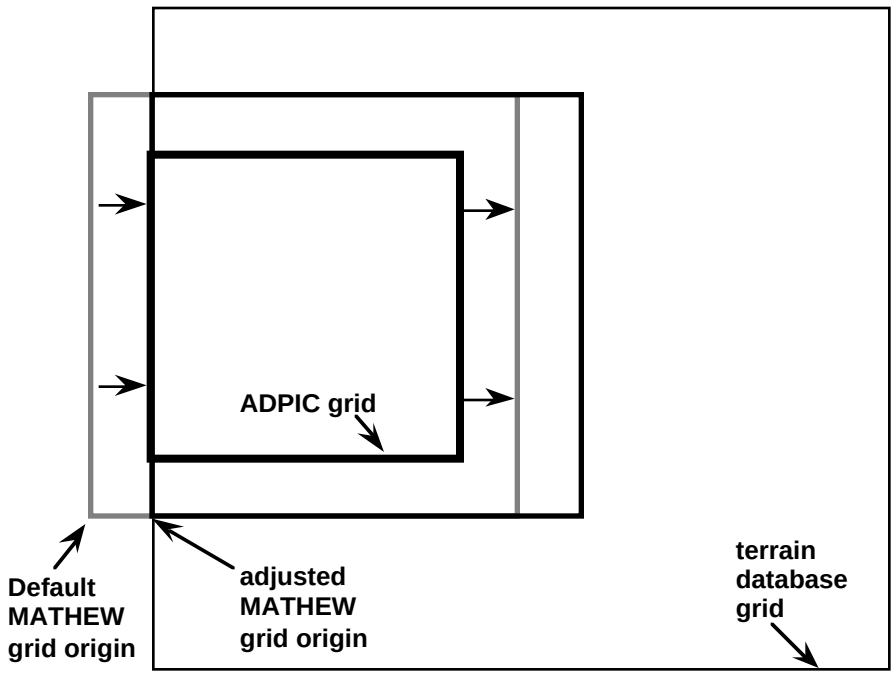


Fig. II.C.1. Example of the automatic shift of the CG-MATHEW grid by TOPOG to create a permissible system of grids.

The ADPIC grid can be specified as being as much as one DELX or DELY step out of the area covered by the regional elevation file grid. If so, the ADPIC grid will be shifted so that the appropriate boundary matches the elevation file grid boundary. The CG-MATHEW grid will also be shifted as described above to match the elevation file grid boundary along the corresponding border. If the ADPIC grid lies further from the border that one CG-MATHEW/ADPIC grid step, then an error is reported and TOPOG ends.

If there is no important terrain relief in an area or if no elevation data is available, TOPOG can generate a flat grid of arbitrary size (see FLAT_TOPO in Section III.B.1.). There are then no constraints on the CG-MATHEW and ADPIC grids with respect to the elevation data base grid. Regardless of the means of selecting a grid (or even if errors are discovered during validation), all grid parameters are displayed on the terminal and in the TOPOG.LOG file to allow the user to determine the acceptability of the model grids produced by TOPOG, or to determine the cause of any errors.

The final CG-MATHEW grid, along with the vertical grid spacing (DELZ) selected by the user, defines a system of grid cells filling a grid volume. Terrain is represented by specifying which grid cells in a vertical column are open (wind is permitted to pass through at least one of the cell's faces) and which cells are closed (i.e., underground). The terrain is described by a two-dimensional array of integers with each element in the array specifying the integer number of grid cells that lie underground in the CG-MATHEW grid.

TOPOG generates the terrain arrays by averaging the data in the regional elevation data base over the CG-MATHEW grid. The standard elevation data file specifies elevations for a region covered by a grid of square cells oriented along the appropriate map coordinate system (typically UTM coordinates for regional problems). Elevation data base grids are typically dimensioned 400 by 400 with each grid cell commonly a 500 m square (in such cases the area described is 200 km by 200 km). The terrain file contains an array of values with each value being the average height, in meters above sea level, of the corresponding grid cell. Since the grid has been accepted by TOPOG before the averaging begins, each CG-MATHEW cell is an integer multiple of one quarter the elevation grid spacing and, as a result, the average height of a CG-MATHEW cell can be found by averaging the heights of the portions of the elevation data base grid cells it contains with the averaging weights reflecting the area of the portion of the elevation grid cell contained in the CG-MATHEW grid cell. On completing this step a height in meters above sea level is associated with each CG-MATHEW cell. In the past, the terrain averaging done in TOPOG was based on CG-MATHEW double cells, i.e., four CG-MATHEW grid cell in a 2 by 2 array were averaged as an entity. This was used to avoid single cell holes in the model terrain that permit ADPIC particles to diffuse into them but cannot contain any winds, since five of the six faces are closed, so such particles cannot be advected out of them. Current procedures in TOPOG, largely interactive, allow single cell holes to be removed in other ways (automatically if the code is being run non-interactively) so this option is rarely used in ARAC applications. However, TOPOG is occasionally ported to other systems that may not be able to support the necessary graphics tools, so the option for this double cell averaging is maintained (see DOUBLECELL in Section III.B.1.),

To complete the averaging, each cell height is rounded to the nearest integer multiple of DELZ. The lowest value for all the cells in the grid is then subtracted from each grid value, thereby re-defining the bottom of the CG-MATHEW grid volume. The integer height of each cell is then assigned to the appropriate CG-MATHEW grid cell. This array is written to the TOPOG*.GRID file for use by the remaining models. The ADPIC cell heights are extracted directly from this array when

ADPIC reads the TOPOG*.GRID file, accounting for any offsets due to the typically larger CG-MATHEW grid dimensions. CG-MATHEW requires its terrain heights to be offset so that the bottom of the grid has a value of one. Hence, both MEDIC and CG-MATHEW increment each cell height by one when they read the TOPOG*.GRID file. A two-dimensional illustration of the terrain representation is shown in Fig. II.C.2.

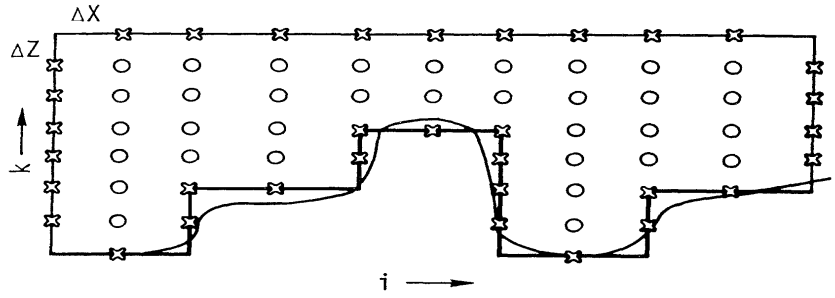


Fig. II.C.2. Illustration of the topography specification in two dimensions.

II.C.2. MEDIC

Since CG-MATHEW adjusts the extrapolated winds by the *minimum* necessary amount in producing a mass-consistent arrangement, a reasonable, first-guess field of wind velocities, $\underline{U}^0$ in Eq. (II.A.1), must be supplied by MEDIC, the wind extrapolation code. Attention to detail in the preparation of the extrapolated field is critical. Fairly minor variations in the parameters input to MEDIC can lead to grossly different wind fields, all of which are consistent with the measured data. For this reason, we rely heavily on the interpretive ability of an experienced meteorologist to determine the acceptability of a result. Using the tools of his trade (e.g., weather maps, local observations, upper air data, pilot reports), a meteorologist can factor in all of the known and relational information (in the form of model input) to produce a realistic and meteorologically consistent wind field. If necessary, the model is rerun with altered input until the desired result is achieved. This procedure is extremely important in that physical processes, many of which are not modeled in CG-MATHEW, can be implicitly represented in the structure of the extrapolated field.

Three separate layers of the atmosphere are recognized in constructing the 3-D wind field. The surface layer is the lowest layer in which surface effects predominate and no direction shear with height is allowed. Within the surface layer a "reference level height" is defined and used by MEDIC. This height is set at the typical height of the surface intruments, and enables normalization of all surface measurements to a common height, from which they can be horizontally interpolated.The highest layer, the geostrophic layer, is the region of the atmosphere where surface effects have virtually dissipated and the winds reflect larger-scale synoptic flow. Wind speed and direction are assumed to be constant with height in this layer, i.e., there is no wind shear. The central layer, or boundary layer, is the region where conditions are intermediate between the surface and geostrophic layers; both speed and directional shear can occur.

There are basically three steps in constructing the three dimensional wind field, the first of which is to determine the gridded reference level data:

Step 1: Determine gridded reference level data

Extrapolate the surface input wind data ("SFC" stations, single-level "TOW" stations below the surface layer height, and (if USE_UPR_AT_SFC = 'Y) the lowest level of any upper air or gridded input data if it is in the surface layer) to the reference level height. A power law is used for the wind speed, while the direction remains unchanged from the input data. This vertically-extrapolated data for each of the input locations is then horizontally interpolated (using the inverse square distance) to construct a 2-D gridded array of winds at the reference level height.

The second and third steps are different depending upon the method that will be used to vertically extrapolate the upper air winds. The "Parameterized Method" uses surface observations and user-defined parameters to construct the required three-dimensional wind field with minimal upper air data required, and is generally used when no upper air soundings are available or when the credibility of a sounding is in doubt. The other approach is the "Profile Method", which makes

use of all surface and upper air observations in the wind extrapolation process, and is the preferred method if at least one recent (within past 6 hrs) local upper air sounding is available. Parameterized Extrapolation is the default in MEDIC (see PROFILE_EXTRAP in Section III.B.4.b).

Step 2: Determine preliminary grid point column data	
If using Profile Method: 2a) Construct synthesized profiles at each grid point: For each input upper air ("UPR" stations and/or gridded data input) input data location, interpolate to each of the grid point column heights. Use constant speed and direction if necessary to extend the profile up to the grid top, or down to the surface layer height, using a power law to extend further down to the reference level height. 2b) Construct background profile for each tower location: For each multi-level tower or tower with data above the surface layer height, use the inverse square distance law to construct a vertical profile (i.e., addtional "synthesized profile") at that location from synthesized profiles from step 2b. 2c) Blend tower data: For each tower location, blend tower data with the synthesized profile (from step 2b) as shown in Fig. II.C.4.	*If using Parameterized Method:* Interpolate each input upper air profile (i.e., "UPR" stations and/or gridded data input) to the boundary layer height, using constant speed and direction if necessary to extend the profile up above the highest profile height.

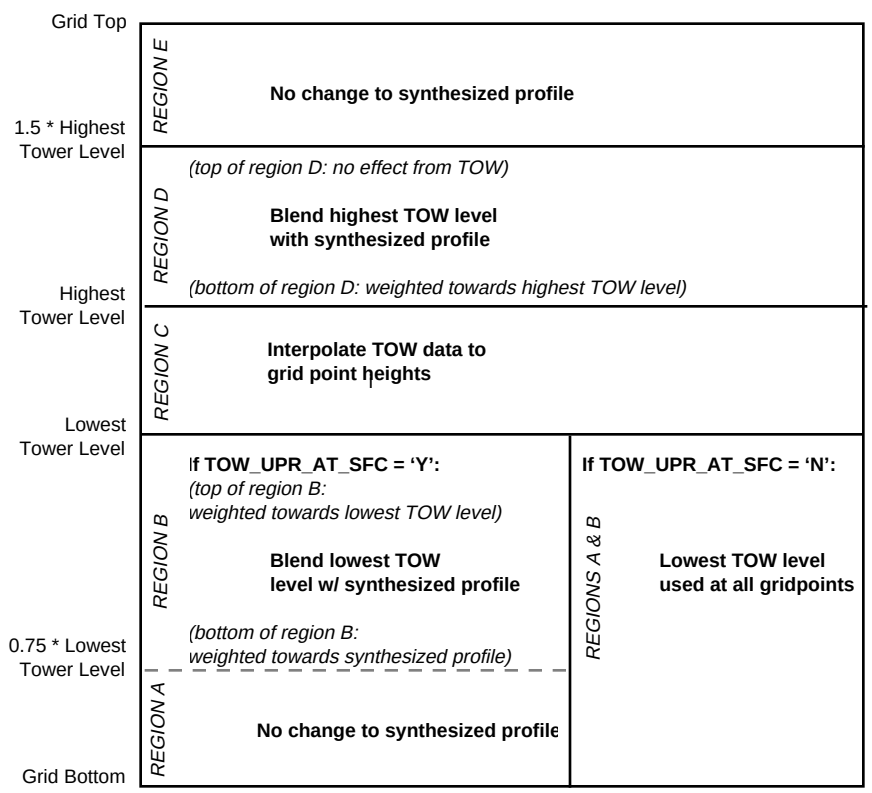


Fig. II.C.4. Step 2c: Tower data is blended with the synthesized profile using different criteria in certain vertical regions of the profile

The third and final step is to construct the final vertical profiles at each grid point:

Step 3: Construct vertical grid point columns	
If using Profile Method: For each grid point column, use the inverse square distance law to horizontally interploate from nearest synthesized profiles (from steps 2a and 2c), and then adjust profile as shown in Fig. II.C.5a.	*If using Parameterized Method:* For each grid point column, use the inverse square distance law to horizontally interpolate from the nearest station locations to obtain a reference hieght value (from step 1) and a boundary layer height value (from step 2), and then determine values for each vertical grid point in that column as shown in Fig. II.C.5b

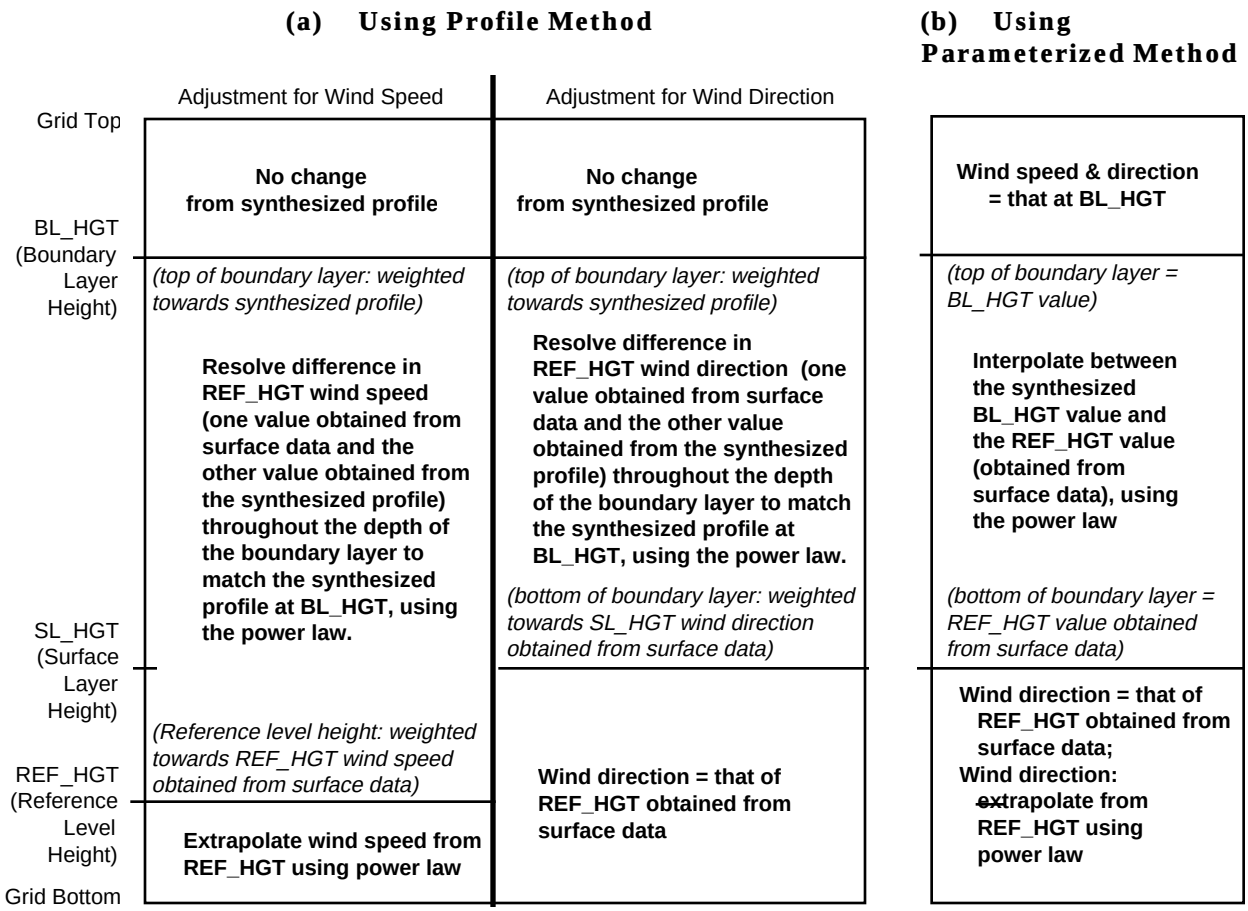


Fig. II.C.5. Step 3: For each column of grid points, a final profile is obtained depending upon the extrapolation method: with the Profile Method, the synthesized profile is adjusted as shown in (a); with the Parameterized Method, a profile is constructed as shown in (b).

Both the Profile Method and the Parameterized Method produce two three-dimensional arrays of horizontal wind components, one array for the u-components and the other array for the v-components, containing the wind vectors at each grid point of a volume having the same dimensions

as the CG-MATHEW grid. However, unlike the CG-MATHEW grid, the extrapolation grid volume is adjacent to but entirely above the model terrain surface (i.e., in the extrapolation grid, heights above grid bottom are always equal to heights above model terrain). On completion of the extrapolation, model terrain is pushed up through the grid bottom with a corresponding upward shift in the extrapolated winds. Thus, the atmospheric layers defined in the extrapolation process (Z_{sl} and Z_{bl}) are flat in the extrapolation grid volume and have the shape of the terrain in the CG-MATHEW grid volume (see Fig. II.C.7.). This produces the wind fields that are passed to CG-MATHEW. CG-MATHEW transforms the winds into face-centered components for ease of calculation (see Section II.A.3.).

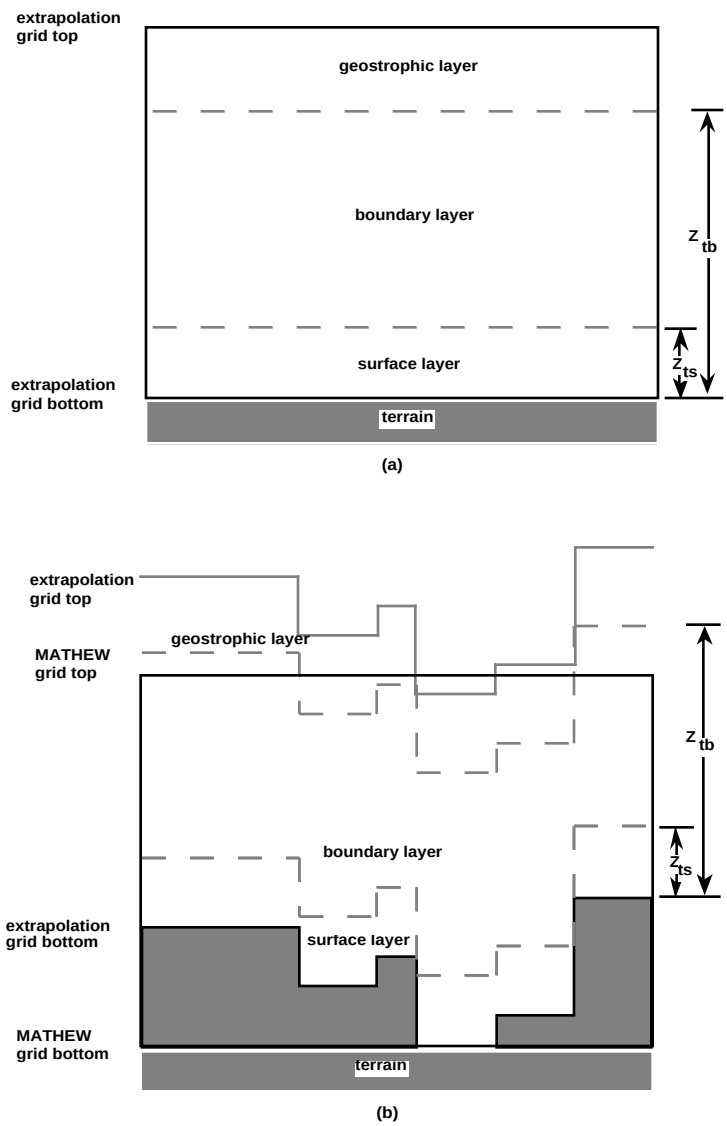


Fig. II.C.7. Schematic of a CG-MATHEW grid in two dimensions: (a) before, and (b) after the introduction of model terrain.

II.C.2a. Tower Data

Incorporating data from meteorological towers presents a problem. In contrast to upper air profiles, towers typically extend upward only a fraction of the depth of the model grid, so one is left without defined wind values at model levels above the highest tower level. This prevents MEDIC from constructing a complete vertical profile at the tower location. Historically the approach taken to avoid this problem was to use only the lowest available level of tower data, treating it as a surface observation.

In late 1996 a change to MEDIC allowed use of all available tower data when using the Profile Method of extrapolation. The new procedure uses upper air and/or gridded data to construct a background wind set. Next, the background winds are interpolated to the tower locations, and tower data are inserted into the model domain. Then the tower data along with the interpolated background values are used to construct complete vertical profiles, and these complete profiles are used as additional upper air data in the Profile Extrapolation procedure.

This scheme defines five vertical regions (see Fig. II.C.4). The tower data all lie within Region C. In this region, only tower data are used to construct the final profile.

Region B extends downward from the lowest tower level to a height 0.75 times that level. Region A extends downward from Region B to the surface. The parameter TOW_UPR_AT_SFC controls use of tower data in Regions B and A. If this parameter is set to 'N', the lowest available tower value is applied at all model levels in Regions B and A, so the background data are not used at the tower location in these regions. If the flag is set to 'Y', the background profile and the tower data are blended in Region B, and the background profile alone is used in Region A. The blending in Region B reduces the effect of the tower data linearly from 100% at the top of Region B to 0% at its bottom.

Region D extends upward from the height of the highest tower level to 1.5 times that level. Within Region D, the uppermost tower value is blended into the background profile, with the resulting value equal to the tower value at the bottom of Region D, and the effect of the tower data vanishing at the top of Region D. The blending is controlled by the TOW_BLEND_EXPNT parameter. If this parameter is set = 1.0, MEDIC does a simple linear interpolation. If the parameter > 1.0, tower data retain more influence higher into Region D, and if TOW_BLEND_EXPNT < 1.0, the tower data influence diminishes more rapidly with height. Within Region D, the TOW_MAX_VEER parameter controls whether blending results in veering or backing with height. Winds will veer unless the TOW_MAX_VEER angle is exceeded.

Region E extends from the top of Region D to the top of the grid. Only the background profile is used in this region.

Some meteorological towers report wind values at only one level. For these towers, if the level of the data is within the surface layer, the tower data are treated as surface data; this scheme allows a low-level single-level tower to satisfy MEDIC's requirement for at least one surface observation. If a

tower has data at only one level, which is above the surface layer, the data are treated as tower data. In this case, Region C collapses to a single level.

Towers reporting data at more than one level can also satisfy the requirement for at least one surface observation, if the tower data are within the surface layer and the USE_UPR_AT_SFC parameter is set = 'Y'.

II.C.2b. Parameterized Extrapolation

The Parameterized Method of extrapolation involves two basic steps. First, wind speed and direction values must be assigned to two height levels in each column of grid points of the extrapolation grid volume. One level is near the surface and the other level is at or above the top of the grid. Second, winds along the columns of grid points are determined by interpolating between the wind values at the two levels, and by extrapolating to the surface below the lower level. The interpolations and extrapolations are controlled by a number of user-defined parmeters that aid in simulating the vertical structure of the atmosphere.

The near-surface level wind for each column of grid points is derived from surface wind observations. First, all surface speed measurements are normalized to a user-specified height above terrain.called the reference height (see REF_HGT in Section III.B.5.). In order to minimize the alteration caused by normalization, REF_HGT is usually chosen to be the height above terrain of most of the observing instruments. The surface layer power law formula used in the normalization is

$$S_{\text{norm}} = S_{\text{obs}} \left(Z_{\text{ref}} / Z_{\text{obs}} \right)^{\gamma_{\text{sl}}} \quad , \tag{II.C.1}$$

where S_{norm} is the wind speed at height REF_HGT, S_{obs} is the observed wind speed, Z_{ref} is the reference height, Z_{obs} is the observation height, and γ_{sl} is the power law exponent for the surface layer (see PWR_LAW_EXPNT_SL in Section III.B.5. and the description of the OBSERV.MET file in Section III.B.7). Wind directions are not altered when normalization occurs since directions rarely show significant changes for typical adjustment heights. The reference level speed and direction for a column of grid points are then derived from the normalized measurements by an extrapolation based on the inverse square of the distance to nearby observation points according to the formula:

$$S_{\text{ref}} = \frac{\sum_{n=1}^{N} S_n / R_n^2}{\sum_{n=1}^{N} 1 / R_n^2} \tag{II.C.2}$$

where S_{ref} is the reference level speed for the grid point column, N is the number of nearest observations being used in the extrapolation, S_n is the normalized speed measurement for a given station, and R_n is the distance from the horizontal location of the column to the station. The four nearest stations are normally used, although this can be changed by recompiling. The reference level direction for the column is calculated by separate inverse-square extrapolations of the sines and the cosines of the observed values based on formulas analogous to Eq. (II.C.2.). The sines and cosines are

extrapolated separately to avoid the discontinuity caused by interpolating through 0° (360°). and are then used to generate a consistent angle using an arctangent function. The subset of the observation stations used to determine the direction may not be the same as the subset for speed since a station may report only speed or direction. Therefor the selection of the nearest observation stations is performed separately for the speed and direction extrapolations. At least one surface speed and one surface direction observation, not necessarily at the same point, must be input to allow the extrapolation to proceed.

The upper level wind in a grid point column is generated from upper air wind observations. The upper level is usually taken to be the top of the extrapolation grid volume. However, if the top of the boundary layer is above the top of the extrapolation grid, the wind is instead determined at the top of the boundary layer. In order to extract values at arbitrary heights from the discrete upper air profile measurements provided by a sounding, it is assumed that winds vary linearly between successive measurement heights. Directions vary through an arc describing the smallest angle between two measurements. Above the highest measurement level, winds are assumed to remain constant with height. Winds below the lowest measurement level are taken to be constant down to the top of the surface layer and to obey a power law for speed within the surface layer. The inverse square extrapolation procedure [see Eq. (II.C.2)] is then used to assign a speed and direction at the upper level of each grid point column. Profiles with speed measurements only or direction measurements only will be accepted as input. At least one upper air speed measurement and one upper level direction measurement, not necessarily at the same location, must be input to allow the extrapolation to proceed.

Having extrapolated winds at two levels, values can now be assigned to all the grid points in a column using an interpolation method that reflects the basic three layer structure of the atmosphere. For grid points in the surface layer above and below the reference height, the wind speed is determined using a power law formula similar to that used for the reference level normalization (Eq.II.C.1) :

$$S(Z) = S_{\mathrm{ref}} \left(Z / Z_{\mathrm{ref}} \right)^{\gamma_{\mathrm{sl}}} \qquad \text{(II.C.3)}$$

where S is the speed at a surface layer grid point, Z is the height of the surface layer grid point, and S_{ref} and Z_{ref} are the reference level speed and height for the column of grid points. Since there is no wind shear in the surface layer, the reference level direction is assigned to all surface layer grid points of the column. The power law formula is also used to generate a surface slip velocity at the surface roughness height, Z_{srh} (see SFC_ROUGH_HGT in Section III.B.5.). In the geostrophic layer, constant winds are assumed and the upper level speed and direction are assigned to all grid points in the column above the boundary layer.

Winds in the boundary layer are computed so as to provide continuity between the surface layer winds and the geostrophic layer winds. The simplest way of satisfying this condition is to linearly interpolate between the winds at the top of the surface layer and the top of the boundary layer. This capability is provided and is adequate for many situations. However, atmospheric conditions can

arise which require greater generality in the interpolation. The speed shear in the boundary layer is often variable, with the greatest change occurring near the top, as frequently occurs when the top of the boundary layer coincides with a temperature inversion. This behavior may be modeled by a power law interpolation formula with a user-defined exponent. Another important consideration in the boundary layer is the variation of direction with height. The difference between any two angles can be determined along two directions of rotation, clockwise or counter clockwise. As a result, there are two possible interpolations between the direction at the top of the surface layer and the direction at the top of the boundary layer. In middle latitudes of the northern hemisphere, winds usually change in a clockwise direction with increasing height, i.e., they "veer" with height. Therefore, it is not always advisable to determine angular difference through the smallest angle. There are also cases where the wind directions turn counter clockwise with height, i.e., they "back." This can occur, for example, when a front moves through an area. It is important for an assessor to be able to control the sense of the directional shear in the boundary layer, a capability which is provided in MEDIC.

Interpolation in the boundary layer is accomplished using the following formulas:

$$S(Z) = \frac{\Delta S_{\mathrm{bl}}\left(Z - Z_{\mathrm{ts}}\right)^{\gamma_{\mathrm{bl}}}}{\left(\Delta Z_{\mathrm{bl}}\right)^{\gamma_{\mathrm{bl}}}} + \mathrm{Sts}\ , \tag{II.C.4a}$$

$$\theta(Z) = \frac{\Delta'\theta_{\mathrm{bl}}\left(Z - Z_{\mathrm{ts}}\right)^{\gamma_{\mathrm{bl}}}}{\left(\Delta Z_{\mathrm{bl}}\right)^{\gamma_{\mathrm{bl}}}} + \theta\mathrm{ts} \tag{II.C.4b}$$

where γ_{bl} is the boundary layer extrapolation exponent (see EXTRAP_EXPNT_BL in Section III.B.5.). ΔS_{bl} is the speed shear over the depth of the boundary layer, i.e., $\Delta S_{\mathrm{bl}} = S_{\mathrm{tb}} - S_{\mathrm{ts}}$ where S_{tb} and S_{ts} are the speeds at the top of the boundary layer and the top of the surface layer, respectively. ΔZ_{bl} is the depth of the boundary layer, i.e., $\Delta Z_{\mathrm{bl}} = Z_{\mathrm{tb}} - Z_{\mathrm{ts}}$ where Z_{tb} and Z_{ts} are the top of the boundary layer and the top of the surface layer heights, respectively (see BL_HGT and SL_HGT in Section III.B.5.). $\Delta'\theta_{\mathrm{bl}}$ is the direction difference over the depth of the boundary layer. This difference depends on θ_{tb} and θ_{ts}, the directions at the top of the boundary layer and the surface layer, respectively, and θ_{r} (see MAX_VEER_PARAM_VERT in Section III.B.5.) according to the following recipe:

$$\Delta\theta = \theta_{\mathrm{tb}} - \theta_{ts}\ . \tag{II.C.5}$$

IF $\theta_{\mathrm{r}} - 360^{\circ} \leq \Delta\theta \leq \theta_{\mathrm{r}}$, then $\Delta'\theta_{\mathrm{bl}} = \Delta\theta$;
if $\Delta\theta < \theta_{\mathrm{r}} - 360^{\circ}$, then $\Delta'\theta_{\mathrm{bl}} = \Delta\theta + 360^{\circ}$,
if $\Delta\theta > \theta_{\mathrm{r}}$, then $\Delta'\theta_{\mathrm{bl}} = \Delta\theta - 360^{\circ}$.

The assignment of a value to θ_{r} causes wind directions to veer with height if the directional shear, determined in the clockwise sense, is less than θ_{r} ; it causes wind directions to back with height if the clockwise shear is greater than θ_{r}. Equations (II.C.4a) and (II.C.4b) are evaluated at the heights of all the grid points within the boundary layer. When the entire process described above is completed for every column of grid points in the grid, the extrapolation volume is ready to be examined by the assessor. The assessor can adjust the parameters in the extrapolation

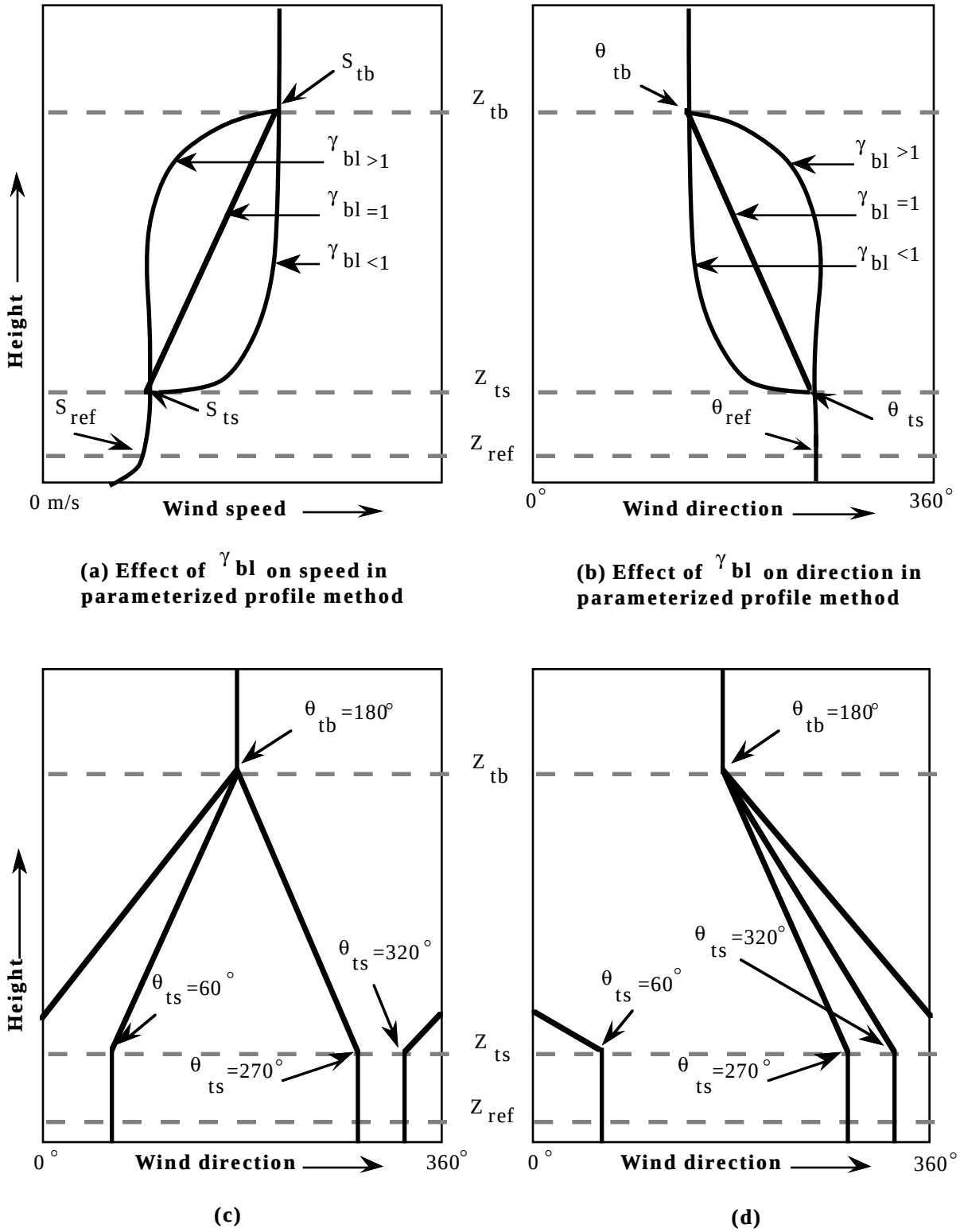


Fig. II.C.7. Effect of (c) θ_r = 240˚ and (d) θ_r = 100˚ on various values of θ_{ts} in parameterized profile method.

$(Z_{srh}, Z_{ref}, Z_{ts}, Z_{tb}, \gamma_{sl}, \gamma_{bl},$ and $\theta_r)$ if the extrapolated field does not provide a reasonable picture of the atmosphere. The effects of two of the parameters, γ_{bl} and θ_r are shown in Figs.II.C.7a-d.

As mentioned previously, the parameterized extrapolation method is normally used only in the absence of acceptable upper air data. When upper air data is unavailable for a site, an estimate of the upper level winds must be supplied. A reasonable evaluation of the wind speed and direction might be extracted from synoptic charts for an appropriate height. If no other basis can be found for a selection, climatological data might be helpful in providing an estimate. If a recent, nearby upper air sounding is available, then the profile extrapolation method should be used because this procedure takes greater advantage of the available information.

II.C.2.c. Profile Extrapolation

The Profile Method of extrapolation provides a mechanism for the controlled melding of surface and upper air wind observations controlled by the same variables used in the parameterized method, although some of the variables are used in slightly different ways. It is assumed that surface observations provide the most reliable picture of the actual winds in the lower levels of the atmosphere and should be weighted more heavily than upper air observations in any interpolation scheme since the density of surface stations is almost always much higher than the density of upper air stations. For a typical vertical grid dimension, an upper air sounding provides the best wind information for extrapolation near the top of the grid, while at intermediate grid point levels, the relative importance of the surface and upper air observations will vary with the meteorological conditions. It is also assumed in this method that the “shape” of a measured profile, i.e., its general features, can be applied to different locations in a region, even if the actual speed and direction values at a given level do not match those for the other positions.

Three main steps are required in the profile extrapolation method. First, a wind speed and direction derived from the surface observations must be assigned to each column of grid points in the CG-MATHEW grid at a level near the bottom of the extrapolation grid. Next, each grid point in a column is assigned speed and direction values which are derived entirely from the upper air soundings, i.e., a profile is synthesized for each grid point column from the upper air data alone. Finally, the surface wind is combined with the synthesized profile to give an extrapolated wind at each grid point in the column. The surface and upper air components are weighted differently at different heights, with the weighting being controlled by various user-defined parameters. This scheme is illustrated in Fig. II.C.8.

The near surface wind at the reference height Z_{ref} is generated from surface observations using the same procedure as in parameterized extrapolation. For grid points below Z_{ref} the wind speed is found according to Eq. (II.C.3) and the slip velocity is found by applying Eq. (II.C.3) at the surface roughness height.

A synthesized profile is created along the column of grid points by inverse square extrapolation of the nearest upper air observations at the same height (Eq.II.C.2). It consists of wind speeds and

directions for each grid point in the column $S_{syn}(Z)$ and $\theta_{syn}(Z)$, as well as for the reference level Z_{ref}, the top of the surface layer (Z_{ts}), and the top of the boundary layer (Z_{tb}).

In general, the near-surface wind speed derived from the surface data will not match the wind speed at the same level derived from upper air data. Based on the difference between these wind speeds, MEDIC calculates a height-dependent correction term, which is added to the synthesized profile value at each grid point in the column. The correction term is:

$$C_s(Z) = \frac{-\Delta S_{ref}}{Z_{tb} - Z_{ref}}(Z - Z_{ref}) + \Delta S_{ref} \text{ for } Z_{ref} \le Z < Z_{tb} \quad , \tag{II.C.6a}$$

$$C_s(Z) = 0 \qquad \text{for } Z \ge Z_{tb} \quad , \tag{II.C.6b}$$

where Z_{tb} and Z_{ref} are the heights of the top of the boundary layer and at the reference level, Z is the height above terrain of the point under consideration, and ΔS_{ref} is the discrepancy between the reference level wind speed and the speed from the synthesized profile at the same height, i.e., $\Delta S_{ref} = S_{ref} - S_{syn}$ at Z_{ref}. The extrapolated wind speeds for grid points in the column are given by:

$$S(Z_k) = S_{syn}(Z_k) + C_s(Z_k) \qquad \text{for} \qquad Z_k \ge Z_{ref} \tag{II.C.7}$$

where Z_k is the height of the grid point of interest. From examination of Eqs. (II.C.6) and (II.C.7), it can be seen that when $Z = Z_{ref}$, then $C_s(Z_{ref}) = \Delta S_{ref}$ and $S(Z_{ref}) = S_{ref}$. When $Z \ge Z_{tb}$, then $C_s(Z) = 0$ and $S(Z) = S_{syn}(Z)$. The correction term varies linearly between Z_{ref} and (Z_{tb}), and goes to zero at the top of the boundary layer, above which the extrapolated profile remains the same as the synthesized profile. A sample extrapolation for a column of points is shown in Fig. II.C.8.

The directional extrapolation procedure is somewhat more complicated than that for the speed. Upper air observations have no effect on the surface layer. Therefore, since there is no directional shear in the surface layer, the reference level direction, θ_{ref}, is used for all grid points below Z_{ts} (it is always assumed that the reference height is within the surface layer). The effect of upper air soundings begins at the top of the surface layer and increases with height in the boundary layer until they completely dominate in the geostrophic regime (above Z_{tb}). The directional shear in the intermediate boundary layer is controlled by the same parameters as in parameterized extrapolation (γ_{bl} and θ_r). The correction term is related to the difference between the synthesized direction (from upper air data) and the reference level direction (from surface data), evaluated at the top of the surface layer. (The reference level direction is used throughout the entire depth of the surface layer.) The correction term for direction is given by:

$$C_\theta(Z) = \frac{\Delta'\theta}{(\Delta Z_{bl})^{\gamma_{bl}}}(Z - Z_{ts})^{\gamma_{bl}} - \Delta'\theta_{ts} \text{ for } Z_{ts} \le Z < Z_{tb} \quad , \tag{II.C.8a}$$

$$C_\theta(Z) = 0 \qquad \text{for} \qquad Z \ge Z_{tb} \quad , \tag{II.C.8b}$$

where ΔZ_{bl}, Z_{tb}, Z_{ts}, and γ_{bl} have the same definitions as in the parameterized method, Z is the height of the point under consideration, and $\Delta'\theta_{ts} = \theta_{syn}(Z_{ts}) - \theta_{ts}$ is the direction discrepancy at

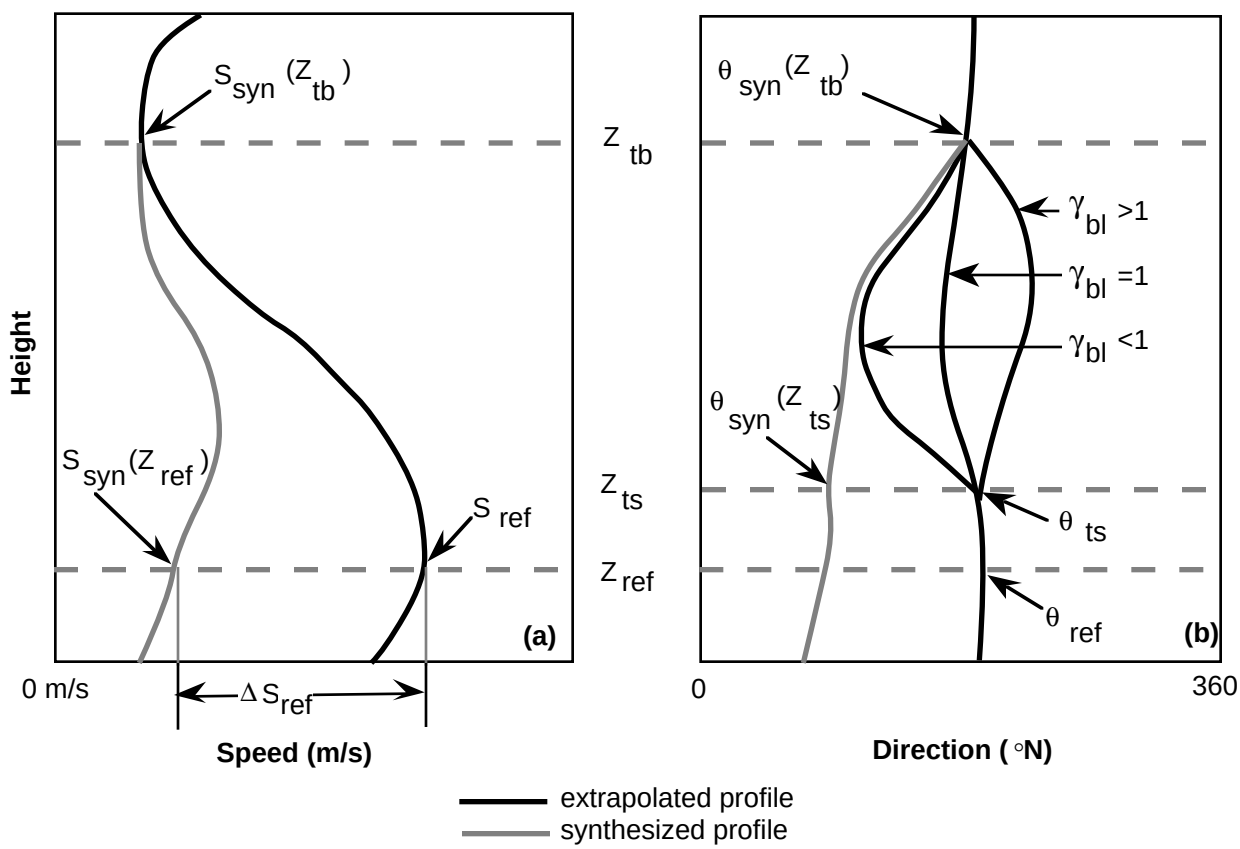


Fig. II.C.8. Examples of (a) speed and (b) direction extrapolation (as a function of γ_{bl}) using the profile method.

the top of the surface layer between the surface observations and the profile synthesized from the upper air data. The sense of how this discrepancy is resolved (via backing or veering) is controlled by θ_r in a manner analogous to Eq. (II.C.5), except that $\Delta\theta = \theta_{syn}(Z_{ts}) - \theta_{ts}$. It is important to note that θ_r in the profile method is used for comparing angles at the top of the surface layer, while θ_r in the parameterized method is used to compare angles at two different vertical levels (the extremes of the boundary layer). The extrapolated winds for grid points in the column are given by

$$\theta(Z_k) = \theta_{syn}(Z_k) + C_\theta(Z_k) \qquad \text{for} \qquad Z_k \geq Z_{ts} \ , \qquad \text{(II.C.9)}$$

where Z_k is the height of the grid point of interest. From examination of Eqs. (II.C.8) and (II.C.9), it can be seen that $\theta(Z_{ts}) = \theta_{ts}$ and $\theta(Z_{tb}) = \theta_{syn}(Z_{tb})$. The correction term varies between Z_{ts} and Z_{tb} as a function of γ_{bl}. If $\gamma_{bl} = 1$, then the influence of the surface observations goes linearly to zero at the top of the boundary layer. If $\gamma_{bl} \gg 1$, the influence of the surface observations is maintained throughout most of the boundary layer before vanishing at the top. If $\gamma_{bl} \ll 1$, then the upper air data dominate the surface observations through most of the boundary layer. The effects of selected choices for γ_{bl} (0.5, 1.0, 2.0, 5.0) are shown in Fig. II.C.8.b. When the process described above is completed for each column of points in the extrapolation grid volume, these winds can be examined by the assessor. As in the parameterized case, all the user-defined parameters in the

process are available for adjustment if the extrapolated wind field fails to give an acceptable description of the atmosphere.

II.C.2.d. Terrain Incorporation

In both methods the final products are grids of *u*- and *v*-component winds The extrapolated wind arrays are transformed to the CG-MATHEW grid volume by the incorporation of terrain which is controlled by the TERRAIN_ADJUSTMENT variable. If set to 'N' (the default for hemispheric MEDIC), the winds are zeroed up to the terrain level, defined as the highest of the (usually four) cell-centered terrain levels adjacent to a grid point column.as generated by TOPOG. If TERRAIN_ADJUSTMENT is set to 'Y' (the default for regional MEDIC), each column of grid points is shifted upwards by the number of grid points along the column that are at, or below, the block terrain surface in the CG-MATHEW grid volume. Slip velocities are then assigned along vertical faces of the terrain surface using the *u*- and *v*-components of the slip velocity at the bottom of the extrapolation grid volume. Components that are tangential to a vertical terrain surface are assigned to the related grid point unless, at the same point, the component is normal to another vertical terrain surface. Once terrain incorporation has been performed, the winds are ready to be passed to CG-MATHEW.

II.C.2.e. Gridded wind fields

Gridded metdata from several different sources may be used. The table below lists these sources and the MEDIC_PARAMS namelist parameters used to access the data. Note that there are additional parameters in MEDIC_CONTROL for each gridded data source that control the graphics output.

Gridded Metdata	Parameters that Control Input of This Data
AFGWC Northern Hemisphere	NHEDATE, NHETIME, NHEFCST
AFGWC Southern Hemisphere	SHEDATE, SHETIME, SHEFCST
FNMOC's NODDS or 2.5-deg NOGAPS	NODDSDATE, NODDSTIME, NODDSFCST
FNMOC's 1-deg NOGAPS	NOGAPS10DATE, NOGAPS10TIME, NOGAPS10FCST, NOGAPS10THINRES
ARAC's version of NORAPS	ARAC3OBSDATE, ARAC3OBSTIME, ARAC3OBSFCST, ARAC3OBSNEST
ATMES variety of ECMWF (GribFM92 format)	ATMESDATE, ATMESTIME, ATMESFCST
ETEX variety of ECMWF	ECMWFETEXDATE, ECMWFETEXTIME, ECMWFETEXFCST
RWM	RWMDATE, RWMTIME, RWMFCST

Upper air data available in the form of AFGWC gridded metdata files can be used by MEDIC. The AFGWC files contain analysis or forecast data and cover either the northern or southern

hemisphere to within 20 degrees of the equator. The upper air metdata are in the form of u- and v-component gridded winds on constant pressure surfaces. The AFGWC grids are dimensioned 47 by 51 by 15. MEDIC outputs tables of the valid wind data for each AFGWC file input.

Gridded metdata from the Fleet Numerical Meteorological and Oceanographic Center's (FNMOC) Navy Operational Global Atmospheric Prediction System (NOGAPS) can also be used by MEDIC. Currently both the 2.5-degree and the 1-degree data arrive routinely via the internet, are automatically processed, and are available for use by MEDIC without any additional processing. The 2.5-degree data can also be retrieved using the Navy Operational Data Distribution System (NODDS), in which case special interim procedures must be used to prepare the data for use in MEDIC. The controlling variables are the same as for the NODDS input and are used in the same way. To help thin out the amount of 1-degree data to be read in by MEDIC (and therefore decrease model run time), the NOGAPS10THINRES parameter is available.

Gridded output from ARAC's version of the Navy Operational Regional Atmospheric Prediction System (NORAPS) can be read as a source of gridded metdata by MEDIC. The transfers use the ARAC-3 netCDF observational metdata data format (this will be extended to the ARAC-3 gridded metdata format as soon as that is defined). The control variables are ARAC3OBSDATE, ARAC3OBSTIME and ARAC3OBSFCST,. Please see the MEDIC_PARAMS section for more information, as there are key differences between these variables and the variables for NODDS, NHE and SHE data. An additional control variable is required to select the nest to be used. ARAC3OBSNEST is an integer that must equal 1, 2 or 3 with 1 indicating the main grid.

Gridded fields from ECMWF for both the ATMES (Atmospheric Transport and Model Evaluation Study) assessment and ETEX (European Tracer EXperiment) assessment can be read into MEDIC. The ATMES data files for the time of the Chernobyl release (25-Apr-86 to 10-May-86) are kept in a special directory, and the ETEX data files currently need to be in the model run directory.

MEDIC utilizes the gridded data as multiple upper air profiles, one for each grid point of gridded data. The only thing that limits the number of multiple sources of gridded data is the total number of upper air profiles dimensioned in MEDIC; this limit is currently 40,000 gridded profiles with up to 60 levels, as well as 40,000 surface data points. If no separate surface data is available, use of the MEDIC_PARAMS parameter USE_UPR_AT_SFC will allow the lowest level of each upper air profile to be used as surface data.

II.C.2. Hemispheric MEDIC (HMEDIC)

The hemispheric version of MEDIC is built on a 47 by 51 by 15 grid to match the AFGWC grids using a polar stereographic projection. Winds input from AFGWC upper air data (see Section II.C.2.e) are linearly interpolated to the hemispheric computational grid and the appropriate map projection correction is applied. At least two pressure levels of u- and v- data must be present for continued processing of the AFGWC winds from a given file. Otherwise a warning is printed and the

code skips to the next data set. Terrain may be incorporated by zeroing winds up to, but not including, the terrain surface (see Section II.C.2.d).

While the hemispheric version of MEDIC will only utilize the gridded metdata from AFGWC, the regional version of MATHEW/ADPIC can utilize metdata from a variety of combinations of different sources, including AFGWC gridded metdata, as well as FNMOC gridded metdata. Therefore, with the use of a generalized map projection capability, it is now possible to use the "regional" MATHEW/ADPIC models to model any area from a few kilometers up to global scale. It is expected that the special hemispheric version of the MATHEW/ADPIC models will cease to be utilized by ARAC Operations in the near future, since with the appropriate map projection, and the right input parameter defaults for the various scales, the "regional" version has as much capability and much more flexibility than the hemispheric version.

II.C.3. PLCNT

PLCNT is a code for processing the concentrations produced by ADPIC. The ADPIC output is passed to PLCNT in CONC*.BIF (see Section III.C.10), a file that contains one concentration grid set for each sample bin in ADPIC. A concentration grid set includes a main grid, matching the ADPIC advection grid, along with up to five nested grids each with a dimension equal to one half the main grid and a grid step also equal to half the main grid step. A CONC*.BIF file is created at each ADPIC output time, where the output interval is specified by SAMPLING_INTERVAL.

Concentrations can be sampled at specified heights above the surface in six ways: instantaneous, time-integrated, time-averaged, peak-air, total deposition, and integrated deposition (hybrid particle mode only). (Also see Section II.B.4.o "Output" for a description of the various sampling types.) Various conversion factors may be specified for each of the sampling bins, including units conversions factors (i.e., g/m3 to ppm) as well as radiological dose conversions (i.e., dose to a particular organ via a particular pathway).

To produce a desired plot, the user must appreciate the interplay between certain parameters in ADPIC and PLCNT. The critical parameters in ADPIC are SOURCES_TO_SAMPLING_BIN (the sources to be associated with a sampling bin, by number), SAMPLING_TYPE (the type of concentration sampling), and SAMPLING_HGT (the sampling height for integrated and instantaneous air sampling). These arrays are all dimensioned maxsbins (currently 30) with corresponding elements of each array referring to one of the concentration grid sets (i.e. a main grid and up to four nested grids) that define a sampling bin in ADPIC. Thus, the first element of SOURCES_TO_SAMPLING_BIN indicates which of the MAXSOURC sources is to be considered in the first ADPIC bin; the first element of SAMPLING_TYPE indicates the sampling type for the first ADPIC sampling bin; the first element of SAMPLING_HGT indicates the height above terrain at which the first ADPIC sampling bin is to be placed. The second elements of each array describe the second sampling bin, and so on.

PLCNT can be thought of as having a dose or units conversion function and a contour plotting function. The three parameters that control the dose conversion and bin combinations are SAMPLING_TO_DOSE_BIN, DCON, and DOSE_TO_FINAL_BIN, which are contained in the CONC_ANALYSIS.NML file. The first two parameters allow the user to combine bins to produce combined nuclide dose plots (e.g., combined dose from multiple nuclides or multiple hybrid sources), and to re-use bins to produce different contour plots from the same ADPIC sampling bin (e.g., thyroid dose and effective WB dose derived from integrated air concentration). SAMPLING_TO_DOSE_BIN specifies how the sampling bins are to be assigned to the dose bins; DCON specifies the dose conversion factors and/or scaling factors to be applied to the dose bins (also see description for DCON in Section III.A.8); DOSE_TO_FINAL_BIN specifies how the dose bins are to be assigned to the final bins. Examples and their translations are shown in Fig. II.C.9.

A	SPECIES	='I-131'	'Kr-88'	'Pu-239'		
	SOURCES_TO_SAMPLING_BIN(1,1)	=1				
	SOURCES_TO_SAMPLING_BIN(1,2)	=2				
	SOURCES_TO_SAMPLING_BIN(1,3)	=3				
	SAMPLING_TYPE	='INTAIR'	'INTAIR'	'INTAIR'		
	SAMPLING_HGT	=1.5	1.5	1.5		
B	SAMPLING_TO_DOSE_BIN	=1	1	2	3	3
	DCON	=3.60E2	7.63	3.65E-1	1.13E5	3.96E5
C	DOSE_TO_FINAL_BIN(1)	=1				
	DOSE_TO_FINAL_BIN(2)	=2	3	4		
	DOSE_TO_FINAL_BIN(3)	=5				

Translation of A:

Sampling bin #1 will contain integrated (at 1.5m height) air concentration of I-131 source.
Sampling bin #2 will contain integrated (at 1.5m height) air concentration of Kr-88 source.
Sampling bin #3 will contain integrated (at 1.5m height) air concentration of Pu-239 source.

Translation of B:

Dose bin #1 will contain sampling bin #1 converted to I-131 Thyroid dose via inhalation.
Dose bin #2 will contain sampling bin #1 converted to I-131 Effective WB dose via inhalation.
Dose bin #3 will contain sampling bin #2 converted to Kr-88 Effective WB dose via immersion.
Dose bin #4 will contain sampling bin #3 converted to Pu-239 Effective WB dose via inhalation.
Dose bin #5 will contain sampling bin #3 converted to Pu-239 lung dose via inhalation.

Translation of C:

Final bin #1 will contain dose bin #1 (data for thyroid dose plot from I-131).
Final bin #2 will contain dose bins #2, #3, #4 (data for Effective WB dose plot for three nuclides).
Final bin #3 will contain dose bin #5 (data for lung dose plot from Pu-239).

Fig. II.C.9. Example of interplay between ADPIC and PLCNT parameters to produce desired types of plots.

The times of contour plot generation are determined by defining one or more plot series for each final bin of interest. A plot series has a beginning and an ending point in time along with a time step that specifies how ofter a plot is to be generated. The first plot is produced at the beginning of the plot series (which must match the time of a CONC*.BIF file) and subsequent plots in the series are produced at equal intervals after that until time steps beyond the end of the plot series. In the case of interval integrated air plots, an integration step may be specified that may be less than the plot step. In such cases. the integrated plot will include concentrations beginning one integration step before the end of the current plot step, and thus, the integration period will end at the time of the next plot. Plot series are started with the variables PLOT_START_DATE/TIME and explicitly ended with PLOT_END_DATE/TIME. If a PLOT_END_DATE/TIME is not specified then the current plot series is ended when another plot series for the same final bin begins or by the end of the available

concentration data in the series of CONC files. The plot step is specified by PLOT_STEP and the integration step by INTEGRATION_STEP. All these variables are described in more detail in Section III.B.9.

PLCNT allows the user to select up to maxcontlevel (currently 5) contour levels using the CONTOUR_LEVELS variable (see Section III.B.9). PLCNT will also generate contour levels in the absence of user-specified values. The code will select the largest value of the form 1.0En or 3.0En that is lower than the highest grid point concentration value for a given final bin (if HALF_POWER_OF_10 is set to 'N' only values of the form 1.0En will be selected). This becomes the value of the innermost contour. For example, if the maximum grid point concentration is 6.9E8, then the innermost contour will be 3.0E8. If the maximum grid point concentration is 2.4E8, then the innermost contour will be 1.0E8. Up to four more contours, each decreasing by an order of magnitude, are then computed to fill out the maximum desired number of contours (specified by MAX_CONTOURS). The above example strictly applies only if no restrictions are made on the minimum area to be covered by the maximum contour. (See the description of MIN_CONTOUR_AREA in Section III.B.9 for more information). If the user selected contour values but the concentrations are too small to produce a contour with area greater than MIN_CONTOUR_AREA, then PLCNT will optionally compute contours based on the maximum concentration (see RECOMPUTE_USER_CONTOURS and NUM_RECOMPUTED_CONTOURS in Section III.B.9).

ADPIC produces concentrations at grid points. PLCNT smooths the values maintained in the final bins along the edges of the nested grids, thereby incorporating some influence of the values in the coarser grid surrounding the nest. This avoids almost all discontinuities in the contour lines when they cross nest boundaries. This smoothing is not required for the X-Windows versions concentration plotting codes and therefore the site workstation products are written from the final bins before these bins are smoothed.

Since ARAC provides a service to more than one customer, and each customer has slightly different needs, limited flexibility of plot layout has been allowed for, primarily focused on the lower half of the plot legend. In addition, the exact wording contained in almost all of the legend is also under user control. The layout and wording of the contour plot is controlled by a multitude of parameters. Figs. II.C.10, II.C.11, and II.C.12 show examples of three of the more common layouts and the values of the PLCNT parameters which control the resulting appearance.

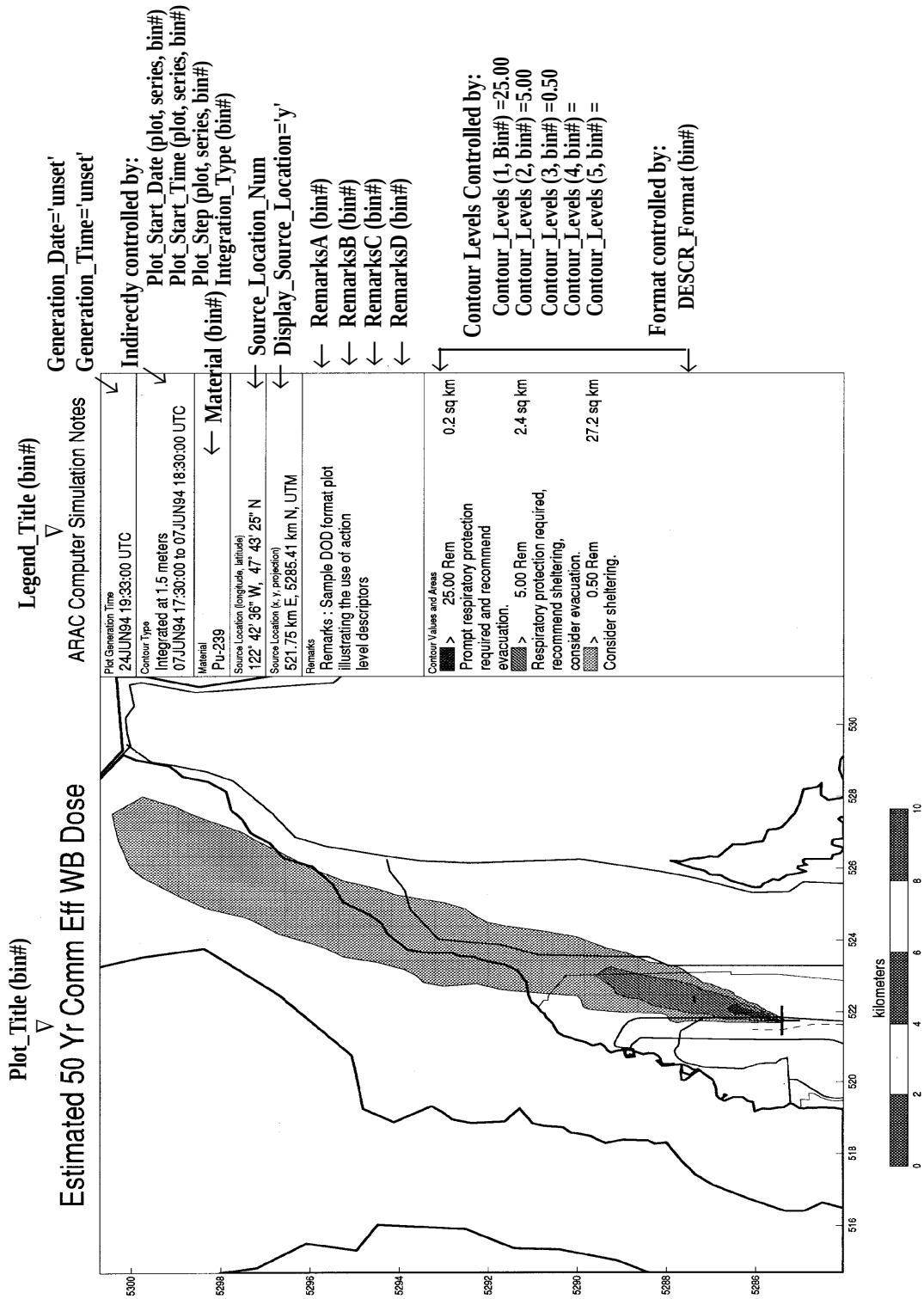


Fig. II.C.10. Example of plot layout for DOD plots and PLCNT parameters which control the layout and wording.

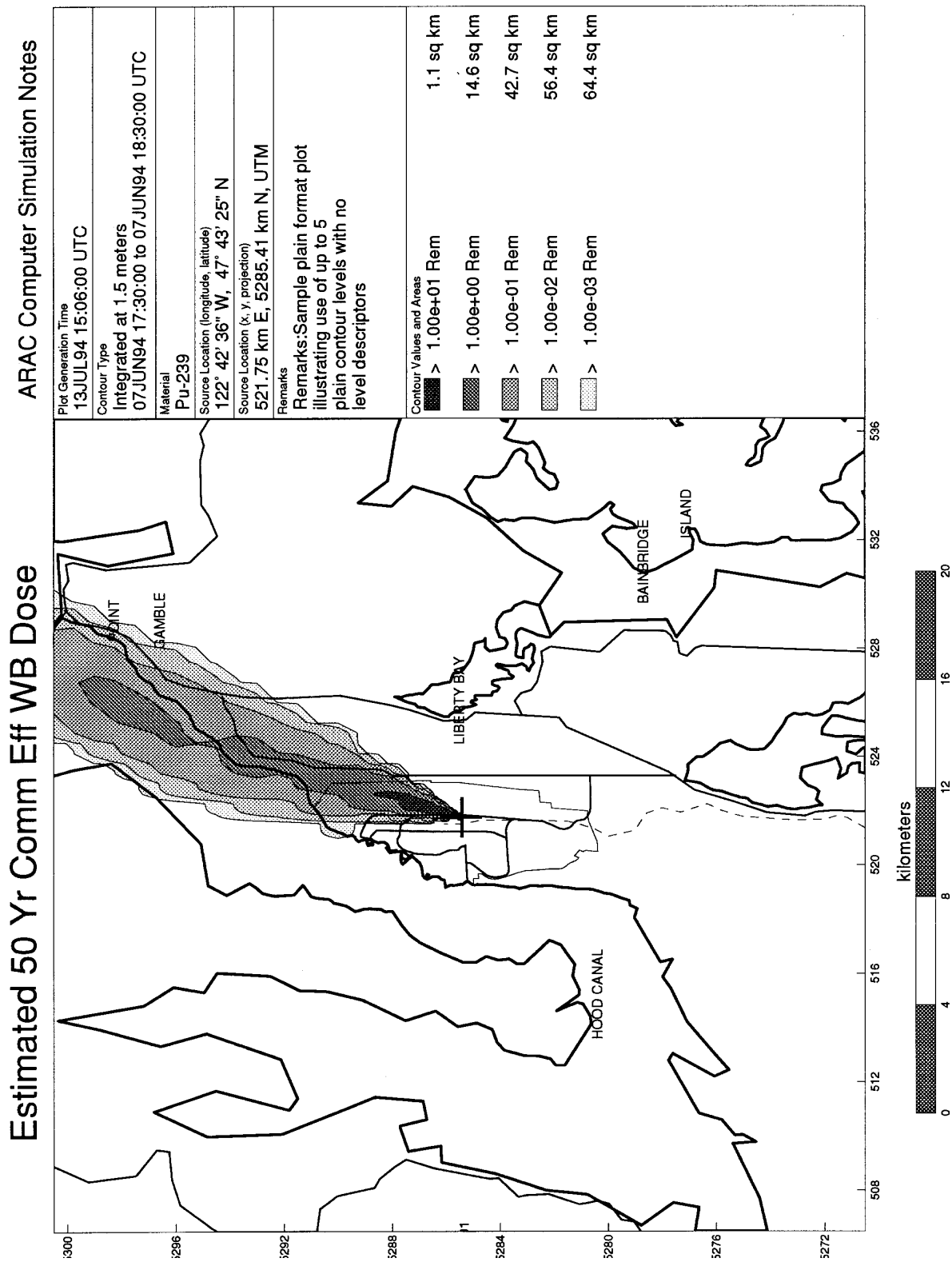


Fig. II.C.11. Example of plot layout for plain plots and PLCNT parameters which control the layout and wording.

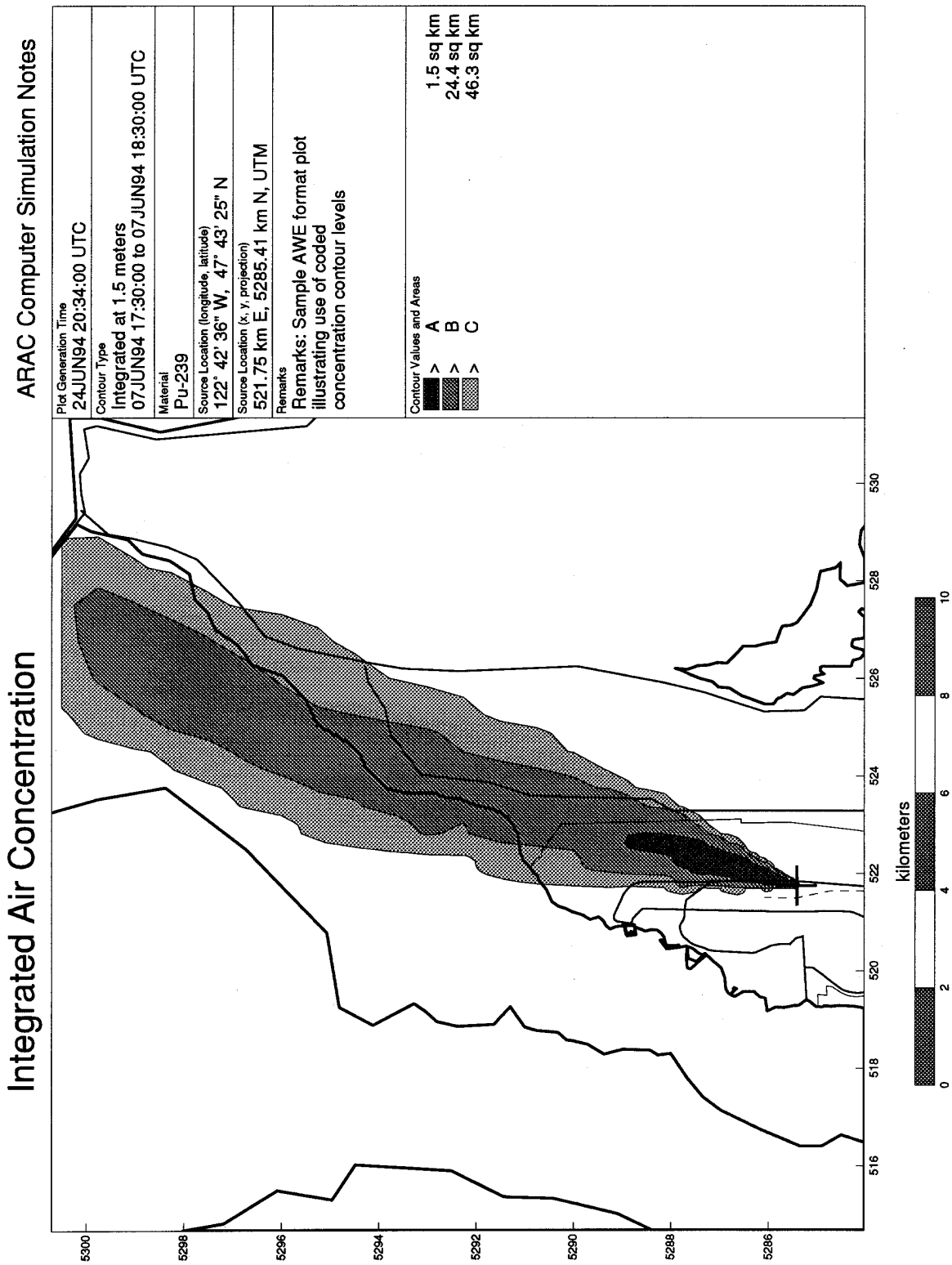


Fig. II.C.12. Example of plot layout for AWE plots and PLCNT parameters which control the layout and wording.

The ability to specify the area to blow up (or "window") for plotting is provided by the XMIN_WINDOW, XMAX_WINDOW, YMIN_WINDOW, and YMAX_WINDOW parameters. These four parameters specify the coordinates of the area to be blown up. Be aware that the areas specified in the legend of a blown-up plot refer to the areas covered by the contours in the original-size plot.

The ability to automatically generate a mosaic of subplots covering a specified area at a specified scale is provided by the following parameters: MAP_SCALE_FLAG, MAPSCALE, SOURCE_OCTANT, BLOWUP_SOURCE, PLOT_SIZE_CM. Up to 225 subplots (15 by 15) can be generated for a specified scale and output device. The placement of the ADPIC source location in the subplot containing it is controlled by SOURCE_OCTANT. The area to be split into subplots can be narrowed down by use of the blowup parameters mentioned in the previous paragraph.

The centerline capability of PLCNT starts at a user-specified ADPIC source location and searches along arcs of increasing radius for the maximum along each radial arc. The resultant series of maxima, along with their locations are available in tabular format in the CENLINE*.DAT file, and the locations are plotted on each Site Workstation plot. All centerline parameters are contained in the CONC_ANALYSIS_CONTROL namelist: CENTERLINE_SOURCE is the only required parameter; optional parameters include RADIAL_STEP_FACTOR, FULL_SEARCH_FACTOR, ANGLE_WIDTH_FACTOR, SECTOR_ANGLE_MIN, and SECTOR_ANGLE_MAX.

II.C.4. TIMEHIS

The Time History (TIMEHIS) code is an offspring of the PLCNT code. Concentration values are bilinearly interpolated for specific point locations. The times of the interpolations are controlled in the same way as in PLCNT and are tabulated in the TIMEHIS.LOG file as well as be plotted on a semi-log plot (log concentration vs. time). The number of data points per plot is controlled by the TIMESTEPS_PER_PLOT parameter. Interpolated points with values of zero are considered to be 1.0e-30 by the plotting routine so those values are plotted off scale to the bottom of the logarithmic vertical scale of the time history plot.

If actual measurement values are available, these values can also be input via the MEASUREMENTS section of the SAMPLER.DATA file, and appear on the plots along with the model-calculated values for the specified locations and times. Some additional statistics, based on the most straightforward ones used in the ATMES study, are also performed to compare the computed and measured concentrations. In addition to the TIMEHIS.LOG, which contains listings of the same time history data that is plotted, TIMEHIS produces two other ASCII files: SAMPOUT.DAT and STATS.DAT. SAMPOUT contains the interpolated value at each point along with the minimum and maximum point concentrations found within angles of various sizes (hit angles) of the main interpolation point. That is, concentrations are interpolated at a grid of points (currently 11 by 11)

ranging from -*dtheta* to +*dtheta* about angle *theta* and -*dtheta***radius* to +*dtheta***radius* centered on (*radius*,*theta*) where *radius* and *theta* are the polar coordinates of the main interpolation point with respect to a user selected source location and *dtheta* is specified hit angle (see HIT_ANGLE and STATISTICS_SOURCE in Section III.B.11.d). These minima and maxima are compared against measurements and if the measurement lies between the two values it is considered an exact match at that angle. The smallest hit angle is considered to be zero so the main point interpolated value is found listed in the first entry in the hit angle table (the minimum and maximum will always be the same for this entry). The STATS.DAT file contains the hit angle statistics along with some other simple statistics based on those used in ATMES.

II.D. MATHEW/ADPIC Validation and Evaluation

Because of the expense in computer time, the complexity of the three-dimensional transport and diffusion models, and the ensuing large number of variable parameters involved, no comprehensive error analysis of MATHEW/ADPIC has yet been undertaken. However, a number of tracer validation studies have been conducted and others are still in progress.

The ADPIC code using the RDM was validated against analytic solutions to the advection-diffusion equation (Ermak *et al.*, 1995) for both homogeneous and inhomogeneous turbulence. Numerical error was found to be less than 5% in these comparisons to analytic solutions. Over the last twenty years the MATHEW/ADPIC codes were also evaluated against numerous field tracer release experiments conducted under a variety of meteorological and topographical conditions (Foster and Dickerson, 1990). Recent work indicates that these evaluations are still representative of errors that can be expected when the RDM option in ADPIC is used. Neutrally buoyant tracers released both as surface and elevated point sources have been studied. A summary of the results is shown in Fig. II.D.1.

The results show that the MATHEW/ADPIC models generally estimate the tracer air concentrations to within a factor of two of the measured values 20% to 50% of the time, and within a factor of five of the measurements 35% to 85% of the time depending on the complexity of the meteorology and terrain, and the release height of the tracer. These results are achieved without "tuning" the model to any given site, type of source, or sampling method.

A consensus has emerged as to the degree of model sensitivity toward certain important input variables. The key input data and parameters affecting the quality of MATHEW/ADPIC results, in order of decreasing importance, are:

Wind direction. A difference of 10 degrees in wind direction can have a substantial effect on the agreement of model concentrations with individual sampler measurements. This is especially true on small horizontal scales (e.g., 10 km). Errors in model calculations are commonly caused by the lack of a sufficiently representative meteorological (wind) measurements over the model domain. Also, we must contend with the fact that the NOAA and FAA only report wind directions to the nearest ten degrees.

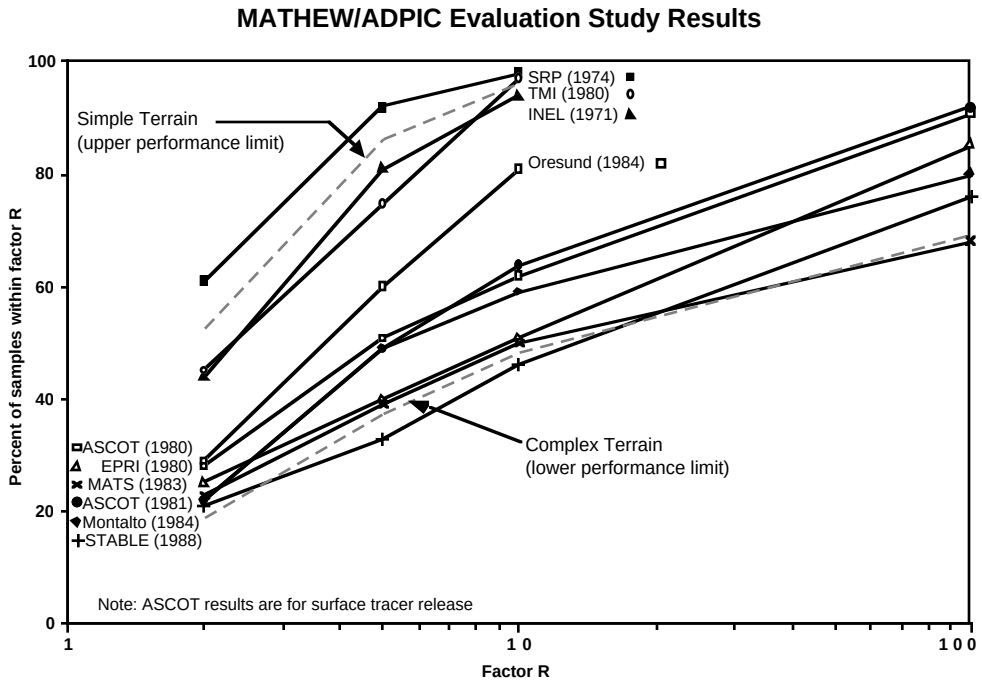
Topography. There is close interaction between topography and the wind field, especially near the surface. Because of the limitations on the number of computational cells available, the resolution of important topographical features, such as riverbeds, ridges, and canyons, is frequently poor. This is most severe in complex terrain situations and under stable atmospheric conditions.

Turbulence parameters. Most turbulence parameters are semi-empirical, even for homogeneous turbulence. To describe the variation of turbulence parameters in space and time for all but the most trivial atmospheric conditions is very difficult. Factors of two to five in concentration

differences computed by MATHEW/ADPIC can appear because of uncertainties in turbulence parameters.

Wind speed. While much less likely to produce errors than the wind direction, the wind speed can, nevertheless, produce errors of factors of two quite easily. Model errors due to wind speed are harder to detect because they are difficult to separate from errors caused by the turbulence parameterization.

Source strength. In controlled experiments the source strength is generally well known; however, in accident situations this is not always true. During an emergency response to an accident, the uncertainty of the source term and the properties of the source material can introduce significant errors into the model results.



STUDY	YEAR	LOCATION	TOPOGRAPHY	ATMOSPHERIC STABILITY	RELEASE HEIGHT
INEL	1971	Idaho Falls, ID	Flat-Rolling	Unstable	Surface
SRP	1974	Aiken, SC	Flat-Rolling	All	Surface, Elevated
ASCOT	1980	The Geysers, CA	Complex	Stable	Surface, Elevated
ASCOT	1981	The Geysers, CA	Complex	Stable	Surface, Elevated
TMI	1980	Harrisburg, PA	Flat-Rolling	All	Elevated
EPRI	1980-1	Kincaid, IL	Flat	All	Elev + Plumerise
Øresund	1984	Oresund Strait, Denmark/Sweden	Flat-Rolling	Neutral (spatially transitional)	Elevated
MATS	1983	Aiken, SC	Flat-Rolling	Neutral, Unstable	Elevated
Montalto	1984	Italy	Flat-Rolling	Unstable	Surface, Elevated
STABLE	1988	Aiken, SC	Flat-Rolling	Stable	Elevated

Fig. II.D.1. Percentage of cases in which MATHEW/ADPIC results are within a factor N of field data.

III. User's Guide

III.A. ARAC Models File System and Flowcharts

Two classes of information need to be passed along the ARAC model sequence. First, the major results of each model must be passed to the next model, mainly as various arrays of data (e.g., model elevations, winds, concentrations). Second, parameters used by one model that are needed by subsequent models for purposes of processing and labeling. There is also a need to maintain a record of the information used in a given model execution to support precise analysis and debugging, i.e., a traceback capability is necessary. The ARAC models file system provides for these three requirements. This section will discuss the file system (both naming conventions and content) which allows the ARAC models to handle these three functions.

The first component of the file system is the (invisible) TraceBack Block (TBB) that appears at the beginning of every file used to pass data between models. It consists of directory and file names that indicate the data files used to generate the associated model results contained in the remainder of the file. For this traceback function to work, each file referenced by the TBB must be uniquely named. These unique names include qualifiers and sequence numbers as described later. The input files indicated may also be read by subsequent models as the source of any parameters required for that model's execution. Thus the only data transferred via binary intermodel files (BIFs) are actual model results. The exception is grid/topography data produced by TOPOG. This information will be read by all the models to define the grid geometry and so occupies a unique place with respect to the rest of the models. The grid definition file (TOPOG*.GRID) contains the grid parameters as well as the model topography cell heights (here we use a convention convenient in discussing these uniquely qualified files: TOPOG*.GRID means all qualified files beginning with TOPOG and ending with the suffix .GRID. Similarly, *.NML means all files which end with the suffix .NML; in addition to files that are required to be uniquely names to support traceback, some other types of files also conform to this convention for consistency, e.g., *.CGMB files). Due to its central place in the model scheme and its small size the TOPOG*.GRID file is maintained in ASCII and can be viewed like any other such file.

Each model is controlled by a namelist file (*.NML) which contains the parameters controlling the model run. These files are read by the appropriate model from generically named files (e.g., TOPOG.NML, MEDIC.NML) after which the information is rewritten to a uniquely named completed namelist file (*.CNML) that will contain the values of all variables in the namelist (including data-loaded defaults) in a namelist-readable format. Subsequent models read these CNML files as needed. Almost all output files contain one data set per file. That exception is the *.LOG files which are intended to record a log of a particular model run and not remain as part of the files documenting the run. *.LOG files have version numbers to distinguish them, but one the ARAC VMS systems multiple files of the same name and a different version number are purged on a frequent basis. Thus, uniquely named files survive a system initiated purge while *.LOG files do not. A single ADPIC run generally processes a number of MEDVEL/MATVEL files. To document this, a file listing

the MEDVEL/ MATVEL files used during the creation of a specific concentration output file (CONC*.BIF) in generated (CONC*.VLST) to pair with it. Similarly, PLCNT and TIMEHIS write files (*.CLST) which documents the CONC files used in the program execution. These lists of data files provide a starting point in the event a complete traceback of an ADPIC, PLCNT or TIMEHIS run should be necessary.

There are three main components that comprise the technical details of this system: 1) file naming conventions, 2) the TBB structure, and 3) a TBB definition capability that allows substantial flexibility in permitting essentially unbounded expansion of the models in terms of the number of files read and written. The descriptions of the last two of these components are implementation details intended largely for programming staff and are described in Appendix C. The rest of this section discusses the file naming conventions.

As mentioned above, the traceback system relies on unique file names for all files maintained as part of it. The need for unique file names and some descriptive information on the file's contents have been combined to create human-readable file names. To assist understanding and file manipulations, the filenames follow one of three standard formats distinguished by the qualifier field. The various fields in a name of a given format type will tend to line up when listed with a directory search command. This feature helps both man and machine to see 'at a glance' what each file contains. The general file name structure has the following stencil:

prefix	qualifier	sequence	extension
7	24	4	4/5

The *prefix* in combination with the extension indicates specific file type. If the file extension is sufficient to identify the file, the name of the model that created the file is used as the prefix. Graphics output files are of this type, for the suffix .CGMB uniquely identifies the file type and the originating program's name is needed for graphics processing.

The *qualifier* identifies the data set as uniquely as possible given the space constraints of the filename. There are three distinct qualifier formats. The first is used with the TOPOG*.GRID files, which contain grid information. The second format includes time information appropriate to the file and applies to most other files in the system. These qualifiers include a starting date and time along with duration or averaging time as appropriate. For clarity, three character alphabetic months are used in dates. The last format uses the first 12 characters of both the problem and run names to qualify the file name.This last type is useful for STNLOC.CMET, where the selection of station locations being output for reference is not dependent on time, but rather the location or region used in the problem. Thus, the problem and run names are sufficient to be unique qualifiers.

<u>GRID files</u>: rrrrrkmzzzzzmxxxxx_yyyyy

rrrrr	=	the larger of east/north range in rounded km
zzzzz	=	the vertical grid range in m
xxxxx	=	the x coordinate of the grid center in rounded km
yyyyy	=	the y coordinate of the grid center in rounded km
underscores	=	unassigned characters

date/time files: ddmmmyy_hhmm_ss_ddd_hhmm

dd	=	the date w/ leading zeros
mm	=	the month as three alphabetic characters
yy	=	the year w/ leading zeros
ddd	=	duration in days w/ leading zeros
hh	=	the hour or number of hours of duration w/ leading zeros
mm	=	the minute or number of minutes of duration w/ leading zeros
ss	=	the seconds or number of seconds of duration w/ leading zeros

NOTE: For conc*.bif and conc*.vlst files, the ddd_hhmm field indicates time from start of run while for most other files that field gives an averaging time or valid time interval.

time-independent files: pppppppppppppprrrrrrrrrrrr

pppppppppppp	=	the first 12 characters of the problem name
rrrrrrrrrrrr	=	the first 12 characters of the run name
underscores	=	unassigned characters

Having a *sequence* number which is always changing (increasing) forces unique file names with repeated model executions with the same or similar data. It is always one larger than the highest sequence number of any previously existing file. The sequence number is normally displayed as three digits with a leading underscore for clarity; however, if the highest sequence number of an existing file equals or exceeds 999 then the underscore prefix is usurped to allow sequence numbers up to 9999.

The *extension* indicates the class of files as follows:

.NML	Input namelist file
.CNML	Completed namelist file
.MET	Metdata input file (observations or locations)
.CMET	Completed metdata file (observations or locations)
.DATA	Sampler data input file
.CDAT	Completed sampler data file
.BIF	Binary Intermodel file
.CGMB	Computer Graphics Metafile binary format
.GRID	Model grid file
.VLST	Velocity filename list
.CLST	Concentration filename list
.TBB	PLCNT/TIMEHIS ASCII traceback block
.LOG	Model run log file

The following is a list of the files to be used by the main model system, grouped by the relevent model:

TOPOG.NML
TOPOG__rrrrrkmzzzzzmxxxxx_yyyyynnn.CNML
TOPOG__rrrrrkmzzzzzmxxxxx_yyyyynnn.CGMB
TOPOG__rrrrr kmzzzz mxxxxxyyyyy_nnn .GRID
TOPOG.LOG

MEDIC.NML
MEDIC__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CNML
STNLOC.MET
STNLOC_pppppppppppprrrrrrrrrrr.CMET
OBSERV.MET
OBSERV_ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CMET
MEDIC__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CGMB
MEDVEL_ddmmmyy_hhmm_ss_ddd_hhmm_nnn .BIF
MEDIC.LOG
MEDIC.VLST

MATHEW.NML
MATHEW__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CNML
MATHEW_ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CGMB
MATVEL_ddmmmyy_hhmm_ss_ddd_hhmm_nnn .BIF
MATHEW.LOG
MATHEW.VLST

ADPIC.NML
ADPIC__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CNML
ADPIC__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .RST
ADPIC__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CGMB
CONC___ddmmmyy_hhmm_ss_ddd_hhmm_nnn .BIF
CONC___ddmmmyy_hhmm_ss_ddd_hhmm_nnn .VLST
CONC___ddmmmyy_hhmm_ss_ddd_hhmm_nnn .RST
PARTPOS___ddmmmyy_hhmm_ss_ddd_hhmm_nnn .BIF
ADPIC.LOG
ADPIC.CLST

CONC_ANALYSIS.NML
PLCNT__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CNML
PLCNT__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CGMB
PLCNT__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .CLST
PLCNT__ddmmmyy_hhmm_ss_ddd_hhmm_nnn .TBB
PLCNT.LOG

TIMEHISddmmmyy_hhmm_ss_ddd_hhmm_nnn .CNML
SAMPLER.DATA
SAMPLERddmmmyy_hhmm_ss_ddd_hhmm_nnn .CDAT
TIMEHISddmmmyy_hhmm_ss_ddd_hhmm_nnn .CGMB
TIMEHISddmmmyy_hhmm_ss_ddd_hhmm_nnn .CLST
TIMEHISddmmmyy_hhmm_ss_ddd_hhmm_nnn .TBB
TIMEHIS.LOG

Figure III.A.1 illustrates the flow of the overall CG-MATHEW/ADPIC model system. The step-by-step progression through each of the five executable programs is shown by bolded arrows. (The TIMEHIS program is only used in conjunction with sampler measurement data.) Figures III.A.2 - III.A.4 show in greater detail the files associated with each of the five programs.

The ARAC models can be run on a variety of map projections, which can be selected to minimize the projection-induced scale distortion or to match a projection chosen by an external organization. In addition, to match the details of the geometry of a particular study area it is possible to reposition the origin of a projection as well as to rotate the projection. The models are executed on the current map projection as defined by the logical MAP$F_PROJECTION_PARAMETERS. This logical points at an ASCII file that defines a projection.

Not all map projections are appropriate for modeling with the ARAC models. The applicable projections are conformal, which implies that that a single map scale applies at a given location and that relative direction is unaffected by the projection. The conformal projections currently implemented and available for use in the modeling system are the UTM, Ordnance Survey and GWC North and South specific projections and any normal Mercator, transverse Mercator, Lambert conformal conic, polar stereographic or general stereographic projection. If a model is run with a projection, the wind directions and speeds are corrected in MEDIC to account for the projection-induced distortion. The projection information is also used in the model graphics to indicate the grid orientation via a north arrow or a graticule. As a result, all the models need to know the current projection. The choice of whether to use a projection or not is made in TOPOG with the namelist variable MAP_ADJUSTMENT. If a map projection is not used the winds are not adjusted in MEDIC and no grid orientation indication is made on the graphics.

The step of choosing a map projection takes place in production and Beta when a new problem is created using the Select_Map_Projection and Create_Map_Projection commands. The map projection file is placed in a problem-specific directory that is referenced with the logical MAP$A_PROJECTION_PARAMETERS. Outside of the operational system, the user must ensure that the MAP$F_PROJECTION_PARAMETERS and MAP$A_PROJECTION_PARAMETERS logicals are set to point at the appropriate projection definition file. for additional details, please see the document "The ARAC Map Projection System".

The input files TOPOG.NML, MEDIC.NML, MATHEW.NML, ADPIC.NML, and CONC_ANALYSIS.NML contain model parameters in Fortran namelist format. These namelist input files are created and modified by the user. Each executable produces a log file (primarily a journal file used for debugging purposes) and a graphics file, as well as other files which are described in this section.

TOPOG uses model parameters from TOPOG.NML and terrain data to create the underlying model grid cell heights, which are written to the GRID file.

MEDIC uses model parameters from MEDIC.NML to select meteorological data from various sources and to specify parameters used in interpolating and extrapolating that data. MEDIC can

access met station location either from a Problem Station Library or from a STNLOC.MET namelist file, and meteorological data can be accessed either from Problem Metdata Files or from an OBSERV.MET file. The former methods for met station information and meteorological data are the primary methods used by ARAC operational responses, while the latter methods are used primarily for canned metdata cases. MEDIC produces MEDVEL files, one for each met dataset, containing the three-dimensional gridded wind fields.

CG-MATHEW uses the model parameters from the MATHEW.NML file to adjust the gridded wind fields from the MEDVEL files to make them mass-consistent. These mass-adjusted three-dimensional wind fields are written to MATVEL files.

ADPIC uses the model parameters from the ADPIC.NML file to release marker particles which simulate the actual release of effluent into the wind field. The grid cell concentrations for specified heights for specified plot types for a specified time interval are written to CONC*.BIF files, corresponding CONC*.VLST files are also written containing the MEDVEL/MATVEL filenames used in generating the CONC*.BIF file. Information for individual particles can be saved in the ADPIC*.RST file, so that an ADPIC run can be restarted. Information required for displaying dots over terrain is contained in PARTPOS*.BIF files.

PLCNT and TIMEHIS are post-processor codes which use the parameters from the CONC_ANALYSIS.NML file to display the concentration data from the CONC*.BIF files in different ways: PLCNT generates contour plots of the concentration data, while TIMEHIS generates semi-log time history plots of the concentration data.

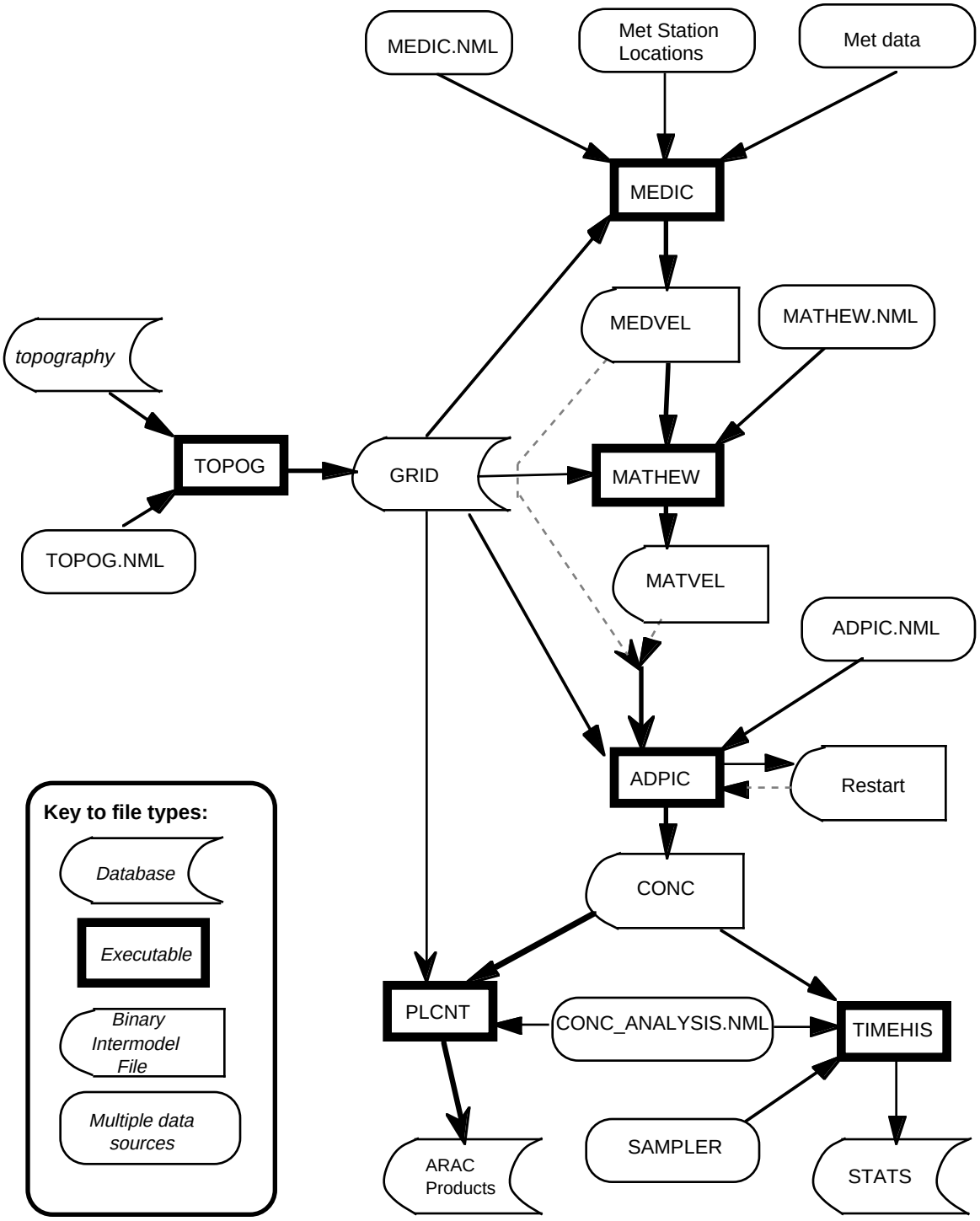


Fig. III.A.1 Overview of the CG-MATHEW/ADPIC Models

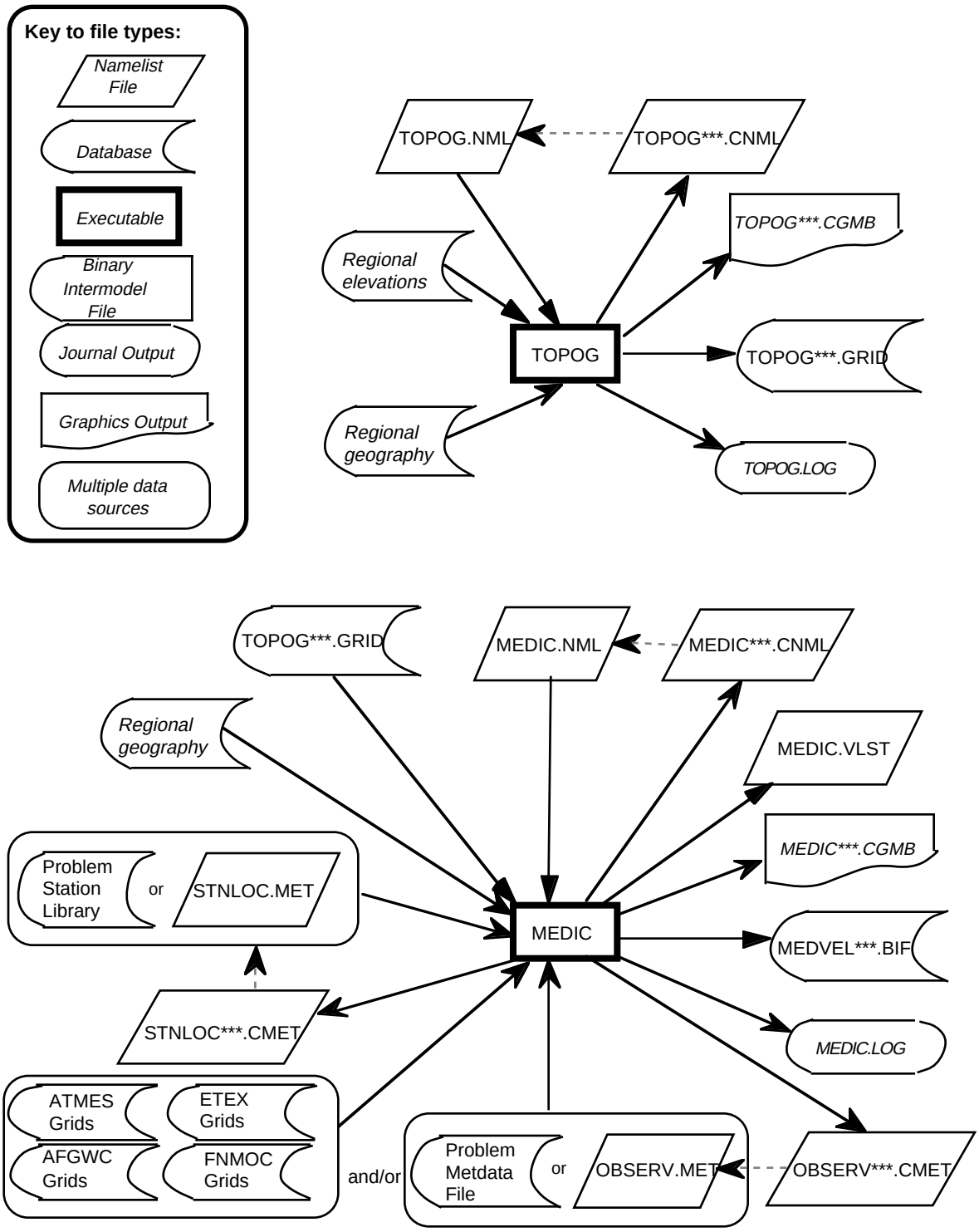
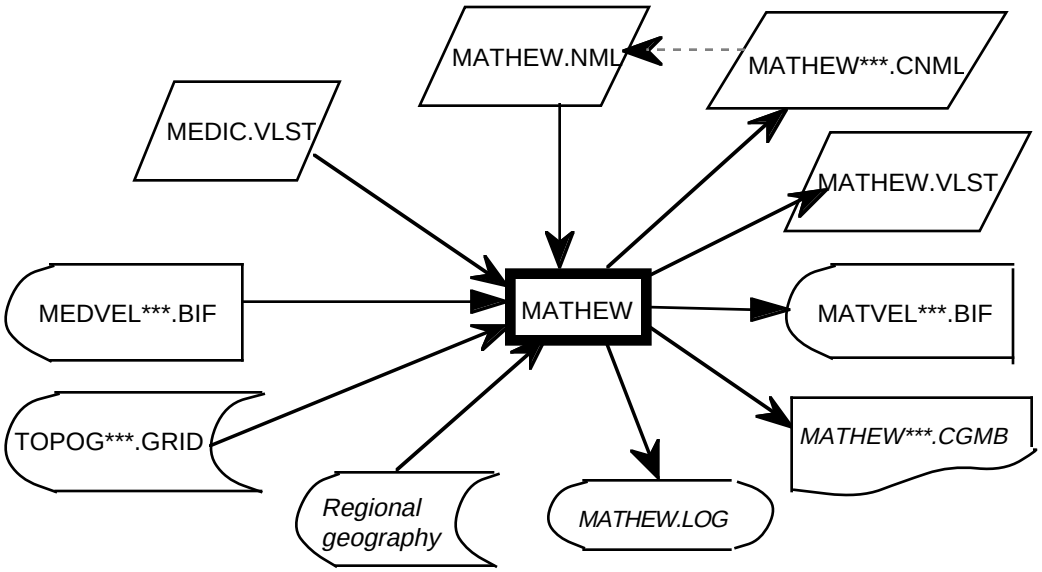


Fig. III.A.2 Detail for TOPOG (top) and MEDIC (bottom)



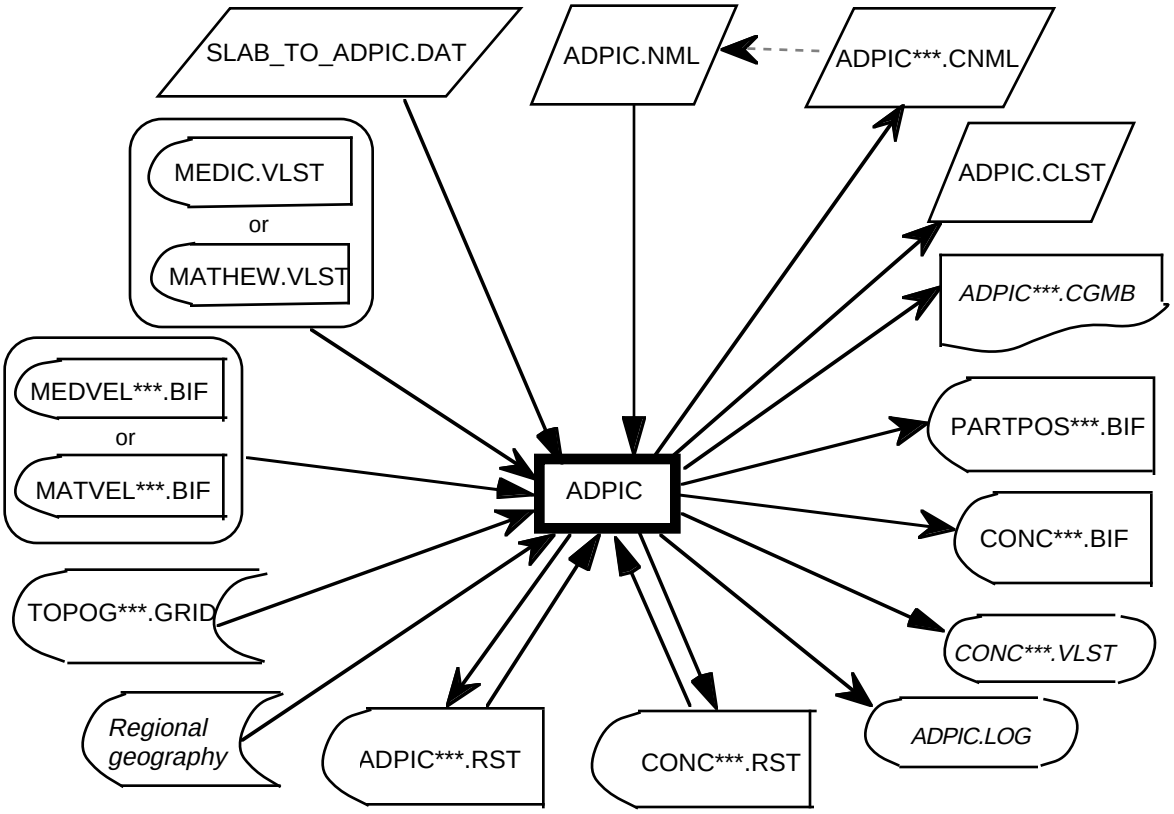


Fig. III.A.3 Detail for CG-MATHEW (top) and ADPIC (bottom)

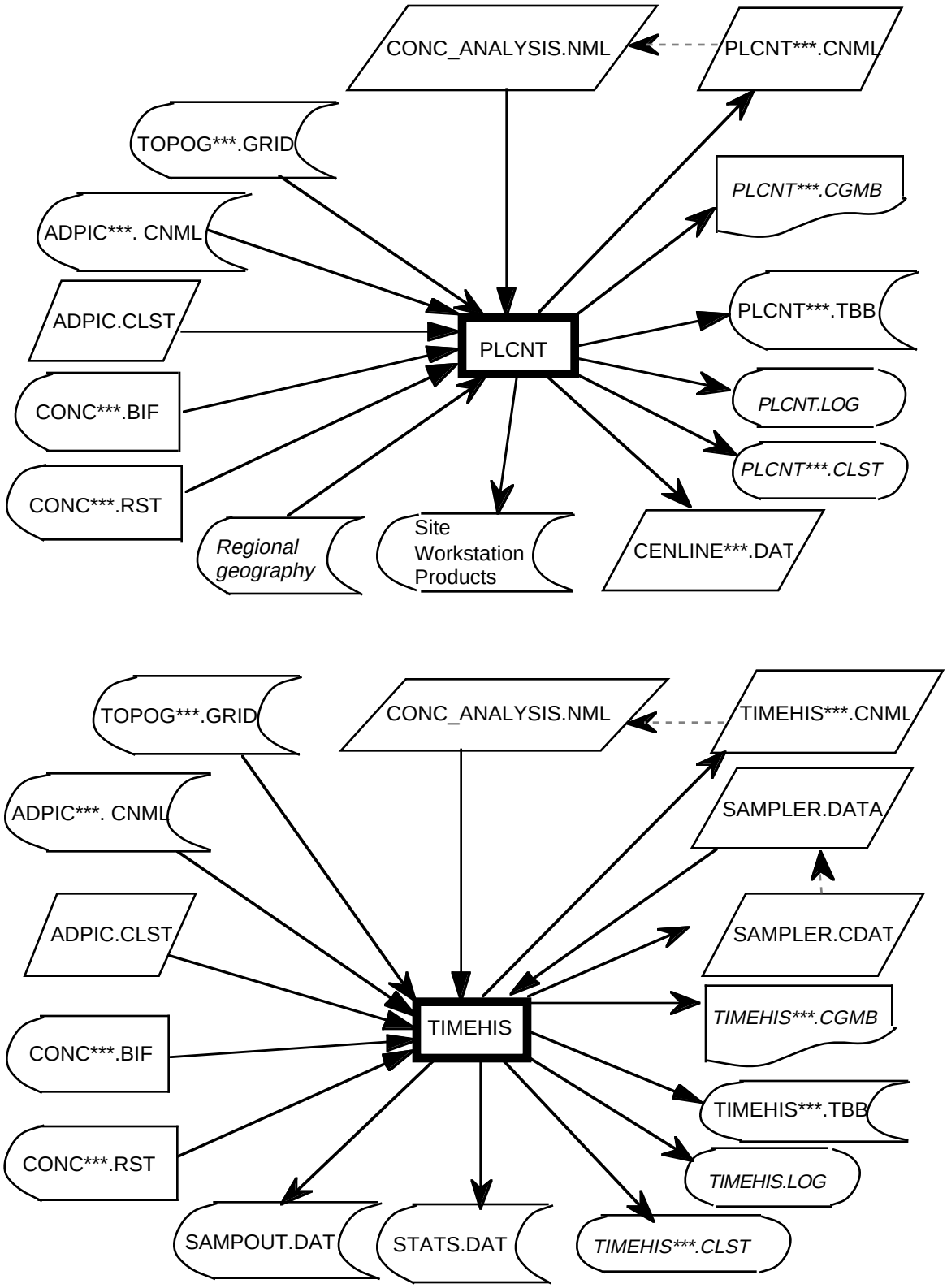


Fig. III.A.4 Detail for PLCNT (top) and TIMEHIS (bottom)

III.B. Input Files

There are several conventions that are followed in all the model input files. All program control flags are input as single characters with acceptable values of 'Y', 'y', 'N', and 'n'. Horizontal distances are input in kilometers and vertical distances in meters. Dates are all input as seven character strings in ddMMMyy format where dd is the day of the month, MMM is the alphabetic month (case insensitive) and yy is the last two digits of the year. The date/time utilities in the models work from January 1, 1950 to December 31, 2049 by assuming the yy values of less than 50 are in the next century and yy values of greater than 50 are in this century. Times are strings of up to eight characters and can be in one of the four following formats:

'hhmm'

'hhmmss'

'hh:mm'

'hh:mm:ss'

where hh is the hours (<24), mm is the minutes (<60) and ss is an optional seconds field (<60). Note the in the description of the time input variables below, they will typically be described as being in 'hhmmss' format although all of the formats above are acceptable. There are also a number of time interval inputs (e.g., ..._INTERVAL variables in ADPIC and ..._STEP variables in PLCNT) where a prefix can be added to a legal time string to indicate a number of days (<1000) in the duration. Thus, the following is a legal interval input string (note that the days field along with the double colon are not required if the interval is less than 24 hours but if the days field is included then the double colon must separate the days and hours fields):

'DDD::hh:mm:ss'

III.B1. TOPOG.NML

TOPOG.NML is the input file of grid size and position information for the TOPOG code. Since TOPOG creates a grid that is fixed in space, a large enough area must be chosen to account for the wind and stability conditions that might affect the effluent as the problem unfolds. An overview of the input is necessary because of the appreciable interplay between the individual parameters in TOPOG.NML as will as other parameters in the code system. Please also refer to section II.C.1 "TOPOG" for additional background regarding the TOPOG model.

Since the TOPOG.NML input defines a three-dimensional grid for ADPIC, the first step in preparing the file is to estimate the area of interest for the duration of the problem. The overall objective is to keep at least 90% of the particles within the grid volume so as to maximize resolution of the effluent puff or plume. We have found streamline analyses using past, present and, if available, forecast weather maps to be extremely helpful in estimating the effluent trajectory. A calculated mean wind speed in conjunction with this directional information will then serve to guide the analyst in choosing the proper horizontal (x and y) grid dimensions. Care should be taken to

insure that the resulting ADPIC grid will have positive x-y coordinates, since PLCNT will fail in low level graphics calls with negative coordinates.

In selecting the vertical grid dimension, it is necessary to consider the height of the release, topography, upper air winds, and the stability of the atmosphere. Topography is one of the more important considerations in this decision process. TOPOG assigns a zero height to the lowest terrain elevation in the grid. The top of the grid is generally chosen to be above the highest topographic feature. There are two exceptions to this rule: (1) if an isolated mountain peak extends well above the nearby topography, the peak should be allowed to protrude through the top of the grid so as to improve the resolution elsewhere, and (2) if it is highly unlikely that the effluent cloud would rise above a particular terrain level, it may be advantageous to lower the grid top to that level.

There are two ways of altering the grid dimension: (1) the size of the grid cell can be varied in the TOPOG.NML file as described below, and (2) the number of grid points along each axis can be varied. (For example the R41 see appendix F, CG-MATHEW and ADPIC grids have 51 by 51 by 15 points and 41 by 41 by 15 points, respectively.) The first option is the one of choice in most ARAC problems. However, there may be times when it is desirable to change the number of grid points to achieve the optimum grid resolution for a given grid volume. In order to do this, the grid point parameters must be changed in appropriate include files and the codes recompiled. The parameter names in TOPOG, MEDIC, and CG-MATHEW and ADPIC are IMAXPIC, JMAXPIC, and KMAXPIC for the ADPIC grid and IMAXMAT, JMAXMAT, and KMAXMAT for the CG-MATHEW grid. (Computer memory and execution speeds are limiting factors in choosing a total number of grid points.)

The following is a list of the TOPOG.NML variables grouped alphabetically within the two namelist blocks, TOPOG_CONTROL and TOPOG_PARAMS:

II.B1a. TOPOG_CONTROL namelist

CONTOUR_INTERVAL

The model terrain contour interval in meters.

(Default: CONTOUR_INTERVAL = DELZ)

Warning errors:	CONTOUR_INTERVAL $\leq$ 1.0
Fatal errors:	CONTOUR_INTERVAL $\leq$ 0.001
	CONTOUR_INTERVAL > 5000.0 (M/A)

FLAT_TOPO

Flag ('Y' or 'N') indicating if flat terrain is to be used. Special Note for HM/A: valid values for the terrain file (defined by the “Select Topography” menu option) are: NHEMISTD, NHEMIAVG, NHEMIMAX.

(Default: FLAT_TOPO = 'N' $\rightarrow$ do not use flat terrain)

INTERACTIVE

Flag ('Y' or 'N') specifying whether or not user interaction is required during the running of TOPOG. Minimal user interaction involves resolution of any 1* DELX “holes”; in the noninteractive mode, the holes are filled automatically.

(Default for HANDSOFF mode: INTERACTIVE = 'N' → no user interaction; Default for non-HANDSOFF mode: INTERACTIVE = 'Y' → user interaction required)

LISTDETAILS

Flag ('Y' or 'N') specifying whether or not additional information about the TOPOG grid will be written to the echo file. The additional information consists of: cell heights and DELZ heights.

(Default: LISTDETAILS = 'N' → no additional information is written to the echo file)

RESTART

Flag ('Y' or 'N') indicating that an existing TOPOG*.GRID file is to be opened and read. This allows a previous grid to be modified interactively without rerunning all of TOPOG.

(Default: RESTART = 'N' → start from scratch and create new TOPOG*.GRID)

III.B.1.b. TOPOG_PARAMS namelist

DELX

The grid cell size in kilometers along the *x*-axis. DELX must be an integer multiple of one-quarter the terrain database resolution. For example, an ARAC elevation file with a resolution of 0.5km, the DELX must be a multiple of 0.125km. DELX should be 381.0 for an H51 grid and 190.5 for an H101 grid (see Appendix F for operational model grid conventions).

Warning errors:	none
Fatal errors:	DELX $\leq$0.001
	DELX >1250.0

DELY

The grid cell size in kilometers along the *y*-axis. DELY must be an integer multiple of one-quarter the terrain database resolution. For example, an ARAC elevation file with a resolution of 0.5km, the DELX must be a multiple of 0.125km. DELY should be 381.0 for DELX should be 381.0 for an H51 grid and 190.5 for an H101 grid (see Appendix F for operational model grid conventions).

Warning errors:	none
Fatal errors:	DELX $\leq$0.001
	DELX >1250.0

DELZ

The grid cell size in meters along the *z*-axis. See Appendix F for the number or vertical grid cells in the operationally supported grids.

Warning errors:	DELZ > 1000.0
	DELX <1.0
Fatal errors:	DELZ ≤0.001
	DELZ > 5000.0

DOUBLECELL

Flag ('Y' or 'N') specifying whether or not grid cell heights will be assigned in blocks of four grid cells from the lower left corner of the grid.

(Default: DOUBLECELL = 'N' → blocks of four will not be used, i.e., the height for each grid cell is determined individually.)

MAP_ADJUSTMENT

Flag ('Y','N') specifying whether or not a map projection adjustment is to be made which would align map north with true north for the map projection selected. One effect of setting this flag is to correct the wind direction arrays, and adjust the wind speed to account for local scale variations caused by the map projection. Note: In order to use MAP_ADJUSTMENT ='Y', the map projection logicals need to be set, i.e., you may need to have selected a map projection.

(Default: MAP_ADJUSTMENT = 'Y')

RANGE

ADPIC grid extent along both the x- and y axes in kilometers. RANGE can be used to specify both XRANGE and YRANGE. RANGE may also be used instead of DELX—also see notes for DELX.

Warning errors:	RANGE < 1.0
Fatal errors:	RANGE ≤0.5
	RANGE > 45000.0

X_GRIDCENTER

The model x coordinate of the center of the ADPIC grid, input in kilometers.

Note:	X_GRIDCENTER and Y_GRIDCENTER may be used instead of X_ORIGIN_PIC and Y_ORIGIN_PIC.
	*Special note for H51 and H101 X_GRIDCENTER = 8763 should be used.
Fatal errors:	X_GRIDCENTER ≤ -45000.0
	X_GRIDCENTER > 45000.0

X_OFFSET_MAT

Real number specifying the offset (km) in the x-direction of the ADPIC grid from the CG-MATHEW grid. The ADPIC grid must be contained in the CG-MATHEW grid; therefore X_OFFSET_MAT must be less than 0.5 * (CG-MATHEW grid size - ADPIC grid size).

(Default: X_OFFSET_MAT = 0.0 → no offset)

X_ORIGIN_PIC

The Model x coordinate of the lower left-hand corner of the ADPIC grid in kilometers.

Note: X_ORIGIN_PIC and Y_ORIGIN_PIC may be used instead of X_GRIDCENTER and Y_GRIDCENTER.

Fatal errors: X_ORIGIN_PIC ≤ -45000.0
X_ORIGIN_PIC > 45000.0

XRANGE

ADPIC grid extent along the x-axis in kilometers. XRANGE may be used instead of DELX—also see notes for DELX.

Warning errors: XRANGE < 1.0

Fatal errors: XRANGE ≤0.5
XRANGE > 45000.0

Y_GRIDCENTER

The model y coordinate of the center of the ADPIC grid, input in kilometers.

Note: X_GRIDCENTER and Y_GRIDCENTER may be used instead of X_ORIGIN_PIC and Y_ORIGIN_PIC.
Special note for H51 and H101: Y_GRIDCENTER = 9525.,should be used.

Fatal errors: Y_GRIDCENTER ≤ -45000.0
Y_GRIDCENTER > 45000.0

Y_OFFSET_MAT

Real number specifying the offset (km) in the y-direction of the ADPIC grid from the CG-MATHEW grid. The ADPIC grid must be contained in the CG-MATHEW grid; therefore Y_OFFSET_MAT must be less than 0.5 * (CG-MATHEW grid size - ADPIC grid size).

(Default: Y_OFFSET_MAT = 0.0 → no offset)

Y_ORIGIN_PIC

The Model y coordinate of the lower left-hand corner of the ADPIC grid in kilometers.

Note: X_ORIGIN_PIC and Y_ORIGIN_PIC may be used instead of X_GRIDCENTER and Y_GRIDCENTER.

Fatal errors: Y_ORIGIN_PIC ≤ -45000.0
Y_ORIGIN_PIC > 45000.0

YRANGE

ADPIC grid extent along the y-axis in kilometers. YRANGE may be used instead of DELY–also see notes for DELY.

Warning errors: YRANGE < 1.0

Fatal errors: YRANGE $\leq$0.5

YRANGE > 45000.0

ZRANGE

ADPIC grid extent along the z-axis in meters. ZRANGE may be used instead of DELZ – also see notes for DELZ.

Warning errors: ZRANGE < 10.0 (M/A)

ZRANGE $\geq$5000.0

Fatal errors: ZRANGE > 70000.0 (M/A)

Sample TOPOG.NML Input File (with center reference)

```
$topin_control                          beginning of control namelist
FLAT_TOPO          = 'Y'                flag for using flat terrain
RESTART            = 'N'                flag for using existing GRIDIN file
INTERACTIVE        = 'Y'                flag for non-interactive execution
LISTDETAILS        = 'N'                flag for writing additional information to echo file
$end                                    end of control namelist

$topin_params                           beginning of params namelist
X_GRIDCENTER       = 115.0      ←       X of center of ADPIC model grid
Y_GRIDCENTER       = 115.0      ←       Y of center of ADPIC model grid
RANGE              = 30.000     ←       range (km) of ADPIC grid in x- and y-directions
ZRANGE             = 700.       ←       range (m) of ADPIC grid in z-direction
X_OFFSET_MAT       = 0.000      ←       offset (km) for CG-MATHEW grid in x-direction
Y_OFFSET_MAT       = 0.000      ←       offset (km) for CG-MATHEW grid in y-direction
DOUBLECELL         = 'N'        ←       flag for assigning grid cell heights in blocks of four
$end                                    end of params namelist
```

Sample TOPOG.NML Input File (with lower left corner reference)

```
$topin_control                          beginning of control namelist
FLAT_TOPO          = 'Y'                flag for using flat terrain
RESTART            = 'N'                flag for using existing GRIDIN file
INTERACTIVE        = 'Y'                flag for non-interactive execution
LISTDETAILS        =' N'                flag for writing additional information to echo file
$end                                    end of control namelist

$topin_params                           beginning of params namelist
X_ORIGIN_PIC       = 100.0      ←       X of lower left corner of ADPIC model grid
Y_ORIGIN_PIC       = 100.0      ←       Y of lower left corner of ADPIC model grid
RANGE              = 30.000     ←       range (km) of ADPIC grid in x- and y-directions
ZRANGE             = 700.       ←       range (m) of ADPIC grid in z-direction
X_OFFSET_MAT       = 0.000      ←       offset (km) for CG-MATHEW grid in x-direction
Y_OFFSET_MAT       = 0.000      ←       offset (km) for CG-MATHEW grid in y-direction
DOUBLECELL         = 'N'        ←       flag for assigning grid cell heights in blocks of four
$end                                    end of params namelist
```

III.B.2. Geography

The geography file contains location and classification information about geographic features (e.g. roads, lakes, rivers, political boundaries). This information is used to plot a base map for some of the model graphics products. These files are normally not provided with the models.

III.B.3. Problem Elevation Data

The problem elevation file contains the altitudes of the topographic surface around a site. It is composed of a header that describes the grid being used, followed by a two-dimensional array of cell heights, one for each grid cell. These files are in netCDF format. netCDF files are binary data files together with public-domain software that should be installed on all systems that run the ARAC models. The software together with the data format form a system-independent means of storing and transfering data between programs. TOPOG reads these netCDF elevation files (by linking against netCDF library software), which are named according to the convention:

sssssssssmpppppppppp_rrrrr_sss.ELEV:

where "sssssssss" is the site_id or equivalent, "m" is an underscore for unmodified projections or an 'M' for modified projections, "pppppppp" is a map projection string, e.g.,

UTM_____'
'OS_____'
'GWCNORTH_'
'GWCSOUTH_'
'GWCTROPIC'
'NMERCATOR'
'TMERCATOR'
'LAMBERTCC'
'POLARSTER'

"rrrrr" is the map range in km and "sss" is a sequence number that ensures that the filename will be unique.

Elevation File Header

The NetCDF problem elevation file header contains the following information:

Item	Description
elev_filename	name of this elevation data file as described above
elev_site_id	the site_id associated with this map
elev_description,	textual description of nature of geodata
elev_method_string	textual description of processing method (stored as global attribute)

elev_grid_string	textual description of grid structure (stored as global attribute)
elev_data_source_1	primary source of the elevation data used to generate this file,e.g.,'DMA Planar'; 'DMA DTED'; 'ARAC 500m'; 'ETOPO5'
elev_data_source_2	secondary source of the elevation data used to generate this file (mainly required to fill holes in the primary data coverage)
elev_projection_filename	filename of projection definition file
elev_projection_name	string indicating the map projection (ARAC std); see projection_names.cli in geogutil
elev_projection_id	index indicating the map projection (ARAC std); see projection_names.cli in geogutil
elev_ellipsoid_name	string indicating the earth figure (ellipsoid or sphere) (USGS GCCP std); see projection_names.cli in geogutil
elev_ellipsoid_id	index indicating the earth figure (ellipsoid or sphere) (USGS GCCP std); see projection_names.cli in geogutil
elev_central_latitude	central latitude of map projection for this elevation file
elev_central_longitude	central longitude of map projection for this elevation file
elev_std_parallel_1	first standard parallel of map projection for this elevation file
elev_std_parallel_2	second standard parallel of map projection for this elevation file
elev_scale_factor	scale factor for the map projection used for this elevation file
elev_false_easting	false easting for the map projection used for this elevation file
elev_false_northing	false northing for the map projection used for this elevation file
elev_origin_latitude	latitude of origin for a modified map proj. used for this elevation file
elev_origin_longitude	longitude of origin for a modified map proj. used for this elevation file
elev_origin_rotation	rotation of origin for a modified map proj. used for this elevation file
elev_datum_name	datum name for this map
xmin_domain_elev	minimum x coordinate of largest normal plotting window (km)
ymin_domain_elev	minimum y coordinate of largest normal plotting window (km)
xmax_domain_elev	maximum x coordinate of largest normal plotting window (km)
ymax_domain_elev	maximum y coordinate of largest normal plotting window (km)
west_limit_elev	minimum longitude coordinate of grid
east_limit_elev	maximum longitude coordinate of grid
south_limit_elev	minimum latitude coordinate of grid
north_limit_elev	maximum latitude coordinate of grid
x_cell_size_elev	grid cell size in the x direction (km)
y_cell_size_elev	grid cell size in the y direction (km)

x_dimension_elev	dimension in the x direction
y_dimension_elev	dimension in the y direction
elev_minimum	minimum elevation in the domain (m)
elev_maximum	maximum elevation in the domain (m)

Elevation Grid

The array of elevations corresponds to the grid defined in the header. Each grid cell is associated with an array index pair (i,j), with the pair (1,1) indicating the grid cell at the southwest corner of the grid. The value of an array element is usually the average height (although other resampling options are available, see The ARAC II Geodata System for details) in meters above sea level of the corresponding grid cell. An array value of -9999 indicates that no valid data was available to generate an elevation for this grid cell. TOPOG treats these missing data flags as sea level (0) heights. TOPOG does not care what the dimensions of the elevation grid in the netCDF elevation file are but to use the SHOTER (i.e., PERSPEC) function in operations the grids should be left at the default of 400 by 400.

III.B.4. MEDIC.NML

MEDIC.NML is the principal input file for control of the MEDIC code. (Please also refer to section II.C.2 "MEDIC" for additional background regarding the MEDIC model.) It provides MEDIC with numerous parameters controlling the wind field extrapolation or interpolation procedures Two types of Fortran namelists make up the MEDIC.NML file. The first, MEDIC_CONTROL, permits the user to control general processing and output options. The second, MEDIC_PARAMS, controls parameters which are specific to a set of meteorological data. A separate MEDVEL output file is created for each occurrence of a MEDIC_PARAMS namelist within MEDIC.NML. These MEDVEL data sets are used by CG-MATHEW to create snapshots of the atmospheric winds adjusted for mass-consistency throughout a gridded volume.

Meteorological data may come from an OBSERV.MET file or Problem Metdata files, and/or gridded met data files (see section II.C.2.e "Gridded wind fields" section for more details). The variable METDATASET given in a MEDIC_PARAMS namelist is matched to a keyword which prefaces every METDATASET within an OBSERV.MET file. Typically, the MEDIC_PARAMS namelist and the corresponding METDATASET within the OBSERV.MET file track at intervals which match data availability, typically every hour.

For the Vax versions of MEDIC, the source of metdata (Problem Metdata Files, OBSERV.MET file, or gridded data) is not related to the source of met station loc ation information (Problem Station Library or STNLOC.MET file). However, for the Alpha versions of MEDIC, the STNLOCPSL parameter in the MEDIC.NML file controls whether or not the build_ascii_probmet executable will be run by the Start_Medic (STAMED) command: if STNLOCPSL = 'Y', then a STNLOC.MET and OBSERV.MET file are created for an R81 MEDIC run; i.e., If STNLOCPSL = 'N' for an R81 MEDIC run, then you have to already have a STNLOC.MET and an OBSERV.MET file in the run directory for MEDIC to run on the Alpha machine.

The table below describes some of the combinations of initial metdata ("initial" refers to what metdata info exists prior to using the STAMED command) and met station location info, and how these combinations will work for the VAX versions (R41, R51) and ALPHA version (R81) of regional MEDIC. (PMF = Problem Metdata File, and PSL = Problem Station Library)

Stn Location Info Initial Metdata Info	Problem Station Library (STNLOCPSL = 'Y')	STNLOC.MET file (STNLOCPSL = 'N')
PMF's PROBMET_DST... (no OBSERV.MET) METDATASET	VAX: yes, using PMF's ——————————— ALPHA: yes, using a new OBSERV.MET and STNLOC.MET created from the PMF's and PSL via STAMED (which runs Build_ascii_probmet)	VAX: yes, using PMF's ——————————— **ALPHA: no,** since PMF's will not be converted
PMF's PROBMET_DST... OBSERV.MET METDATASET	VAX: yes, using PMF's ——————————— ALPHA: yes, using a new OBSERV.MET and STNLOC.MET created from the PMF's and PSL via STAMED (which runs Build_ascii_probmet)	VAX: yes, using PMF's ——————————— ALPHA: yes, using existing OBSERV.MET
PMF's PROBMET_DST... (no OBSERV.MET) (no METDATASET)	VAX: yes, using PMF's ——————————— **ALPHA: no,** since METDATASET not defined	VAX: yes, using PMF's ——————————— **ALPHA: no,** since PMF's will not be converted
(no PMF's) (no PROBMET_DST...) OBSERV.MET METDATASET	VAX: yes, using existing OBSERV.MET ——————————— **ALPHA: no,** since no PMF's to convert	VAX: yes, using existing OBSERV.MET ——————————— ALPHA: yes, using exising OBSERV.MET
(no PMF's) (no PROBMET_DST...) (no OBSERV.MET) (no METDATASET) ALL_WINDS...	VAX: yes, using ALL_WINDS... (doesn't use PSL) ——————————— **ALPHA: no,** since METDATASET not defined	VAX: yes, using ALL_WINDS... (doesn't use STNLOC.MET) ——————————— ALPHA: yes, using ALL_WINDS... (doesn't use STNLOC.MET)
PMF's PROBMET_DST... (no OBSERV.MET) METDATASET SINGLE_PROFILE_WINDS	VAX: yes, using single profile from PMF ——————————— **ALPHA: no,** but it should work; ASRF is in	VAX: yes, using single profile from PMF ——————————— **ALPHA: no,** sinc PMF's will not be converted

Because CG-MATHEW does a minimal wind field adjustment and because the advection winds in ADPIC persist for extended periods, it is very important that the analyst provide the best possible

set of extrapolated winds. The extrapolated winds are sensitive to relatively small changes in the MEDIC parameter values, and the effects on the wind field are often complex and hard to visualize. It is therefore essential that the assessor (a meteorologist) carefully examines the plots of the extrapolated winds which MEDIC produces to determine the validity of the wind field. If the wind field fits the assessor's concept of the state of the atmosphere, then CG-MATHEW may be run with the data set. Otherwise, several of the variables in MEDIC.NML may have to be changed and MEDIC run again. It may also be necessary to omit meteorological data if it is obviously erroneous, e.g., several hours of unchanged direction readings from a station may indicate a "frozen" wind vane. This process is iterative, and is continued until the assessor is satisfied that the best extrapolation (consistent with the data) has been produced. If only gridded upper air data is used, profile extrapolation is generally to be preferred over parameterized extrapolation (PROFILE_EXTRAP = 'Y').

The hemispheric variant HMEDIC (see Part II.C.2.f) uses a subset of the MEDIC.NML namelist variables. All of the MEDIC_CONTROL namelist variables apply *except* for REGMET_PARAMFILE, SFC_ROUGH_HGT, and STNLOCPSL. However, since HMEDIC uses only AFGWC gridded winds and does not perform extrapolation, *only* MET_START_DATE, MET_START_TIME, AVGTIME, NHEDATA, NHEFCST. NHETIME, SHEDATE, SHEFCST, SHETIME are used from the MEDIC_PARAMS namelist.

The following is a list of variables for the two MEDIC namelists, MEDIC_CONTROL and MEDIC_PARAMS. Variables not marked as (MEDIC/HMEDIC variable) apply to MEDIC *only*.

III.B.a. MEDIC_CONTROL namelist

ARAC3OBS_BARB_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value specifying the density of barbs on the ARAC 3 observation data wind barb plots. A value of one (1) indicates that a vector is plotted for every observation. A value of two (2) indicates that a vector is plotted for every second observation, etc.

(Default : 1)

Warning errors: None
Fatal errors: ARAC3OBS_BARB_PLOT_FREQ < = 0

ARAC3OBS_BARB_SCALE (MEDIC/HMEDIC variable)

Floating point value scaling the size of the barbs on the ARAC 3 observation data wind barb plots in the horizontal direction.

(Defaults : ARAC3OBS_BARB_SCALE = 0.35 for 100< # stns <500,

ARAC3OBS_BARB_SCALE = 0.6 for # stns <100,

ARAC3OBS_BARB_SCALE = 0.2 for #stns >500)

Warning errors: None

Fatal errors: ARAC3OBS_BARB_SCALE < = 0.0

ECMWFETEX_BARB_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value specifying the density of barbs on the ECMWF ETEX observation data wind barb plots. A value of one (1) indicates that a vector is plotted for every observation. A value of two (2) indicates that a vector is plotted for every second observation, etc.

(Default : 1)

Warning errors: None

Fatal errors: ECMWFETEX_BARB_PLOT_FREQ < = 0

ECMWFETEX_BARB_SCALE (MEDIC/HMEDIC variable)

Floating point value scaling the size of the barbs on the ECMWF ETEX gridded data wind barb plots in the horizontal direction.

(Defaults : ECMWFETEX_BARB_SCALE = 0.35 for 100< # stns <500,

ECMWFETEX_BARB_SCALE = 0.6 for # stns <100,

ECMWFETEX_BARB_SCALE = 0.2 for #stns >500)

Warning errors: None

Fatal errors: ECMWFETEX_BARB_SCALE < = 0.0

GWC_BARB_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value specifying the density of barbs on the GWC wind barb plots. A value of one (1) indicates that a vector is plotted for every observation. A value of two (2) indicates that a vector is plotted for every second observation, etc.

(Default : 1)

Warning errors: None

Fatal errors: GWC_BARB_PLOT_FREQ < = 0

GWC_BARB_SCALE (MEDIC/HMEDIC variable)

Floating point value scaling the size of the barbs on the GWC wind barb plots in the horizontal direction.

(Defaults : GWC_BARB_SCALE = 0.35 for 100< # stns <500,

GWC_BARB_SCALE = 0.6 for # stns <100,

GWC_BARB_SCALE = 0.2 for #stns >500)

Warning errors: None

Fatal errors: GWC_BARB_SCALE < = 0.0

HORZ_VECTOR_SCALE (MEDIC/HMEDIC variable)

Floating point value which scales the size of the vectors on the vector plots in the horizontal direction.

(Default : 0.5 for MEDIC, 0.1 for HMEDIC)

Warning errors: None

Fatal errors: HORZ_VECTOR_SCALE < = 0.0

IPROFILE (MEDIC/HMEDIC variable)

Array (max size = MAXPROF = 10) of integers (1 to 51 for standard R41 CG-MATHEW grid) representing the *i* indices of the sample profiles to be plotted. The first value in IPROFILE is matched with the first value in JPROFILE to give the horizontal grid indices of the first profile. Succeeding indices from each list are matched in a similar fashion. The default for IPROFILE with a standard 51 by 51 by 15 R41 CG-MATHEW grid is: 14 26 38 14 26 38 14 26 38. This gives the normal nine sample profiles. The variables XPROFILE and YPROFILE allow desired locations for vertical profiles to be entered in current map coordinates. See the description of those variables for more information.

JPROFILE (MEDIC/HMEDIC variable)

Array (max size = MAXPROF = 10) of integers (1 to 51 for standard R41 CG-MATHEW grid) representing the *j* indices of the sample profiles to be plotted. The first value in JPROFILE is matched with the first value in IPROFILE to give the horizontal grid indices of the first profile. Succeeding values from each list are matched in a similar fashion. The default for JPROFILE with a standard 51 by 51 by 15 R41 CG-MATHEW grid is: 14 14 14 26 26 26 38 38 38. This gives the normal nine sample profiles. The variables XPROFILE and YPROFILE allow desired locations for vertical profiles to be entered in current map coordinates. See the description of those variables for more information.

MEDIC_VLST (MEDIC/HMEDIC variable)

6-character string ('NEW', 'NONE', 'MODIFY') which controls the creation of the MEDIC.VLST file. If set to 'NEW', a MEDIC.VLST file is created containing a list of the fully qualified MEDVEL file names produced by the run. If set to "NONE', no MEDIC.VLST file is created. If the flag is set to 'MODIFY', the existing MEDIC.VLST file is read in and updated from the MEDVEL files created during the current run.

(Default MEDIC_VLST = 'NEW'.)

Warning errors: None

Fatal errors: None

NODDS_BARB_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value (1,2,?) controlling the barb density: one out of every NODDS_BARB_PLOT_FREQ will be plotted on the NODDS horizontal vector plots.

(Default NODDS_BARB_PLOT_FREQ = 1 -> every barb is plotted)

NODDS_BARB_SCALE (MEDIC/HMEDIC variable)

Floating point value (>0, usually less than 2) that scales the barbs on the NODDS horizontal vector plots.

(Default NODDS_BARB_SCALE = 1 -> default barb size is used)

NOGAPS10_BARB_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value (1,2,?) controlling the barb density: one out of every NOGAPS10_BARB_PLOT_FREQ will be plotted on the 1-deg NOGAPS horizontal vector plots.

(Default NOGAPS10_BARB_PLOT_FREQ = 1 -> every barb is plotted)

NOGAPS10_BARB_SCALE (MEDIC/HMEDIC variable)

Floating point value (>0, usually less than 2) that scales the barbs on the 1-deg NOGAPS horizontal vector plots.

(Default NOGAPS10_BARB_SCALE = 1 -> default barb size is used)

NOGAPS10THINRES (MEDIC/HMEDIC variable)

Real value (1.0, 1.5, 2.0, 2.5, 3.0, 4.5) specifying the resolution (in degrees) of a discrete approximation to a Kurihara grid. This controls filtering of NOGAPS 1-degree gridded data to minimize the time cost of doing large-area problems using this data, while producing an approximately equal areal density of profiles over the globe. The NOGAPS10THINRES is the spacing of the profiles along the equator. For NOGAPS 1-deg data, using NOGAPS10THINRES = 1.0 eliminates about half of the available profiles. If the parameter is omitted, all of the profiles are used.

(Default: none -> all profiles all used)

PLOT_LEVELS (MEDIC/HMEDIC variable)

Array (max size = KMAXMAT = 15) of integers (1 to 15 for standard R41 MEDIC grid) representing the *K* levels above terrain at which horizontal vector plots are to be produced.

(Default PLOT_LEVELS : 1, 2, 7, 15, and the top layer)

PLOT_LEVELS_ARAC3OBS (MEDIC/HMEDIC variable)

Array (max size = MAXLVL_ARAC3OBS = 36 currently, a typical number of NORAPS grid levels) of integers representing the ARAC NORAPS data grid levels to be plotted in the MEDIC graphics file.

For example, PLOT_LEVELS_ARAC3OBS=1 4 15 will plot the first, fourth, and fifteenth levels. Note the these are model levels in the NORAPS coordinate system, which is terrain following in pressure coordinates (i.e., these surfaces are flat in σ_p coordinates)

(Default PLOT_LEVELS_ARAC3OBS := -99999, no plots)

PLOT_LEVELS_ECMWFETEX (MEDIC/HMEDIC variable)

Array (max size = KMAX_ECMWF = 14 currently, a typical number of grid levels provided in the ETEX data set, the actual model has 31 levels) of integers representing the ETEX ECMWF data grid levels to be plotted in the MEDIC graphics file. For example, PLOT_LEVELS_ECMWFETEX=1 4 15 will plot the first, fourth, and fifteenth levels. Note the these are model levels in the ECMWF hybrid coordinate system, which is pure terrain following near the ground and blends to a pure pressure coordinate near the model grid top, which is well above the levels provided for ETEX. That is, these surfaces are flat in ECMWF coordinates.

(Default PLOT_LEVELS_ECMWFETEX := -99999, no plots)

PLOT_LEVELS_NHE (MEDIC/HMEDIC variable)

Array (max size = KMAX_UPR_HEMI = 15 currently, the number of hemispheric grid levels) of integers representing the Northern Hemisphere data grid levels to be plotted in the MEDIC graphics file. For example, PLOT_LEVELS_NHE=1 4 15 will plot the first (1000~mb), fourth (500~mb), and fifteenth (10~mb) levels.

(Default PLOT_LEVELS_NHE : 1, 5, 10, 15)

PLOT_LEVELS_NODDS (MEDIC/HMEDIC variable)

Array (max size = KMAX_UPR_NODDS = 9) of integers representing the NODDS (Navy Oceanographic Data Display System) data grid levels (1000mb, 925mb, 850mb, 700mb, 500mb, 400mb, 300mb, 200mb, 100mb) to be plotted as barbs in the MEDIC graphics file. For example, PLOT_LEVELS_NODDS=1 2 3 5 will plot the first (1000mb), second (925mb), third (850mb), and fifth (500mb) levels.

(Default PLOT_LEVELS_NODDS = 0 -> no levels plotted)

PLOT_LEVELS_NOGAPS10 (MEDIC/HMEDIC variable)

Array (max size = KMAX_UPR_NOGAPS10 - 2 = 7) of integers representing the 1-deg NOGAPS data grid levels (1000mb, 925mb, 850mb, 700mb, 500mb, 400mb, 300mb) to be plotted as barbs in the MEDIC graphics file. For example, PLOT_LEVELS_NOGAPS10=1 2 3 5 will plot the first (1000mb), second (925mb), third (850mb), and fifth (500mb) levels.

(Default PLOT_LEVELS_NOGAPS10 = 0 -> no levels plotted)

PLOT_LEVELS_RWM

Array (max size = KMAX_UPR_RWM = 9 currently, the number of Relocatable Window Model levels) of integers representing the Relocatable Window Model grid levels to be plotted in the MEDIC graphics file. For example, PLOT_LEVELS_RWM = 1 2 6 9 will plot the first (surface), second (1000~ft), sixth (15000~ft), and ninth (30000~ft) levels.

PLOT_LEVELS_SHE (MEDIC/HMEDIC variable)

Array (max size = KMAX_UPR_HEMI = 15 currently, the number of hemispheric grid levels) of integers representing the Southern Hemisphere data grid levels to be plotted in the MEDIC graphics file. For example, PLOT_LEVELS_SHE= 1 4 15 will plot the first (1000~mb), fourth (500~mb), and fifteenth (10~mb) levels.

(Default PLOT_LEVELS_SHE : 1, 2, 7, 15)

PRINT_WINDFIELDS (MEDIC/HMEDIC variable)

Flag ('Y', 'N') that controls if the reference level and upper level winds (MEDIC) or the GWC input winds (HMEDIC) and the extrapolated wind fields are to be printed.

(Default : 'N' -> none of the above wind fields are printed)

Warning errors: None

Fatal errors: None

REGMET_PARAMFILE

22-character string which gives the name of the regmet parameter file to be used. The default value, ' ', is used to check if a string was given in the MEDIC_CONTROL namelist. (WARNING: Not yet implemented! !)

(Default : ' ')

Warning errors: None

Fatal errors: None

RWM_BARB_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value that controls the density of barbs on the RWM wind barb plots. A value of one (1) indicates that a vector is plotted for every observation. A value of two (2) indicates that a vector is plotted for every second observation, etc.

(Default : 1)

Warning errors: None

Fatal errors: RWM_BARB_PLOT_FREQ < = 0

RWM_BARB_SCALE (MEDIC/HMEDIC variable)

Floating point value that scales the size of the barbs on the RWM wind barb plots in the horizontal direction.

(Default : set according to the number of barbs plotted)

Warning errors: None

Fatal errors: RWM_BARB_SCALE < = 0.0

SFC_BARB_PLOT_FREQ

Integer value that controls the density of barbs on the surface wind barb plots. A value of one (1) indicates that a vector is plotted for every surface observation. A value of two (2) indicates that a vector is plotted for every second surface observation, etc.

(Default : 1)

Warning errors: None

Fatal errors: SFC_BARB_PLOT_FREQ < = 0

SFC_BARB_SCALE

Floating point value that scales the size of the barbs on the surface wind barb plots in the horizontal direction.

(Default : set according to the number of barbs plotted)

Warning errors: None

Fatal errors: SFC_BARB_SCALE < = 0.0

SFC_ROUGH_HGT

Floating point value that represents the surface roughness height in meters. The surface roughness height is approximately the average height of most land-based features (e.g., grass, trees, buildings) divided by 30. The analyst should consider features over the entire gridded area before entering a value. This is a subjective parameter since we are usually dealing with very diverse geographical areas. Figure III.B.3 gives typical values of surface roughness for various terrain types.

Warning errors: SFC_ROUGH_HGT $\geq$ 2.0

Fatal errors: SFC_ROUGH_HGT $\leq$ 0.0

SFC_ROUGH_HGT > 5.0

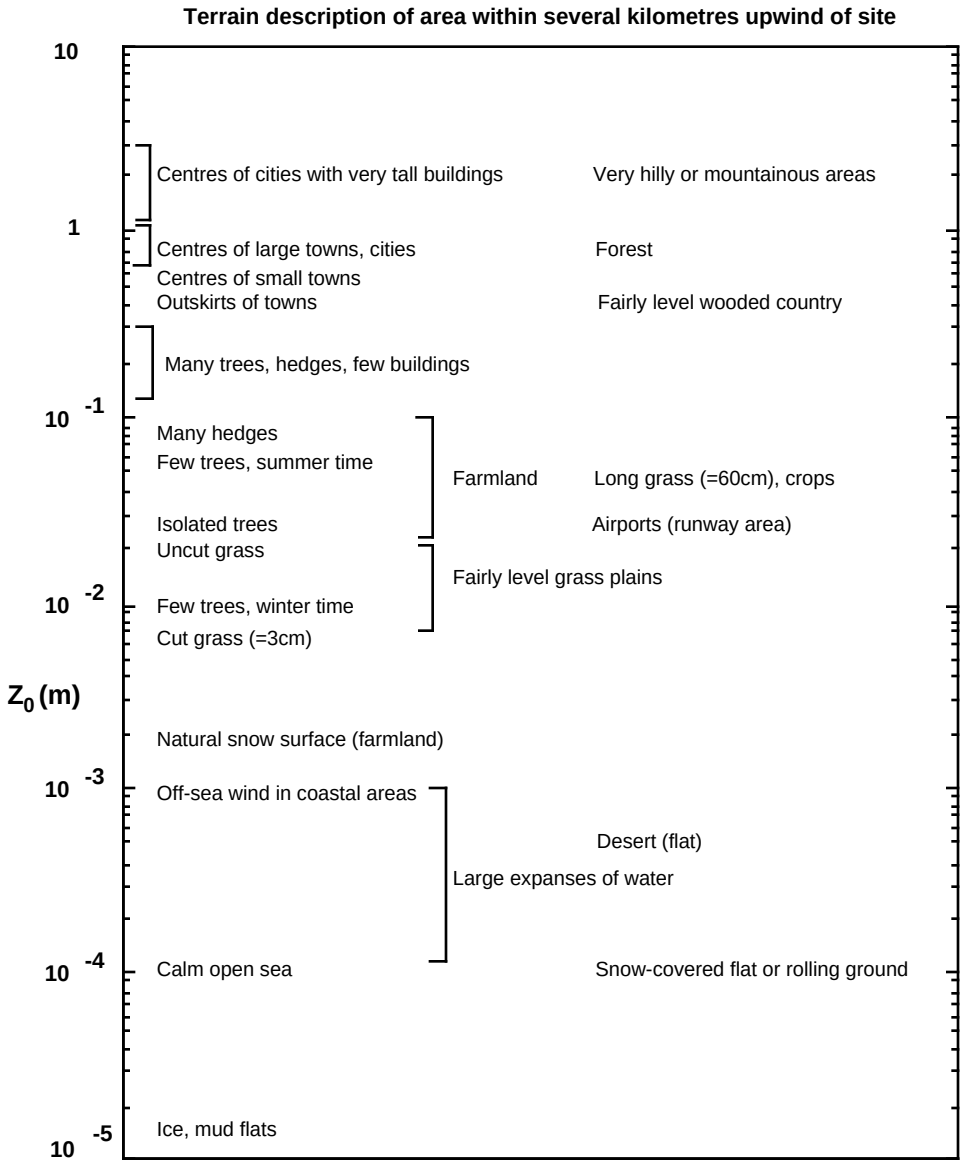


Figure III.B.3. z_0 values for typical terrain types (After ESDU 72026, 1972)

STNLOCPSL

Flag ('Y', 'N') indicating whether or not to use the problem station library. When running MEDIC on the Alpha, STNLOCPSL also controls whether an OBSERV.MET is created from the Problem Metdata Files.

(Default: 'N' -> either no station location data is required or it will be provided in STNLOC.MET)

TERRAIN_ADJUSTMENT (MEDIC/HMEDIC variable)

Flag ('Y', 'N') specifying whether the winds should be terrain shifted ('Y') or zeroed inside the terrain ('N').

(Default : 'Y' for MEDIC and 'N' for HMEDIC)

TOW_BLEND_EXPNT (MEDIC/HMEDIC variable)

Real value representing a power law exponent used to blend the tower data with the upper air data for model levels falling within Zone 2 (maximum tower level to 1.5 * maximum tower level): 1 = simple linear interpolation; <1 = blends the data more quickly (i.e., upper air data is weighted more than tower data); >1 = blends the data more slowly (i.e., tower data is weighted more than upper air data).

(Default: TOW_BLEND_EXPNT = 1 => simple linear interpolation)

TOW_MAX_VEER (MEDIC/HMEDIC variable)

Integer value (0-360) controlling the sense of direction discrepancies when blending the tower data with the upper air data within Zone 2 (maximum tower level to 1.5 * maximum tower level). Winds will veer (i.e., rotate clockwise with height) unless the TOW_MAX_VEER angle is exceeded, in which case the winds will back (i.e., rotate counterclockwise with height).

(Default: TOW_MAX_VEER = 180 => winds will veer unless angle is greater than 180 deg)

TOW_UPR_AT_SFC (MEDIC/HMEDIC variable)

Flag ('Y', 'N') controlling blending for model levels which fall within or below Zone 1 (0.75 * minimum tower level to minimum tower level). 'Y' = Use synthesized upper air to surface, with linear interpolation at model levels which fall in this zone; 'N' = use minimum tower level data, constant to surface.

(Default: TOW_UPR_AT_SFC = 'N' => use lowest tower level data, constant to surface)

TOW_USE_GRIDDED (MEDIC/HMEDIC variable)

Character flag ('Y' or 'N') to control if gridded data is to be used in the blending of multi-level tower data. The reading of input data in MEDIC is arranged so that upper air data is read after all input gridded data. You may use gridded data, upper air data, or both in the blending of multi-level tower data to form upper air profiles. Note that at least one of the following parameters needs to be set to 'Y': TOW_USE_GRIDDED and TOW_USE_UPR.

(Default: TOW_USE_GRIDDED = 'Y' => include gridded data in tower data blending)

TOW_USE_UPR (MEDIC/HMEDIC variable)

Character flag ('Y' or 'N') to control if upper air data is to be used in the blending of multi-level tower data. The reading of input data in MEDIC is arranged so that upper air data is read after all

input gridded data. You may use gridded data, upper air data, or both in the blending of multi-level tower data to form upper air profiles. Note that at least one of the following parameters needs to be set to 'Y': TOW_USE_GRIDDED and TOW_USE_UPR.

(Default: TOW_USE_UPR = 'Y' => include upper air data in tower data blending)

VECTOR_PLOT_FREQ (MEDIC/HMEDIC variable)

Integer value controlling the density of vectors on the vector plots. A value of one (1) indicates that a vector is plotted at every horizontal grid point. A value of two (2) indicates that a vector is plotted at every other grid point, etc. (Default : VECTOR_PLOT_FREQ = 2)

Warning errors: None

Fatal errors: VECTOR_PLOT_FREQ < = 0

XPROFILE (MEDIC/HMEDIC variable)

Array (max size = MAXPROF = 10) of floating point values representing the x-coordinate of the sample profile locations. XPROFILE/YPROFILE constitute a list of the map coordinates of the sample profiles to be plotted. The first value in XPROFILE is matched with the first value in YPROFILE to give the horizontal grid indices of the first profile. Succeeding values from each list are matched in a similar fashion. The XPROFILE/YPROFILE pair is interpolated to the nearest horizontal grid location. The map coordinates in arrays XPROFILE/YPROFILE will in all instances override the values in IPROFILE/JPROFILE, including defaults. If no values are entered for XPROFILE/YPROFILE, the values in IPROFILE/JPROFILE are used.

YPROFILE (MEDIC/HMEDIC variable)

Array (max size = MAXPROF = 10) of floating point values representing the y-coordinate of the sample profile locations. See XPROFILE for a full description.

III.B.4b. MEDIC_PARAMS namelist

ALL_WINDS_DIR (MEDIC/HMEDIC variable)

Array (max size = MAXLEVEL_ALL) of floating point values representing the wind direction profile for a uniform wind field. Uniform wind fields are created if the direction (ALL_WINDS_DIR), speed (ALL_WINDS_SPD), and optionally height (ALL_WINDS_HGT) are set. No met station information (i.e., problem station library or STNLOC.MET) is required. Interpolation is done linearly, with rotation sense determined by the MEDIC parameter MAX_VEER_PARAM_VERT, and following existing direction interpolation rules. Constant winds relative to the grid may be created by setting the TOPOG_PARAMS namelist parameter MAP_ADJUSTMENT = 'N'. Otherwise constant winds relative to geographic coordinates are assumed (MAP_ADJUSTMENT ='Y'). NOTE #1: In order to achieve circumpolar winds in HMEDIC, you can set ALL_WINDS_SPD to the speed at 60 deg latitude and leave MAP_ADJUSTMENT = 'Y'; ALL_WINDS_DIR has no influence in this case. NOTE #2: When using the ALL_WINDS... parameters, there should not be a METDATASET nor a PROBMET_DST... parameters set.

ALL_WINDS_HGT (MEDIC/HMEDIC variable)

Array (max size = MAXLEVEL_ALL) of floating point values representing the heights (m) above terrain of the levels specified in the ALL_WINDS_SPD and ALL_WINDS_DIR arrays. ALL_WINDS_HGT need not be specified if only a single wind speed and direction are to be used. NOTE: When using the ALL_WINDS... parameters, there should not be a METDATASET nor a PROBMET_DST... parameters set.

ALL_WINDS_SPD (MEDIC/HMEDIC variable)

Array (max size = MAXLEVEL_ALL) of floating point values representing the wind speed (m/s) profile for a uniform wind field. Uniform wind fields are created if the direction (ALL_WINDS_DIR), speed (ALL_WINDS_SPD), and optionally height (ALL_WINDS_HGT) are set. No met station information (i.e., problem station library or STNLOC.MET) is required. Interpolation is done linearly, with rotation sense determined by the MEDIC parameter MAX_VEER_PARAM_VERT, and following existing direction interpolation rules. Constant winds relative to the grid may be created by setting The TOPOG_PARAMS namelist parameter MAP_ADJUSTMENT = 'N'. Otherwise constant winds relative to geographic coordinates are assumed (MAP_ADJUSTMENT ='Y'). NOTE #1: In order to achieve circumpolar winds in HMEDIC, you can set ALL_WINDS_SPD to the speed at 60 deg latitude and leave MAP_ADJUSTMENT = 'Y'; ALL_WINDS_DIR has no influence in this case. NOTE #2: When using the ALL_WINDS... parameters, there should not be a METDATASET nor a PROBMET_DST... parameters set.

ARAC3OBSDATE (MEDIC/HMEDIC variable)

7-character string representing the date (ddmmmyy) of the ARAC 3 observational upper air metdata to be used by MEDIC. This capability is currently used to transfer ARAC NORAPS model output to MEDIC. The NORAPS gridded metdata is represented as upper air observations for the area covered by the MEDIC grid.

ARAC3OBSFCST (MEDIC/HMEDIC variable)

Integer specifying the forecast period (hh) of the ARAC 3 observational upper air metdata to be used by MEDIC. For example, a value of 0 refers to a zero-hour forecast or initialization; a value of 24 refers to a 24-hour forecast. This capability is currently used to transfer ARAC NORAPS model output to MEDIC. Current possible values for the for the ARAC 3 observational upper air data are 0, 1, 2, ... as controlled by the NORAPS namelist input. The NORAPS gridded metdata is represented as upper air observations for the area covered by the MEDIC grid.

ARAC3OBSTIME (MEDIC/HMEDIC variable)

8-character string specifying the valid time (hh:mm:ss) of the ARAC 3 observational upper air metdata to be used by MEDIC. This capability is currently used to transfer ARAC NORAPS model output to MEDIC. The NORAPS gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

ARAC3OBS_NEST (MEDIC/HMEDIC variable)

An integer specifying the NORAPS nest for the ARAC 3 observational upper air metdata to be used by MEDIC. This capability is currently used to transfer ARAC NORAPS model output to MEDIC. The NORAPS gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid. The legal values are 1, 2 and 3, with 1 representing the main grid.

ATMESDATE (MEDIC/HMEDIC variable)

7-character string representing the date (ddmmmyy) of the ATMES gridded metdata to be used by Medic. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid. Note regarding source of "ATMES gridded metdata": GribFM92 formatted data from 25-Apr-86 to 10-May-86 obtained from ECMWF as part of the ATMES study was run through Bob's code to degrib it to this form:

GRIB_OUT_2.yymmddhhmm - geopotential

GRIB_OUT_3.yymmddhhmm - surface winds

GRIB_OUT_5.yymmddhhmm - upper air winds

MEDIC expects these files to be in the directory:

2dua18:[kfoster.modev.datasets.chernobyl.raw]

ATMESTIME (MEDIC/HMEDIC variable)

8-character string representing the time (hh:mm:ss) of the ATMES gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid. Note regarding source of "ATMES gridded metdata": GribFM92 formatted data from 25-Apr-86 to 10-May-86 obtained from ECMWF as part of the ATMES study was run through Bob's code to degrib it to this form:

GRIB_OUT_2.yymmddhhmm - geopotential

GRIB_OUT_3.yymmddhhmm - surface winds

GRIB_OUT_5.yymmddhhmm - upper air winds

MEDIC expects these files to be in the directory:

2dua18:[kfoster.modev.datasets.chernobyl.raw]

AVGTIME (MEDIC/HMEDIC variable)

13-character string representing the time interval (DDD::hh:mm:ss) which is used to specify the averaging time applicable to a given dataset. This value is not used in the calculation, but is used to construct the fully qualified name of the resulting MEDVEL/MATVEL files. It is a required input.

BL_HGT

Floating point value representing the height (m) of the boundary layer above terrain. The height of the boundary layer is the level at which the wind speed and direction become nearly geostrophic, i.e., change little with height because of the negligible effects of surface drag. Upper air sounding (RAWINS or PIBALS) are the best data source for determining BL_HGT. If no soundings are available, an alternative procedure to obtain BL_HGT is to use Figure III.B.1. BL_HGT as used by the model is the height at which the extrapolated upper air profile matches the observed upper air profile. The wind speed and direction above BL_HGT matches the observed upper air profile if PROFILE_EXTRAP='Y', but remains constant if PROFILE_EXTRAP='N'.

Warning errors: BL_HGT $\leq$ 50.0

BL_HGT $\geq$ 3000.0

Fatal errors: BL_HGT $\leq$ 0.0

BL_HGT $\geq$ 5000.0

ECMWFETEXDATE (MEDIC/HMEDIC variable)

7-character string representing the date (ddmmmyy) of the ECMWF ETEX gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

ECMWFETEXFCST (MEDIC/HMEDIC variable)

Integer specifying the forecast period (hh) of the ECMWF ETEX gridded metdata to be used by MEDIC. For example, a value of 0 refers to a zero-hour forecast or initialization; a value of 24 refers to a 24-hour forecast. Current possible values for the for the ECMWF ETEX gridded data are 0, 6, 12, ... 60. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

ECMWFETEXTIME (MEDIC/HMEDIC variable)

8-character string specifying the valid time (hh:mm:ss) of the ECMWF ETEX gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

EXTRAP_EXPNT_BL

Floating point value representing the interpolation exponent for the boundary layer. It is used to interpolate winds within the boundary layer, and is valid between the top of the surface layer (SL_HGT) and the top of the boundary layer (BL_HGT). A more complete discussion of this very important parameter is contained in Section II.C.2.c.

Warning errors:	EXTRAP_EXPNT_BL > 10.0
Fatal errors:	EXTRAP_EXPNT_BL < 0.0
	EXTRAP_EXPNT_BL > 50.0

MAX_VEER_PARAM_VERT

Integer value controlling the sense of the vertical direction extrapolation in the boundary layer, and is only used when PROFILE_EXTRAP = 'N' (the parameterized extrapolation). It is the largest angle, measured in degrees, which will be resolved by veering (i.e., the winds rotate in a clockwise direction with height) rather than by backing.

(Default : 240)

Warning errors:	NONE
Fatal errors:	MAX_VEER_PARAM_VERT < 0
	MAX_VEER_PARAM_VERT >360

MAX_VEER_PROF_HORZ

Integer value controlling the sense of how upper air and surface direction discrepancies are resolved at the top of the surface layer, and is only used when PROFILE_EXTRAP='N' (the profile extrapolation).

(Default : 180)

Warning errors:	NONE
Fatal errors:	MAX_VEER_PROF_HORZ < 0
	MAX_VEER_PROF_HORZ > 360

METDATASET

40-character string designating which met data set in the OBSERV.MET file is to be used for this case (i.e., with this MEDIC_PARAMS namelist). The string must match EXACTLY that in the file OBSERV.MET. Suggested string composition is 'yymmddhhq' for most cases. A given dataset may be used more than once, or not at all, in a given MEDIC run: OBSERV.MET is reprocessed for every MEDIC_PARAMS namelist processed so that any dataset can be located. The METDATASET parameter is required for Alpha versions of MEDIC; for Vax versions, METDATASET will be ignored if any of the PROBMET_DST ... parameters are present.

(Default: METDATASET = 'unset' = OBSERV.MET file not used)

MET_START_DATE (MEDIC/HMEDIC variable)

7-character string indicating the day (ddmmmyy) for which a MEDVEL wind dataset is to be created.

MET_START_TIME (MEDIC/HMEDIC variable)

8-character string representing the time (hh:mm:ss) for which a MEDVEL wind dataset is to be created.

Warning errors:	None
Fatal errors:	MET_START_TIME < 0
	MET_START_TIME > 2400

NHEDATE (MEDIC/HMEDIC variable)

7-character string representing the date (ddmmmyy) of the Northern Hemisphere gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NHEFCST (MEDIC/HMEDIC variable)

Integer specifying the forecast period (hh) of the Northern Hemisphere gridded metdata to be used by MEDIC. For example, a value of 00 refers to a zero-hour forecast or initialization; a value of 24 refers to a 24-hour forecast. Current possible values for the for the hemispheric gridded data are 00, 12, 24, 36, 48, and 60. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NHETIME (MEDIC/HMEDIC variable)

8-character string specifying the valid time (hh:mm:ss) of the Northern Hemisphere gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NODDSDATE (MEDIC/HMEDIC variable)

7-character string representing the date (ddmmmyy) of the 2.5-degree NOGAPS gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NODDSFCST (MEDIC/HMEDIC variable)

Integer specifying the forecast period (hh) of the 2.5-degree NOGAPS gridded metdata to be used by MEDIC. For example, a value of -1 refers to a zero-hour forecast or initialization; a value of 24 refers to a 24-hour forecast. Current possible values for the for the NODDS gridded data are -1, 12, 24, 36, 48, 60, 72, 84, 96, 108, and 120. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NODDSTIME (MEDIC/HMEDIC variable)

8-character string specifying the valid time (hh:mm:ss) of the 2.5-degree NOGAPS gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NOGAPS10DATE (MEDIC/HMEDIC variable)

7-character string representing the date (ddmmmyy) of the 1-degree NOGAPS gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NOGAPS10FCST (MEDIC/HMEDIC variable)

Integer specifying the forecast period (hh) of the 1-degree NOGAPS gridded metdata to be used by MEDIC. For example, a value of -1 refers to a zero-hour forecast or initialization; a value of 24 refers to a 24-hour forecast. Current possible values for the for the 1-deg NOGAPS gridded data are -1, 6, 12, 18, 24, 30, 36, 42, and 48. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

NOGAPS10TIME (MEDIC/HMEDIC variable)

8-character string specifying the valid time (hh:mm:ss) of the 1-degree NOGAPS gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

PROBMET_DST

9-character (yymmddhhq) string representing the Data Set Time of the Problem Metdata Files (surface, tower, and upper air) if the three Data Set Times are not explicitly given. PROBMET_DST is used as the default for a missing Data Set Time if any, but not all, of PROBMET_DST_SFC, PROBMET_DST_UPR, or PROBMET_DST_TOW are specified. When used simultaneously with the

METDATASET parameter, METDATASET is ignored on the VAX and PROBMET_DST is ignored on the Alpha. (However, PROBMET_DST is used by the Alpha MEDIC preprocessor to create an OBSERV.MET file.) This avoids the need for different versions of MEDIC.NML on the VAX and the Alpha.

PROBMET_DST_SFC

9-character (yymmddhhq) string representing the Data Set Time of the Problem Metdata File for surface data. PROBMET_DST_SFC will override PROBMET_DST for surface datasets. NOTE: When used simultaneously with the METDATASET parameter; METDATASET is ignored on the VAX and PROBMET_DST_SFC is ignored on the Alpha. (However, PROBMET_DST_SFC is used by the Alpha MEDIC preprocessor to create an OBSERV.MET file.) This avoids the need for different versions of MEDIC.NML on the VAX and the Alpha.

PROBMET_DST_TOW

9-character (yymmddhhq) string representing the Data Set Time of the Problem Metdata Files for tower data. PROBMET_DST_TOW will override PROBMET_DST for tower datasets. When used simultaneously with the METDATASET parameter; METDATASET is ignored on the VAX and PROBMET_DST_TOW is ignored on the Alphas. (However, PROBMET_DST_TOW is used by the Alpha MEDIC preprocessor to create an OBSERV.MET file.) This avoids the need for different versions of MEDIC.NML on the VAX and the Alphas.

PROBMET_DST_UPR

9-character (yymmddhhq) string representing the Data Set Time of the Problem Metdata Files for upper air data. PROBMET_DST_UPR will override PROBMET_DST for upper air datasets.. When used simultaneously with the METDATASET parameter; METDATASET is ignored on the VAX and PROBMET_DST_UPR is ignored on the Alphas. (However, PROBMET_DST_UPR is used by the Alpha MEDIC preprocessor to create an OBSERV.MET file.) This avoids the need for different versions of MEDIC.MNL on the VAX and the Alphas.

PROFILE_EXTRAP

Flag ('Y', 'N') specifying if upper air profiles are used to perform the vertical extrapolation. If PROFILE_EXTRAP is 'N', only the extrapolation parameters are used to generate three-dimensional gridded winds from two-dimensional grids of winds. (Also, see BL_HGT concerning the relationship between PROFILE_EXTRAP and BL_HGT.) If gridded upper air data is used, profile extrapolation is generally preferred.

(Default : 'N', => use parameterized profile method)

PWR_LAW_EXPNT_SL

Floating point value representing the power law exponent for the surface layer. It can be calculated directly from surface-layer wind observations in the vertical using the power law formula

given by Eq. (II.C.1). Alternatively, it can be obtained as a function of surface roughness height (surface roughness height is approximately 1/30th of the average height of features such as buildings, grass, trees) as shown in Fig. III.B.1, and the following correction for atmospheric stability applied:

Stable:	add 0.1
Neutral:	as is
Unstable:	subtract 0.1

PWR_LAW_EXPNT_SL is used within the code to extrapolate: (1) wind speeds from their measured height to REF_HGT (see below), (2) wind speeds from the SFC_ROUGH_HGT to the top of the surface layer above terrain in the parameterized extrapolation procedure (see SL_HGT below), and (3) wind speeds from the SFC_ROUGH_HGT and REF_HGT in the profile extrapolation procedure (see Section II.C.2.c for details).

Warning errors:	PWR_LAW_EXPNT_SL > 0.5
Fatal errors:	PWR_LAW_EXPNT_SL < 0.0
	PWR_LAW_EXPNT_SL > 10.0

REF_HGT

Floating point value representing the height (m) above terrain to which the surface wind observations are adjusted using the surface power law (PWR_LAW_EXPNT_SL). Adjustments of the measurements to a common height, usually the typical height of the surface instruments, permits the extrapolation of winds in the horizontal direction.

Warning errors:	REF_HGT $\leq$ 2.0
	REF_HGT $\geq$ 100.0
Fatal errors:	REF_HGT $\leq$ 0.0
	REF_HGT $\geq$ 500.0

RWMDATE

7-character string specifying the valid date (ddmmmyy) of the Relocatable Window Model gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

RWMFCST

Integer specifying the forecast period (hh) of the Relocatable Window Model gridded metdata to be used by MEDIC. For example, a value of 00 refers to a zero-hour forecast or initialization; a value of 24 refers to a 24-hour forecast. Current possible values for the Relocatable Window Model are 00, 06, 24, and 36. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

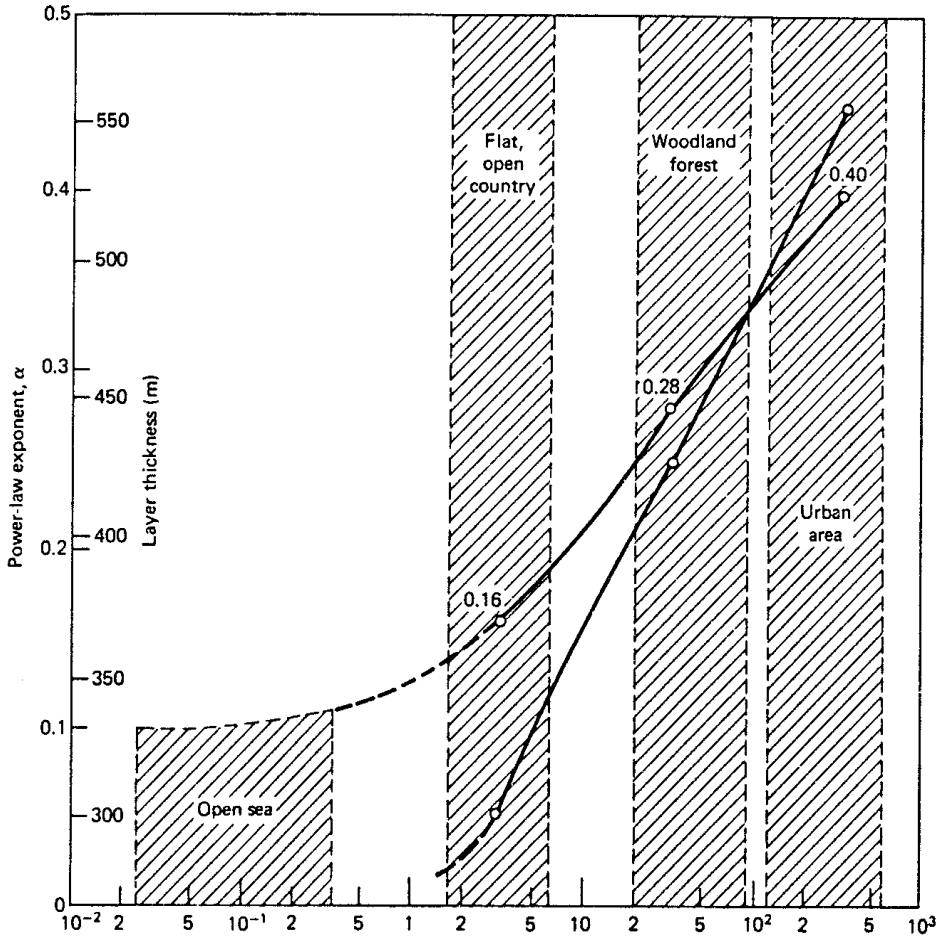


Figure III.B.1 **Modeling the planetary boundary layer (plot from Davenport 1965)**

RWMTIME

8-character string specifying the valid time (hh:mm:ss) of the Relocatable Window Model gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

SHEDATE (MEDIC/HMEDIC variable)

7-character string specifying the valid date (ddmmmyy) of the Southern Hemisphere gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

SHEFCST (MEDIC/HMEDIC variable)

Integer specifying the forecast period (hh) of the Southern Hemisphere gridded metdata to be used by MEDIC. For example, a value of 00 refers to a zero-hour forecast or initialization; a value of

24 refers to a 24-hour forecast. Current possible values for the hemispheric gridded data are 00, 12, 24, 36, and 48. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

SHETIME (MEDIC/HMEDIC variable)

8-character string specifying the valid time (hh:mm:ss) of the Southern Hemisphere gridded metdata to be used by MEDIC. The gridded metdata is transformed into upper air observations for the area covered by the MEDIC grid.

SINGLE_PROFILE_WINDS

8-character string specifying the upper air metdata station id for which the upper air metdata profile from the Problem Metdata File (met dataset time specified by the PROBMET_DST... parameters) is to be used to construct a uniform wind field. Interpolation is done linearly, with rotation sense determined by the MEDIC parameter MAX_VEER_PARAM_VERT, and following existing direction interpolation rules.

(Default: SINGLE_PROFILE_WINDS = 'unset')

SL_HGT

Floating point value representing the height (m) of the surface layer above terrain. The surface boundary layer is defined as that part of the atmosphere boundary layer where momentum, heat, and energy fluxes are constant. While the height of this layer is typically about 10% of the boundary layer height (BL_HGT), it is more useful to consider SL_HGT as the level at which the wind direction begins to turn with height.

Warning errors:	SL_HGT $\leq$ 2.0
	SL_HGT $\geq$ 100.0
Fatal errors:	SL_HGT $\leq$ 0.0
	SL_HGT $\geq$ 500.0

USE_UPR_AT_SFC

Flag ('Y' or 'N') which controls whether the lowest level of upper air observations from all sources which are also within the surface layer is used to construct the reference level (surface) winds. Note that if you are just using gridded data whose lowest level is 1000mb, you should probably use a surface layer height of 150m. Note also that for the FNMOC 2.5-deg NOGAPS gridded data, the lowest level of the gridded data is also included and labeled as surface data as sent by FNMOC.

(Default : USE_UPR_AT_SFC = 'N')

SAMPLE MEDIC.NML INPUT FILE USING PROBLEM MET DATA

```
$medic_control                                  beginning of medic control namelist
medic_vlst        =  'new'          ←  flag controlling creation of MEDIC.VLST file
print_windfields  =  'Y'            ←  prints wind components
sfc_rough_hgt     =  0.1            ←  surface roughness height
stnlocpsl         =  'Y'            ←  required for Alpha versions
$end                                ←  end of medic control namelist

$medic_params                                   beginning of medic params namelist
metdataset        =  '01APR85/06:00'  ←  required for Alpha versions
probmet_dst       =  '850401060'    ←  specification of problem met data file
met_start_date    =  '01APR85'      ←  date(ddMMMyy) of medvel file to be created
met_start_time    =  '0600'         ←  time (hhmmss) of medvel file to be created
avgtime           =  '0100'         ←  averaging time for medvel file to be created
sl_hgt            =  25.0           ←  height of the surface layer above the terrain
bl_hgt            =  1400.0         ←  height of the boundary layer above the terrain
pwr_law_expnt_sl  =  0.30           ←  exponent for surface layer power law
extrap_expnt_bl   =  0.30           ←  extrapolation exponent for boundary layer
profile_extrap    =  'N'            ←  method of extrapolation
ref_hgt           =  10.0           ←  hgt above terrain to which sfc winds are adjusted
$end                                ←  end of medic params
```

SAMPLE MEDIC_PARAMS NAMELIST SECTION FOR HEMISPHERIC CASE

```
$medic_params                                   beginning of medic params namelist
met_start_date    =  '01APR85'      ←  date(ddMMMyy) of medvel file to be created
met_start_time    =  '0600'         ←  time (hhmmss) of medvel file to be created
avgtime           =  '0100'         ←  averaging time for medvel file to be created
nhedate           =  '01APR85'      ←  date (ddMMMyy) of AFGWC met dataset to be used
nhefcst           =  00             ←  analysis (00hr) AFGWC data to be used
nhetime           =  '1200'         ←  time ('hhmmss') of AFGWC met dataset to be used
$end                                ←  end of medic params namelist
```

SAMPLE MEDIC_PARAMS NAMELIST SECTION USING OBSERV.MET DATA

```
$medic_params                                   beginning of params namelist
metdataset        =  'SET1'         ←  pointer id for met dataset in OBSERV.MET
met_start_date    =  '01APR85'      ←  date(ddMMMyy) of medvel file to be created
met_start_time    =  '0600'         ←  time (hhmmss) of medvel file
avgtime           =  '0100'         ←  averaging time for medvel file
sl_hgt            =  25.0           ←  height of the surface layer above the terrain
bl_hgt            =  1400.0         ←  height of the boundary layer above the terrain
pwr_law_expnt_sl  =  0.30           ←  exponent for surface layer power law
extrap_expnt_bl   =  0.30           ←  extrapolation exponent for boundary layer
profile_extrap    =  'N'            ←  method of extrapolation
ref_hgt           =  10.0           ←  hgt above terrain to which sfc winds are adjusted
$end                                ←  end of params namelist
```

SAMPLE MEDIC INPUT FILE USING ALL_WINDS

```
$medic_control                                  beginning of control namelist
medic_vlst          =  'new'          ←         flag controlling creation of MEDIC.VLST file
print_windfields    =  'Y'            ←         prints wind components
sfc_rough_hgt       =  0.1            ←         surface roughness height
stnlocpsl           =  'N'            ←         no problem station library info required
$end                                  ←         end of control namelist

$medic_params                                   beginning of params namelist
met_start_date      =  '01APR85'      ←         date(ddMMMyy) of medvel file to be created
met_start_time      =  '0600'         ←         time (hhmmss) of medvel file
avgtime             =  '0100'         ←         averaging time for medvel file
all_winds_hgt       =  10. 100. 500.  ←         array of heights AGL (m)
all_winds_dir       =  160.180. 182   ←         array of wind directions (deg)
all_winds_spd       =  1.5 2.0 2.3    ←         array of wind speeds (m/s)
sl_hgt              =  25.0           ←         height of the surface layer above the terrain
bl_hgt              =  1400.0         ←         height of the boundary layer above the terrain
pwr_law_expnt_sl    =  0.30           ←         exponent for surface layer power law
extrap_expnt_bl     =  0.30           ←         extrapolation exponent for boundary layer
profile_extrap      =  'N'            ←         method of extrapolation
ref_hgt             =  10.0           ←         hgt above terrain to which sfc winds are adjusted
$end                                  ←         end of params namelist
```

SAMPLE MEDIC_PARAMS NAMELIST SECTION USING SINGLE_PROFILE_WINDS = 'metstnid'

```
$medic_params                                   beginning of medic params namelist
metdataset          =  '01APR85/06:00'  ←       required for Alpha versions
probmet_dst         =  '850401060'      ←       specification of problem met data file
met_start_date      =  '01APR85'        ←       date(ddMMMyy) of medvel file to be created
met_start_time      =  '0600'           ←       time (hhmmss) of medvel file to be created
avgtime             =  '0100'           ←       averaging time for medvel file to be created
single_profile_winds =  'ARACTES1'      ←       use single wind profile for station ARACTES1 from
                                                specified probmet_dst file
sl_hgt              =  25.0             ←       height of the surface layer above the terrain
bl_hgt              =  1400.0           ←       height of the boundary layer above the terrain
pwr_law_expnt_sl    =  0.30             ←       exponent for surface layer power law
extrap_expnt_bl     =  0.30             ←       extrapolation exponent for boundary layer
profile_extrap      =  'N'              ←       method of extrapolation
ref_hgt             =  10.0             ←       hgt above terrain to which sfc winds are adjusted
$end                                    ←       end of medic params
```

III.B.5. STNLOC.MET

The STNLOC.MET file is the input file containing the met station information for the MEDIC code when the Problem Station Library file is not used. It specifies meteorological measurement stations (surface, tower, and upper air) by name, location, and (for the surface stations) measurement height. Each meteorological measurement station referenced in either the Problem Metdata Files or the OBSERV.MET file must have been assigned a location in the STNLOC.MET file if there is no Problem Station Library. While the STNLOC.MET file normally is left unchanged for a well-characterized site, it can be changed at any time between MEDIC runs to provide locations for additional meteorological stations that have become available during an accident response.

This file is a Fortran list-directed input file (rather than a Fortran namelist file). Preceding station location records is a keyword identifying which type of station follows: SFC, TOW, or UPR, corresponding to surface, tower, or upper air meteorological data stations. The records following the keyword have no identifying names, but order is important. The data to specify a surface location is the name (8 characters), x coordinate, y coordinate, and height. Tower and upper air location are similarly specified, except a height is not specified. No entry is required for the number of either surface or upper air records; a count of valid stations of each type is done in the input processing.

At least one surface or tower station must be specified (unless using USE_UPR_AT_SFC), as well as at least one upper air station.

Surface Location Record

There is one record per surface station (maximum of 500 total surface and single-level tower stations within the surface layer), and the record consists of four items:

1. Character string of up to 8 characters, delimited by apostrophes, representing the station id
2. Model x-coordinate of the station location (must be $\geq$ -45000.0 and < 45000.0)
3. Model y-coordinate of the station location (must be $\geq$ -45000.0 and < 45000.0)
4. Height (m) of the instrument above ground level (must be > 0.0 and < 10000.0)

Tower Location Record

There is one record per tower station (maximum of 200 total tower stations,), and the record consists of three items:

1. Character string of up to 8 characters, delimited by apostrophes, representing the station id
2. Model x-coordinate of the station location (must be $\geq$ -45000.0 and < 45000.0)
3. Model y-coordinate of the station location (must be $\geq$ -45000.0 and < 45000.0)

Upper Air Location Record

There is one record per upper air station (maximum of 200 total upper air, single-level tower stations with height above the surface layer, and multi-level tower stations), and the record consists of three items:

1. Character string of up to 8 characters, delimited by apostrophes, representing the station id
2. Model x-coordinate of the station location (must be ≥ -45000.0 and < 45000.0)
3. Model y-coordinate of the station location (must be ≥ -45000.0 and < 45000.0)

SAMPLE STNLOC.MET FILE

UPR				
	'745040'	544.196	4150.254	
	'OAK'	569.007	4178.162	
TOW				
	'ARACTES1'	613.496	4171.685	
	'LIVELLNL'	614.661	4172.278	
SFC				
	'HWD'	577.921	4167.145	6.1
	'LVK'	604.317	4172.984	6.1
	'OAK'	569.022	4176.308	6.1
	'NGZ'	560.170	4181.787	6.1
	'SCK'	653.864	4195.958	6.1
	'CCR'	583.429	4204.182	6.1

III.B.6. OBSERV.MET

OBSERV.MET is the input file used when meteorological data is not obtained from the Problem Metdata Files. The file is constructed to be read as a Fortran list-directed file, as was STNLOC.MET. An OBSERV.MET file can contain many individual meteorological data sets, called a metdatset. Each such set of data is marked by the occurrence of the keyword METDATASET, followed on the same line by the name (up to 40 characters), in apostrophes, by which it is to be referred in this MEDIC run. Following the METDATASET identifier record is any of the keywords SFC, TOW, or UPR, which denote that the meteorological data to follow is either surface, tower, or upper air data, respectively. Following the type-identifier record are individual data records. When the keywords SFC, TOW, or UPR are again encountered, then input processing toggles to that type. When the METDATASET keyword is encountered, a new set of data is deemed to begin, terminating the previous input one. The format of both types of individual data records is now given.

Surface Met Record

There is one record for each surface observation, and this record consists of three items:

1. Character string of up to 8 characters, delimited by apostrophes, representing the station id; note that this station id must match exactly with one previously input as a surface station via the STNLOC.MET file or from the Problem Station Library.
2. Wind direction (deg); if no wind direction data (i.e. this record is only for a wind speed entry), enter -1.
3. Wind speed (m/s); if no wind speed data (i.e., this record is only for a wind direction entry), enter -1. A zero wind speed is assigned a -1. direction.

Tower Met Record

There is one record for each tower level (maximum of MAXLEVEL_ALL levels per tower station), and the record consists of four items. Note that sigma theta data must be entered via the SIGMA_THETA_DATA namelist in the ADPIC.NML file.

1. Character string of up to 8 characters, delimited by apostrophes, representing the station id; note that this station id must match exactly with one previously input as a surface station via the STNLOC.MET file or from the Problem Station Library. This must be specified for the first tower level, while subsequent levels/records for the same station may simply contain a comma instead of the station identifier. (See example at end of section)
2. Height (m) of the observation
3. Wind direction (deg); if no wind direction data (i.e. this record is only for a wind speed entry), enter -1.
4. Wind speed (m/s); if no wind speed data (i.e., this record is only for a wind direction entry), enter -1. A zero wind speed is assigned a -1. direction.

Upper Air Met Record

There is one record for each upper air level (maximum of MAXLEVEL_ALL levels per upper air station), and the record consists of four items. Note that sigma theta data must be entered via the SIGMA_THETA_DATA namelist in the ADPIC.NML file.

1. Character string of up to 8 characters, delimited by apostrophes, representing the station id; note that this station id must match exactly with one previously input as a surface station via the STNLOC.MET file or from the Problem Station Library. This must be specified for the first upper air level, while subsequent levels/records for the same station may simply contain a comma instead of the station identifier. (See example at end of section)
2. Height (m) of the observation
3. Wind direction (deg); if no wind direction data (i.e. this record is only for a wind speed entry), enter -1.
4. Wind speed (m/s); if no wind speed data (i.e., this record is only for a wind direction entry), enter -1. A zero wind speed is assigned a -1. direction.

SAMPLE OBSERV.MET FILE

```
METDATASET      'SET1'
UPR
                'OAK'          10.0      270.0      1.0
                          ,    500.0     270.0      3.0
                          ,    900.0     270.0      3.0
                          ,    1400.0    270.0      3.0
TOW
                'LIVELLNL'     10.0      250.       1.0
                          ,    40.0      255.       1.5
SFC
                'CCR'                    270.       2.5
                'HWD'                    325.       1.0
                'LVK                     270.       1.0
                'SCK'                    350.       1.0
```

III.B.7. MATHEW.NML

MATHEW.NML is the input file that controls a CG-MATHEW run. A basic MATHEW.NML file is a list of the CG-MATHEW stabilities (or SIGMA_VERT values) and the date/times when they take effect. The MATHEW.NML file may also contain a list of the MEDVEL*.BIF files to be processed although these are more typically specified in a MEDIC.VLST file.

The following is a list of the MATHEW.NML variables grouped alphabetically within the two namelist blocks, MATHEW_CONTROL and MATHEW_PARAMS:

III.B.7.a. MATHEW_CONTROL namelist

HORZ_VECTOR_SCALE

Floating point value which scales the size of the vectors on the vector plots in the x direction.

(Default: HORZ_VECTOR_SCALE = 0.5).

Warning errors: HORZ_VECTOR_SCALE $\geq$ 25.0

Fatal errors: HORZ_VECTOR_SCALE $\leq$ 0.0

IPROFILE

Array (max size = MAXPROF = 10) of integers (1 to 51 for standard R41 grid) of the i indices of the sample profiles of the adjusted winds to be plotted. The first value in IPROFILE is matched with the first value in JPROFILE to give the horizontal grid indices of the first profile. Succeeding indices from each list are matched in a similar fashion. The default for IPROFILE with a standard 51 by 51 by 15 MATHEW grid is: 14 26 38 14 26 38 14 26 38. This gives the normal nine sample profiles. Any profiles specified by IPROFILE and JPROFILE (along with the defaults) are superceded by any locations specified by XPROFILE and YPROFILE.

ISLICE

Array (max size = IMAXMAT = 51) of integers (1 to 51 for standard R41 grid) of i-indices at which vector plots of $v - w$ component winds are to be produced. The default value is no slices. Any slices specified by ISLICE are superceded by any locations specified by XSLICE.

ITER_MESSAGE

Integer value specifying the interval number of iterations at which status messages are sent to the terminal. The message gives the number of iterations and the number of “cells” that must still converge.

(Default: ITER_MESSAGE = 50).

Warning errors: None

Fatal errors: ITER_MESSAGE < 0

JPROFILE

Array (max size = MAXPROF = 10) of integers (1 to 51 for a standard R41 grid) of the *j* indices of the sample profiles of the adjusted winds to be plotted. The first value in JPROFILE is matched with the first value in IPROFILE to give the horizontal grid indices of the first profile. Succeeding indices from each list are matched in a similar fashion. The default for JPROFILE with a standard 51 by 51 by 15 MATHEW grid is: 14 14 14 26 26 26 38 38 38. This gives the normal nine sample profiles. Any profiles specified by IPROFILE and JPROFILE (along with the defaults) are superceded by any locations specified by XPROFILE and YPROFILE.

JSLICE

Array (max size = JMAXMAT = 51) of integers (1 to 51 for a standard R41 grid) of *j* indices at which vector plots of $u - w$ component winds are to be produced. The default value is no slices. Any slices specified by JSLICE are superceded by any locations specified by YSLICE.

OUTPUT_DESTINATION_DIR

10-character string ('WINDS', 'DISPERSION', 'VLST', or 'GRID') which directs all output from MATHEW (except the MATHEW.LOG file) to a specified directory.

(Default: OUTPUT_DESTINATION_DIR = 'WINDS')

PLOT_LEVELS_ABOVE_TOPO

Array (max size = KMAXMAT = 15) of integers (1 to 15 for a standard R41 grid) representing the *k* levels above terrain at which horizontal vector plots are to be produced.

(Default: PLOT_LEVELS_ABOVE_TOPO = 2 -> produce vector plot at 1 *DELZ above terrain)

PLOT_GRID_LEVELS

Array (max size = KMAXMAT = 15) of integers (1 to 15 for a standard R41 grid) representing the *k* levels above grid bottom (thus some areas may contain vectors of zero length corresponding to grid points underground) at which horizontal vector plots are to be produced. The default is no plots.

PRINT_ADJUSTWIND_ADPIC

Flag ('Y', 'N') specifying whether or not ADPIC winds are to be printed in the MATHEW.LOG file.

(Default: PRINT_ADJUSTWIND_ADPIC = 'N' -> don't print ADPIC winds in MATHEW.LOG)

PRINT_ADJUSTWIND_DIVERG

Flag ('Y', 'N') specifying whether or not the divergence of the adjusted grid point ADPIC winds are to be printed in the MATHEW.LOG file.

(Default: PRINT_ADJUSTWIND_DIVERG = 'N' -> don't print the divergence of the adjusted grid point ADPIC winds in the MATHEW.LOG file)

PRINT_ADJUSTWIND_FACE

Flag ('Y', 'N') specifying whether or not the adjusted face-centered winds are to be printed in the MATHEW.LOG file.

(Default: PRINT_ADJUSTWIND_FACE = 'N' -> don't print these winds in the MATHEW.LOG)

PRINT_ADJUSTWIND_GRID

Flag ('Y', 'N') specifying whether or not the grid point adjusted winds are to be printed in the MATHEW.LOG file.

(Default: PRINT_ADJUSTWIND_GRID = 'N' -> don't print these winds in the MATHEW.LOG)

PRINT_CONVERGENCE

Flag ('Y' or 'N') specifying whether or not the convergence status is to be displayed to the screen during iteration.

(Default: PRINT_CONVERGENCE = 'Y')

PRINT_ICCG_CHECK

Flag ('Y' or 'N') which controls the printing of the divergence checks on the conjugate-gradient solution.

(Default = PRINT_ICCG_CHECK = 'N')

PRINT_INITIALWIND_DIVERG

Flag ('Y', 'N') specifying whether or not the divergence of the extrapolated winds is to be printed in the MATHEW.LOG file.

(Default: PRINT_INITIALWIND_DIVERG = 'N' -> don't print the divergence in the MATHEW.LOG)

PRINT_INITIALWIND_FACE

Flag ('Y', 'N') specifying whether or not the face-centered extrapolated winds are to be printed in the MATHEW.LOG file.

(Default: PRINT_INITIALWIND_FACE = 'N' -> don't print these winds in the MATHEW.LOG)

PRINT_INITIALWIND_GRID

Flag ('Y', 'N') specifying whether or not the grid point extrapolated winds are to be printed in the MATHEW.LOG file.

(Default: PRINT_INITIALWIND_GRID = 'N' -> don't print these winds in the MATHEW.LOG)

PRINT_LAMBDAS

Flag ('Y', 'N') specifying whether or not the Lagrangian multipliers are to be printed in the MATHEW.LOG file.

(Default: PRINT_LAMBDAS = 'N' -> don't print the multipliers in the MATHEW.LOG)

PRINT_SIDES

Flag ('Y' or 'N') which controls the printing of the three-dimensional arrays identifying the cell side classifications.

(Default: PRINT_SIDES = 'N')

VECTOR_PLOT_FREQ

Integer value controlling the density of vectors on the vector plots. A value of one (1) indicates that a vector is plotted at every horizontal grid point. A value of two indicates that a vector is to be plotted every other grid point, etc.

(Default: VECTOR_PLOT_FREQ = 2)

Warning errors: None

Fatal errors: VECTOR_PLOT_FREQ < 0

VERT_VECTOR_SCALE

Floating point value which scales the size of the vectors on the vector plots in the z direction.

(Default: VERT_VECTOR_SCALE = 25.0)

Warning errors: VERT_VECTOR_SCALE $\geq$ 200.0

Fatal errors: VERT_VECTOR_SCALE $\leq$ 0.0

VLST_OPTION

6-character string ('NONE', 'NEW', 'MODIFY') specifying how MATHEW is to handle output of a VLST file. If it is set to 'NONE ' then MATHEW does not produce a MATHEW.VLST file, this is the default. If it is 'NEW ' then MATHEW produces a MATHEW.VLST file that supercedes any preceeding versions. If it is set to 'MODIFY' then MATHEW reads the MATHEW.VLST file currently available (if it exists) and the overwrites MATVEL filenames that match those being processed in the current run except for the sequence number and appends new filenames to the end of the MATHEW.VLST records.

XPROFILE

Array (max size = MAXPROF = 10) of integers (1 to 51 for a standard R41 grid) of the x coordinates of the sample profiles of the adjusted winds to be plotted. The first value in XPROFILE is matched with the first value in YPROFILE to give a horizontal location for the first profile. The

profile location plotted is the *i,j* grid location nearest to the specified *x,y* coordinates. Succeeding coordinates from each list are matched in a similar fashion. Values for XPROFILE, YPROFILE supercede any user settings for IPROFILE and JPROFILE as well as the nine default profiles (see IPROFILE and JPROFILE for the defaults). Each XPROFILE value must lie within the MATHEW grid.

XSLICE

Array (max size = IMAXMAT = 51 for a standard R41 grid) of floating point values representing the *x* coordinates of the vertical planes of $v-w$ winds vectors of the adjusted winds to be plotted. The slice location plotted is the *i* grid location nearest to the specified *x*coordinate. Values for XSLICE supercede any user settings for ISLICE. The default is no slice plots. Each XSLICE value must lie within the MATHEW grid.

YPROFILE

Array (max size = MAXPROF = 10) of integers (1 to 51 for a standard R41 grid) of the *y* coordinates of the sample profiles of the adjusted winds to be plotted. The first value in YPROFILE is matched with the first value in XPROFILE to give a horizontal location for the first profile. The profile location plotted is the *i,j* grid location nearest to the specified *x,y* coordinates. Succeeding coordinates from each list are matched in a similar fashion. Values for XPROFILE, YPROFILE supercede any user settings for IPROFILE and JPROFILE as well as the nine default profiles (see IPROFILE and JPROFILE for the defaults). Each YPROFILE value must lie within the MATHEW grid.

YSLICE

Array (max size = JMAXMAT = 51 for a standard R41 grid) of floating point values representing the *y* coordinates of the vertical planes of $u-w$ winds vectors of the adjusted winds to be plotted. The slice location plotted is the *j*grid location nearest to the specified *y*coordinate. Values for YSLICE supercede any user settings for JSLICE. The default is no slice plots. Each YSLICE value must lie within the MATHEW grid.

III.B.7.b. MATHEW_PARAMS namelist

CONV_TOLERANCE

Floating point value specifying the required convergence tolerance limit for the conjugate-gradient solver.

(Default: CONV_TOLERANCE = 0.01)

ELLIPTIC_EQN_TEST

Flag ('Y' or 'N') which controls whether the code sets up and runs an elliptic equation test based on sinusoidal fields to test the implementation of boundary conditions and the conjugate-gradient solver.

(Default: ELLIPTIC_EQN_TEST = 'N')

FIX_LATERAL_INFLOW

Flag ('Y' or 'N') which controls whether the inflow is fixed on all lateral faces.

(Default: FIX_LATERAL_INFLOW = 'N')

FIX_XMAX_INFLOW

Flag ('Y' or 'N') which controls whether the inflow is fixed on the maximum index x face. Overridden if FIX_LATERAL_INFLOW is set.

(Default: FIX_XMAX_INFLOW = 'N')

FIX_XMIN_INFLOW

Flag ('Y' or 'N') which controls whether the inflow is fixed on the minimum index x face. Overridden if FIX_LATERAL_INFLOW is set.

(Default: FIX_XMIN_INFLOW = 'N')

FIX_YMAX_INFLOW

Flag ('Y' or 'N') which controls whether the inflow is fixed on the maximum index y face. Overridden if FIX_LATERAL_INFLOW is set.

(Default: FIX_YMAX_INFLOW = 'N')

FIX_YMIN_INFLOW

Flag ('Y' or 'N') which controls whether the inflow is fixed on the minimum index y face. Overridden if FIX_LATERAL_INFLOW is set.

(Default: FIX_YMIN_INFLOW = 'N')

ITER_HALT

Integer value specifying the maximum allowed number of iterations for the conjugate gradient solver.

(Default: ITER_HALT = 1500)

LATERAL_BOUNDARY

15-character string('ADJUST_NORMAL', 'FIXED_NORMAL', or 'MIXED') specifying the boundary condition on all lateral faces.

(Default: LATERAL_BOUNDARY = 'ADJUST_NORMAL')

MEDVEL_NAMES

Array (max size = MAX_VEL = 10000) of 40-character strings that specify the MEDVEL***.BIF files to be processed by the current MATHEW run. Each string is a fully qualified, and thus unique, filename. The list of files entered via MEDVEL_NAMES supercedes the list of files specified in the MEDIC.VLST file, an alternative way of indicating those MEDVEL***.BIF files to be processed.

MIXED_LATERAL_ADJUST

Floating point value in inverse meters specifying the relative amount of normal to tangential adjustment for MIXED boundary conditions on all lateral faces.

(Default: MIXED_LATERAL_ADJUST = 1.0)

MIXED_TOP_ADJUST

Floating point value in inverse meters specifying the relative amount of normal to tangential adjustment for MIXED boundary conditions on the top face.

(Default: MIXED_TOP_ADJUST = 1.0)

MIXED_XMAX_ADJUST

Floating point value in inverse meters specifying the relative amount of normal to tangential adjustment for MIXED boundary conditions on the maximum index x face. Overridden if MIXED_LATERAL_ADJUST is set.

(Default: MIXED_XMAX_ADJUST = 1.0)

MIXED_XMIN_ADJUST

Floating point value in inverse meters specifying the relative amount of normal to tangential adjustment for MIXED boundary conditions on the maximum index x face. Overridden if MIXED_LATERAL_ADJUST is set.

(Default: MIXED_XMIN_ADJUST = 1.0)

MIXED_YMAX_ADJUST

Floating point value in inverse meters specifying the relative amount of normal to tangential adjustment for MIXED boundary conditions on the maximum index y face. Overridden if MIXED_LATERAL_ADJUST is set.

(Default: MIXED_YMAX_ADJUST = 1.0)

MIXED_YMIN_ADJUST

Floating point value in inverse meters specifying the relative amount of normal to tangential adjustment for MIXED boundary conditions on the maximum index y face. Overridden if MIXED_LATERAL_ADJUST is set.

(Default: MIXED_YMIN_ADJUST = 1.0)

PARAMS_DATE

Array (max size = MAX_TIMES = 10000) of 7-character strings specifying the dates (ddmmmyy) for the time-varying inputs, STAB_MATHEW and SIGMA_VERT, i.e., it determines the date component of the date/time when one or the other of these variables (but not both) change values.

PARAMS_TIME

Array (max size = MAX_TIMES = 10000) of 8-character strings specifying the times (hh:mm:ss) for the time-varying inputs, STAB_MATHEW and SIGMA_VERT, i.e., it determines the time component of the date/time when one or the other of these variables (but not both) change values.

SIGMA_HORZ

Floating point value that, together with SIGMA_VERT, controls how much mass-adjustment takes place in the horizontal as opposed to the vertical direction. Since the ratio of SIGMA_VERT to SIGMA_HORZ controls MATHEW's behavior, SIGMA_HORZ is normally set to 1.0 and only SIGMA_VERT is changed. The default value is 1.0.

Warning errors:	SIGMA_HORZ > 5.0
Fatal errors:	SIGMA_HORZ $\leq$ 0.0
	SIGMA_HORZ $\geq$ 100.0

SIGMA_VERT

Array(max size = MAX_TIMES=10,000) of floating point values that, together with SIGMA_HORZ, control how much mass-adjustment takes place in the vertical as opposed to the horizontal direction. The choice of SIGMA_VERT is a function of the grid cell geometry and the atmospheric stability and can be associated, all be it crudely, with Pasquill categories (see MATHEW input variable STAB_MATHEW below). The assessor may use SIGMA_VERT to gain finer control over the MATHEW adjustment process than is provided via STAB_MATHEW. SIGMA_VERT is a time-varying input like STAB_MATHEW, thus any change in its value must be associated with corresponding entries in the PARAMS_DATE and PARAMS_TIME arrays.

Warning errors:	SIGMA_VERT > 2.0
Fatal errors:	SIGMA_VERT ≤ 0.0
	SIGMA_VERT > 100.0

STAB_MATHEW

Array (max size = MAX_TIMES = 10000) of integers (1-6) representing the Pasquill-Gifford stability classes that, when associated with the PARAMS_DATE and PARAMS_TIME arrays, allows MATHEW to determine the appropriate stability for any given data set it is processing. Thus, STAB_MATHEW can be considered a time-varying input analogous to those in the ADPIC.NML file. These times need only be specified when STAB_MATHEW changes, not necessarily for every data set. STAB_MATHEW is used to control the relative degree of adjustment by assigning values to SIGMA_VERT according to the table below. Thus, SIGMA_VERT is a more direct way of controlling MATHEW's behavior and is also a time-varying input array. The use of SIGMA_VERT directly supercedes the use of STAB_MATHEW.

STAB_CLASS	SIGMA_VERT
1	3.3×(2×DELZ/DELX)
2	2.4×(2×DELZ/DELX)
3	1.6×(2×DELZ/DELX)
4	1.0×(2×DELZ/DELX)
5	0.7×(2×DELZ/DELX)
6	0.33×(2×DELZ/DELX)

(Default: STAB_MATHEW = 4 -> neutral stability)

TOP_BOUNDARY

15-character string (‘ADJUST_NORMAL’, ‘FIXED_NORMAL’, or ‘MIXED’) specifying the boundary condition on the top face (Default: TOP_BOUNDARY = ‘ADJUST_NORMAL’).

XMAX_BOUNDARY

15-character string ('ADJUST_NORMAL', 'FIXED_NORMAL', or 'MIXED') specifying the boundary condition on the maximum index x face. Overridden if LATERAL_BOUNDARY is set.

(Default: XMAX_BOUNDARY = 'ADJUST_NORMAL')

XMIN_BOUNDARY

15-character string ('ADJUST_NORMAL', 'FIXED_NORMAL', or 'MIXED') specifying the boundary condition on the minimum index x face. Overridden if LATERAL_BOUNDARY is set.

(Default: XMIN_BOUNDARY = 'ADJUST_NORMAL')

YMAX_BOUNDARY

15-character string ('ADJUST_NORMAL', 'FIXED_NORMAL', or 'MIXED') specifying the boundary condition on the maximum index y face. Overridden if LATERAL_BOUNDARY is set.

(Default: YMAX_BOUNDARY = 'ADJUST_NORMAL')

YMIN_BOUNDARY

15-character string ('ADJUST_NORMAL', 'FIXED_NORMAL', or 'MIXED') specifying the boundary condition on the minimum index y face. Overridden if LATERAL_BOUNDARY is set.

(Default: YMIN_BOUNDARY = 'ADJUST_NORMAL')

A sample MATHEW namelist file is shown below:

```
$MATHEW_PARAMS
print_adjustwind_diverg                    =  'Y'      ←  print adjusted divergence
print_initialwind_diverg                   =  'Y'         print initial divergence
vector_plot_freq                           =  1           plot all wind vectors
$end

$MATHEW_PARAMS
MEDVEL_NAMES                               =              ←  datasets to be processed.
'MEDVEL_01APR85_0000_00_000_0100__012.BIF'
'MEDVEL_01APR85_0100_00_000_0100__012.BIF'
'MEDVEL_01APR85_0200_00_000_0100__012.BIF'
'MEDVEL_01APR85_0300_00_000_0100__012.BIF'
'MEDVEL_01APR85_0400_00_000_0100__012.BIF'
'MEDVEL_01APR85_0500_00_000_0100__012.BIF'
'MEDVEL_01APR85_0600_00_000_0100__012.BIF'
'MEDVEL_01APR85_0700_00_000_0100__012.BIF'
'MEDVEL_01APR85_0800_00_000_0100__012.BIF'

PARAMS_DATE    = '01APR85'  '01APR85'              ←  date of new stabilities
PARAMS_TIME    =     '0000'       '0500'           ←  time of new stabilities
STAB_MATHEW  =          3            5             ←  new stabilities
$end
```

III.B.8. MEDIC.VLST

MATHEW can optionally read a list of fully qualified, and therefore unique, MEDVEL***.BIF filenames from MEDIC.VLST. This file is produced by MEDIC and contains the list of MEDVEL***.BIF files created by a given MEDIC run. This is an ASCII file that can be edited by an assessor and provides a mechanism to handle multiple MEDVEL groups in a single directory by allowing the user to maintain a series of MEDIC.VLST files (under different names, with the desired file being copied to MEDIC.VLST as needed).

III.B.9. ADPIC.NML

ADPIC.NML is an input file to the ADPIC code which contains the source and editing parameter data for an ADPIC problem. (Please also refer to section II.B "ADPIC" and its various subsections for descriptions of the various capabilities of ADPIC.) Before ADPIC is run, either initially or as a restart, an ADPIC.NML file must be prepared.

There are six namelist sections in the ADPIC.NML file, and their general purposes are listed in the table below:

Namelist Section	Purpose
ADPIC_CONTROL	Specifies the timing, echo file printing contents, basic diffusion controls, sampling bin contents, flags for special capabilities (moving receptors & sources, explosive cloud rise, etc.), windowing and nesting controls.
ADPIC_METPARAMS	Specifies meteorological parameters affecting the diffusion (e.g., stability, mixing layer height, rainout, etc.)
ADPIC_SOURCE	Specifies source term parameters (e.g., decay mode, stack plume rise, particle size distribution, release rate & timing, etc.)
ADPIC_RADPARAMS	Specifies the parameters for the hybrid particle capability.
SIGMA_THETA_DATA	Specifies the sigma theta profile data used for diffusion parameterizations.
ADPIC_EXPL_CLD	Specifies the parameters for the explosive cloud rise module.

Descriptions of all of the individual ADPIC.NML parameters follows, by the namelists in which they are to be entered:

III.B.9.a ADPIC_CONTROL namelist

<u>DIFF_METHOD</u>

5-character string (‘RDM’ or 'GRADI') specifying the type of diffusion calculation method to be used. DIFF_METHOD = 'RDM' refers to the new Random Displacement Method (RDM). For this method, the types of horizontal and vertical turbulence parameterizations to be used for K_Z and K_H respectively, by the RDM must be specified using the ADPIC_METPARAMS namelist parameters TURB_PARAM_VERT and TURB_PARAM_HORZ. DIFF_METHOD = 'GRADI' refers to ADPIC's original particle-in-cell gradient diffusion method which uses a hybrid Eulerian-Langragian method. The ADPIC_METPARAMS namelist parameter TURB_PARAM_TYPE controls the diffusion coefficients to be used for this diffusion method.

INITIAL_TIME_STEP

Floating point value specifying the value for the initial time step (seconds) for ADPIC; all succeeding time steps will be calculated by the code. ADPIC calculates the succeeding time steps such that a particle should not move more than one cell in that time step. INITIAL_TIME_STEP is also used to generate a warning error ("Time step has decreased to x.xxxExx") whenever code-calculated time steps are less than INITIAL_TIME_STEP/10.

NESTS

Integer (1-4) controlling the number of sampling nests to be used. fewer nests require less buffer zone between the source and the edge of the grid. The default center of the nests will be the least squares center of all the source locations. This center can be overridden with the ADPIC_CONTROL namelist parameters X_NEST_LOC and Y_NEST_LOC.

(Default: NESTS = 4)

PARTPOS

A 1-character string ('N', 'P', 'V') indicating in which format to generate PARTPOS files at the time interval specified by PLOT_INTERVAL:

'N' = no PARTPOS file is to be generated
'P' = PERSPEC format (3 particle position arrays)
'V' = video format (3 particle position arrays, plus source and identifier arrays)

(Default: PARTPOS = 'N' → no PARTPOS files are to be generated)

PK_INTERVAL

13-character string (ddd::hh:mm:ss) specifying the desired concentration averaging interval used in collecting the data for SAMPLING_TYPE = 'PKAIR'. If PK_INTERVAL is not an even multiple of SAMPLING_INTERVAL, then PK_INTERVAL is internally rounded down, if possible, so that it can be exactly divided into SAMPLING_INTERVAL.

Minimum value = 1 minute (smaller values will be changed to 1 minute)

Max value = SAMPLING_INTERVAL (larger values will be changed to SAMPLING_INTERVAL by ADPIC)

(Default: PK_INTERVAL = '000::00:15:00')

PLOT_INTERVAL

A 13-character time interval string (ddd::hhmmss) specifying the time interval at which particle plots are written to the graphics file.

(Default: PLOT_INTERVAL = '000::01:00:00' → 1-hour plot interval)

PRINT_ADVECT_VEL

Flag ('Y' or 'N') which controls the printing of advection velocities in echo file as they are read from the MATVEL file.

(Default: PRINT_ADVECT_VEL = 'N' → don't print advection velocities)

PRINT_CELL_CONC

Flag ('Y' or 'N') which controls the printing of cell concentrations in echo file at each SAMPLING_INTERVAL interval.

(Default: PRINT_CELL_CONC = 'N' → print cell concentrations)

PRINT_FRCTN_VEL

Flag ('Y' or 'N') which controls the printing of friction velocities in the echo file at each STATUS_INTERVAL interval.

(Default: PRINT_FRCTN_VEL = 'N' → don't print friction velocities)

PRINT_PART_COORD

Flag ('Y' or 'N') which controls the printing of particle coordinates in echo file at each SAMPLING_INTERVAL interval.

(Default: PRINT_PART_COORD = 'N' → don't print particle coordinates)

PRINT_SAMPLING_BINS

Flag ('Y' or 'N') which controls the printing of sampling bin concentrations to the echo file at each SAMPLING_INTERVAL interval.

(Default: PRINT_SAMPLING_BINS = 'N' → don't print sampling bin concentrations)

PRINT_TURB_PARAM_GRADI

Flag ('Y' or 'N') which controls the printing (to the ADPIC log file) of horizontal and vertical diffusion coefficients (K_H and K_z) at each grid point over the portion of the grid that contains particles.

(Default: PRINT_TURB_PARAM_GRADI = 'N' → don't print Kh and Kz)

PRINT_PART_VEL

Flag ('Y' or 'N') which controls the printing of all velocities in echo file at each STATUS_INTERVAL interval.

(Default: PRINT_PART_VEL = 'N' → don't print velocities)

PRINT_TOPOG

Flag ('Y' or 'N') which controls the printing of topography in echo file at beginning of problem.

(Default: PRINT_TOPOG = 'Y' → print topography)

PROBLEM_TITLE

70-character string specifying the label for the particle plot and other ADPIC output.

REFLECT_AT_GRIDTOP

A value of REFLECT_AT_GRIDTOP = 'Y' (yes) causes particles approaching the computational grid top (due to advection or diffusion) to be reflected back into grid. When the grid top height does not equal the mixed layer height, this is an artificial restriction and is provided as a "safety net"; that is, reflection at the grid top is used to prevent particles from diffusing upward through the top of the grid, being lost to the calculation, and, therefore, unable to diffuse back downward. However, reflection at grid top should not be relied upon to contain these particles. Rather, computational grids should constructed with sufficient depth that they will contain particles of interest in the calculation. For example, for boundary layer problems it is recommended that the grid depth be specified so that the difference between the maximum terrain elevation and the elevation of the top of the grid is at least two times the mixed layer height. Note that this parameter is used *only* with DIFF_METHOD = 'RDM'.

(Default: 'Y').

REFLECT_AT_MLHGT

A value of REFLECT_AT_MLHGT = 'Y' (yes) causes particles approaching a height equal to the grid bottom height plus the mixing layer depth, to be reflected (this applies to both upward- and downward-moving particles). Note that this is not necessarily the mixed layer height above terrain, if terrain elevations vary within the computational grid. This option is recommended for *flat terrain only*, because the wind fields adjusted for terrain effects by MATHEW are not adjusted for this assumed rigid elevated surface, and because ADPIC cannot handle the reflection of particles at mixed layer surfaces if it intersects terrain. This reflection method may be physically realistic when a strong elevated inversion limits vertical mixing at a fixed height above sea level, but may not be realistic for many cases, especially mesoscale or long-range cases or for cases of significant variation in terrain elevation. Also, refer to parameter REFLECT_AT_GRIDTOP. Note: This parameter used *only* with DIFF_METHOD = 'RDM'.

(Default: 'N').

RESTART_DATE

7-character date string (ddMMMyy) the restart date of the ADPIC calculation. This restart date/time MUST have a corresponding ADPIC*.RST and CONC*.RST files (see RESTART_WRITE_INTERVAL description). Also see RESTART_TIME, which specifies the time.

(RESTART_DATE = 'unset' is the default, i.e. ,for a non-restart run)

RESTART_TIME

8-character string specifying the restart time (hh:mm:ss) of the ADPIC calculation. This restart date/time MUST have a corresponding dump in the ADPIC*.RST and CONC*.RST files (see RESTART_WRITE_INTERVAL description). Also see RESTART_DATE, which specifies the date.

(RESTART_TIME = 'unset' is the default, i.e., for a non-restart run)

RESTART_WRITE_DATE

Array (max size = MAX_RESTART = 10) of 7-character strings specifying the dates (ddmmmyy) in increasing chronological order at which data is output from ADPIC into restart dump files (ADPIC*.RST and CONC*.RST). It therefore determines the times at which a problem can be restarted since the dump files contain all of the necessary information to restart the problem. When a restart is initiated, each particle will begin to move from its last location. Since restart files are quite large, the user should be cautious in specifying too many restart files. RESTART_WRITE_DATE and RESTART_WRITE_TIME override RESTART_WRITE_INTERVAL.

RESTART_WRITE_INTERVAL

13-character string specifying the time interval (ddd::hh:mm:ss) at which data is output from ADPIC into a restart dump files (ADPIC*.RST and CONC*.RST). It therefore determines the times at which a problem can later be restarted since the restart file contains all fo the necessary information, i.e., coordinates of all of the particles. When a restart is initiated, each particle will begin to move from its last location. Since restart files are quite large, the user should be cautious in specifying an interval which produces a large number of such files. To specify date/times for restart file writes which are not multiples of RESTART_WRITE_INTERVAL, use RESTART_WRITE_DATE and RESTART_WRITE_TIME; RESTART_WRITE_DATE and RESTART_WRITE_TIME override RESTART_WRITE_INTERVAL

No restart file (RESTART_WRITE_INTERVAL = '000::0000') is usually specified for an Initial calculation.

RESTART_WRITE_TIME

Array (max size = MAX_RESTART = 10) of 8-character strings specifying the times (hh:mm:ss) in increasing chronological order at which data is output from ADPIC into restart dump files (ADPIC*.RST and CONC*.RST). It therefore determines the times at which a problem can be restarted since the dump files contain all of the necessary information to restart the problem. When a restart is initiated, each particle will begin to move from its last location. Since restart files are quite large, the user should be cautious in specifying too many restart files. RESTART_WRITE_DATE and RESTART_WRITE_TIME override RESTART_WRITE_INTERVAL.

RUN_DURATION

13-character string specifying the time interval (ddd::hh:mm:ss) for the current ADPIC run. It is relative to RUN_START_DATE \ RUN_START_TIME if it is not a restart run, and from RESTART_DATE \ RESTART_TIME if it is a restart run. Alternatively, RUN_STOP_DATE and RUN_STOP_TIME can be used instead of RUN_DURATION to specify the length of an ADPIC run.

RUN_START_DATE

7-character string specifying the start date (ddmmmyy) of the ADPIC calculation. Note that this value must remain unchanged from the original run to a restart run.

RUN_START_TIME

8-character string specifying the start time (hh:mm:ss) of the ADPIC calculation. Note that this value remains unchanged from the original run to a restart run.

RUN_STOP_DATE

7-character string specifying the stop date (ddmmmyy) of the ADPIC calculation. Specifying both RUN_STOP_DATE and RUN_STOP_TIME determines the total duration of an ADPIC execution. RUN_STOP_DATE\RUN_STOP_TIME will override RUN_DURATION.

RUN_STOP_TIME

8-character string specifying the stop time (hh:mm:ss) of the ADPIC calculation. Specifying both RUN_STOP_DATE and RUN_STOP_TIME determines the total duration of an ADPIC execution. RUN_STOP_DATE/RUN_STOP_TIME will override RUN_DURATION.

SAMP_CELL_DELZ_FRACT

Floating point value representing the vertical height of the sampling cell expressed as a fraction of DELZ. This allows finer resolution of concentration in the vertical, provided there is a sufficient number of particles in the sampling volume.

(Default: SAMP_CELL_DELZ_FRACT = 1.0)

SAMPLING_HGT

Array (max size = MAXSBINS = 30) of floating point values specifying the heights (m) above ground at which the output bin contents (determined by SOURCES_TO_SAMPLING_BIN and SAMPLING_TYPE) are to be calculated. For example:

a) if inhalation doses or concentrations are desired, a SAMPLING_HGT value of 1.5m (breathing height) would be used;
b) if concentrations at stack heights or flight levels are desired, a SAMPLING_HGT equal to the height of interest would be used;
c) for ground deposition, a SAMPLING_HGT of 0.0m would be used.

SAMPLING_HGT_REF

11-Character string ('SEA_LEVEL', 'GRID_BOTTOM', 'TERRAIN') specifying which reference level/type would be used for sampling bins.

(Default: SAMPLING_HGT_REF = 'TERRAIN' = sampling hgts are meters above terrain)

SAMPLING_INTERVAL

13-character string specifying the output interval (ddd::hh:mm:ss) at which particle information is written to the CONC file.

(Default: SAMPLING_INTERVAL = '000::0100' → 1-hour dumps to the CONC file)

SAMPLING_TYPE

Array (max size = MAXSBINS = 30) of 6-character strings ('INTAIR', 'INSAIR', 'TOTDEP', 'INTDEP', 'AVGAIR', or 'PKAIR') representing the type of concentration output desired for the ADPIC output bins:

SAMPLING_TYPE	=	'INTAIR'	→	integrated air concentration
SAMPLING_TYPE	=	'INSAIR'	→	instantaneous air concentration
SAMPLING_TYPE	=	'INTDEP'	→	integrated deposition
SAMPLING_TYPE	=	'TOTDEP'	→	total ground deposition
SAMPLING_TYPE	=	'AVGAIR'	→	time-avg (multiples of SAMPLING_INTERVAL) air conc
SAMPLING_TYPE	=	'PKAIR'	→	composite peak (over SAMPLING_INTERVAL) of PK_INTERVAL-time-averaged concentrations

Option 'INTDEP' may <u>only</u> be used with the Hybrid Particle ADPIC. Particles reaching the ground are saved in a list that includes their age, deposition time, and deposition position. At sampling times they are assigned their appropriate activity and toxicity and distributed in sampling bins defined on a Eulerian grid. This permits accurate decay in sampling bins that contain multiple course and enables the total time integrated deposition dose to be calculated. Rainout is not included.

Option 'AVGAIR' produces ADPIC bins of time-averaged (averaging time = integer factors of SAMPLING_INTERVAL) air concentrations. The time averaging is achieved by taking INTAIR bins and dividing by the SAMPLING_INTERVAL. The final output from PLCNT/TIMEHIS is averaged over the PLOT_INTERVAL (which can be a multiple of SAMPLING_INTERVAL). For PLOT_INTERVALs less than 30min, a power-law scaling factor (= (30min/PLOT_INTERVAL)**0.2) is applied to the AVGAIR bin contents to adjust for the fact that ADPIC diffusivities represent averaging periods of 10 to 60 minutes, with a mean of about 30 minutes.

Option 'PKAIR' computes PK_INTERVAL-time-averaged air concentrations, and stores the peak values encountered over the SAMPLING_INTERVAL time interval; i.e., at a given SAMPLING_INTERVAL time, the output CONC*.BIF file for a bin with SAMPLING_TYPE =

'PKAIR' contains, for a given location, the peak value of PK_INTERVAL-averaged air concentration encountered over successive PK_INTERVAL time intervals from the beginning of the run. The internal arrays collecting 'PKAIR' concentration data are continually updated so that output for successive SAMPLING_INTERVALs will contain the highest short-term concentration to that point in the run. Thus, at the end of a run the concentrations collected under the 'PKAIR' option represents the highest short-term concentration at all locations during the entire simulation. As with the AVGAIR bins, a power-law scaling factor (= (30min/PK_INTERVAL)**0.2)is applied to the concentrations for PK_INTERVALs less than 30min.

For toxic chemical responses, an AVGAIR bin with SAMPLING_INTERVAL equivalent to 1 hr is typically used. Additionally, a PKAIR bin (with PK_INTERVAL set for 15 min and SAMPLING_INTERVAL set for 1 hr) is used to produce plots for concentration-dependent chemicals (i.e., those chemicals which have very short-term health effects, typically 15 minutes or less).

NOTE: PKAIR will use two sampling bins — one in its original positioning in the SAMPLING_TYPE array specification, and one at the end of the SAMPLING_TYPE array, the latter being used as a temporary storage for accumulating the peak concentrations. Therefore, if you wish to have 3 PKAIR sampling bins, there will be only 24 (30-3*2) other possible sampling bins available.

SKIP_RANDOM_COUNT

Integer number of random numbers to skip in random number sequence before the first random number is used. This parameter is primarily for programmer's use as a debugging tool: use of SKIP_RANDOM_COUNT can identify how much variability in results is due to randomness.

SOURCES_TO_SAMPLING_BIN

2-D array (max ADPIC sources, max sampling bins) of integers (1 to max ADPIC sources) specifying which ADPIC sources are to be associated with which sampling bin. SOURCES_TO_SAMPLING_BIN(1,2) = 3 indicates that sampling bin 2 includes particles from source 3 (it may also include others, this entry just specifies that part of the sampling strategy). The source indices must be used in sequence for a given sampling bin index. See sample ADPIC.NML files in this document for further examples.

(Default: all elements of SOURCES_TO_SAMPLING_BIN default to 0)

STATUS_INTERVAL

13-character string specifying the edit interval (ddd::hh:mm:ss) at which particle status information lines are written to the screen and to the echo file.

(Default: STATUS_INTERVAL = '000::0100' → 1-hour edit interval)

USE_EXPL_CLD_RISE

Flag ('Y' or 'N') controlling whether or not the explosive cloud rise option is to be used.

Note: the rest of the parameters for the explosive cloud rise are contained in the namelist ADPIC_EXPL_CLD

(Default: USE_EXPL_CLD_RISE = 'N' ⇒ do not use explosive cloud rise)

USE_MOVING_RECEPTORS

Flag ('Y' or 'N') to for the moving receptor capability, which allows sampling to be done at the location of multiple moving "receptors".

(Default: USE_MOVING_RECEPTORS = 'N' = don't use moving receptors)

USE_MOVING_SOURCE

Array (max size= MAXSOURCE=9) of flags ('Y' or 'N') used to indicate if source is moving or stationary.

(Default: USE_MOVING_SOURCE = 'N' = stationary)

USE_SLAB_CONC

Flag ('Y' or 'N') used to specify if SLAB concentrations are to be used for this ADPIC run. If this flag is set, then other SLAB parameters (in ADPIC_SOURCE namelist: SLAB_SOURCE, SLAB_SOURCE_RATE, SLAB_SAMPLING_BINS, SLAB_START_INDEX, AND SLAB_SPECIES) need to be set, as well as having a SLAB_TO_ADPIC.DAT file available for input to ADPIC.

(Default: USE_SLAB_CONC = 'N')

USE_VLST

Flag ('Y' or 'N') controlling whether the file 'MATHEW.VLST' or 'MEDIC.VLST is to be used to obtain a list of valid MATVEL/MEDVEL files for this run. 'Y' means use the appropriate vlst file, and 'N' means search for '

'MATVEL*.BIF" or 'MEDVEL*.BIF' in the current MODEL$A_WINDS directory.

(Default: USE_VLST = 'N' -> search for 'MATVEL*.BIF' or 'MEDVEL*.BIF' in the current MODEL$A_WINDS directory)

WIND_TYPE

9-character string ('MATHEW', 'MEDIC', or 'POWER_LAW') controlling whether MATVEL files, MEDVEL files, or analytic power law wind profile files are to be used for input wind velocity data. 'MATHEW' means use MATVEL files, and 'MEDIC' means use MEDVEL files (which have not been adjusted by the MATHEW model. 'POWER_LAW' means use vertical power law wind field in ADPIC which is purely analytical and not gridded (no gridded input wind files are required). Power law winds are controlled by the ADPIC_METPARAMS namelist parameters U_MEAN_REF, U_MEAN_REF_HGT, PWRLAW_EXPNT_U, and U_MEAN_DIR, that must be entered for this

option. Winds vary with power law in the vertical, but do not vary in the horizontal directions at any given height. WARNING: Use 'POWER_LAW' only with with flat terrain.

(Default: WIND_TYPE= 'MATHEW' ⇒ use MATVEL files)

X_NEST_LOC

Floating point value representing the x-coordinate about which the nested grid structure will be built. This is especially useful if there are multiple source locations and you wish to override the default center (which is the least squares distance from all of the source locations) of the nested grid structure.

(Default: X_NEST_LOC = -99999.0 = use default center of all source locations.)

X_WINDOW_MAX

Floating point value representing a map coordinate (km) indicating the right-hand X edge of a window to be specified and fixed for outputing dot plots.

(Default: X_WINDOW_MAX = 0 -> use standard windows)

X_WINDOW_MIN

Floating point value representing a map coordinate (km) indicating the left-hand X edge of a window to be specified and fixed for outputing dot plots.

(Default: X_WINDOW_MIN = 0 -> use standard windows)

Y_NEST_LOC

Floating point value representing the y-coordinate about which the nested grid structure will be built. This is especially useful if there are multiple source locations and you wish to override the default center (which is the least squares distance from all of the source locations) of the nested grid stucture.

(Default: Y_NEST_LOC = -99999.0 = use default center of all source locations.)

Y_WINDOW_MAX

Floating point value representing a map coordinate (km) indicating the right-hand Y edge of a window to be specified and fixed for outputing dot plots.

(Default: Y_WINDOW_MAX = 0 -> use standard windows)

Y_WINDOW_MIN

Floating point value representing a map coordinate (km) indicating the left-hand Y edge of a window to be specified and fixed for outputing dot plots.

(Default: Y_WINDOW_MIN = 0 -> use standard windows)

Z_WINDOW_MAX

Floating point value representing the grid distance (m) indicating the top of the window to be specified and fixed for outputing dot plots.

(Default: X_WINDOW_MAX = 0 -> use standard windows)

Z_WINDOW_MIN

Floating point value representing the grid distance (m) indicating the bottom of the window to be specified and fixed for outputing dot plots.

III.B.9.b. ADPIC_METPARAMS namelist

DIFF_ON_X

Flag which allows user to turn diffusion off in *x* (east-west) direction. (Note: *x* is not downwind distance). Used for DIFF_METHOD = 'RDM' only.

(Default: DIFF_ON_X = 'Y')

DIFF_ON_Y

Flag which allows user to turn diffusion off in *y* (north-south) direction. (Note: *y* is not crosswind distance). Used for DIFF_METHOD = 'RDM' only.

(Default: DIFF_ON_Y = 'Y').

DIFF_ON_Z

Flag which allows user to turn diffusion off in *z* (vertical) direction. Used for DIFF_METHOD = 'RDM' only.

(Default: DIFF_ON_Z = 'Y')

GAUSS_DIFF_MULT_X

Floating point value used as a multiplier to QNSH, which determines how long an ADPIC particle remains a source particle. Also see GAUSS_DIFF_MULT_Z. Used only with DIFF_METHOD = 'GRADI'.

(Default: GAUSS_DIFF_MULT_X = 1.0)

GAUSS_DIFF_MULT_Z

Floating point value used as a multiplier to QNSV, which determines how long an ADPIC particle remains a source particle. Also see GAUSS_DIFF_MULT_X. Used only with DIFF_METHOD = 'GRADI'.

(Default: GAUSS_DIFF_MULT_Z = 1.0)

HORZ_TIME_SCALE

Horizontal turbulence time scale, τ_H (seconds). Applies to TURB_PARAM_HORZ = 'SIGH_SIGTHETA_USER' option only.

(Default: 50 seconds)

INTERP_VEL_WINDS

8-character string ('NONE', 'LINEAR1', 'LINEAR2', 'GAUSS1', 'GAUSS2') used to invoke time-interpolation of MEDIC or MATHEW wind fields. If the flag is absent from the namelist or set to

'NONE", ADPIC does no interpolation of wind fields and uses wind datasets in a stepwise manner. 'LINEARn' results in linear interpolation between wind field datasets at each model timestep, while 'GAUSSn' results in Gaussian interpolation. For n=1, ADPIC uses dataset start times to define the time intervals for interpolation; for n=2, ADPIC shifts each wind field starting time by half its duration time and uses these shifted times to define the interpolation time intervals. In other words, the winds are true at the beginning of the dataset period for n=1, and at the mid-point of the dataset period for n=2. If calculation time is outside the time range of available wind data, ADPIC uses the wind dataset nearest in time with no interpolation. Parameters in ADPIC which are not strong functions of wind velocities are computed at wind dataset intervals.

(Default: INTERP_VEL_WINDS = 'NONE')

INTERP_WINDS_STEP_MEAN

A character variable ('y'/'n') which allows a more accurate interpolation of winds at the mean position during the random vertical displacement. If 'y', a more accurate calculation is possible in instances where winds change rapidly in the vertical.

(Default: INTERP_WINDS_STEP_MEAN = 'N')

INV_OBUKHOV_LEN_ML

Array (max size = MAXTIM=50) of floating point values representing the inverse of the Monin-Obukhov length in the mixed layer. The Monin-Obukhov length (usually referred to as L) is the height above the surface at which mechanical and thermal turbulence are of equal importance. From an estimate of SFC_ROUGH_HGT and the atmospheric stability, INV_OBUKHOV_LEN_ML can be found from the nomogram in Figure III.B.2. INV_OBUKHOV_LEN_ML is a time-varying parameter with date/times controlled by MET_START_DATE / MET_START_TIME.

Warning errors:	INV_OBUKHOV_LEN_ML < -0.15
	INV_OBUKHOV_LEN_ML > 0.15
Fatal errors:	INV_OBUKHOV_LEN_ML < - 1.00
	INV_OBUKHOV_LEN_ML > 1.00
	INV_OBUKHOV_LEN_ML > 0.0 and STAB_CLASS < 4
	INV_OBUKHOV_LEN_ML < 0.0 and STAB_CLASS > 4

INV_OBUKHOV_LEN_SL

Array (max size = MAXTIM=50) of floating point values representing the inverse of the Monin-Obukhov length in the surface layer. The Monin-Obukhov length (usually referred to as L) is the height above the surface at which mechanical and thermal turbulence are of equal importance. From an estimate of SFC_ROUGH_HGT and the atmospheric stability, INV_OBUKHOV_LEN_SL can be found from the nomogram in Figure III.B.2.

Warning errors:	INV_OBUKHOV_LEN_SL < -0.15
	INV_OBUKHOV_LEN_SL > 0.15

Fatal errors: INV_OBUKHOV_LEN_SL < - 1.00
INV_OBUKHOV_LEN_SL > 1.00
INV_OBUKHOV_LEN_SL > 0.0 and STAB_CLASS < 4
INV_OBUKHOV_LEN_SL < 0.0 and STAB_CLASS > 4

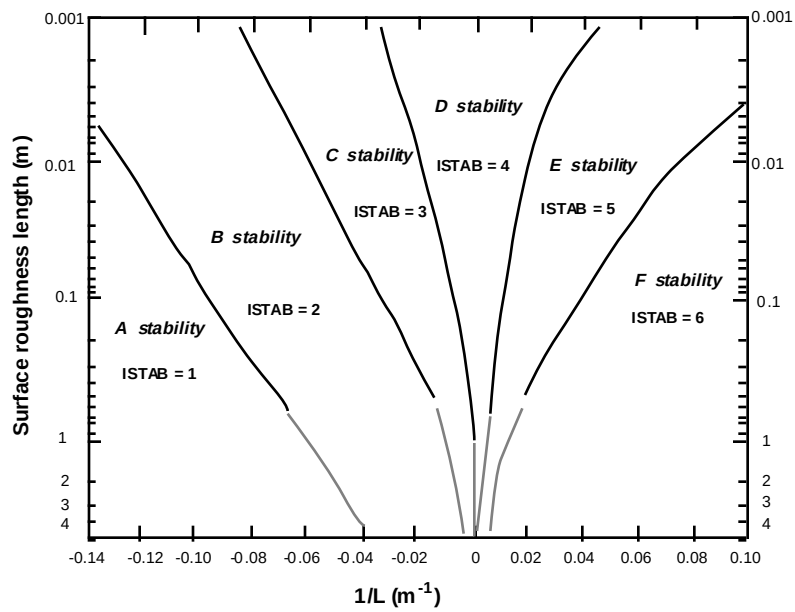


Figure III.B.2. Relation of Monin-Obukhov L to Pasquill class and roughness length (Golder, 1972)

K_VON_KARMAN

Optional input parameter to override default value of the von Karman constant, *k*. (Default: K_VON_KARMAN = 0.4)

KZ_CONSTANTZ

Constant K_z value used when TURB_PARAM_VERT= 'KZ_CONSTANTZ'. Must be input by the user. No internal default value.

KZ_LINEARZ_REF

Reference value K_{zref} (m^2/s) for linear vertical eddy diffusivity profile, $K_z = K_{z\mathrm{ref}}\left(z/z_{\mathrm{ref}}\right)$. Applies to TURB_PARAM_VERT = 'KZ_LINEARZ' option only, and must be input for that option.

KZ_LINEARZ_REF_HGT

Reference height z_{ref} (m) for power law vertical eddy diffusivity reference value. Applies to TURB_PARAM_VERT = 'KZ_LINEARZ' only, and must be input for that option.

KZ_SIMTHRY_PHI_A

Constant, a, for similarity theory vertical eddy diffusivity profile phi function. Applies to TURB_PARAM_VERT = 'KZ_SIMTHRY_USER' option only, and must be input for that option.

KZ_SIMTHRY_PHI_B

Constant, b, for similarity theory vertical eddy diffusivity profile phi function. Applies to TURB_PARAM_VERT = 'KZ_SIMTHRY_USER' option only, and must be input for that option.

KZ_SIMTHRY_C

Constant, c, for similarity theory vertical eddy diffusivity profile. Used only when TURB_PARAM_VERT = 'KZ_SIMTHRY_USER' option is used, and must be input for that option.

KZ_SIMTHRY_C2

Constant, c_2, for similarity theory vertical eddy diffusivity profile. Used only when TURB_PARAM_VERT = 'KZ_SIMTHRY_USER' option is used, and must be input for that option.

KZ_SIMTHRY_C3

Constant, c_3, for similarity theory vertical eddy diffusivity profile. Used only when TURB_PARAM_VERT = 'KZ_SIMTHRY_USER' option is used, and must be input for that option.

KZ_SIMTHRY_TROPO

Constant value of K_z^{tropo} used above $z > h$, but only when TURB_PARAM_VERT= 'KZ_SIMTHRY_USER' (refer to TURB_PARAM_VERT parameter for other constants that must also be specified to use the 'KZ_SIMTHRY_USER' option).

MAX_DELZ_SHIFT

Integer representing the maximum number of cells that a particle can pop up. There is a tendency for particles to impact with topography in complex terrain and become 'stuck'. In order to help alleviate this problem we have introduced a procedure which allows particles to pop up a given number of times to get the particles back out into the flow field. This procedure involves moving the particle up one cell at a time in the vertical until the particle has either cleared the topography or has reached the allowed limit of vertical shift (MAX_DELZ_SHIFT grid cells) or the upper limit of the grid is encountered. If this limit (MAX_DELZ_SHIFT) has been reached, the particle is moved only with the velocity component parallel to the topography. This procedure will allow the particle to either move over or around the topography. MAX_DELZ_SHIFT specifies the limit of cells a particle is allowed to be shifted vertically.

(Default: MAX_DELZ_SHIFT = 1)

MAX_DITHER

This parameter is used only for DIFF_METH = 'GRADI' (Gradient Diffusion method). It is a floating point value specifying the multiplicative factor of the timestep delta for a given computational cycle, and that product is then used as a time to multiply the maximum particle speed

in each direction. When the advection component of the velocity is much less than the diffusion component, the particles will try to line up on grid lines. This is particularly true in the vertical direction. To help break up this alignment we have introduced a small random change (a dither, similar to that in control systems). MAX_DITHER controls the amount of this small random movement. Since the resulting 'small' distance is in effect a fraction of the maximum movement for the next cycle. By then multiplying by a random number (between -1. and +1.) the correction acts to prevent the alignment on horizontal grid lines.

(Default: MAX_DITHER = 0.01)

MAX_GLOBAL_DELTA_T

A parameter which can be used to limit the global timestep to a specific value. A positive number representing a timestep (secs) is input if this feature is to be active. (No default)

MET_START_DATE

Array (max size = MAXTIM = 100) of 7-character strings specifying the dates (ddmmmyy) at which new values of the time-varying met parameters (TURB_PARAM_TYPE, STAB_CLASS, INV_OBUKHOV_LEN_ML, INV_OBUKHOV_LEN_SL, ML_HGT, SIGMA_THETA_FACT, SIGMA_THETA, SIGMA_THETA_HGT, and PRECIP_SCAVENG_COEF) take effect. Also see MET_START_TIME, which specifies the times.

MET_START_TIME

Array (max size = MAXTIM = 100) of 8-character strings specifying the times (hh:mm:ss) at which new values of the time-varying met parameters (TURB_PARAM_TYPE, STAB_CLASS, INV_OBUKHOV_LEN_ML, INV_OBUKHOV_LEN_SL, ML_HGT, SIGMA_THETA_FACT, SIGMA_THETA, SIGMA_THETA_HGT, and PRECIP_SCAVENG_COEF) take effect. Also see MET_START_DATE, which specifies the dates.

MIN_MASS_FRACT

Array (max size = MAXTIM=50) of floating point values representing the factor used to determine whether or not an ADPIC particle should be eliminated due to decreased mass or activity: If mass or activity is less than MIN_MASS_FRACT times the original mass or activity of the ADPIC particle, then the particle is eliminated from the problem.

(Default: MIN_MASS_FRACT = 0.001)

ML_HGT

Array (max size = MAXTIM=50) of floating point values representing the height (m) of the mixed layer above terrain. The height of the mixed layer is that demarcation between well mixed, turbid air below, and relatively clear air above. The mixed layer, typically ranging from 300 to 3000 m above terrain, basically indicates the height of the temperature inversion base. ML_HGT is usually obtained from the radiosonde nearest the source (or area of interest). In the absence of a

temperature profile, observations have often shown that the wind will shear rapidly in direction and be accompanied by a speed minima as the sonde passes through the inversion layer.

Warning errors:	ML_HGT $\leq$ 50.0
	ML_HGT $\geq$ 3000.0
Fatal errors:	ML_HGT < DELZ
	ML_HGT $\geq$ 20000.0

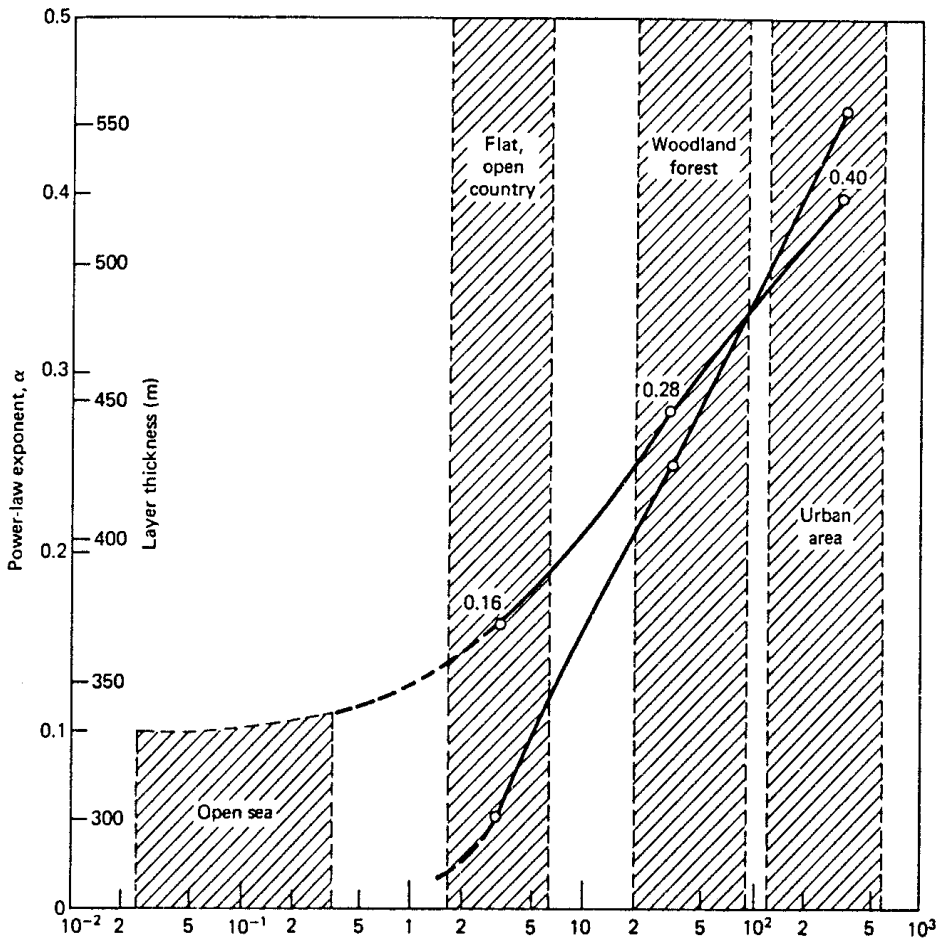
PWRLAW_EXPNT_U

Exponent *m* for power law wind profile used to generate mean winds when. WIND_TYPE= 'POWER_LAW'. This allows mean winds to be generated without using input gridded winds. See parameters U_MEAN_DIR, U_MEAN_HGT, AND UMEAN_REF. Must be input if WIND_TYPE= 'POWER_LAW'.

PWR_LAW_EXPNT_SL

Array (max size = MAXTIM=50) of floating point values representing the power law exponent wind speed in the surface layer. PWR_LAW_EXPNT_SL is used within the code to calculate the mean wind at the reference height U_MEAN_HGT for use in the calculation of friction velocity. It can be calculated directly from surface-layer wind observations in the vertical using the power law formula given by Eq. (II.C.1). Alternatively, it can be obtained as a function of surface roughness height and atmospheric stability, as shown in Fig. III.B.1.

Warning errors:	PWR_LAW_EXPNT_SL > 0.5
Fatal errors:	PWR_LAW_EXPNT_SL < 0.0
	PWR_LAW_EXPNT_SL > 10.0



Surface roughness height (Zo)– *m*

The exponent in the power law and the height of the boundary layer as functions of the roughness height and the type of terrain. From Davenport (1965).

Z_o = surface roughness height (m) ~ $h_o/30$

where h_o = average height of terrain features (e.g., building, trees, grass)

PWR_LAW_EXPNT_SL is obtained from graph using appropriate Z_o and the following correction for stability (if necessary):

Stable:	add 0.1
Neutral:	as is
Unstable:	subtract 0.1

Figure III.B.1 Modeling the planetary boundary layer

PRECIP_SCAVENG_COEF

Array (max size = MAXTIM=50) of floating point values representing the washout coefficient for rainout calculations. PRECIP_SCAVENG_COEF must be accompanied by entries for RAIN_START and RAIN_STOP if only the first element of PRECIP_SCAVENG_COEF is set. Otherwise, PRECIP_SCAVENG_COEF is controlled by date/times of the met_start_date/met_start_time arrays. Suggested values: PRECIP_SCAVENG_COEF = 1.0E-3 for light rain, 2.0E-3 for light snow.

RAIN_START

13-character string specifying the time (ddd::hh:mm:ss) relative to the problem start time (RUN_START_TIME) when the rain is to start. This is used in conjunction with RAIN_STOP (rain stop time) and PRECIP_SCAVENG_COEF (washout coefficient), first element only.

RAIN_STOP

13-character string specifying the time (ddd::hh:mm:ss) relative to the problem start time (RUN_START_TIME) when the rain is to stop. This is used in conjunction with RAIN_START (rain start time) and PRECIP_SCAVENG_COEF (washout coefficient).

SFC_ROUGH_HGT

Floating point value representing the surface roughness height (m). The surface roughness height is approximately the average height of most land-based features (e.g., grass, trees, buildings) divided by 30. The analyst should consider features over the entire gridded area before entering a value. This is a subjective parameter since we are usually dealing with very diverse geographical areas. Figure III.B.3 gives typical values of surface roughness for various terrain types.

(Default: SFC_ROUGH_HGT = 0.15)

Warning errors:	SFC_ROUGH_HGT $\geq$ 2.0
Fatal errors:	SFC_ROUGH_HGT $\leq$ 0.0
	SFC_ROUGH_HGT > 5.0

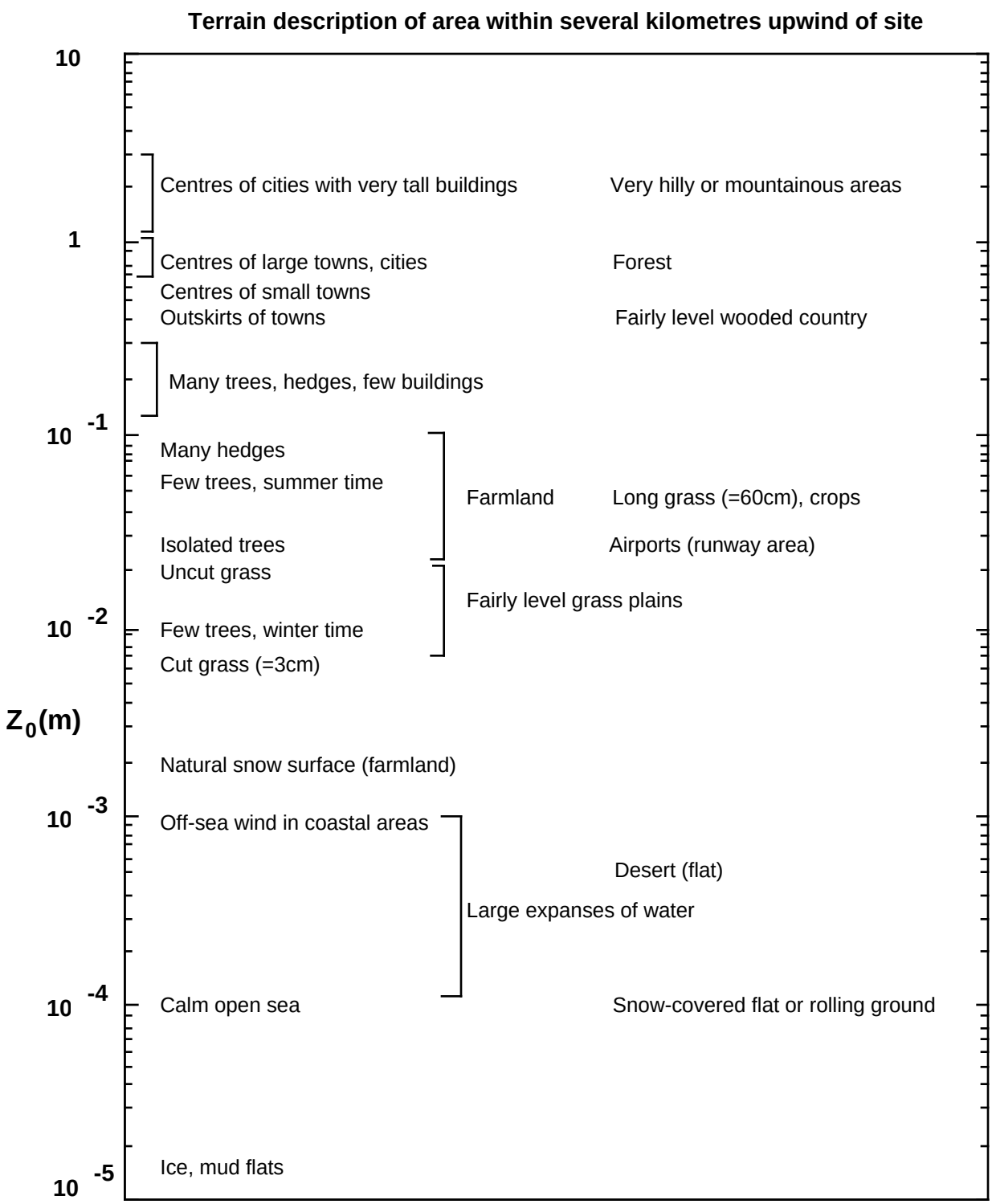


Figure III.B.3. z_0 **values for typical terrain types (After ESDU 72026, 1972)**

SIGH_PWRLAWX_ALPHA

Constant α in power-law equation for horizontal concentration standard deviation versus downwind distance, $\sigma_H = \alpha x^\beta$, used to calculate horizontal eddy diffusivity. Applies to TURB_PARAM_HORZ = 'SIGH_PWRLAWX_USER' option only, and must be input for that option.

SIGH_PWRLAWX_BETA

Constant β in power-law equation for horizontal concentration standard deviation versus downwind distance, $\sigma_H = \alpha x^\beta$, used to calculate horizontal eddy diffusivity. Applies to TURB_PARAM_HORZ = 'SIGH_PWRLAWX_USER' option only, and must be input for that option.

SIGH_PWRLAWX_XMAX

Maximum downwind distance which the power law equation for horizontal concentration standard deviation versus downwind distance is to be used. After this distance the value of horizontal diffusivity, K_H, is held constant at its value at this distance. Applies to TURB_PARAM_HORZ = 'SIGH_PWRLAWX_USER' option only, and must be input for that option.

SIGMA_THETA_FACT

Array (max size = MAXTIM = 100) of floating point values specifying a time-varying factor by which the sigma theta profile generated from the SIGMA_THETA array of the SIGMA_THETA_DATA namelist is multiplied.

SIGZ_PWRLAWX_GAMMA

Constant γ in power-law equation for vertical concentration standard deviation versus downwind distance, $\sigma_Z = \gamma x^\rho$, used to calculate vertical eddy diffusivity. Applies to TURB_PARAM_VERT = 'SIGZ_PWRLAWX_USER' option only, and must be input for that option.

SIGZ_PWRLAWX_RHO

Constant ρ in power-law equation for vertical concentration standard deviation versus downwind distance, $\sigma_Z = \gamma x^\rho$, used to calculate vertical eddy diffusivity. Applies to TURB_PARAM_VERT = 'SIGZ_PWRLAWX_USER' option only, and must be input for that option.

SIGZ_PWRLAWX_XMAX

Maximum downwind distance (m) which the power law equation for vertical concentration standard deviation versus downwind distance is to be used. After this distance the value of vertical diffusivity, K_Z, is held constant at its value at this distance. Applies to TURB_PARAM_VERT = 'SIGZ_PWRLAWX_USER' option only, and must be input for that option.

STAB_CLASS

Array (max size = MAXTIM=50) of integers (1-6) representing the Pasquill-Gifford stability category, A-F. Stability class is used by some of the turbulence parameterization options (see

TURB_PARAM_VERT and TURB_PARAM_HORZ). If a horizontal turbulence parameterization based on sigma theta data is used, then it is also used to specify a default sigma theta surface value if no sigma theta data is input (see SIGMA_THETA_DATA namelist). There are many ways to determine stability class. One is the Pasquill-Turner method, which incorporates insolation assessments based on hourly cloud observations. The heat flux at the earth's surface is qualitatively estimated from these cloud observations, and then related to stability on the basis of the station wind speed. This method is similar to the method used to define the stability categories during the original development of the Pasquill-Gifford curves. STAB_CLASS must be representive of the entire model domain since only one value at a time is used for the entire domain.

Warning errors: NONE
Fatal errors: STAB_CLASS < 1
STAB_CLASS > 6

TIMESTEP_GLOBAL_FRACT

A parameter which can be used to decrease the timestep for both the Gradient Diffusion and RDM options. TIMESTEP_GLOBAL_FRACT is a decimal fraction multiplier applied after the timestep after it is determined in the code. For the DIFF_METH='RDM' option, it applies only to the global time step and not the local particle time step (see TIME_STEP_LOCAL_FRACT). Allowed values are 0. to 1.

(Default: TIMESTEP_GLOBAL_FRACT = 1.0)

TIMESTEP_LOCAL_MAX

A parameter (secs)which can be used to provide an upper limit for the local (particle-specific) timestep used to calculate particle movement. This parameter is likely used only in sensitivity studies of the RDM calculation scheme. Used for DIFF_METHOD = 'RDM' only. (Default: 'infinity')

TIMESTEP_LOCAL_MIN

A parameter (secs)which can be used to provide a lower limit for the local (particle-specific) timestep. This parameter is likely used only in sensitivity studies of the RDM calculation scheme. Used for DIFF_METHOD = 'RDM' only. (Default: 0.0)

TIMESTEP_LOCAL_FRACT

A parameter (decimal fraction) which multiplies the internally calculated local (particle-specific) timestep, scaling it either upward or downward. If timestep_local_min and/or timestep_local_max are set, those limits have precedence over a timestep determined by scaling from this variable (timestep_local_fract). Used for DIFF_METHOD = 'RDM' only. (Default: 1.0)

TURB_PARAM_TYPE

Array (max size = MAXTIM=50) of integers (1-5) specifying the turbulence parameterization to be used. Current possible values of TURB_PARAM_TYPE for use with gradient diffusion are 1, 2, 4, and 5. Used only with DIFF_METHOD = 'GRADI'.

When stack plume rise is used, the input parameters for the inverse Monin-Obukhov length (INV_OBUKHOV_LEN_SL) and the top of the mixed layer (ML_HGT) are required for computation of friction velocity for all values of TURB_PARAM_TYPE.

TURB_PARAM_TYPE	Turbulence parameterization to be used
1	Gaussian coefficients, Pasquill-Gifford
2	Gaussian coefficients, Idaho Falls MesoDif model

The following statements apply to both TURB_PARAM_TYPE's 4 and 5: Generalized turbulence parameters are computed for the entire atmospheric boundary layer as a function of wind profile, stability, surface roughness, and mixing layer thickness. The following input parameters must be provided in the Adpic.nml file: stability category (STAB_CLASS), inverse Monin-Obukhov length (INV_OBUKHOV_LEN_SL), top of mixing layer (ML_HGT), power law exponent in surface layer (PWR_LAW_EXPNT_SL), and surface roughness height (SFC_ROUGH_HGT). The vertical turbulence coefficient Kz is from Businger, Arya, and Deardorff in the outer mixing layer, and similarity theory in the surface layer. The Idaho Falls MesoDif Gaussian diffusion sigma-y curves are used for sub-grid diffusion. These coefficients result in more diffusion under stable conditions due to meandering effects when compared to the classical Pasquill-Gifford sigma-y curves.

TURB_PARAM_TYPE = 4 → Sigma-Theta method. Kh's obtained from Taylor's Theory using sigma-theta profile (fluctuation of the horizontal wind direction). The sigma-theta profile is input via the SIGMA_THETA and SIGMA_THETA_HGT arrays in the namelist sigma_theta_data of the ADPIC.NML namelist file. This diffusion scheme is suitable for continuous and moderately elevated releases within the mixed layer where sigma-theta data are available.

TURB_PARAM_TYPE = 5 → Energy dissipation rate (epsilon) method. Kh's obtained from scale-dependent horizontal diffusion using energy dissipation rate, epsilon. This diffusion scheme is suitable for instantaneous surface and elevated releases where horizontal diffusion is based upon the atmospheric energy dissipation rate.

TURB_PARAM_VERT

Array (max size = MAXTIM=50) of 22-character strings identifying *vertical* turbulence parameterization option to be used. The parameter applies only if DIFF_METHOD = 'RDM' in the ADPIC_CONTROL namelist. The recommended value is TURB_PARAM_VERT= 'KZ_SIMTHRY'. Possible values are as follows:

TURB_PARAM_VERT	Description
'KZ_SIMTHRY'	K_z as function of z calculated from boundary layer similarity theory as function of u_*, h, z , L . A constant value of K_z^{tropo} is used above $z = h$.
'KZ_SIMTHRY_USER'	$K_z(z)$ as function of z calculated from boundary layer similarity theory as function of u_*, h, z and L, but with *user-specified* coefficients a, b, c , and K_z(tropo (KZ_SIMTHRY_PHI_A, KZ_SIMTHRY_PHI_B, KZ_SIMTHRY_C, KZ_SIMTHRY_C2, KZ_SIMTHRY_C3 and KZ_SIMTHRY_TROPO *must be input* to use this option)
'SIGZ_PWRLAWX_PG'	K_z as function of downwind distance, x, calculated from *Pasquill-Gifford* $\sigma_z(x)$ in a power law form.
'SIGZ_PWRLAWX_USER'	K_z as function of downwind distance x (in meters) calculated from $\sigma_z(x)$ (in meters) using *user-specified* power law coefficients γ and ρ (SIGZ_PWRLAWX_GAMMA and SIGZ_PWRLAWX_RHO) in the power law equation: $\sigma_z = \gamma x^{\rho}$.
'KZ_LINEARZ'	K_z calculated from power law equation, $K_z = K_{z_{\text{ref}}}\left(z/z_{\text{ref}}\right)$, where K_{zref} and z_{ref} (KZ_LINEARZ_REF and KZ_LINEARZ_REF_HGT) are specified by the user.
'KZ_CONSTANTZ'	K_z fixed at constant value = KZ_CONSTANTZ, specified by the user.

TURB_PARAM_HORZ

Array (max size = MAXTIM=50) of 22-character strings identifying *horizontal* turbulence parameterization option to be used. This parameter applies only if DIFF_METHOD = 'RDM'. The recommened value is TURB_PARAM_HORZ= 'SIGH_SIGTHETA'. Possible values are as follows:

TURB_PARAM_HORZ	Description
'SIGH_SIGTHETA'	K_H as function of t calculated from Draxler σ_y (t) using input σ_θ data (see SIGMA_THETA_DATA namelist) and internal-default value of HORZ_TIME_SCALE, τ_H.
'SIGH_SIGTHETA_USER'	K_H as function of t calculated from Draxler $\sigma_y(t)$ using input σ_θ data (see SIGMA_THETA_DATA namelist) and *user-input* value of HORZ_TIME_SCALE, τ_H.
'SIGH_PWRLAWX_PG'	K_H as function of downwind distance x calculated from *Pasquill-Gifford* $\sigma_y(x)$ in a power law form ($\sigma_H = \sigma_y = \alpha x^{\beta}$)
'SIGH_PWRLAWX_MESO'	K_H as function of downwind distance x calculated from *MESODIF* $\sigma_y(x)$
'SIGH_PWRLAWX_LONGRANGE'	K_H as function of downwind distance x calculated from *Dan Rodriguez's long-range* $\sigma_y(x)$

'SIGH_PWRLAWX_USER'	K_H as function of downwind distance x (in meters) calculated from $\sigma_y(x)$ (in meters) using *user-specified* power law coefficients SIGH_PWRLAWX_ALPHA, α, and SIGH_PWRLAWX_BETA, β in the power equation: $\sigma_H = \alpha x^{\beta}$.

U_CALM

Floating point value representing the minimum value (m/s) for wind speed in friction velocity calculations. The friction velocity is computed at every horizontal grid point, and is dependent on the surface rougness height, stability, and wind speed at the grid points. In order to prevent the friction velocity from becoming zero, U_CALM is used for the wind speed when the wind speed is zero.

(Default: U_CALM = 0.2)

U_MEAN_DIR

Mean horizontal wind direction (in degrees) using standard meteorolgical convention (clockwise from north for direction wind is blowing from). Applies to WIND_TYPE= 'POWER_LAW' option only, and must be input for that option.

U_MEAN_HGT

Floating point value representing the height (m) of mean wind used to compute friction velocity.

(Default: U_MEAN_HGT = 10.0)

U_MEAN_REF

Reference wind speed value $\bar{u}_1$ (m/s) for power law wind profile:

$$\bar{u}(z) = \bar{u}_1 \left(\frac{z}{z_1} \right)^m .$$

Applies to WIND_TYPE= 'POWER_LAW' option only, and must be input for that option.

U_MEAN_REF_HGT

Reference height z_1 (m) for power law wind profile reference wind speed, U_MEAN_REF. Applies to WIND_TYPE= 'POWER_LAW' option only, and must be input for that option.

III.B.9.c. ADPIC_SOURCE namelist

AMBIENT_TEMP

2-D array (MAXTIM = 100, MAXSOURC = 9) of floating point values representing the ambient air temperature (K). as a function of time, for each source. This array is part of the stack plumerise model. If AMBIENT_TEMP and STACK_TEMP are specified, then HEAT_EMISSION_RATE should be omitted.

(Default: AMBIENT_TEMP = 288.)

CENTER_HGT

2-D array (MAXTIM = 100, MAXSOURC = 9) of floating point values representing the height (m) above 'TERRAIN', 'SEA_LEVEL', or 'GRID_BOTTOM' for the source centers. The first index of this array lines up with the SOURCE_START_DATE/TIME arrays. Note that you do not need to "pad" the rest of the array for a particular source; i.e., if there are other entries in the SOURCE_START_DATE/TIME arrays after the final change in a particular source's time-varying source center height, you do not need to have additional entries for CENTER_HGT for this particular source.

CENTER_HGT_REF

Array (maz size=MAXSOURC=9) of 12-character strings used to indicate if CENTER_HGT is relative to 'TERRAIN', 'SEA_LEVEL', or 'GRID_BOTTOM'.

(Default for all sources is 'TERRAIN')

CHEM_BIO_DECOMP_TAU

Array (MAXTIM = 100, MAXSOURC = 9) of time-varying real values specifying the time (hours) for decomposition of a chemical/biological material to 1/e of the original amount. Usually a decay rate in percent per minute is known (DR %/min), in which case from Eq. II.B.43:

CHEM_BIO_DECOMP_TAU = -1 / [60 * ln(1 - DR/100)].

This parameter will be used if DECAY_MODE = 'CHEM_BIO_DECOMP'.

(Default: none -- this is a required parameter for DECAY_MODE = 'CHEM_BIO_DECOMP')

DECAY_MODE

Array (MAXSOURC = 9) of 16-Character strings ('STABLE', 'RAD_DECAY', 'CHAIN_RAD_DECAY', 'CHEM_BIO_DECOMP') specifying if and how the source material will decrease in activity or amount, or change its form, state, or other characteristics. 'STABLE' implies that the material will not change. 'RAD_DECAY' implies that the material will undergo a simple radioactive decay (used in conjunction with the HALFLIFE parameter), which will not include any consideration of daughter products. 'CHAIN_RAD_DECAY' triggers the hybrid particle capability (activating the use of the ADPIC_RADPARAMS namelist), which will allow for complex radioactive decay, including daughter products. 'CHEM_BIO_DECOMP' implies that the material will undergo a chemical or biological time-dependent decomposition (see CHEM_BIO_DECOMP_TAU parameter).

(Default: DECAY_MODE = 'RAD_DECAY' = simplistic radioactive decay used)

EXIT_VEL

Array (max size = MAXSOURC = 9) of floating point values specifying the vertical exit velocity (m/s) of the gas emitted from the stack of each ADPIC source. Used in the plume rise calculation of buoyancy flux and momentum flux. Normal range of values are 3 to 50 m/sec. Any value less than or

equal to 2 m/sec is treated as zero. The ratio of horizontal wind velocity at the source location to the vertical exit velocity is used to determine if vertical plume equations or bent-over plume equations are used. If that ratio is less than 0.1, then vertical plume equations are used.

HALFLIFE

Array (max size = MAXSOURC = 9) of floating point values specifying the radioactive half-life (hours) of each ADPIC source. Use HALFLIFE = 0 for all non-radioactive substances.

HEAT_EMISSION_RATE

Array (max size = MAXSOURC = 9) of floating point values specifying the sensible heat emission rate (MW) for each ADPIC source. This is an optional parameter used (only if STACK_TEMP and AMBIENT_TEMP is not input) to calculate buoyancy flux in plume rise calculations. Typical values might be 0.01 to 100 MW. This array is part of the stack plumerise model.

INV_HGT_AT_STACK

2-D array (MAXTIM = 100, MAXSOURC = 9) of floating point values representing the height (m) of strong inversion affecting plume rise. This is an optional parameter; if a value is input, plume rise for source will be limited by this height, but only in cases involving buoyancy plume rise and neutral/unstable stability classes. If a value is not input, the ML_HGT value serves this function, but only for cases of vertical plumes in neutral/unstable stability classes.

PART_DENSITY

Array (max size = MAXSOURC = 9) of floating point values specifying the particle density (kg/m3) for each ADPIC source. PART_DENSITY is usually a value that has been normalized to 1 g/cc = 1000 kg/m3, but the actual particle density may also be used. Note that the PART_DENSITY chosen should be consistent with the values for PART_DIAM_MEDIAN, PART_DIAM_MIN, and PART_DIAM_MAX.

(Default: PART_DENSITY = 1000. → 1 g/cc)

PART_DIAM_MAX

Array (max size = MAXSOURCE = 9) of floating point values specifying the largest particle diameter (μm) of the effluent. It is usually taken to be two orders of magnitude greater than PART_DIAM_MEDIAN. The terminal fall velocities for those particles falling outside the realm of validity of Stoke's Law, i.e., Reynolds number greater than one, are calculated using an algorithm derived from McDonald's computational aid for the terminal fall velocity of spheres. See Section II.B.4.d for more information. If PART_DIAM_MEDIAN is set to zero, no entry is required for PART_DIAM_MAX. Typical values are:

PART_DIAM_MAX = 200.0 → Pu HE detonation, based upon CS-I data

PART_DIAM_MAX = 200.0 → Pu fire, based upon Rocky Flats data

PART_DIAM_MEDIAN

Array (max size = MAXSOURCE = 9) of floating point values specifying the effluent particle size median diameter (μm) for each ADPIC source. If there is no particular range of particle sizes, use PART_DIAM_MEDIAN of zero, which will result in a zero gravitational settling velocity. Typical values are:

PART_DIAM_MEDIAN = 40.0 → Pu HE detonation, based upon CS-I data

PART_DIAM_MEDIAN = 0.6 → Pu fire, based upon Rocky Flats data

PART_DIAM_MEDIAN = 0.0 → passive pollutant (gases, smoke,...)

PART_DIAM_MIN

Array (max size = MAXSOURCE = 9) of floating point values specifying the smallest particle diameter (μm) of the effluent. It is usually taken to be two orders of magnitude less than PART_DIAM_MEDIAN. If PART_DIAM_MEDIAN is set to zero, no entry is required for PART_DIAM_MIN. Typical values are:

PART_DIAM_MIN = 0.2 → Pu HE detonation, based upon CS-I data

PART_DIAM_MIN = 0.2 → Pu fire, based upon Rocky Flats data

PART_DIAM_SGD

Array (max size = MAXSOURCE = 9) of floating point values specifying the standard geometric deviation of the log-normal particle size distribution for each ADPIC source, and is defined as the following ratio:

$$\frac{\text{radius at 50\%}}{\text{radius at 16\%}} \quad \text{or} \quad \frac{\text{radius at 84\%}}{\text{radius at 50\%}}$$

on a log-normal frequency distribution plot. If PART_DIAM_MEDIAN is set to zero, no entry is required for PART_DIAM_SGD. Typical values are:

PART_DIAM_SGD = 5.71 → Pu HE detonation, based upon CS-I data

PART_DIAM_SGD = 3.0 → Pu fire, based upon Rocky Flats data

PART_GEN_MODE

Array (max size = MAXSOURCE = 9) of 20-character strings ('MASS_ACTIVITY_FRACT' or 'TIME_FRACT') used to control whether the number of marker particles for an ADPIC source generated for a particular time interval is proportional to the activity/mass of the source, or proportional to the time that the source is "on". Although the first method is generally

recommended, the user should be aware that while the particle statistics will be improved during peak release times, they will also be degraded during the non-peak release times.

(Default: PART_GEN_MODE = 'MASS_ACTIVITY_FRACT')

RELEASE_START (recommend use of SOURCE_START_DATE and SOURCE_START_TIME)

Array (max size = MAXSOURCE = 9) of 13-character time interval strings (ddd::'hh:mm:ss) specifying the release start time relative to the run start time (RUN_START_DATE \ RUN_START_TIME for non-restart, RESTART_DATE \ RESTART_TIME for restart) for each ADPIC source. Use of SOURCE_START_DATE and SOURCE_START_TIME will override use of RELEASE_START. Use of SOURCE_START_DATE and SOURCE_START_TIME instead of RELEASE_START is recommended because they are absolute times and allow for time-varying source rates.

RELEASE_STOP (recommend use of SOURCE_START_DATE and SOURCE_STOP_TIME)

Array (max size = MAXSOURCE = 9) of 13-character time interval strings(ddd::hh:mm:ss) specifying the release stop time relative to the run start time (RUN_START_DATE \ RUN_START_TIME for non-restart, RESTART_DATE \ RESTART_TIME for restart) for each ADPIC source. RELEASE_STOP will override RUN_DURATION. Use of SOURCE_START_DATE and SOURCE_START_TIME will override use of RELEASE_STOP. Use of SOURCE_START_DATE and SOURCE_START_TIME instead of RELEASE_STOP is recommended because they are absolute times and allow for time-varying source rates.

SFC_DEP_HGT

Floating point value representing the height (m) above ground level used for dry deposition calculations. SFC_DEP_VEL decreases linearly with height and goes to zero at the height specified by SFC_DEP_HGT.

(Default: SFC_DEP_HGT = DELZ from TOPOG.NML)

SFC_DEP_VEL

Array (max size = MAXSOURCE = 9) of floating point values specifying the surface deposition velocity (m/s) of the effluent. This is not a gravitational settling velocity, but rather a measure of the affinity of the material for the ground. SFC_DEP_VEL is a function of particle size, atmospheric stability, and surface roughness height. The surface deposition velocity is the downward particle flux divided by the particle concentration--so the units are m/sec. SFC_DEP_VEL is only used in the bottom grid cell to deposit particles onto the ground, and is weighted according to the distance from the bottom of the cell (i.e., zero at the top of the cell to full value at the bottom). The only mechanisms by which particles or a portion of the particle activity can be removed from the atmosphere and deposited on the ground are via SFC_DEP_VEL, rainout, and gravitational settling. Experimental data have shown that SFC_DEP_VEL usually lies between 0.001 and 0.05 m/s:

Particulate Effluent	SFC_DEP_VEL (m/s)
Pu-238, Pu-239	0.001- 0.01
SO2, Ru	0.01- 0.03 (0.028)
Cs-137, Sr-90	0.001- 0.002
I-131	0.003
Inert particles	0.001- 0.002
HTO	0.005- 0.008

SIGX

Array (max size - MAXSOURC = 9) of floating point values specifying the horizontal standard deviation (m) in the X-direction (East-West) of the initial stabilized source geometry for each non-moving ADPIC source. For a moving source (i.e., USE_MOVING_SOURCE = 'Y'), this direction is in the down-trajectory direction. (i.e., in line with the direction of motion)

SIGY

Array (max size - MAXSOURC = 9) of floating point values specifying the horizontal standard deviation (m) in the Y-direction (North-South) of the initial stabilized source geometry for each non-moving ADPIC source. For a moving source (i.e., USE_MOVING_SOURCE = 'Y'), this direction is in the cross-trajectory direction (i.e., perpendicular to the direction of motion).

SIGZ

Array (max size = MAXSOURC = 9) of floating point values specifying the vertical standard deviation (m) of the initial stabilized source geometry for each ADPIC source.

SLAB_SAMPLING_BINS

Array (MAXSBINS = 30) of integers (1 to MAXSBINS=30) specifying into which sampling bins the SLAB "source" results are to be placed. Note that the only SAMPLING_TYPE's allowed for any of the sampling bins specified by the SLAB_SAMPLING_BINS parameter are PKAIR and AVGAIR. Note also that if a sampling bin is to contain only the SLAB source results (i.e., no other ADPIC source is to be combined with the SLAB source), then there should not be a SOURCES_TO_SAMPLING_BIN specified for that sampling bin.

SLAB_SOURCE

An integer (1 to MAXSOURCE=9) specifying which ADPIC source location is to be used for the SLAB dense gas source. Note that you do not have to have a separate ADPIC source to represent the SLAB source, since none of the ADPIC source-specific parameters (except for source location) are used in the "modeling" of a SLAB source.

SLAB_SOURCE_RATE

Array (MAXTIM=100) of real values specifying the floating point values for the SLAB source rate. IMPORTANT: This array cannot contain any zeros! To enable the SLAB source rate to start after the earliest source release time, the SLAB_START_INDEX is used to offset how the SLAB_SOURCE_RATE lines up with the SOURCE_START_DATE and SOURCE_START_TIME arrays. The last entry in the SLAB_SOURC_RATE array should be the last non-zero SLAB source rate; you do not insert zero's to indicate the turn-off of the SLAB source rate -- this information is in the contents of the SLAB_TO_ADPIC file. You also do not need to "pad" the rest of the SLAB_SOURCE_RATE array with this last non-zero SLAB source rate; i.e., if there are other entries in the SOURCE_START_DATE/TIME arrays after the termination of the SLAB source rate, you do not need to have additional entries in the SLAB_SOURCE_RATE array. Note that no entry should be made in the SOURCE_RATE parameter array regarding any SLAB source rates.

SLAB_SPECIES

10-Character string specifying the name of the dense gas effluent modeled by the SLAB source. Note that this string is only used by TIMEHIS for labeling of the plot and textual file output. The string in the SPECIES array with the index of SLAB_SOURCE will be used (in the absence of a value for the PLCNT_LABELING_PARAMS namelist parameter MATERIAL) for labeling the contour plots.

SLAB_START_INDEX

Integer that serves as a pointer into the set of SOURCE_START_DATE and SOURCE_START_TIME arrays to allow the SLAB_SOURCE_RATE array to be offset: SLAB_SOURCE_RATE (n) corresponds to SOURCE_START_DATE/TIME (n-1+SLAB_START_INDEX). For example, if SLAB_START_INDEX = 3, then SLAB_SOURCE_RATE(1) starts at SOURCE_START_DATE/TIME(3), and SLAB_SOURCE_RATE(2) starts at SOURCE_START_DATE/TIME(4), etc.

SOURCE_RATE

2-D array (MAXTIM = 100, MAXSOURC = 9) specifying the floating point values for the source rate. The first index of this array lines up with the SOURCE_START_DATE/TIME arrays. Note that you do not need to "pad" the rest of the array for a particular source; i.e., if there are other entries in the SOURCE_START_DATE/TIME arrays after the final change in a particular source's time-varying source rate, you do not need to have additional entries for SOURCE_RATE for this particular source. The actual units of the bin contents to be plotted by PLCNT are determined by a combination of SOURCE_RATE, DCON (a PLCNT parameter), and the ADPIC internal units. See the description for DCON in the PLCNT section of this User's Guide for a more complete discussion of the interrelation of these parameters. NOTE: The SLAB_SOURCE_RATE parameter should be used to specify any SLAB source rates.

SOURCE_START_DATE

Array (max size = MAXTIM = 100) of 7-character date strings (ddMMMyy) specifying the dates at which new values of the time-varying source parameters (SOURCE_RATE. CENTER_HGT, AMBIENT_TEMP, INV_HGT_AT_STACK, and VERT_TEMP_GRAD) take effect. Also see SOURCE_START_TIME, which specifies the times

SOURCE_START_TIME

Array (max size = MAXTIM = 100) of 8-character time strings (hh:mm:ss) specifying the times at which new values of the time-varying source parameters (SOURCE_RATE. CENTER_HGT, AMBIENT_TEMP, INV_HGT_AT_STACK, and VERT_TEMP_GRAD) take effect. Also see SOURCE_START_DATE, which specifies the dates.

SPECIES

Array (max size = MAXSOURC = 9) of 10-character strings specifying the name of the effluent for each ADPIC source.

STACK_RADIUS

Array (max size = MAXSOURC = 9) of floating point values specifying the internal stack radius (m) for each ADPIC source. This is used to calculate buoyancy flux and momentum flux for plume rise calculations. It is NOT used to specify the initial source geometry. The parameters ZPOS_CUTOFF, ZNEG_CUTOFF, XPOS_CUTOFF, XNEG_CUTOFF, YPOS_CUTOFF, YNEG_CUTOFF, SIGX, SIGY, and SIGZ are always used for this and should be consistent with STACK_RADIUS. Typical values are 1 to 5 m.

STACK_TEMP

Array (max size = MAXSOURC = 9) of values specifying the temperature (degrees K) of the gas emitted from the stack of each ADPIC source. Used to calculate buoyancy flux for plume rise calculations. If STACK_TEMP and AMBIENT_TEMP are specified, then HEAT_EMISSION_RATE should be omitted.

TOTPART

Array (max size = MAXSOURC = 9) of integers specifying the total number of particles to be generated for each ADPIC source. TOTPART is used to calculate the particle release rate. Although ADPIC allows a total maximum of 20,000 particles from all sources at any given time, a continuous release with particle depletion (via deposition, advection, and upward diffusion) can easily release more than 20,000 particles without exceeding this limit at any one time. However, if this maximum is exceeded, ADPIC will redistribute the mass or activity evenly among the 20,000 particles. Particles will be removed from the grid via deposition, advection, or upward diffusion.

(Recommendation: TOTPART = 3000 for multi-species, TOTPART = 5000 for single species)

USE_PLUME_RISE

Array (max size = MAXSOURC = 9) of integer flags ('Y' or 'N') indicating whether plume rise should be calculated for a specific source. If other plume rise parameters are present, but USE_PLUME_RISE = 'N', then the other parameters will be ignored.

(Default: USE_PLUME_RISE = 'N' → no plume rise)

VERT_TEMP_GRAD

Array (MAXTIM = 100, MAXSOURC = 9) of floating point values representing vertical temperature gradient (K/m) for use in plume rise calculations. The time varying dimension corresponds to the same index in SOURCE_START_DATE and SOURCE_START_TIME. Used to calculate the Brunt-Vaisalla frequency. Defaults are provided in ADPIC for each stability class if a value is not input. (Note: The adiabatic, neutral temperature gradient is -0.0098 K/m. The standard atmosphere temperature gradient is -0.0065 K/m)

XLOC

2-D array (MAXTIM=100, MAXSOURC = 9) of floating point values specifying the Model x coordinate (km) of the source center as a function of time. For stationary sources, specify only the first time value. Note: Both XLOC and YLOC may not be closer than 3 grid cells from the edges of the ADPIC grid.

XNEG_CUTOFF

Array (max size = MAXSOURC = 9) of floating point values specifying the radial cutoff of the initial stabilized source geometry in the negative X-direction (i.e., to the West or “left”), referenced to the source center (XLOC) for each ADPIC source.

(Note: since this is distance is reference to the source center, XNEG_CUTOFF should have a negative value.)

XPOS_CUTOFF

Array (max size = MAXSOURC = 9) of floating point values specifying the radial cutoff of the initial stabilized source geometry in the positive X-direction (i.e., to the East or “right”), referenced to the source center (XLOC) for each ADPIC source.

YLOC

2-D array (MAXTIM=100, MAXSOURC = 9) of floating point values specifying the Model y coordinate (km) of the source center as a function of time. For stationary sources, specify only the first time value. Note: Both XLOC and YLOC may not be closer than 3 grid cells from the edges of the ADPIC grid.

YNEG_CUTOFF

Array (max size = MAXSOURC = 9) of floating point values specifying the radial cutoff of the initial stabilized source geometry in the negative Y-direction (i.e., to the South or “left”), referenced to the source center (YLOC) for each ADPIC source.

(Note: since this is distance is reference to the source center, YNEG_CUTOFF should have a negative value.)

YPOS_CUTOFF

Array (max size = MAXSOURC = 9) of floating point values specifying the radial cutoff of the initial stabilized source geometry in the positive Y-direction (i.e., to the North or “right”), referenced to the source center (YLOC) for each ADPIC source.

ZNEG_CUTOFF

Array (max size = MAXSOURC = 9) of floating point values specifying the radial cutoff of the initial stabilized source geometry in the negative Z-direction (i.e., downward or to the “bottom”), referenced to the source center height (CENTER_HGT) for each ADPIC source.

(Note: since this is distance is reference to the source center height, ZNEG_CUTOFF should have a negative value.)

ZPOS_CUTOFF

Array (max size = MAXSOURC = 9) of floating point values specifying the radial cutoff of the initial stabilized source geometry in the positive Z-direction (i.e., upward or to the “top”), referenced to the source center height (CENTER_HGT) for each ADPIC source.

III.B.9.d. ADPIC_RADPARAMS namelist

The section ADPIC_RADPARAMS controls the Hybrid Particle part of Adpic. This permits the user to incorporate all nuclides that may be present in a given scenario. In the Hybrid Particle model, all nuclides that have similar properties may be grouped together and treated as a single source (an example would be noble gases). The time dependence of the activity for each source of hybrid particles is calculated in tables at the beginning of the problem and applied during the calculation The presence of radioactive decay products (daughters) is included in the calculation. One may remove the effect of any member of a decay chain by setting the dose conversion factor to zero.

DCF

A one-dimensional array (max size = MAX_DCF_LIST = 500) of real numbers. The dose conversion factor related to a specific DCF_NUCLIDE_NAME and DCF_PATH_DESCRIPTOR entry.

(Required parameter - no default)

DCF_NUCLIDE_NAME

A one-dimensional array (max size = MAX_DCF_LIST = 500) of 20-character strings (same format as the NUCLIDE_NAME) giving the names of the nuclides and their daughters. One entry for each dose conversion path.

(Required parameter - no default)

DCF_PATH_DESCRIPTOR

A one-dimensional array (max size = MAX_DCF_LIST = 500) of 20-character strings (same format as DOSE_PATH_DESCRIPTOR) giving the dose path for each DCF_NUCLIDE_NAME entry.

(Required parameter - no default)

DECAY_START_INTERVAL

A one-dimensional array (max size = MAXSOURC = 9) of 13-character strings (ddd::hh:mm:ss) that specify the time interval between initial decay time and initial release time. This is used to model cases where the course is initially contained and at a later time escapes.

(Default: DECAY_START_INTERVAL = 000::00:00:00)

DOSE_PATH_DESCRIPTOR

A one -dimensional array (max size = MAXSBIN = 30) of 20-character strings used to describe the dose path of the hybrid particle. Any character string may be used, but the ones used by model parameter are given below:

ACTIVITY - dose conversion factor is one (such as Deposition)
50YRCOINHALEADEFFECTI - 50 year committed dose equivalent by inhale.
50YRCOINHALADTHYROID - Thyroid dose 50 yr committed by inhal.
GAIRIMMADEFFECTIVEWB - Whole body gamma dose from air immersion

(Required parameter - no default)

NUMBER_OF_TOXIC_TIMES

Integer (max = 500) the number of entries in the hybrid_toxicity array. This should be large enough so the time interval between entries is small compared to the toxicity decay rates. Normally 100-200 should do. Larger number are fine if they don't noticeable slow the problem run speed.

(Default: NUMBER_OF_TOXIC_TIMES = 200)

NUCLIDE_MIX

A two-dimensional array (MAX_PARENTS = 100, MAXSOURC = 9) of real numbers. For each source, the mixes are normalized in the code to sum over the nuclide names to unity. This means that for each source, it is only the ratio of the nuclide_mixes that matters.

(Required parameter - no default)

NUCLIDE_NAME

A two-dimensional array (MAX_PARENTS = 100, MAXSOURC = 9) of 20-character strings that are the name of each parent nuclide for each source. Names have the form: element symbol-isotope number e.g. Cs-137, Sm-151.

(Required parameter - no default)

III.B.9.e. ADPIC_RECEPTOR namelist

The moving receptor capability allows users to move one or more receptors (samplers) through the ADPIC domain and accumulate a quantitative integrated exposure from the ADPIC cloud to each of these recptor(s). (Please also refer to section II.B.4.j "Moving Receptors" for more background.) Note: In addition to this namelist, the user needs to set the flag USE_MOVING_RECEPTORS in the ADPIC_CONTROL namelist.

RCPTR_DELX

Array (MAX_RCPTR = 500) specifying the x-offset value (Km) from each receptor's reference trajectory (specified by TRAJ_X, TRAJ_Y, TRAJ_Z).

(Default: RCPTR_DELX = 500*0.0 = x offset from all receptors' specified trajectory coords is zero)

RCPTR_DELY

Array (MAX_RCPTR = 500) specifying the y-offset value (Km) from each receptor's reference trajectory (specified by TRAJ_X, TRAJ_Y, TRAJ_Z).

(Default: RCPTR_DELY = 500*0.0 = y offset from all receptors' specified trajectory coords is zero)

RCPTR_DELZ

Array (MAX_RCPTR = 500) specifying the z-offset value (M) from each receptor's reference trajectory (specified by TRAJ_X, TRAJ_Y, TRAJ_Z).

(Default: RCPTR_DELZ = 500*0.0 = z offset from all receptors' specified trajectory coords is zero)

RCPTR_HGT_REF

Array (MAX_TRAJ = 500) of 12-character strings ('TERRAIN', 'SEA_LEVEL', or 'GRID_BOTTOM') specifying the z-value reference type.

(Default: RCPTR_HGT_REF = 'TERRAIN' = TRAJ_Z values are meters above ground)

RCPTR_ID

Array (MAX_RCPTR = 500) of 12-character strings specifying the identifiers for receptors.

(Default: blank string)

RCPTR_INFL_X_FRACT

Real value specifying the range of influence (expressed as a fraction of the advection grid cell size in the x-direction) of ADPIC particles on the receptors. If the grid cell size is large, and you just don't want any particles farther away than 0.25*DELX from each receptor location to contribute to the receptor concentration, you would set RCPTR_INFL_X_FRACT = 0.25.

(Default: RCPTR_INFL_X_FRACT = 1.0 = particles up to 1*DELX away contribute to the receptor concentrations)

RCPTR_INFL_Y_FRACT

Real value specifying the range of influence (expressed as a fraction of the advection grid cell size in the y-direction) of ADPIC particles on the receptors. If the grid cell size is large, and you just don't want any particles farther away than 0.25*DELY from each receptor location to contribute to the receptor concentration, you would set RCPTR_INFL_Y_FRACT = 0.25.

(Default: RCPTR_INFL_Y_FRACT = 1.0 = particles up to 1*DELY away contribute to the receptor concentrations)

RCPTR_INFL_Z_FRACT

Real value specifying the range of influence (expressed as a fraction of the advection grid cell size in the z-direction) of ADPIC particles on the receptors. If the grid cell size is large, and you just don't want any particles farther away than 0.25*DELZ from each receptor location to contribute to the receptor concentration, you would set RCPTR_INFL_Z_FRACT = 0.25.

(Default: RCPTR_INFL_Z_FRACT = 1.0 = particles up to 1*DELZ away contribute to the receptor concentrations)

RCPTR_INTERVAL

13-Character string (ddd::hh:mm:ss) specifying the accumulation period and integration interval for the moving receptor output.

(Default: RCPTR_INTERVAL = '000::01:00:00' = 1 hour)

RCPTR_MULT_GLOBAL

Real value specifying a multiplier for output concentration values used whenever not overridden by a group (via RCPTR_MULT_GROUP) or individual value (via RCPTR_MULT_IND).

(Default: RCPTR_MULT_GLOBAL = 1.0 = output concentration values unchanged)

RCPTR_MULT_GROUP

Array (MAX_TRAJ = 500) of real values specifying multipliers for output concentration values when not overridden by an individual value (via RCPTR_MULT_IND). (RCPTR_MULT_GROUP overrides RCPTR_MULT_GLOBAL)

(Default: none; optional parameter)

RCPTR_MULT_IND

Array (MAX_RCPTR = 500) of real values specifying multipliers for output concentration values. (RCPTR_MULT_IND overrides both RCPTR_MULT_GROUP and RCPTR_MULT_GLOBAL)

(Default: none; optional parameter)

RCPTR_SBIN

Array (MAX_RCPTR = 500) of integers specifying which ADPIC sampling bin is to be used for each receptor.

(Default: none; required parameter)

RCPTR_TITLE

70-Character string specifying the title line to appear in the RECEPTOR.DAT file.

(Default: blank string)

RCPTR_TRAJ

Array (MAX_RCPTR = 500) of integers specifying which reference trajectory (specified by TRAJ_X, TRAJ_Y, TRAJ_Z) is to be used for a particular receptor. For example, RCPTR_TRAJ = 2 5 4, would imply that trajectory #2 is to be used for receptor #1, trajectory #5 is to be used for receptor #2, and trajectory #4 is to be used for receptor #3.

(Default: none; required parameter)

TRAJ_X

Array (MAX_TRAJ_TIMES = 100, MAX_TRAJ = 500) of real values specifying the time-varying x-coordinates (km) of each trajectory.

(Default: none; required parameter)

TRAJ_Y

Array (MAX_TRAJ_TIMES = 100, MAX_TRAJ = 500) of real values specifying the time-varying y-coordinates (km) of each trajectory.

(Default: none; required parameter)

TRAJ_Z

Array (MAX_TRAJ_TIMES = 100, MAX_TRAJ = 500) of real values specifying the time-varying z-coordinates (m) of each trajectory.

(Default: none; required parameter)

TRAJ_DATE

Array (MAX_TRAJ_TIMES = 100) of 7-character strings specifying the date ('yymmmdd') portion of the date/time at which new values of the time-varying trajectory coordinate parameters (TRAJ_X, TRAJ_Y, TRAJ_Z) take effect.

(Default: none; required parameter)

TRAJ_TIME

Array (MAX_TRAJ_TIMES = 100) of 8-character strings specifying the time ('hh:mm:ss)' portion of the date/time at which new values of the time-varying trajectory coordinate parameters (TRAJ_X, TRAJ_Y, TRAJ_Z) take effect.

(Default: none; required parameter)

III.B.9.f. SIGMA_THETA_DATA namelist

SIGMA_THETA

Array (MAXTIM by MAXLEVEL_ALL) of floating point values specifying sigma theta values (the standard deviation of wind direction, expressed in degrees). The first index matches entries in MET_START_DATE/MET_START_TIME while the last index matches the corresponding index of the array SIGMA_THETA_HGT. Sigma_theta is only used when TURB_PARAM_HORZ = 'SIGH_SIGTHETA' or 'SIGH_SIGTHETA_USER' for RDM diffusion, and when TURB_PARAM_TYPE = 4 for gradient diffusion. The scheme for determining the values of SIGMA_THETA depending upon the quantity of input data is given in the table below:

	SIGMA_THETA		
Height	*no data specified*	*single data point*	*two or more data points*
below 10m	same as at 10m	same as at 10m, unless explicitly specified	same as at 10m, unless explicitly specified
10m	A stability: SIGMA_THETA = 25 B stability: SIGMA_THETA = 20 C stability: SIGMA_THETA = 15 D stability: SIGMA_THETA = 10 E stability: SIGMA_THETA = 5 F stability: SIGMA_THETA = 2.5	use power law to correct the given sigma theta to a reference height of 10m, if not already given at 10m	linear interpolation scheme

0.02 ML_HGT 0.04 ML_HGT 0.07 ML_HGT 0.10 ML_HGT	use power law	(Warning to be issued if positive gradient of 5 deg / 100m exceeded)
0.2 ML_HGT 0.4 ML_HGT 0.7 ML_HGT 1.0 ML_HGT	**A-D stability:** Continue with power law up to 0.9 ML_HGT, then taper to 1 deg at 1.1 ML_HGT. **E&F stability:** Linear interpolation between value at 0.1 ML_HGT and 1 deg at ML_HGT	(Assumes SIGMA_THETA of 1 deg at ML_HGT and above if not explicitly specified and not implied by the slope of the highest two outer points)

SIGMA_THETA_HGT

Array (MAXTIM by MAXLEVEL_ALL) of floating point values specifying the height (m) above terrain of the SIGMA_THETA array values. SIGMA_THETA and SIGMA_THETA_HGT must always be entered as pairs. The interpolation algorithm assumes that heights are ordered from lowest to highest.

III.B.9.g. ADPIC_EXPL_CLD namelist

The ADPIC_EXPL_CLD namelist directs the explosive cloud rise model in ADPIC. However,.whether or not variables are set using this namelist, the explosive cloud rise calculation will only be made if the flag USE_EXPL_CLD_RISE is set in the previous ADPIC.NML namelist ADPIC_CONTROL.

DIF_IN_EXPL_CLD

Character ('Y' or 'N') specifying whether or not diffusion is permitted for particles within the explosive cloud.

(Default: DIF_IN_EXPL_CLD = 'Y' → diffusion is permitted within the explosive cloud)

DTDZ1

Floating point value representing the lapse rate from ground to elevation of lowest layer (specified by parameter ZI). Degrees C / m.

DTDZ2

Floating point value representing the lapse rate for elevations higher than the lowest layer ,ZI. Degrees C / m.

HEAMT

Array (max size = number of explosive cloud sources, currently limited to 1) of floating point values representing the mass (# of TNT equivalent) of high explosive contributing to the explosion for each explosive cloud source.

HEATDET

Array (max size = number of explosive cloud sources, currently limited to 1) of floating point values representing the heat of detonation (J/kg) for each explosive cloud source. For high explosive detonation, use HEATDET = 5.52E6 J/kg.

PLOT_EXPL_CLD

Integer specifying the time interval (sec) between ADPIC particle plots during the dynamic explosive cloud rise period of the ADPIC calculation. The possible range is from 1 through 60; if an out-of-range value is specified, the default value is used.

(Default: PLOT_EXPL_CLD = 60 → 60 second interval between particle plots)

PRINT_EXPL_CLD

Flag ('Y'/'N') which controls creation and printing of the output text file EXPL_CLD.PRT.

(Default: 'N')

PRINT_TYPE_EXPL_CLD

5-character string ('SHORT'/'FULL') which controls the amount of output to the output text file EXPL_CLD.PRT.

(Default: 'SHORT')

REL_HUM

Floating point value (0 < REL_HUM < 1.0) representing the relative humidity (fraction) at the surface in the explosive cloud source area.

SIG_OVER_R

Floating point value which is a multiplier which converts the explosive cloud radius into the initial sigma. It is applied in all three directions, i.e., the initial sigma in each sirection is

sig = sig_over_r * r_expl_cld

(Default: SIG_OVER_R = 10.)

SRC_EXPL_CLD

Double-dimensioned array (max size = ADPIC source counter by the number of explosive cloud sources, currently limited to 1) of integers (values = ADPIC source numbers) specifying which ADPIC

source (1 to MAXSOURC) goes into which explosive cloud source. The first index is a counter for whichof the MAXSOURC possible ADPIC sources will be used with the specificied explosive cloud source (the second index). For example, “SRC_EXPL_CLD(1,1) = 2 3 6” indicates that ADPIC sources #2, #3, and #6 will be contained in a single explosive cloud source #1. NOTE: MULTIPLE EXPLOSIVE CLOUD MODELING IS NOT YET IMPLEMENTED!!!!!

SRC_PRESS

Floating point value representing the atmospheric pressure (mb) at the height of the initial explosive cloud source.

TA0

Floating point value representing the ground level temperature, degrees C.

TEMP_PROFILE

Array (max size = MAX_EXPL_CLD_PROF = 30), giving an air temperature profile (C) at various levels in the atmosphere, at heights specified by TEMP_PROFILE_HGT).

TEMP_PROFILE_HGT

Array (max size = MAX_EXPL_CLD_PROF = 30), representing the height (m) above ground level for the temperature profile given in the array TEMP_PROFILE.

UAEXP

Floating point value representing the wind power-law exponent.

UAREF

Floating point value representing wind speed (m/s) at the reference height UAZREF.

UAZREF

Floating point value representing the wind speed reference height (m).

VEL_COUPL

Floating point value representing the velocity coupling coefficient. The suggested value of “VEL_COUPL = 0.35” was determined from the Clean Slate I dataset of the Roller Coaster experiment.

ZI

Floating point value representing the height (m) of the lowest layer.

ZINIT

Array (size = number of explosive cloud sources, currently limited to 1) of floating point values representing the initial height (m) above ground level of the center of each explosive cloud source.

Sample ADPIC.NML Namelist Input File

```
$adpic_control                                                    namelist title
 PROBLEM_TITLE     = 'Jul 91: Run1G - Stability & src hgt'        title for plots

 RUN_START_DATE              = '01APR85'                          start of run
 RUN_START_TIME              = '00:00'
 RUN_DURATION                = '00::04:00'                        duration of run
 SAMPLING_INTERVAL           = '00::01:00'                        interval for CONC files
 RESTART_WRITE_INTERVAL      = '00::00:00'                        interval for .RST files
 PLOT_INTERVAL               = '00::01:00'                        dot plot interval
 STATUS_INTERVAL             = '00::00:15'                        screen write interval
 INITIAL_TIME_STEP           = 30                                 initial time step
 DIFF_METHOD                 = 'RDM'                              diffusion method

 SOURCES_TO_SAMPLING_BIN(1,1)  =  1
 SOURCES_TO_SAMPLING_BIN(1,2)  =  1
 SOURCES_TO_SAMPLING_BIN(1,3)  =  1
 SOURCES_TO_SAMPLING_BIN(1,4)  =  2
 SOURCES_TO_SAMPLING_BIN(1,5)  =  2                               bin arrangement
 SOURCES_TO_SAMPLING_BIN(1,6)  =  2
 SOURCES_TO_SAMPLING_BIN(1,7)  =  3
 SOURCES_TO_SAMPLING_BIN(1,8)  =  3
 SOURCES_TO_SAMPLING_BIN(1,9)  =  3
 SOURCES_TO_SAMPLING_BIN(1,10) =  1 2 3
 SAMPLING_TYPE =  'INTAIR'   'INSAIR'   'TOTDEP'  'INTAIR'        types of sampling bins
                  'INSAIR'   'TOTDEP'  'INTAIR'   'INSAIR'
                  'TOTDEP'  'INTAIR'
 SAMPLING_HGT  =  1.5  1.5  0.0  1.5  1.5  0.0  1.5  1.5  0.0  75.  hgts of sampling bins
REFLECT_AT_MLHGT = 'N'
REFLECT_AT_GRIDTOP =' Y'
PARTPOS = 'P'                                                     for dots on terrain
 $end                                                             end of namelist

 $ADPIC_METPARAMS                                                 namelist title
 MET_START_DATE   =     '01APR85'  '01APR85'  '01APR85'  '01APR85'  time for met params
 MET_START_TIME   =     '00:00'    '01:00'    '02:00'    '03:00'
 INV_OBUKHOV_LEN_SL =0.0           -0.06      0.0        0.06
 PWR_LAW_EXPNT_SL =     0.17       0.13       0.17       030
 INV_OBUKHOV_LEN_ML= 0.0           –0.05      0.0        0.04
 ML_HGT           =     500        750        500        250
 TURB_PARAM_VERT= 4 *'KZ_SIMTHRY'
 TURB_PARAM_HORZ= 4 * 'SIGH_SIGTHETA'
 STAB_CLASS       =     4          2          4          6
 SFC_ROUGH_HGT    =     0.10

 $end                                                             end of namelist
```

```
$adpic_source                                                    namelist title
SPECIES          =   'GND'     'ELEVATED'    'COLUMN'            species names
DECAY_MODE = 3 * 'RAD_DECAY'                                     hybrid particle flag
SIGX             =   1.0       1.0           4.0                 std deviation in x
SIGY             =   1.0       1.0           4.0                 std deviation in y
SIGZ             =   1.0       1.0           40.0                std deviation in z
XPOS_CUTOFF      =   2.5       2.5           10.                 x cutoff to right
XNEG_CUTOFF      =   -2.5      -2.5          -10.                x cutoff to left
YPOS_CUTOFF      =   2.5       2.5           10.                 y cutoff to forward
YNEG_CUTOFF      =   -2.5      -2.5          -10.                y cutoff to backward
ZPOS_CUTOFF      =   2.5       2.5           80.                 z cutoff to top
ZNEG_CUTOFF      =   -0.       -2.5          -120.               z cutoff to bottom

XLOC (1,1)       =   105.                                        x coords of  each of the
XLOC (1,2)       =   105.                                        3 src location
XLOC (1.3)       =   105.
YLOC (1,1)       =   135.                                        y coords of each of  the
YLOC (1,2)       =   135.                                        3 src location
YLOC (1,3)       =   135.
TOTPART          =   6000      6000          6000                total # of particles
HALFLIFE         =   0.0       0.0           0.0                 decay half life
SFC_DEP_VEL      =   0.01      0.01          0.01                deposition velocity

PART_DIAM_MEDIAN =   0.3       0.3           0.3                 particle median diam.
PART_DIAM_SGD    =   3.0       3.0           3.0                 particle std geom dev
PART_DIAM_MIN    =   0.1       0.1           0.1                 particle min. diameter
PART_DIAM_MAX    =   100.      100.          100.                particle max. diameter
PART_DENSITY     =   1000.     1000.         1000.               particle density

USE_PLUME_RISE   =   'N'       'N'           'N'                 plume rise flag

SOURCE_START_DATE    =   '01APR85'  '01APR85'  '01APR85'         start for src rates
SOURCE_START_TIME    =   '00:00'    '02:00'    '05:00'
SOURCE_RATE(1,1)     =   1.0        0.0        0.0              rates for 1st species
SOURCE_RATE(1,2)     =   1.0        0.0        0.0              rates for 2nd species
SOURCE_RATE(1,3)     =   0.0        1.0        0.0              rates for 3rd species
CENTER_HGT(1,1)      =   0.                                     hgts for 1st species
CENTER_HGT(1,2)      =   100.                                   hgts for 2nd species
CENTER_HGT(1,3)      =   120.                                   hgts for 3rd species
$end                                                            end of namelist

$adpic_expl_cld                                                 namelist title
ZINIT            =
HE_AMT           =
HEATDET          =
REL_HUM          = -99999.0
SRC_PRESS        = -99999.0
TEMP_PROFILE_HGT=
TEMP_PROFILE     =
$END                                                            end of namelist
```

III.B.10. ADPIC.CLST

PLCNT can optionally read a list of fully qualified, and therefore unique, CONC***.BIF filenames from ADPIC.CLST. This file is produced by ADPIC and contains the list of CONC***.BIF files created by the most recentADPIC run. This is an ASCII file that can be edited by an assessor and provides a mechanism to easily handle multiple CONC groups in a single directory by allowing the user to maintain a series of ADPIC.CLST files (under different names with the desired file being copied to ADPIC.CLST as needed). In the absence of an ADPIC.CLST file, PLCNT processes the entire set of unique CONC***.BIF qualifiers in the appropriate directory, taking the highest version number associated with each qualifier.

III.B.11. CONC_ANALYSIS.NML

CONC_ANALYSIS.NML is the input file that directs the execution of both PLCNT and TIMEHIS. (Please also refer to section II.C.3 "PLCNT" and section II.C.4 "TIMEHIS" for more background regarding these models.) In PLCNT it supports control of the types of plots produced and the times when they are produced, the dose and final bin processing, the contour levels and numerous details of the plot format and labeling. TIMEHIS is supported by the same dose and final bin processing and the same time controls as PLCNT but for the interpolation of point concentration values.

There are four namelist sections in the CONC_ANALYSIS.NML file, and their general purposes are listed in the table below:

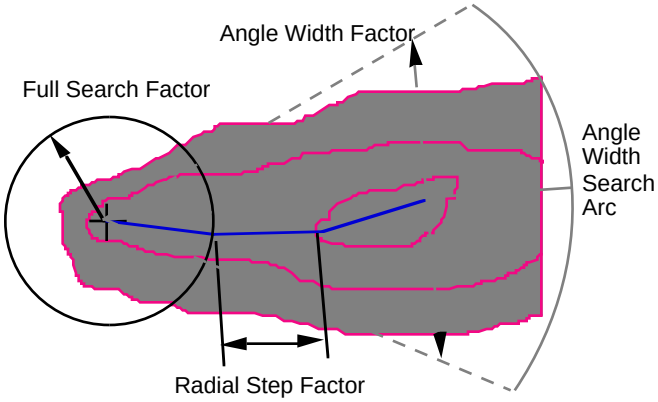
Namelist Section	Purpose
CONC_ANALYSIS_CONTROL	Specifies which sampling bins are combined into which dose bins (and which conversion factors need to be applied), and which dose bins are combined into which final bins. Also controls the type of integration (if any) to be done, the centerline capability, the timing of the plots (start, stop, and interval for each final bin), etc.
PLCNT_GRAPHICS_PARAMS	Controls various options for the graphics portion of the plot: number of isopleths, isopleth values, map scale, windowing, etc.
PLCNT_LABELING_PARAMS	Controls various options and labeling for the legend portion of the plot.
TIMEHIS PARAMS	Controls options used for TIMEHIS code (obtaining model-calculated values for sampler locations, and optionally comparing to measured values) but not for PLCNT.

The first namelist block is used by both PLCNT and TIMEHIS, the next two are used only by PLCNT, and the last block only by TIMEHIS. This order must be maintained by all namelist blocks present in the file, although unused blocks can be omitted.

III.B.11a. CONC_ANALYSIS_CONTROL namelist

ANGLE_WIDTH_FACTOR

Floating point factor applied to the horizontal (x) grid cell size for the centerline capability. This parameter controls the distance tangent to the previous maximum over which the centerline search is performed. A line of the specified length is evaluated perpendicularly to a line from the source to the previous centerline point at that centerline point. The centerline function then calculates an arc tangential to this line and the search for the next centerline value is determined along this arc:



This parameter takes over at radii beyond the FULL_SEARCH_FACTOR. This feature works best with a plume that moves directly away from the source. It can have problems with a meandering plume, especially a plume that ends up oriented radially around the source. To avoid the zig-zags, it is best to leave this value low (e.g., 2 to 4); however if the value is too low the maximum along an arc may be missed.

(Default: ANGLE_WIDTH_FACTOR = 3.0)

CENTERLINE_SOURCE

Integer (1 to MAXSOURC) representing the ADPIC source whose location is to be used as a starting point for the centerline processing. This is the only required input for the centerline capability; if it is missing, then the centerline function is not performed.

(Default: CENTERLINE_SOURCE = missing)

CONC_RESTART_DATE

7-character string (ddmmmyy) specifying the restart date of an ADPIC*.RST file. PLCNT will read the corresponding CONC*.RST file and accumulate concentration data from all CONC*.BIF files with times greater than the restart time and generate contour plots. Note that there must be at least one CONC*.BIF file with a time greater than the restart time. This feature enables the user to not have to have all of the CONC*.BIF files in a single directory in order to make a PLCNT run which needed integrated air concentration data.

CONC_RESTART_TIME

8-character string (hh:mm:ss) specifying the restart time of an ADPIC*.RST file. PLCNT will read the corresponding CONC*.RST file and accumulate concentration data from all CONC*.BIF files with times greater than the restart time and generate contour plots. Note that there must be at least one CONC*.BIF file with a time greater than the restart time. This feature enables the user to not have to have all of the CONC*.BIF files in a single directory in order to make a PLCNT run which needed integrated air concentration data.

DCON

Array (max size = MAXDBINS = 30) of values, each of which act as a numerical multiplier to the concentrations calculated by ADPIC for a dose bin. The size of the array is required to be equal to the number of dose bins (maximum of 30) specified in SAMPLING_TO_DOSE_BIN. The DCON parameter must either be specified completely or be omitted, in which case the concentrations in the dose bins remain unchanged. The actual units of the bin contents to be plotted by PLCNT are determined by a combination of SOURCE_RATE (an ADPIC.NML parameter), DCON, and the ADPIC model units (s/m^3 for instantaneous and time-averaged, s^2/m^3 for integrated, s/m^2 for deposition):

actual units = (SOURCE_RATE) $\times$ (DCON) $\times$ (ADPIC model units)

There are several possible combinations involving SOURCE_RATE and DCON; below are four of the most common:

1) SOURCE_RATE = actual source rate (e.g., g/s or Ci/s),
   DCON = dose conversion factor (dcf)
2) SOURCE_RATE = unit source rate in 1/s,
   DCON = dcf and the actual amount (e.g., g or Ci)
3) SOURCE_RATE = unit amount (instead of a rate),
   DCON = dcf $\times$ actual source rate (e.g., g/s or Ci/s)
4) SOURCE_RATE = dcf $\times$ actual source rate (e.g., g/s or Ci/s),
   DCON = 1

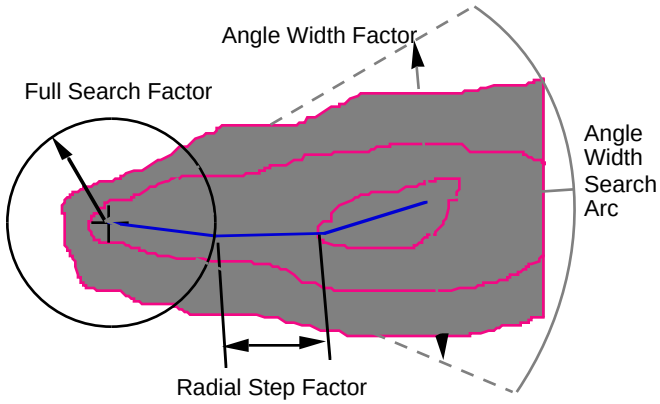
Combination #1 is the one used by the model parameters system. Combination #4 is currently necessary when dose plots for multi-nuclides are desired, and also for hybrid particle ADPIC. It should be noted that if Hybrid Particle ADPIC is used, the dose conversion factors have already been applied. Therefore the DCON should not include dose conversion factors.

DOSE_TO_FINAL_BIN

2-D array (max size =MAXDBINS, MAXFBINS = 30) of integers (values = dose bin numbers) specifying which dose bin numbers will be combined into final bin *n*, i.e., the DOSE TO FINAL bin correlation. This allows for specification of the combination of dose bins to be delayed until PLCNT/TIMEHIS, as well as allowing for the re-use of the dose bins. (Also see SAMPLING_TO_DOSE_BIN.)

FULL_SEARCH_FACTOR

Floating point factor applied to the horizontal (x) grid cell size for the centerline capability. This parameter controls the radial distance over which to perform a search from SECTOR_ANGLE_MIN counterclockwise to SECTOR_ANGLE_MAX (usually 0 to 360 degrees) for a concentration maximum; thus the ANGLE_WIDTH_FACTOR is ignored within this radius:



This search was designed to be the initial search pattern to find out which way the plume is going. It is not recommended to make this value very high, since in a splotchy, well spread out plume it will cause a zig-zag centerline that will follow individual high points across the map. A value of 1 to 3 should be adequate for simple plumes. In a complex plume case where the plume initially extends one direction, then breaks up, and later extends in a different direction, you may need to use a larger FULL_SEARCH_FACTOR to find the beginning of the later extension.

(Default: FULL_SEARCH_FACTOR = 3.0)

INTEGRATION_STEP

A two-dimensional array (max plot series, max final bins) of 13-character strings (ddd::hh:mm:ss) that specifies the time interval over which interval integrations are to be performed for a given plot series. The INTEGRATION_STEP must be an integer multiple of the SAMPLING_INTERVAL in ADPIC.NML and less than or equal to the PLOT_STEP for the same plot series. By default the INTEGRATION_STEP for a plot series is equal to the PLOT_STEP.

INTEGRATION_TYPE

An array (max final bins) of four-character strings ('CUMM', 'INTV', or 'NONE') that specifies the type of integration to perform for a given final bin. 'CUMM' refers to cumulative integration, 'INTV' refers to interval integration, 'NONE' refers to no integration. Only 'CUMM' or 'INTV' can be used for an integrated sampling bin (i.e., SAMPLING_TYPE='INTAIR' in the adpic_control namelist).

NEST_GRIDS

Flag ('Y' or 'N') which determines whether the nested grid or the coarse sampling grid is to be used.

(Default: NEST_GRID = 'Y' → used nested grid.)

PLOT_END_DATE

A two-dimensional array (max plot series, max final bins) of 7-character strings (ddmmmyy) that specifies the date portion of the date/time when a given plot series for a given final bin is to end. The date/times for each final bin should be in increasing order. Specifying an end date/time for a plot series is optional. If it is omitted, then a given plot series is terminated by the beginning of a second series or by the absence of available concentration data. A plot end date/time must corresponding to the date/time of a CONC*.BIF file.

PLOT_END_TIME

A two-dimensional array (max plot series, max final bins) of 8-character strings (hh:mm:ss) that specifies the time portion of the date/time when a given plot series for a given final bin is to end. The date/times for each final bin should be in increasing order. Specifying an end date/time for a plot series is optional. If it is omitted, then a given plot series is terminated by the beginning of a second series or by the absence of available concentration data. A plot end date/time must corresponding to the date/time of a CONC***.BIF file.

PLOT_START_DATE

A two-dimensional array (max plot series, max final bins) of 7-character strings (ddmmmyy) that specifies the date portion of the date/time when a given plot series for a given final bin is to begin. The date/times for each final bin should be increasing order. A plot start date/time must corresponding to the date/time of a CONC***.BIF file.

PLOT_START_TIME

A two-dimensional array (max plot series, max final bins) of 8-character strings (hh:mm:ss) that specifies the time portion of the date/time when a given plot series for a given final bin is to begin. The date/times for each final bin should be increasing order. A plot start date/time must corresponding to the date/time of a CONC***.BIF file.

PLOT_STEP

A two-dimensional array (max plot series, max final bins) of 13-character strings (ddd::hh:mm:ss) that specifies the time interval between plots for a given plot series. The PLOT_STEP must be an integer multiple of the SAMPLING_INTERVAL in ADPIC.NML.

PRINT_CONTOUR_CONC

Flag ('Y', 'N') for writing final bin concentrations to the echo file. This writing also includes the location and value of the max/min concentrations.

(Default: PRINT_CONTOUR_CONC = 'N'→ none written.)

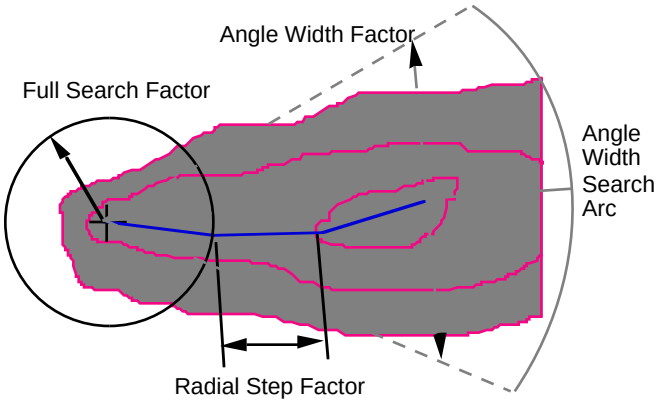
PRINT_INPUT_CONC

Flag ('Y', 'N') which controls the printing of the input concentrations to the echo file.

(Default: PRINT_INPUT_CONC = 'N'→ none are written.)

RADIAL_STEP_FACTOR

Floating point factor applied to the horizontal (x) grid cell size for the centerline capability. This parameter controls the radial step distance for the search for each maximum.



(Default: RADIAL_STEP_FACTOR = 0.5)

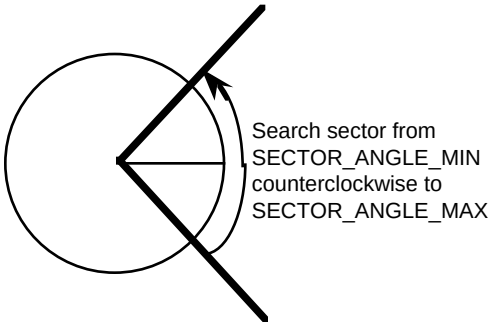
SAMPLING_TO_DOSE_BIN

Array (max size = MAXDBINS = 30) of integers, whose values are ADPIC bin numbers, specifying which sample bin goes into which dose bin, i.e., the "ADPIC TO DOSE" bin mapping. For example, if the same sample bin were put into three different dose bins, different dose conversion factors (DCON's) could be applied to each dose bin (for example: whole body dose, child thyroid dose, and air concentration) without having to have separate sample bins. (Also see DOSE_TO_FINAL_BIN.)

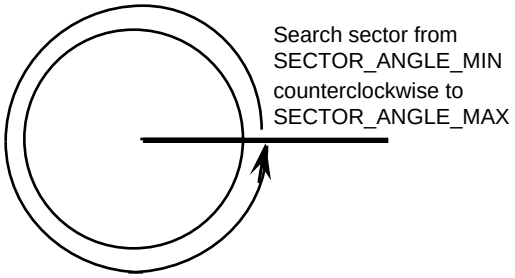
(Default: SAMPLING_TO_DOSE_BIN = 1 2 3 4 5 6 7 8 9 10 → one dose bin for each sample bin from ADPIC, with the dose bins in the same order as the sample bins)

SECTOR_ANGLE_MAX

Floating point value (0. to 360.) limiting all centerline searches (close-in full search, and further-out angle width search). SECTOR_ANGLE_MAX is measured in degrees counterclockwise from east (a mathematical angle, not a meteorological angle). Centerline searches cover angles counterclockwise from SECTOR_ANGLE_MIN to SECTOR_ANGLE_MAX:



Example with SECTOR_ANGLE_MIN = 315 deg
and SECTOR_ANGLE_MAX = 45 deg

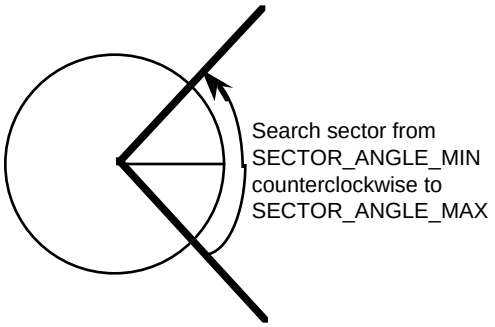


Example with SECTOR_ANGLE_MIN = 0 deg
and SECTOR_ANGLE_MAX = 360 deg

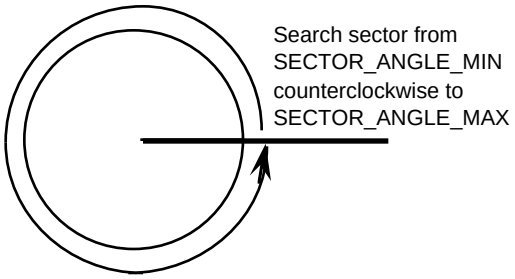
(Default: SECTOR_ANGLE_MAX = 360.)

SECTOR_ANGLE_MIN

Floating point value (0. to 360.) limiting all centerline searches (close-in full search, and further-out angle width search). SECTOR_ANGLE_MIN is measured in degrees counterclockwise from east (a mathematical angle, not a meteorological angle). Centerline searches cover angles counterclockwise from SECTOR_ANGLE_MIN to SECTOR_ANGLE_MAX:



Example with SECTOR_ANGLE_MIN = 315 deg
and SECTOR_ANGLE_MAX = 45 deg



Example with SECTOR_ANGLE_MIN = 0 deg
and SECTOR_ANGLE_MAX = 360 deg

(Default: SECTOR_ANGLE_MIN = 0.)

III.B.11b. PLCNT_GRAPHICS_PARAMS namelist

BLOWUP_SOURCE

An integer specifying the number of the ADPIC source whose location is to be placed as indicated by SOURCE_OCTANT.

CIRCLE_2000

Flag ('Y' or 'N') specifying whether or not the 2000ft blast effects circle will be plotted at the release location. (CIRCLE_2000 = 'Y' is required for DOD plots.)

CONTOUR_LEVELS

A two-dimensional array (MAXCONTLEVELS=5, MAXFBINS=30) of specific contour levels to be plotted for each specified final bin. Thus, up to 5 contour levels can be specified for each final bin.

The CONTOUR_LEVELS parameter is required for DOD and AWE plots as follows (for final bin n):

CONTOUR_LEVELS(1,n)	=	150.	25.	5.	0.5	(DOD CEWBDE)
CONTOUR_LEVELS(1,n)	=	600.	60.	6.		(DOD depostition)
CONTOUR_LEVELS(1,n)	=	4.7	0.94	0.78	0.15	(AWE 50yr CEWBDE)
CONTOUR_LEVELS(1,n)	=	20.0	2.0	0.2	0.03	(AWE depostition)

If CONTOUR_LEVELS(1,n) is not specified, PLCNT will pick its own contour levels, based upon the MIN_CONTOUR_AREA requirement. Also see RECOMPUTE_USER_CONTOURS for note regarding interaction among MIN_CONTOUR_AREA, CONTOUR_LEVELS, and RECOMPUTE_USER_CONTOURS.

HALF_POWER_OF_10

Flag indicating whether half powers of 10 (i.e., $3*10^{n)}$ are to be allowed as possible contour levels.

(Default: HALF_POWER_OF_10 = 'Y')

INITIAL_BANNER

Flag ('Y', 'N') used to indicate an initial calculation. The fact that this is an Initial calculation will be part of the plot description record. (Note: the sending of the description and graphics files is now controlled interactively in Show_Graphics-Site_Workstation_Plot and Show_Graphics-Site_System_Plot.)

(Default: INITIAL_BANNER = 'N' → not an Initial calculation)

MAPSCALE

A two-element integer array specifying the map scale to be used. The first element represents a unit of actual distance on the map and the second element is the corresponding actual physical

distance. For example, a map scale of 1:50,000 means and 1 inch on the map represents 50,000 inches of actual physical distance, and MAPSCALE = 1 50000. This parameter is ignored if MAP_SCALE_FLAG = 'N' for all final bins.

MAP_SCALE_FLAG

Array (max size = MAXFBINS = 30) of flags ('Y', 'N') that indicates whether or not the specified map scale is to be applied to this bin.

(Default: MAP_SCALE_FLAG = 'N')

MAX_CONTOURS

Array (max size = MAXFBINS = 30) of integers (1,2,3,4, or 5) of contour levels to be plotted and shown in legend.

MIN_CONTOUR_AREA

Real number representing minimum area (km^2) that will be plotted and shown in the legend. This will eliminate any contour levels specified by CONTOUR_LEVELS which do not meet the MIN_CONTOUR_AREA requirement. (Also see RECOMPUTE_USER_CONTOURS for note regarding interaction among MIN_CONTOUR_AREA, CONTOUR_LEVELS, and RECOMPUTE_USER_CONTOURS.)

(Default = 0.001% of grid area or $0.01km^2$, whichever is larger)

NEST_TYPE

10-character string which specifies if and how the nested grids are shown on the contour plots. Current values and meanings are:

'NONE' → no nesting stuff drawn
'BOUNDARIES' → boundaries of nested grids drawn
'CELLS' → grid cells and boundaries of nested grids drawn

NUM_RECOMPUTED_CONTOURS

Integer indicating the number of contours to recompute if they are recomputed (See RECOMPUTE_USER_CONTOURS).

(Default: NUM_RECOMPUTED_CONTOURS = 5)

OUTPUT_GRIDS

Flag ('Y', 'N') indicating whether PLCNT is to produce products to be sent to the site workstation. The products send to the site_workstation are the final bin concentrations passed as grids of data.

(Default: OUTPUT_GRIDS = 'Y')

PLOT_SIZE_CM

A real number specifying the size (cm) of the resulting plot as it would appear on the hard copy device. The postscript printers used by ARAC use a value of 16.0 for PLOT_SIZE_CM.

RECOMPUTE_USER_CONTOURS

Flag ('Y', 'N') indicating whether PLCNT should generate contour levels based on the maximum concentration if the estimated area of the highest user-specified contour level is less than the MIN_CONTOUR_AREA (See NUM_RECOMPUTED_CONTOURS). See the table below for the interaction between CONTOUR_LEVELS, MIN_CONTOUR_AREA, and

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Appendix H. The ARAC-2 Models

Background

The MATHEW/ADPIC models were initially developed at Lawrence Livermore National Laboratory (LLNL) in the mid-1970s. They were created as the basis for an emergency response system, the Atmospheric Release Advisory Capability (ARAC), which uses the models to provide estimates of the dispersion of hazardous material in the atmosphere. The initial version of the ARAC system (now referred to as ARAC-1) became operational shortly before the Three Mile Island incident in 1979. In the first ARAC system, the models ran on LLNL's CDC 7600 machines and various small computers were used to gather meteorological data and scenario description information.

During the period from 1982-1985, the entire system was reengineered to run on DEC-VAX machines running VMS. The goals of this development effort included the support of robust acquisition of global meteorological data for the models, as well as operational capabilities for handling geographic data. The system was extended to support a much larger number of sites and to handle more than one response at a time, along with a large number of other improvements. Over the decade since 1985, the current operational system (ARAC-2) has been extended to become a truly global capability. The models underwent a major restructuring in the early 1990s, the MATHEW model's numerical method and handling of boundary conditions were greatly improved in 1994 (the current version of code is CG-MATHEW). More recently, the ADPIC dispersion code has been extended to include a Monte Carlo approach to modeling diffusion, a significant advance of the the original particle-in-cell technique.

Beginning in 1995, a new project was initiated to reengineer the entire system. This project, known as ARAC-3, is in the process of developing new diagnostic and dispersion models that have a continuous terrain represention (as opposed to the stepped terrain used in the ARAC 2 models) as well as variable grids in three-dimensions. Prognostic models developed by the Naval Research Laboratory and used operationally at Fleet Numerical Meteorology and Oceanography Center are also being integrated into the ARAC system. The system is also being reengineered with a variety of goals including rethinking and improving all ARAC-2 capabilities, removal of operating system dependencies, extensive use of third-party software, a consistent and fluent graphical user interface and a design focus on software reuse and extensibility.

ARAC-2 Model Distribution

The current version of the ARAC-2 models is being made available for public distribution. This distribution is normally made via the Energy Science and Technology Software Center in Oakridge, TN. This is expected to be the last version of the ARAC-2 models distributed externally. At some future time, after development has completed on the ARAC-3 diagnostic and dispersion

models and an appropriate amount of operational experience is gained with these new models, they will also be made available publicly.
The native operating system for the ARAC-2 models is DEC-VMS. As a result of work over the last two years differential compile support for UNIX platforms is provided as part of the package. These two versions of the software are provided in separate file groupings. The VMS grouping has the full sources as they exist in the ARAC code management system, along with the MMS files used to build different versions of the models on the VMS system. The UNIX version covers the necessary details for installing the models in a UNIX environment. The UNIX versions have been installed under Solaris, Digital UNIX, IRIX and UNICOS. The information on the UNIX models may also be of assistance to those interested in using the models in other environments by highlighting the areas of concern in porting them to non-ARAC environments. Refer to the User's Guide to the CG-MATHEW/ADPIC Models for the details of the modeling system not presented here.

ARAC-2 Models - UNIX Versions Building and Using ARAC-2 Models in the UNIX Environment
This UNIX version of the ARAC-2 implementation of the MATHEW / ADPIC modeling system for wind fields and dispersion has been derived from the original VMS source code that was being used in ARAC operations as of the beginning of 1997.

Portability issues
General
Differential compilation logic and a set of UNIX-specific utilities have been used to provide equivalent capability in the SUN / UNIX environment. Gayle Sugiyama (LLNL) has also ported the TOPOG, MEDIC, and MATHEW models to an SGI environment for her own limited purposes. These models have also been compiled and executed successfully on a Cray using the f90 compiler under UNICOS. Although, the attempt has been to keep the code portable, there are obvious limitations. Some SUN-specific routines, such as rindex and lnblnk were used. Equivalent routines are available in the os_utils module if needed. Also, the -xl option was utilized to provide a closer mapping to the VMS implementation. This option, for example, defines file I/O record size in 4-byte words, instead of single byte entities. Without this option, the parameter lreclsize should be defined to 4.

Binary record size
For each platform and compiler, the Fortran reference manual should be consulted to ascertain how many bytes are read or written for each unit specified to the RECL keyword of the open statement. To establish the proper read / write of binary "BIF" files, do the following:
1) edit $ARACROOT/src/global_params.con
2) set parameter (lengthrec = SIZE)

where
SIZE = 512 / number_of_bytes_in_one_word_of_your_machine
for a 32-bit machine, this would be SIZE = 512 / 4 = 128
for a 64-bit machine, this would be SIZE = 512 / 8 = 64

lengthrec defines the size of the buffer to be read or written.
3) set parameter (lreclsize = SIZE)
where
SIZE = 512 / (number_of_bytes_specified_by_each_unit_of_
the_recl_keyword * lengthrec)
for the SparcCompiler with -xl set (writes 4 bytes for each
recl unit), SIZE = 512 / (4 * 128) = 1

or the Cray f90 compiler (writes 1 byte for each recl unit),
SIZE = 512 / (1 * 64) = 8
4) Set bytes_word to the number of bytes defined for a word on the target platform. Also set words_block for the number words in a block.
SUN: bytes_word = 4 (with -xl option)
words_block = 128
CRAY: bytes_word = 8
words_block = 64

The lreclsize and lengthrec variables work together to set each block to 512 bytes. The buffer size is driven by lengthrec and the machine's byte size. Number of bytes in a word times lengthrec should equal 512. Your compiler may warn you with something like:
Warning: unformatted record length adjusted

FORTRAN-to-C interface issues
There is no standard for interfacing between FORTRAN and C routines. The SparcCompiler uses the function name appended with an underscore character to indicate the invocation of C from FORTRAN. It also offers and extension with a pragma statement to facilitate that implementation. The Cray F90 compiler wants the C function to be specified with "all caps." You will need to determine how your compiler does this and implement those calls in $ARACROOT/src/os_utils/files.f.

GKS graphics
Note that, though the modeling code includes GKS graphics, no attempt has been made to make this capability work in the UNIX environment. The ARAC-2 models augment the strict definition of GKS graphics and use a particular implementation of a CGM standard for graphics metafiles. Some development effort will be necessary to use the ARAC graphic code. It is left in the sources to provide a guide to user's on the generation of plots that have found utility in the ARAC system. All graphics calls can be removed with differential compile logic.

NetCDF

NetCDF (Network Common Data Form) is an interface to a library of data access progams for storing and retrieving scientific data. It is used to store elevation data used by the topog model. It is available from the Unidata Program Center. The web address is http://www.unidata.ucar.edu. It is expected that the implemented will obtain a copy of this software this is update and configure for the target platform. Once NetCDF is installed, a symbolic link should be set as shown in the following example:

```
cd $ARACROOT/inc
ln -s /usr/local/netcdf/netcdf-2.4.3/include/netcdf.inc netcdf.inc
```

Also, the environment variable NETCDF should be set as shown in the section on environment variables.

NetCDF elevation files may be viewed, using the utility distributed by Unidata - ncdump. Use:

```
$NETCDF/bin/ncdump *.elev | more
```

Environment Variables

ARACROOT - root directory for installation point

ARAC_HOME - root directory for model execution context - initially set it to $ARACROOT/data

NETCDF - set to the base directory of your NetCDF installation

Source File Directory Structure

Development directory hierarchy (* ==> after successful build)

```
${ARACROOT}
   README
   bin
         topog*
         medic*
         mathew*
         adpic*
         plcnt*
         timehis*
   lib
         libutil.a*
         libgrid.a*
         libos_utils.a*
         libgeogutil.a*
   inc
         global_dims.h
         netcdf.inc*
   src
         util
```

os_utils
grid
geogutil
aerosutil
topodev
topog
medic
mathew
adpic
plcnt

Each directory listed above contains sources files such as *.F *.f *.c *.con *.blk *.cli as well as a Makefile in each directory.

Build Process

A. Set the LD_LIBRARY_PATH variable to include the compiler libraries (e.g., /opt/SUNWspro/lib:/opt/SUNWspro/SC3.0.1/lib)

B. Address portability issues

Make sure that the netcdf.inc symbolic link is set up as described under "Portability issues."

Before compiling os_utils, determine the FORTRAN-to-C invocation rules for your compilers and modify files.f accordingly.

Edit the $ARACROOT/src/util/global_params.con file to edit lengthrec, lreclsize, bytes_word, and words_block according to instructions in the "Portability issues" under "Binary record size."

C. Establish grid dimensions

The wind field (MATHEW) and dispersion grids are defined by parameters set in $ARACROOT/inc/global_dims.con by the following two lines:

```
parameter ( imaxmat = 51, jmaxmat = 51, kmaxmat = 15 )
parameter ( imaxpic = 41, jmaxpic = 41, kmaxpic = 15 )
```

To set other grid dimensions edit these two lines or find the file dims_??_??_??.con in $ARACROOT/src/grid that has the desired definition. Copy the selected dims_??_??_??.con to $ARACROOT/inc/global_dims.con.

D. Compile Code

For each of the modules (in ${ARACROOT}/src listed in section D) -

```
cd module
edit Makefile and set FC to your FORTRAN compiler name
    and CC to your C compiler name.
```

e.g., FC = f77
CC = acc

If necessary, change FFLAGS (e.g., -DDEBUG in os_utils)

make
make install

E. Module definition

The module list is (first four should be compiled first):

grid
util
geogutil
os_utils

topog
medic
mathew
adpic
plcnt

Execution Environment

A. Execution directory hierachy

```
${ARAC_HOME}
   bin
        topog
        medic
        mathew
        adpic
        plcnt
        timehis
   pathlist
   Misc
        tbb_structure.con
        DLC80A.DAT
   Elevations
   Projections
   Models_Error_File
   Runs
        las_vegas
   Winds
        las_vegas
   Vlst
```

B. Path definition file - pathlist

The ${ARAC_HOME}/pathlist file has entries for each type of file potentially needed by each of the models. There are three modes of path specification: 1) Absolute, 2) Relative, or 3) Environment variable. Absolute

specification is assumed when the file specification begins with a '/' character. The use of an environment variable is assumed when the file specification begins with a '$' character. Note that the {} delimiters should not be used as part of this specification. Any other starting character implies that the relative mode is to be used. A comment line begins with a '!' character. A unique numeric identifier is assigned to each category of directory.

C. Unique identifiers in pathlist

1 Directory for the input gridded terrain
(generated by TOPOG)

2 Directory for windfield generation
(MEDIC/MATHEW input/ output)

3 Directory for dispersion modeling
(ADPIC input/output)

4 Directory for geography files

5 Directory for topography (elevation) data

6 Name of gridded terrain file

7 Name of site map file

8 Site ID string

9 Problem ID string

10 Name of topography (elevation) file

11 Traceback block structure definition file (tbb_structure.con)

12 Run ID string

13 Directory for AFGWC gridded metdata

14 Root directory for metdata

15 Name of error file

16 Directory for VLST files. VLST files are created by models
to specify the list of output files created. Forexample
MATHEW.VLST is created by MATHEW to specify the output adjusted windfield files it generated on the last invocation.

17 Directory for Site Workstation files.

18 Name of the map projection file. The map projection file
specifies details of map projections to the models.
See 3F for an example.

19 Directory for map projection files

20 Nuclide database file, required by ADPIC.

D. Sample pathlist file

pathlist - Manage directory, file, and string references for the
ARAC-2 models

This file holds the names of several directories and files used by the ARAC applications. This file is used by the pathmgr package. It is patterned after the pathmgr used in the SWS software developed by Mark Spruiell.

The entries consist of two pieces of data, an ID number and a string. The ID numbers MUST match those in the pathmgr_private.con header file.

The string should represent a directory or pathname under the root directory specified in an environment variable. When a pathname is retrieved, the PathMgr pacakage will prepend the root path to the string.

only one environmental parameter is used... ARAC_HOME is used

names may have ./foo if current dir is desired
/home/foo if absolute path name for dir is desired
foo if ARAC_HOME for dir is desired
$FOO_DIR

1 Directory for the input gridded terrain (generated by TOPOG)
2 Directory for windfield generation (MEDIC/MATHEW input/ output)
3 Directory for dispersion modeling (ADPIC input/output)
4 Directory for geography files
5 Directory for topography (elevation) data
6 Name of gridded terrain file
7 Name of site map file
8 Site ID string
9 Problem ID string
10 Name of topography (elevation) file
11 Traceback block structure definition file (tbb_structure.con)
12 Run ID string
13 Directory for AFGWC gridded metdata
14 Root directory for metdata
15 Name of error file
16 Directory for VLST files. VLST files are created by models to specify the list of output files created. For example MATHEW.VLST is created by MATHEW to specify the output adjusted windfield files it generated on the last invocation.
17 Directory for Site Workstation files.
18 Name of the map projection file. The map projection file specifies details of map projections to the models. See 3F for an example.

19 Directory for map projection files
20 Nuclide database file, required by ADPIC.

1=Entry for input gridded terrain directory
command line option: N/A
1
Runs/las_vegas

2=Entry for wind field directory (VMS logical = MODEL$A_WINDS)
command line option: -w
2
Winds/las_vegas

3=Entry for dispersion directory (VMS logical = MODEL$A_DISPERSION)
command line option: -d
3
Runs/las_vegas

Entry for Maps directory
command line option: N/A
4
Maps

Entry for topography directory (VMS logical = TOPO$A_REGIONAL)
command line option: N/A
5
Elevations

Entry for gridded terrain file (VMS logical = MODEL$F_GRID)
command line option: -g
6
Runs/las_vegas/TOPOG_____45KM_1300M__658__3975_001.GRID

Entry for site map file (VMS logical = GEOG$F_REGIONAL)
command line option: N/A
7
Maps

Entry for site id string
command line option: -s
8
VEGAS

```
-----------
 9=Entry for problem ID string
 command line option: -p
9
SAMPLE
-----------
 Entry for topography file (VMS logical = TOPO$F_REGIONAL)
 command line option: -t
10
Elevations/lasvegas_utm_________600_001.LAS_VEGAS
-----------
 Entry for traceback block structure file
                (VMS logical = MODEL$F_TBB_STRUCTURE_CON)
 command line option: N/A
11
Misc/tbb_structure.con
-----------
 12=Entry for run ID string
 command line option: -r
12
123
-----------
 Entry for AFGWC directory (VMS logical =
DECAFGWC$A_AFGWC_GRID_FILE)
 command line option: N/A
13
WindField/anl
-----------

 Entry for metdata root (VMS logical = DSK$ARAC_MET_ROOT)
 14
  Metdata_Root
-----------

 Entry for error file
 command line option: N/A
15
Models_Error_File
-----------

 Entry for VLST directory
 command line option: -v
16
Vlst
-----------
```

Entry for Site Workstation products directory
command line option: N/A
17
Runs/las_vegas

Entry for map projection file
(VMS logical = MAP$F_PROJECTION_PARAMETERS)
command line option: -f
18
Projections/lasvegas_utm_____90-117_001.proj

Entry for projection directory
(VMS logical = MAP$A_PROJECTION_PARAMETERS)
command line option: -m
19
Projections

Entry for radio nuclide database (VMS logical = ADPIC$F_NUCLIDE_DATA)
command line option: -n
20
Misc/DLC80A.DAT

E. The necessary arguments may also be supplied from the command line. Only some of these arguments apply to any individual modeling code. The command line arguments include:

-w	wind_directory
-d	dispersion_directory
-s	site_workstation_directory
-g	gridded_terrain_file
-t	elevation_file
-p	problem_id_string
-r	run_id_string
-v	vlst_directory
-f	map_projection_file
-n	nuclide_file

F. Map projection file example

The map projection file las_vegas_utm_____90-117_001.proj contains:

las_vegas_utm_____90-117_001.proj las_vegas

UTM 1 1

GRS 1980 (WGS 84;NAD 83) 9
90.0000000 -117.0000000 -99999000.0000000 -99999000.0000000
500.0000000 0.0000000 9.9959999E-01
for future use
565.03851 3894.70898 765.03851 4094.70898
0.00000 -121.48873
0.00000 0.00000 0.00000

G. Order of model execution

See "User's Guide to the CG-Mathew/Adpic Models" UCRL-MA-103581

topog - create gridded terrain file from elevation data
medic - interpolate met observation data to a grid
mathew - adjust windfield for mass consistency
adpic - model the dispersion, using windfield, source, and control parameters
plcnt - average and scale contour data for a particular dose representation
timehis - calculate time-history statistics

H. Execute sample run to verify nominal functionality

A pathlist file has been included so that the models can compared against the original port during run-time. Output files exist with a ".LLNL" suffix. Compare the newly created files with the existing ".LLNL" files. For example, the output file MEDIC.LOG can be compared with the included MEDIC.LOG.LLNL as follows:

```
diff -w MEDIC.LOG.LLNL MEDIC.LOG | more
```

Note that there may be differences based on directory path names, machine precision, etc. The objective is to spot differences that are significant. The following comprises the list of reference output files:

topog output:
TOPOG*.GRID.LLNL
TOPOG_____45KM_1300M__658__3975_001.GRID.LLNL
medic output:
MEDIC.LOG.LLNL
mathew output:
MATHEW.LOG.LLNL
adpic output:
ADPIC.LOG.LLNL
plcnt output:
PLCNT.LOG.LLNL
SWS____04OCT93_0600_000_0300_AGA_01.CONC.LLNL

SWS____04OCT93_0900_000_0300_AGA_01.CONC.LLNL
SWS____04OCT93_1200_000_0300_AGA_01.CONC.LLNL
SWS____04OCT93_1500_000_0300_AGA_01.CONC.LLNL

timehis output:

TIMEHIS.LOG.LLNL
SAMPOUT.DAT.LLNL
STATS.DAT.LLNL

This exercise assumes that the environment (e.g., environment variable ARAC_HOME and file pathlist) has been properly set up.