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USER'S GUIDE FOR THE URBAN AIRSHED MODEL

Volume III: User's Manual for the Diagnostic Wind Model

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16. ABSTRACT

This document serves as a manual for the Diagnostic Wind Model which produces three-dimensional wind speed and direction components for the Urban Airshed Model.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Ozone Urban Airshed Model Photochemistry Diagnostic Wind Model		

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Volume III: User's Manual for the Diagnostic Wind Model

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Notice

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Preface

This user's guide for the Urban Airshed Model (UAM) is divided into five volumes as follows:

Volume I--User's Manual for UAM(CB-IV)
Volume II-- User's Manual for the UAM(CB-IV) Modeling System (Preprocessors)
Volume III--User's Manual for the Diagnostic Wind Model
Volume IV--User's Manual for the Emissions Preprocessor System
Volume V--Description and Operation of the ROM-UAM Interface Program System

Volume I provides historical background on the model and describes in general the scientific basis for the model. It describes the structure of the required unformatted (binary) files that are used directly as input to UAM. This volume also presents the formats of the output files and information on how to run an actual UAM simulation. For those user's that already possess a UAM modeling data base or have prepared inputs without the use of the standard UAM preprocessors, this volume should serve as a self-sufficient guide to running the model.

Volume II describes the file formats and software for each of the standard UAM preprocessors that are part of the UAM modeling system. The preprocessor input files are ASCII files that are generated from raw input data (meteorological, air quality, emissions). The preprocessor input files are then read by individual preprocessor programs to create the unformatted (binary) files that are read directly by the UAM. Included in this volume is an example problem that illustrates how inputs were created from measurement data for an application of the UAM in Atlanta. The preprocessers available for generating wind fields and emission inventories for the UAM are described separately in Volumes III and IV, respectively.

Volume III is the user's manual for the Diagnostic Wind Model (DWM). This model is a stand-alone interpolative wind model that uses surface- and upper-level wind observations at selected sites within the modeling domain of interest to provide hourly, gridded, three-dimensional estimates of winds using objective techniques. It provides one means of formulating wind field inputs to the UAM.

Volume IV describes in detail the Emission Preprocessor System (EPS). This software package is used to process anthropogenic area and point source emissions for UAM from countywide average total hydrocarbon, NO_x, and carbon monoxide emissions available from national emission inventories, such as the National Emissions Data System or the National Acid Precipitation Assessment Program. An appendix to this volume describes the Biogenic Emissions Inventory System (BEIS), which can be used to generate gridded, speciated biogenic emissions. Software for merging the anthropogenic area, mobile, and biogenic emission files into UAM input format is also described in this volume.

Volume V describes the ROM-UAM interface program system, a softare package that can be used to generate UAM input files from inputs and outputs provided by the EPA Regional Oxidant Model (ROM).

Acknowledgements

Since its initial conception in the early 1970s, many individuals have contributed to the development of the Urban Airshed Model. This document reflects the latest methodology and software development and provides a guide for new user's of the model. Based on the past efforts of the orginal developers of the UAM and the authors of the original 1978 user's manual, the first four volumes were written by the following individuals from Systems Applications, Inc.:

Volume I	Ralph E. Morris, Thomas C. Myers, Jay L. Haney
Volume II	Ralph E. Morris, Thomas C. Myers, Edward L. Carr, Marianne C. Causley, Sharon G. Douglas, Jay L. Haney
Volume III	Sharon G. Douglas, Robert C. Kessler, Edward L. Carr
Volume IV	Marianne C. Causley, Julie L. Fieber, Michele Jimenez, LuAnn Gardner

Volume V, containing the ROM-UAM Interface Program Guide, as well as Appendix D in Volume IV (Biogenics Emission Inventory System) were written by the following individuals of Computer Sciences Corporation and EPA's Atmospheric Science Modeling Division:

Volume V	Ruen-Tai Tang, Susan C. Gerry, Joseph S. Newsom, Allan R. Van Meter, and Richard A. Wayland (CSC); James M. Godowitch and Ken Schere (EPA)

The U.S. Environmental Protection Agency provided support for the preparation of this document. We also acknowledge the support of the South Coast Air Quality Management District for the initial documentation of the UAM (CB-IV). Richard D. Scheffe, Ned Meyer, Dennis Doll, and Ellen Baldridge of the U.S. EPA's Office of Air Quality Planning and Standards contributed to this document with their insightful technical reviews. Henry Hogo and Tom Chico of the South Coast Air Quality Management District also reviewed the documents and provided their comments.

Others at Systems Applications that have contributed to the continued development of the UAM in the last few years include Dr. Gary Whitten and Mr. Gary Moore. The technical editing of this manual was performed by Mr. Howard Beckman. We would like to acknowledge him for his excellent work in reviewing, editing, and clarifying the text of this manual for easier readability. Finally, we would like to acknowledge Rita Beacock, Jo Ann Moennighoff, and Cristi-Ann Griggs for their work in producing the document.

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1 INTRODUCTION

The Diagnostic Wind Model (DWM) is used to generate gridded fields of the horizontal wind components, u and v, at several user-specified vertical levels at a specified time. The model incorporates local surface and upper-air wind observations, where available, while providing some information on terrain-induced air flows in regions where local observations are absent.

The DWM requires gridded terrain heights, domain-mean wind data, and domain-scale stability information (dT/dz). The model will also accept surface and upper-air wind observations.

The generation of the wind field is a two-step procedure. Step 1 is based on the approach taken in the Systems Applications, Inc. Complex-Terrain Wind Model, as described by Liu and Yocke (1980). A domain-mean wind is adjusted for the kinematic effects of terrain (lifting and acceleration of the airflow over terrain obstacles), thermodynamically generated slope flows, and blocking effects. Step 1 produces a spatially varying gridded field of u and v for each vertical layer within the modeling domain.

Step 2 involves the addition of observational information to the Step 1 (u,v) field. An objective analysis scheme is used to produce a new gridded (u,v) field. The scheme is designed so that the observations are used to define the wind field within a user-specified radius of influence while the step 1 (u,v) field is used in subregions in which observations are unavailable. If local observations are unavailable, step 2 is omitted; step 1 alone will produce a gridded wind field grossly representative of the mesoscale perturbation of a mean flow by the aforementioned terrain effects. Conversely, if observations are available throughout the domain, step 2 alone will produce a gridded mass-consistent wind field reflecting the information contained in the observations. Figure 1-1 shows the information flow diagram for the Diagnostic Wind Model.

The Diagnostic Wind Model is described in Section 2. The surface and upper-air data preprocessors are described in Section 3. The generation of wind fields using the wind model is outlined in Section 4. The input parameters are described and some guidelines for the specification of these parameters are offered.

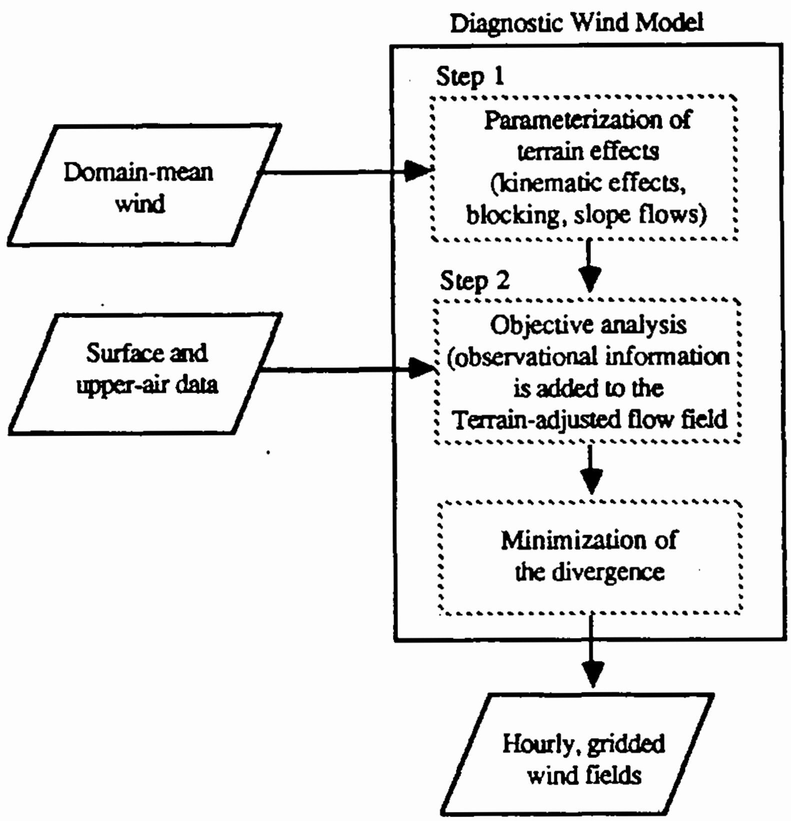

FIGURE 1-1. Flow diagram for the Diagnostic Wind Model.

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2 THE DIAGNOSTIC WIND MODEL

2.1 VERTICAL COORDINATES

The Diagnostic Wind Model is formulated in terrain-parallel vertical coordinates. This allows computation of the wind vectors at constant heights above ground, and also allows variable vertical resolution. The horizontal position variables (x,y) and velocity variables (u,v) are invariant upon transformation from Cartesian to terrain-parallel coordinates. If h denotes terrain height, z denotes the Cartesian vertical position variable, and Z represents the terrain-parallel position variable, then

$$Z = z - h(x,y). \qquad (2\text{-}1)$$

If w denotes Cartesian vertical velocity, and W denotes terrain-parallel vertical velocity,

$$W = w - u\ dh/dx - v\ dh/dy. \qquad (2\text{-}2)$$

In terrain-parallel coordinates, the incompressible conservation-of-mass equation becomes

$$du/dx + dv/dy + dW/dZ = 0. \qquad (2\text{-}3)$$

2.2 DIVERGENCE-MINIMIZATION PROCEDURE

The divergence minimization procedure exercised in both step 1 and step 2 is nearly identical to the procedure described by Goodin et al. (1980). The inputs to the procedure are a three-dimensional (u,v) field and a three-dimensional W field; the latter is defined at points vertically staggered with the (u,v) levels. Assuming the W field is invariant, the divergence-minimization procedure performs an iterative adjustment of the (u,v) field until the centered-difference approximation of the inequality,

$$du/dx + dv/dy + dW/dZ < \varepsilon\ , \qquad (2\text{-}4)$$

is satisfied at all grid points. ε is the maximum allowable three-dimensional divergence specified by the user.

The iterative adjustment is carried out as follows. At each grid point (i,j,k) the three-dimensional divergence D(i,j,k) is computed:

$$D(ijk) = \frac{W(i,j,k + 1/2) - W(i,j,k - 1/2)}{\Delta z} + \frac{u(i + 1,j,k) - u(i - 1,j,k)}{2\Delta x}$$

$$+ \frac{v(i,j + 1,k) - v(i,j - 1,k)}{2\Delta y} \qquad (2\text{-}5)$$

Velocity components at the surrounding grid points are adjusted so that D(i,j,k) is zero. The adjustment at a given grid point adds divergence at surrounding grid points; thus the whole grid must be scanned iteratively until the divergence minimization criterion is met at all points. The adjustments take the form

$$u'(i + 1, j, k) = u(i + 1, j, k) + u_T$$

$$u'(i - 1, j, k) = u(i - 1, j, k) - u_T$$

$$v'(i, j + 1, k) = v(i, j + 1, k) + v_T \qquad (2\text{-}6)$$

$$v'(i, j - 1, k) = v(i, j - 1, k) - v_T$$

In making this adjustment, it is assumed that $u_T = v_T$. Given constant horizontal grid spacing, one can then show from Equation 2-5 that

$$u_T = - D \Delta x/2 \quad . \qquad (2\text{-}7)$$

2.3 STEP 1 FORMULATION

2.3.1 Kinematic Effects of Terrain

The treatment of kinematic terrain effects follows that of Liu and Yocke (1980). Assuming a domain-mean wind, V, and terrain height, h(x,y), a terrain-forced Cartesian vertical velocity of the form

$$w = (V \cdot \text{grad } h) \exp(-kz) \qquad (2\text{-}8)$$

is calculated. Here k is a coefficient of exponential decay that increases with atmospheric stability. Liu and Yocke assume that

$$k = N/|V| \qquad (2\text{-}9)$$

where N is the Brunt-Vaisala frequency and $|V|$ is the magnitude of the mean wind. N is defined as $[(g/\theta)(d\theta/dz)]^{1/2}$ where θ is potential temperature. This formula is only used under stable conditions where $d\theta/dz > 0$.

In the current model the Cartesian w of Equation 2-8 is transformed to a terrain-parallel W as in Equation 2-2 using the domain-mean wind. Thus $dW/dZ = dw/dz$. Using the domain-mean wind as a first-guess gridded (u,v) field, the divergence-minimization scheme is exercised to produce a gridded wind field, $(u,v)_k$, that has been adjusted for the kinematic effects of terrain.

2.3.2 Slope Flows

At each grid point in regions of complex terrain, the DWM computes a slope flow vector $(u,v)_s$. This vector is added to the gridded wind field $(u,v)_k$ to obtain a new field $(u,v)_{ks}$.

The slope flow is calculated as follows. Let h_x and h_y denote $\partial h/dx$ and $\partial h/dy$, respectively. We define the slope angle, α,

$$\alpha = \tan^{-1}[h_x^2 + h_y^2]^{\frac{1}{2}} \quad . \tag{2-10}$$

The drainage direction β_d, is computed as in Allwine and Whiteman (1985). An angle, β', is defined as

$$\beta' = \tan^{-1}(h_y/h_x) \quad . \tag{2-11}$$

A second angle, β'', is defined as follows:

Condition	$h_x = 0$	$h_x < 0$	$h_x > 0$
$h_y = 0$	*	$\beta' + 180$	$\beta' + 360$
$h_y < 0$	270	$\beta' + 180$	$\beta + 360$
$h_y > 0$	90	$\beta' + 180$	β'

* Terrain is flat, no drainage direction.

The final definition of β_d (in degrees) is

$$\beta_d = 90 - \beta'', \qquad 0 < \beta'' < 90$$
$$\beta_d = 450 - \beta'', \qquad 90 < \beta'' < 360 \tag{2-12}$$

The slope flow vector is oriented in the drainage direction. The speed of the slope flow component is determined by the details of the parameterization; a positive speed in this discussion denotes upslope flow.

Analytic solutions for downslope flows under highly idealized conditions have been obtained by Prandtl (1942) and, more recently, by Mahrt (1982) and Fitzjarrald (1984). However, analysis of upslope flow has received much less attention, perhaps because the presence of turbulent mixing over a heated slope complicates the analysis. Although analytic solutions provide useful insight into the physics of slope flow, their direct application to complex-terrain situations is beyond the scope of diagnostic wind modeling. In the DWM the slope flow is parameterized as follows.

The speed, S, of the parameterized slope flow is defined as

$$S = S_0(dT/dz) \times f_1(t) \times f_2(\alpha) \ . \qquad (2\text{-}13)$$

S_0 is the slope flow amplitude based on the domain-scale temperature lapse rate and is an estimate of the maximum slope flow speed. The function f_1 is a specified function of time of day that, in general, is assigned a value of -1 for downslope flow and +1 for upslope flow. The function f_2 describes the variability of the slope flow speed with slope angle. This slope flow parameterization does not account for the nonlinear interaction of slope flow with ambient flow.

2.3.3 Blocking Effects

The treatment of terrain-blocking effects in the DWM follows that of Allwine and Whiteman (1985). From the gridded wind field, (u,v), the available atmospheric stability information, and the gridded terrain heights, a local Froude number,

$$Fr = S/(N \, \Delta h) \qquad (2\text{-}14)$$

is computed at each grid point. Here S is the grid-point wind speed, N is the Brunt-Vaisala frequency as defined in the previous section, and Δh is the "effective obstacle height" at the given grid point. If Fr is less than a critical Froude number, Fr_c (usually equal to 1), and $(u,v)_{ks}$ at the given grid point has an uphill component, $(u,v)_{ks}$ is adjusted so that the flow is in a terrain-tangent direction, with no change in speed. If $Fr > Fr_c$, the flow is not adjusted. Thus a new gridded wind field $(u,v)_1$ is obtained that reflects both the kinematic effects of terrain and thermodynamic blocking effects.

We assume that

$$\Delta h(x,y,Z) = h_{max}(x,y) - z(x,y,Z) \tag{2-15}$$

where Δh is the elevation (above MSL or some reference height) of the "obstacle top"; z is the elevation of the grid point; and $h_{max}(x,y)$ is the largest value of the terrain height, h, within a specified radius of the given grid point. This radius should be determined by the dominant horizontal scale of the terrain.

2.4 STEP 2 FORMULATION

Step 2 of the DWM combines the gridded wind field $(u,v)_1$ generated in step 1 with available observational data to produce a final gridded wind field $(u,v)_2$. This involves four substeps: (1) interpolation, (2) smoothing of the analyzed field, (3) computation of a vertical velocity field, and (4) minimization of the three-dimensional divergence.

2.4.1 Interpolation Scheme

The procedure for interpolating both the surface and upper-air data is a modified inverse-distance weighting scheme based on procedures utilized by Goodin and coworkers (1980), Godden and Lurmann (1983), and Ross and Smith (1986). The interpolation is carried out separately for each model level. Unless otherwise specified, all surface wind observations are incorporated into the lowest model level. Upper-air observations are first vertically and temporally interpolated to model levels and desired simulation times.

For the purpose of discussion, $(u_o,v_o)_k$ denotes an observed wind at station k, and r_k denotes the horizontal distance from station k to a given grid point. At each grid point the wind vector is thus updated as follows:

$$(u,v)' = \left\{ \sum_k [r_k^{-n} (u_o,v_o)_k] + R_1^{-n} (u,v)_1 \right\} / \left(\sum_k r_k^{-n} + R_1^{-n} \right) \tag{2-16}$$

This procedure weights the step 1 wind field, $(u,v)_1$, heavily in regions far removed from observations; the degree of influence exerted by $(u,v)_1$ is inversely related to the value of the parameter, R_1. The exponent controls the relative influence of observations distant from a given grid point. Goodin and co-workers suggest that this exponent should be 2 for a relatively dense set of observations, and 1 for a relatively sparse set of observations.

Several constraints can be placed on the evaluation of Equation 2-16. A maximum radius of influence R_{max} is specified such that if $r_k > R_{max}$, the observation at station k is excluded from the interpolation. If observations are densely spaced and representative of the spatial variability of the air flow, R_{max} should be relatively small; otherwise, evaluation of Equation 2-16 may result in unwanted smoothing effects.

A parameter, K_{max}, is also specified that limits the number of stations to be included in the interpolation at a grid point. This allows the effective maximum radius of influence to increase or decrease depending on local density of the monitoring network.

Finally, the user may construct barriers by specifying end points of line segments in (x,y) space; if a specified barrier lies between a station and a given grid point, that station is not considered in the interpolation at that grid point. This technique can be used to reduce or eliminate deleterious effects on the analysis of stations heavily influenced by local terrain features (e.g., a canyon).

The parameters R_1, R_{max}, and K_{max} as just defined are specified separately for surface and upper-air observations. Each barrier specification will include the maximum model vertical grid level at which the barrier is to be applied.

2.4.2 Smoothing of the Interpolated Wind Field

A simple five-point smoother of the form

$$A_{sm}(i,j) = 0.5A(i, j) + 0.125[A(i + 1, j) + A(i - 1, j) + A(i, j - 1) + A(i, j + 1)] \quad (2\text{-}17)$$

may be applied to the gridded wind field resulting from the objective analysis procedure. The number of smoothing passes (usually no more than four) is specified for each vertical model level. Smoothing of the gridded wind field can reduce the discontinuities caused by the interpolation when adjacent grid points are influenced by different observations. It can also speed up the divergence minimization procedure. However, it should be noted that overuse of such smoothing can eliminate important air flow features (e.g., a well-defined sea-breeze convergence zone).

2.4.3 Computation of the Vertical Velocity

An initial vertical velocity field in terrain-parallel coordinates, W', is computed from (u,v)' by integrating the incompressible conservation-of-mass equation (2-3). The resulting three-dimensional velocity field is thus mass-consistent. However, Godden and Lurmann (1983) note that vertical velocities obtained from objectively analyzed (u,v) fields may be unrealistically large near the top of the model domain. Godden and Lurmann use a procedure suggested by O'Brien (1970) to modify W':

$$W_2(Z) = W'(Z) - (Z/Z_{top})W'(Z_{top}) \tag{2-18}$$

Note that W_2 is zero at the model top, and that W_2 is not mass-consistent with (u,v)'. There may be situations in which use of the O'Brien procedure may not be desirable; for example, the model top may pass through a well-resolved sea-breeze convergence zone within which a large W value is realistic. Thus, in this model, the imposed vertical velocity profile of Equation 2-18 is optional. If the vertical-velocity adjustment procedure is not invoked, the final product of the model, $(u,v)_2$, is equal to (u,v)'.

2.4.4 Minimization of the Three-Dimensional Divergence

If the vertical velocity profile is adjusted to ensure that the vertical velocity at the top of the model is zero, it is necessary to adjust the objective analysis product, (u,v)', so that it is mass consistent with W_2. The divergence minimization procedure described earlier is exercised with (u,v)' as the input horizontal wind field and W_2 (the adjusted vertical velocity) is held constant. The adjusted horizontal wind field, $(u,v)_2$, is the final product of the DWM.

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3 PREPROCESSING THE SURFACE AND UPPER-AIR DATA

In the preprocessing step, wind observations are converted from wind speed and wind direction to u and v wind components. The input observations are then interpolated vertically to model layers and temporally to desired simulation times.

3.1 SURFACE DATA

The surface data are assumed to be valid at a constant height above ground (generally 10 m), which is given by the diagnostic wind model input parameter ZSWIND. While surface data are usually available at hourly intervals, some variation in measurement time may occur. In this case temporal interpolation of the surface data may be used.

The inputs for the surface data preprocessor (PRESFC) are described in Table 3-1. A sample input file for the preprocessor is presented in Exhibit 3-1. The user must specify: (1) the number of surface monitoring stations, (2) the beginning and ending times of the period for which data are to be processed, (3) a temporal interpolation range, and (4) the date. The data are processed for each hour during the specified period. Since surface wind patterns can be quite variable, it is important that the temporal interpolation period is not too large. Table 3-2 lists the logical units that are assigned in the surface preprocessor code to the various input and output files.

The station identifiers and locations (in UTM coordinates) of each of the surface stations are specified next. The data are then input; each station requires two data records. Both records contain the date, station identifier, variable name, and a unit identifier. Variable names are 'WD' for wind direction and 'WS' for wind speed. The unit identifier for wind direction is 'DEG' (degrees), and for wind speed either 'MPS', 'KTS', or 'MPH' (meters per second, knots or miles per hour, respectively). This is followed by the hourly wind direction in the first record and the hourly wind speed in the second record. Note that the hourly wind direction is given in whole degrees and that the wind speed is given in meters per second times 10. Twenty-four values of wind speed and wind direction represent the data for an entire day beginning at 0000 LST. Missing data are indicated by -1.

The resulting processed surface data are written to a file (see Exhibit 3-2 for an example) that is later input to the diagnostic wind model in hourly increments. The

TABLE 3-1. PRESFC input data.

Parameter	Description	Fortran Format
NSTA	Number of surface monitoring stations	(10X,I5)
NSTRHR	Starting time for the data to be processed	(10X,I5)
NENDHR	Ending time for the data to be processed	(10X,I5)
TDIF	Temporal influence range (hour)	(10X,F5.1)
KYEAR	Year	(10X,I5)
KMONTH	Month	(10X,I5)
KDAY	Day	(10X,I5)
NAMST,UTMXST,UTMYST	Surface wind station identifiers and UTM coordinates (easting and northing, km). Specify all surface stations.	(A4,3X,F6.1, 1X,F6.1)
LYEAR,LMONTH,LDAY, LSTAT,LVAR,LUNITS, LDATA	Station data: Year, month, day, station identifier, variable, unit identifier and hourly surface data.	(3I2,2X,A4,2X, A2,2X,A3,2X, 24I3)

90008 17

```
NSTA:          4
NSTRHR:        0
NENDHR:       23
TDIF:        4.0
KYEAR:        84
KMONTH:        6
KDAY:          3
CBA     729.95 3740.7  Charlie Brown Airport, Atlanta, GA
PTA     749.72 3752.3  Dekalb-Peachtree Airport, Atlanta, GA
DOB     729.59 3755.5  Dobbins Air Force Base, GA
DEK     752.78 3731.0  South Dekalb Jr. College 0.4 mi S of I-285
840603  CBA   WD  DEG  240220 -1 -1280290 -1 -1300360 102903301202602603403303203600 -1 -1 -1 -1
840603  CBA   WS  KTS   20 20 -1 -1 20 20 -1 -1 40 50 25 40 40 40 40 40 25 30 25 20 -1 -1 -1 -1
840603  PTA   WD  DEG   -1 -1 -1 -1 -1310330340340330350290310320300340290290310 -1 -1 -1 -1 -1
840603  PTA   WS  KTS   -1 -1 -1 -1 -1 25 25 40 60 75 50 50 35 40 40 50 50 50 30 -1 -1 -1 -1 -1
840603  DOB   WD  DEG  300310310300310320320330330320300310330330310300 -1 -1 -1 -1 -1 -1 -1320
840603  DOB   WS  KTS   40 30 30 30 30 25 50 40 50 30 30 30 25 40 25 20 -1 -1 -1 -1 -1 -1 -1 30
840603  DEK   WD  DEG  290270310300320330280270330330330320320320290300290290300300300290300310
840603  DEK   WS  MPH   20 30 10 20 10 10 20 40 70 40 90 60 60 50 60 50 50 50 40 30 10 04 04 04
```

EXHIBIT 3-1. Sample input file for surface data preprocessor (PRESFC).

TABLE 3-2. File structure for PRESFC.

Logical Unit	File Contents	Format
5	Surface data	ASCII
6	Printed output file	ASCII
7	Preprocessed surface data	ASCII

```
WIND STATION X & Y  CBA     730.0  3740.7
WIND STATION X & Y  PTA     749.7  3752.3
WIND STATION X & Y  DOB     729.6  3755.5
WIND STATION X & Y  DEK     752.8  3731.0
SURFACE WIND 0 CBA    1.0  0.9  0.5
SURFACE WIND 0 PTA    1.0999.0999.0
SURFACE WIND 0 DOB    1.0  1.8 -1.0
SURFACE WIND 0 DEK    1.0  0.8 -0.3
SURFACE WIND 0 LAST
SURFACE WIND 1 CBA    1.0  0.7  0.8
SURFACE WIND 1 PTA    1.0  1.0 -0.8
SURFACE WIND 1 DOB    1.0  1.2 -1.0
SURFACE WIND 1 DEK    1.0  1.3  0.0
SURFACE WIND 1 LAST
SURFACE WIND 2 CBA    1.0  0.8  0.5
SURFACE WIND 2 PTA    1.0  1.0 -0.8
SURFACE WIND 2 DOB    1.0  1.2 -1.0
SURFACE WIND 2 DEK    1.0  0.3 -0.3
SURFACE WIND 2 LAST
SURFACE WIND 3 CBA    1.0  0.9  0.1
SURFACE WIND 3 PTA    1.0  1.0 -0.8
SURFACE WIND 3 DOB    1.0  1.3 -0.8
SURFACE WIND 3 DEK    1.0  0.8 -0.4
SURFACE WIND 3 LAST
SURFACE WIND 4 CBA    1.0  1.0 -0.2
SURFACE WIND 4 PTA    1.0  1.0 -0.8
SURFACE WIND 4 DOB    1.0  1.2 -1.0
SURFACE WIND 4 DEK    1.0  0.3 -0.3
SURFACE WIND 4 LAST
SURFACE WIND 5 CBA    1.0  1.0 -0.4
SURFACE WIND 5 PTA    1.0  1.0 -0.8
SURFACE WIND 5 DOB    1.0  0.8 -1.0
SURFACE WIND 5 DEK    1.0  0.2 -0.4
SURFACE WIND 5 LAST
SURFACE WIND 6 CBA    1.0  1.2 -0.6
SURFACE WIND 6 PTA    1.0  0.6 -1.1
SURFACE WIND 6 DOB    1.0  1.7 -2.0
SURFACE WIND 6 DEK    1.0  0.9 -0.2
SURFACE WIND 6 LAST
SURFACE WIND 7 CBA    1.0  1.5 -0.8
SURFACE WIND 7 PTA    1.0  0.7 -1.9
SURFACE WIND 7 DOB    1.0  1.0 -1.8
SURFACE WIND 7 DEK    1.0  1.8  0.0
SURFACE WIND 7 LAST
SURFACE WIND 8 CBA    1.0  1.8 -1.0
SURFACE WIND 8 PTA    1.0  1.1 -2.9
SURFACE WIND 8 DOB    1.0  1.3 -2.2
SURFACE WIND 8 DEK    1.0  1.6 -2.7
SURFACE WIND 8 LAST
SURFACE WIND 9 CBA    1.0  0.0 -2.6
SURFACE WIND 9 PTA    1.0  1.9 -3.3
SURFACE WIND 9 DOB    1.0  1.0 -1.2
SURFACE WIND 9 DEK    1.0  0.9 -1.5
SURFACE WIND 9 LAST
SURFACE WIND10 CBA    1.0 -0.2 -1.3
SURFACE WIND10 PTA    1.0  0.4  2.5
SURFACE WIND10 DOB    1.0  1.3 -0.8
```

EXHIBIT 3-2. Output from PRESFC used as surface data input file for the Diagnostic Wind Model.

```
SURFACE WIND10 DEK     1.0  2.0 -3.5
SURFACE WIND10 LAST
SURFACE WIND11 CBA     1.0  1.9 -0.7
SURFACE WIND11 PTA     1.0  2.4 -0.9
SURFACE WIND11 DOB     1.0  1.2 -1.0
SURFACE WIND11 DEK     1.0  1.7 -2.1
SURFACE WIND11 LAST
SURFACE WIND12 CBA     1.0  1.0 -1.8
SURFACE WIND12 PTA     1.0  1.4 -1.2
SURFACE WIND12 DOB     1.0  0.6 -1.1
SURFACE WIND12 DEK     1.0  1.7 -2.1
SURFACE WIND12 LAST
SURFACE WIND13 CBA     1.0 -1.8  1.0
SURFACE WIND13 PTA     1.0  1.3 -1.6
SURFACE WIND13 DOB     1.0  1.0 -1.8
SURFACE WIND13 DFK     1.0  1.4 -1.7
SURFACE WIND13 LAST
SURFACE WIND14 CBA     1.0  2.0  0.4
SURFACE WIND14 PTA     1.0  1.8 -1.0
SURFACE WIND14 DOB     1.0  1.0 -0.8
SURFACE WIND14 DEK     1.0  2.5 -0.9
SURFACE WIND14 LAST
SURFACE WIND15 CBA     1.0  2.0  0.4
SURFACE WIND15 PTA     1.0  0.9 -2.4
SURFACE WIND15 DOB     1.0  0.9 -0.5
SURFACE WIND15 DEK     1.0  1.9 -1.1
SURFACE WIND15 LAST
SURFACE WIND16 CBA     1.0  0.4 -1.2
SURFACE WIND16 PTA     1.0  2.4 -0.9
SURFACE WIND16 DOB     1.0  0.9 -0.5
SURFACE WIND16 DEK     1.0  2.1 -0.8
SURFACE WIND16 LAST
SURFACE WIND17 CBA     1.0  0.8 -1.3
SURFACE WIND17 PTA     1.0  2.4 -0.9
SURFACE WIND17 DOB     1.0  0.9 -0.5
SURFACE WIND17 DEK     1.0  2.1 -0.8
SURFACE WIND17 LAST
SURFACE WIND18 CBA     1.0  0.8 -1.0
SURFACE WIND18 PTA     1.0  1.2 -1.0
SURFACE WIND18 DOB     1.0  0.9 -0.5
SURFACE WIND18 DEK     1.0  1.5 -0.9
SURFACE WIND18 LAST
SURFACE WIND19 CBA     1.0  0.0 -1.0
SURFACE WIND19 PTA     1.0  1.2 -1.0
SURFACE WIND19 DOB     1.0  0.9 -0.8
SURFACE WIND19 DEK     1.0  1.2 -0.7
SURFACE WIND19 LAST
SURFACE WIND20 CBA     1.0  0.0 -1.0
SURFACE WIND20 PTA     1.0  1.2 -1.0
SURFACE WIND20 DOB     1.0  1.0 -1.2
SURFACE WIND20 DEK     1.0  0.4 -0.2
SURFACE WIND20 LAST
SURFACE WIND21 CBA     1.0  0.0 -1.0
SURFACE WIND21 PTA     1.0  1.2 -1.0
SURFACE WIND21 DOB     1.0  1.0 -1.2
SURFACE WIND21 DEK     1.0  0.2 -0.1
SURFACE WIND21 LAST
```

EXHIBIT 3-2. Continued.

```
SURFACE WIND22 CBA    1.0  0.0  1.0
SURFACE WIND22 PTA    1.0  1.2 -1.0
SURFACE WIND22 DOB    1.0  1.0 -1.2
SURFACE WIND22 DEK    1.0  0.2 -0.1
SURFACE WIND22 LAST
SURFACE WIND23 CBA    1.0  0.0 -1.0
SURFACE WIND23 PTA    1.0999.0999.0
SURFACE WIND23 DOB    1.0  1.0 -1.2
SURFACE WIND23 DEK    1.0  0.1 -0.1
SURFACE WIND23 LAST
```

EXHIBIT 3-2. Concluded.

station identifiers and locations of all of the surface stations are also contained in this file and are read in at the beginning of the simulation.

3.2 UPPER-AIR DATA

The upper-air data are interpolated both vertically and temporally to provide model inputs for each model level at each hour of the simulation. Two methods of vertical interpolation are available in the preprocessor (PREUPR). In the first method, the data are averaged within each model layer. Here "layer" refers to the area bounded by two vertical cell interfaces and "level" is the center of the layer or the cell-center height. Extrapolation to levels below the lowest observation and above the highest observation is not performed. In the second method the data are linearly interpolated to the model levels (the heights of cell centers). Data are extended to levels below the lowest observation height and above the highest observation height if an observation is within the layer half-width from the level to which it is extrapolated. The vertically interpolated data are then interpolated linearly in time to provide a smoothly varying wind pattern from one observation time to the next.

The inputs for the upper-air data preprocessor are described in Table 3-3. A sample input file for the preprocessor is given in Exhibit 3-3. The input file must contain: (1) the number of upper-air stations, (2) the maximum number of observation levels in a given sounding, (3) the beginning and ending times of the period for the data to be processed, (4) the temporal interpolation range, (5) the number of vertical layers to be used in the model, (6) the date, (7) the interpolation option, and (8) the heights of the vertical layer interfaces in terrain-following coordinates beginning with 0 for the surface. The vertical structure of the diagnostic wind model should be based on the vertical resolution of the upper-air data. Table 3-4 lists the logical units that are assigned in the upper-air preprocessor code to the various input and output files.

Upper-air radiosonde soundings of wind speed and wind direction are usually available twice daily but this can vary, especially during intensive measurement periods. Other types of upper-air data, such as pibal data and Doppler acoustic sounder data, may be available at more frequent intervals. A range of 12 hours is recommended for interpolation of twice-daily upper-air data.

The station identifiers, UTM coordinates, and elevations of the upper-air stations are then specified. This is followed by the input data. Each upper-air sounding requires three input records. Each record contains the date, station identifier, observation time, and a unit identifier. The unit identifier for height is 'MET' (height in meters). The first input record contains the observation heights, the second contains the wind directions, and the third contains the wind speeds. Note that the wind speeds are multiplied by 10. Missing data are indicated by -1. When this delimiter is encountered, the remainder of the sounding is disregarded.

TABLE 3-3. PREUPR input data.

Parameter	Description	Fortran Format
NSTA	Number of upper-air monitoring stations	(10X,I5)
LEVELS	Maximum number of levels in a given sounding	(10X,I5)
NSTRHR	Starting time for the data to be processed	(10X,I5)
NENDHR	Ending time for the data to be processed	(10X,I5)
TDIF	Temporal influence range	(10X,F5.1)
NCELL	Number of vertical layers	(10X,I5)
CELLZB	Heights of the vertical layer interfaces in terrain-following coordinates beginning with 0 for the surface (m)	(10X,10F6.0)
KYEAR	Year	(10X,I5)
KMONTH	Month	(10X,I5)
KDAY	Day	(10X,I5)
IOPT	Vertical interpolation option: 1 = for layer averaging. 2 = for linear interpolation to cell-center heights.	(10X,I5)
NAMST,UTMXST,UTMYST, ELEV	Upper-air wind station identifiers, UTM coordinates (easting and northing, km), and elevations. List all upper-air stations.	(A4,1X,3F7.1)
LYEAR,LMONTH,LDAY LSTAT,LHOUR,LUNITS, LEVEL	Upper-air data: year, month, day, station identifier, observation time, units, upper-air data.	(3I2,A4,1X,I4, 1X,A3,50(I5))

```
NSTA:          4
LEVELS:       20
NSTRHR:        0
NENDHR:       23
TOIF:       12.0
NCELL:        14
CELLZB:        0.    25.    50.   100.   150.   200.   250.   300.   400.   500.
             700.   900.  1100.  1300.  1500.
KYEAR:        84
KMONTH:        6
KDAY:          3
IOPT:          2
7221    940.2 3464.1    44.0
7222    478.5 3637.8   140.0
7231    840.2 3760.3   246.0
7232    538.6 4009.3   180.0
84 6 37221  700 MET   44  129  303  610  935 1226 1517 1524 1836 2142 2436 2748 3171 3653 4264 4882 5850   -1   -1   -1
84 6 37221  700 DEG  220  245  305  320  370  325  320  320  330  350 · 10   35  115  210  210  220  295   -1   -1   -1
84 6 37221  700 MPS   30   50  110  110   90   70   60   60   50   50   50 · 40   20   30   30   20   40   -1   -1   -1
84 6 37221 1900 MET  118  280  317  621  914 1223 1541 1837 2142 2435 2747 3176 3661 4272 4891 5789 5850   -1   -1   -1
84 6 37221 1900 DEG  265  260  275  275  270  275  290  300  280  280  290  260  245  255  235  230  225   -1   -1   -1
84 6 37221 1900 MPS   30   30   50   50   60   50   30   30   30   30   30   20   20   30   50   60   70   -1   -1   -1
84 6 47221  700 MET   44  129  305  615  914 1222 1520 1826 2120 2423 2724 3150 3645 4241 4544 4857 5174 5840   -1   -1
84 6 47221  700 DEG    0  255  295  315  330  290  240  220  190  165  160  185  210  210  215  230  250  275   -1   -1
84 6 47221  700 MPS    0   30   70   60   40   20   30   50   50   60   70   80   80   90  100   80   70   60   -1   -1
84 6 37222  700 MET  140  155  321  618  913 1216 1550 1833 2136 2438 2748 3175 3656 4303 4595 4895 5794 5840   -1   -1
84 6 37222  700 DEG   40   35  320  320  315  300  305  320  255  220  200  200  200  190  190  195  230  230   -1   -1
84 6 37222  700 MPS   20   20   70   70   60   50   30   10   20   50   90  100   90   70   70   60   60   60   -1   -1
84 6 37222 1900 MET  383  612  912 1219 1543 1837 2140 2443 2744 3172 3665 4273 4880 5850   -1   -1   -1   -1   -1   -1
84 6 37222 1900 DEG  230  245  255  240  240  240  230  220  215  205  215  270  280  300   -1   -1   -1   -1   -1   -1
84 6 37222 1900 MPS   30   20   20   10   30   40   50   60   50   40   50   80   60   50   -1   -1   -1   -1   -1   -1
84 6 47222  700 MET  376  621  917 1222 1534 1826 2140 2443 2744 3159 3728 4019 4305 4889 5186 5794 5840   -1   -1   -1
84 6 47222  700 DEG  200  220  230  235  230  225  215  200  195  190  195  195  205  230  245  230  230   -1   -1   -1
84 6 47222  700 MPS   30   30   20   20   30   60   80   70   70   80   60   60   70   80   80   60   60   -1   -1   -1
84 6 37231  700 MET  246  307  614  913 1221 1524 1531 1839 2135 2440 2742 3172 3667 4264 4883 5789 5850   -1   -1   -1
84 6 37231  700 DEG  290  290  315  340  320  290  290  300  285  265  255  250  255  255  295  305  295   -1   -1   -1
84 6 37231  700 MPS [illegible]   50  110   60   30   60   60   60   40   50   70   80  110  110   70   80   90   -1   -1   -1
84 6 37231 1900 MET [illegible]  328  624  917 1217 1525 1843 2139 2443 2745 3162 3681 4267 4873 5183 5840   -1   -1   -1   -1
84 6 37231 1900 DEG  275  270  270  270  270  275  285  290  285  285  285  275  270  255  275  265   -1   -1   -1   -1
84 6 37231 1900 MPS   40   40   70   70   60   60   70   90  100  110  100   70   80  110   60   70   -1   -1   -1   -1
84 6 47231  700 MET  246  307  616  915 1222 1528 1854 2149 2441 2742 3051 3156 3673 4269 4888 5184 5820   -1   -1   -1
84 6 47231  700 DEG  300  320   30   70  100  230  265  270  255  225  220  220  230  240  250  260  255   -1   -1   -1
84 6 47231  700 MPS   20   20   30   20   20   10   40   50   40   50   70   80  110  120   90   90   90   -1   -1   -1
84 6 37232  700 MET [illegible]  610  914 1219 1533 1829 2134 2438 2743 3155 3658 3962 4267 4572 4877 5486 5820   -1   -1   -1
84 6 37232  700 DEG  190  315  315  310  285  275  285  270  260  260  250  245  255  265  260  250  255   -1   -1   -1
84 6 37232  700 MPS   20  100   90   80   50   60   90   90   90  100  100  110  110  100  110  120  110   -1   -1   -1
84 6 37232 1900 MET  427  610  914 1219 1533 1829 2134 2438 2743 3154 3658 4267 4572 4877 5486 5830   -1   -1   -1   -1
84 6 37232 1900 DEG  310  315  305  285  265  255  260  265  265  270  270  260  255  265  280  275   -1   -1   -1   -1
84 6 37232 1900 MPS   30   40   30   30   40   50   50   60   70   70  100  110  110  110  110  110   -1   -1   -1   -1
84 6 47232  700 MET  421  610  914 1219 1528 1829 2134 2438 2743 3142 3658 4267 4877 5810   -1   -1   -1   -1   -1   -1
84 6 47232  700 DEG   40  155  225  245  240  225  240  255  245  235  220  225  245  255   -1   -1   -1   -1   -1   -1
84 6 47232  700 MPS   10   30   20   30   40   30   20   40   60   60   70   90  110  130   -1   -1   -1   -1   -1   -1
```

EXHIBIT 3-3. Sample input file for the upper-air data preprocessor (PREUPR).

TABLE 3-4. File structure for PREUPR.

Logical Unit	File Contents	Format
5	Upper-air data	ASCII
6	Printed output file	ASCII
7	Preprocessed upper-air data	ASCII

The processed hourly upper-air data are output to a file that is read incrementally by the wind model. The site identifiers and locations of the upper-air stations are also transferred in this manner to the model. A sample output is given in Exhibit 3-4.

```
WIND STATION X & Y  7221    940.2  3464.1
WIND STATION X & Y  7222    478.5  3637.8
WIND STATION X & Y  7231    840.2  3760.3
WIND STATION X & Y  7232    538.6  4009.3
UPPER WIND 0 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 0 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 0 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 0 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 0 LAST
UPPER WIND 1 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 1 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 1 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 1 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 1 LAST
UPPER WIND 2 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 2 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 2 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 2 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 2 LAST
UPPER WIND 3 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 3 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 3 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 3 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 3 LAST
UPPER WIND 4 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 4 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 4 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 4 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 4 LAST
UPPER WIND 5 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 5 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 5 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7  2.1  5.5 -2.4
UPPER WIND 5 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5  3.2  5.0 -1.2
```

EXHIBIT 3-4. Output from PREUPR used as the upper-air data input file for the Diagnostic Wind Model.

```
UPPER WIND 5 LAST
UPPER WIND 6 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 6 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 6 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 6 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 6 LAST
UPPER WIND 7 7221   1.0  2.3  2.3  3.1  2.2  4.2  2.1  5.6  0.2  6.8 -2.2  8.1 -4.7  8.9 -6.4  8.4 -6.9  7.8 -7.6  6.9 -8.3
6.1 -7.3  5.1 -6.5  4.0 -5.7  3.9 -4.9
UPPER WIND 7 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.5 -5.4  4.4 -4.9
4.3 -4.1  4.3 -2.9  3.6 -2.2  2.5 -1.7
UPPER WIND 7 7231   1.0  3.3 -0.8  4.0 -1.3  4.8 -2.0  5.3 -3.0  5.8 -4.0  6.3 -5.0  6.8 -5.9  7.6 -7.4  6.2 -7.2  3.3 -6.1
2.0 -4.2  2.2 -2.3  4.7 -2.1  5.5 -2.4
UPPER WIND 7 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.3  2.0  1.9 -0.1  4.4 -3.5  7.0 -7.0  6.7 -6.7
6.3 -6.1  6.2 -5.3  5.5 -3.2  5.0 -1.2
UPPER WIND 7 LAST
UPPER WIND 8 7221   1.0  2.3  2.3  3.1  2.2  4.1  2.0  5.3  0.2  6.5 -2.0  7.7 -4.2  8.6 -5.9  8.1 -6.4  7.6 -7.0  6.8 -7.6
6.1 -6.7  5.2 -5.9  4.1 -5.2  3.9 -4.5
UPPER WIND 8 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.3 -4.8  4.3 -4.8  4.3 -4.8  4.3 -4.8  4.2 -4.4
4.0 -3.7  4.0 -2.7  3.5 -2.0  2.5 -1.5
UPPER WIND 8 7231   1.0  3.4 -0.7  4.0 -1.1  4.8 -1.8  5.3 -2.7  5.8 -3.6  6.3 -4.5  6.8 -5.4  7.5 -6.8  6.3 -6.6  3.6 -5.6
2.4 -3.8  2.5 -2.1  4.8 -2.0  5.5 -2.3
UPPER WIND 8 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.5  1.6  1.9 -0.2  4.2 -3.4  6.7 -6.7  6.3 -6.3
6.0 -5.7  5.9 -4.9  5.3 -2.9  4.9 -1.0
UPPER WIND 8 LAST
UPPER WIND 9 7221   1.0  2.3  2.3  3.1  2.2  4.0  1.8  5.1  0.2  6.2 -1.8  7.3 -3.8  8.3 -5.4  7.9 -5.9  7.3 -6.4  6.6 -7.0
6.1 -6.1  5.2 -5.4  4.1 -4.8  3.8 -4.2
UPPER WIND 9 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  4.1 -4.1  4.1 -4.2  4.1 -4.2  4.1 -4.3  4.0 -4.0
3.8 -3.3  3.8 -2.4  3.3 -1.7  2.5 -1.2
UPPER WIND 9 7231   1.0  3.4 -0.6  4.0 -1.0  4.7 -1.7  5.2 -2.5  5.7 -3.3  6.2 -4.1  6.7 -4.9  7.5 -6.2  6.3 -6.0  3.9 -5.1
2.8 -3.5  2.9 -1.9  4.9 -1.8  5.6 -2.2
UPPER WIND 9 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.7  1.3  1.9 -0.4  4.1 -3.3  6.3 -6.3  6.0 -5.9
5.7 -5.3  5.6 -4.6  5.1 -2.7  4.9 -0.9
UPPER WIND 9 LAST
UPPER WIND10 7221   1.0  2.3  2.3  3.1  2.2  3.9  1.7  4.9  0.2  5.9 -1.6  6.8 -3.4  7.9 -4.9  7.6 -5.3  7.1 -5.8  6.5 -6.3
6.0 -5.5  5.2 -4.9  4.2 -4.4  3.8 -3.9
UPPER WIND10 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  3.9 -3.5  3.9 -3.6  3.9 -3.7  3.8 -3.8  3.8 -3.5
3.6 -2.9  3.5 -2.1  3.1 -1.4  2.5 -0.9
UPPER WIND10 7231   1.0  3.5 -0.6  4.0 -0.9  4.6 -1.5  5.1 -2.2  5.6 -3.0  6.1 -3.7  6.6 -4.5  7.4 -5.6  6.4 -5.4  4.3 -4.6
3.1 -3.1  3.2 -1.7  5.0 -1.7  5.7 -2.1
UPPER WIND10 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  0.8  1.0  2.0 -0.6  3.9 -3.2  6.0 -6.0  5.7 -5.6
5.4 -5.0  5.3 -4.2  5.0 -2.4  4.8 -0.8
UPPER WIND10 LAST
UPPER WIND11 7221   1.0  2.3  2.3  3.1  2.2  3.8  1.5  4.7  0.2  5.6 -1.4  6.4 -2.9  7.6 -4.4  7.3 -4.8  6.9 -5.2  6.3 -5.6
6.0 -4.9  5.3 -4.4  4.3 -3.9  3.8 -3.5
UPPER WIND11 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  3.8 -2.9  3.7 -3.0  3.7 -3.1  3.6 -3.3  3.6 -3.0
3.4 -2.6  3.3 -1.8  2.9 -1.2  2.5 -0.7
UPPER WIND11 7231   1.0  3.5 -0.5  4.0 -0.8  4.6 -1.3  5.0 -2.0  5.5 -2.6  6.0 -3.3  6.5 -4.0  7.3 -4.9  6.5 -4.8  4.6 -4.1
3.5 -2.8  3.5 -1.5  5.1 -1.5  5.7 -1.9
UPPER WIND11 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.0  0.7  2.0 -0.7  3.8 -3.1  5.6 -5.6  5.3 -5.2
5.1 -4.6  5.1 -3.8  4.8 -2.2  4.7 -0.6
UPPER WIND11 LAST
UPPER WIND12 7221   1.0  2.3  2.3  3.1  2.2  3.7  1.4  4.5  0.2  5.2 -1.1  6.0 -2.5  7.3 -3.9  7.0 -4.2  6.6 -4.6  6.2 -5.0
6.0 -4.3  5.3 -3.8  4.4 -3.5  3.7 -3.2
```

EXHIBIT 3-4. Continued.

```
UPPER WIND12 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  3.6 -2.3  3.6 -2.4  3.5 -2.5  3.4 -2.7  3.3 -2.6
3.2 -2.2  3.0 -1.5  2.8 -0.9  2.5 -0.4
UPPER WIND12 7231   1.0  3.6 -0.4  4.0 -0.7  4.5 -1.2  5.0 -1.7  5.5 -2.3  6.0 -2.9  6.5 -3.5  7.2 -4.3  6.5 -4.2  4.9 -3.6
3.9 -2.4  3.8 -1.3  5.2 -1.4  5.8 -1.8
UPPER WIND12 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.2  0.3  2.1 -0.9  3.6 -3.0  5.3 -5.2  5.0 -4.8
4.7 -4.2  4.8 -3.5  4.6 -1.9  4.6 -0.5
UPPER WIND12 LAST
UPPER WIND13 7221   1.0  2.3  2.3  3.1  2.2  3.6  1.2  4.3  0.3  4.9 -0.9  5.5 -2.1  6.9 -3.4  6.7 -3.7  6.4 -4.0  6.0 -4.3
6.0 -3.7  5.3 -3.3  4.4 -3.1  3.7 -2.9
UPPER WIND13 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  3.4 -1.7  3.4 -1.8  3.3 -2.0  3.2 -2.2  3.1 -2.1
3.0 -1.8  2.7 -1.2  2.6 -0.7  2.5 -0.1
UPPER WIND13 7231   1.0  3.7 -0.4  4.0 -0.6  4.4 -1.0  4.9 -1.5  5.4 -2.0  5.9 -2.5  6.4 -3.0  7.2 -3.7  6.6 -3.6  5.2 -3.1
4.3 -2.1  4.1 -1.2  5.3 -1.3  5.9 -1.7
UPPER WIND13 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.3  0.0  2.1 -1.1  3.5 -2.9  4.9 -4.9  4.6 -4.4
4.4 -3.8  4.5 -3.1  4.5 -1.7  4.6 -0.3
UPPER WIND13 LAST
UPPER WIND14 7221   1.0  2.3  2.3  3.1  2.2  3.5  1.0  4.1  0.3  4.6 -0.7  5.1 -1.6  6.6 -2.9  6.4 -3.1  6.2 -3.4  5.8 -3.7
5.9 -3.1  5.4 -2.8  4.5 -2.6  3.7 -2.5
UPPER WIND14 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  3.2 -1.1  3.2 -1.2  3.1 -1.4  3.0 -1.7  2.9 -1.6
2.8 -1.4  2.5 -0.9  2.4 -0.4  2.6  0.1
UPPER WIND14 7231   1.0  3.7 -0.3  4.0 -0.5  4.3 -0.8  4.8 -1.2  5.3 -1.7  5.8 -2.1  6.3 -2.5  7.1 -3.1  6.7 -3.0  5.5 -2.5
4.7 -1.7  4.4 -1.0  5.4 -1.1  5.9 -1.6
UPPER WIND14 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.5 -0.3  2.2 -1.2  3.3 -2.9  4.6 -4.5  4.3 -4.1
4.1 -3.4  4.2 -2.7  4.3 -1.4  4.5 -0.2
UPPER WIND14 LAST
UPPER WIND15 7221   1.0  2.3  2.3  3.1  2.2  3.4  0.9  3.8  0.3  4.3 -0.5  4.7 -1.2  6.3 -2.4  6.1 -2.6  5.9 -2.8  5.7 -3.0
5.9 -2.5  5.4 -2.3  4.6 -2.2  3.6 -2.2
UPPER WIND15 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  3.0 -0.5  3.0 -0.6  2.9 -0.8  2.7 -1.2  2.7 -1.2
2.6 -1.0  2.2 -0.6  2.2 -0.2  2.6  0.4
UPPER WIND15 7231   1.0  3.8 -0.3  4.0 -0.4  4.3 -0.7  4.7 -1.0  5.2 -1.3  5.7 -1.7  6.3 -2.0  7.0 -2.5  6.7 -2.4  5.8 -2.0
5.0 -1.4  4.7 -0.8  5.5 -1.0  6.0 -1.5
UPPER WIND15 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.6 -0.6  2.2 -1.4  3.2 -2.8  4.2 -4.2  4.0 -3.7
3.8 -3.0  3.9 -2.4  4.1 -1.2  4.4 -0.1
UPPER WIND15 LAST
UPPER WIND16 7221   1.0  2.3  2.3  3.1  2.2  3.3  0.7  3.6  0.3  3.9 -0.2  4.3 -0.8  6.0 -1.9  5.8 -2.1  5.7 -2.2  5.5 -2.4
5.9 -1.9  5.5 -1.8  4.6 -1.8  3.6 -1.9
UPPER WIND16 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  2.8  0.1  2.8  0.0  2.7 -0.3  2.5 -0.6  2.5 -0.7
2.4 -0.6  1.9 -0.4  2.0  0.1  2.6  0.7
UPPER WIND16 7231   1.0  3.8 -0.2  4.0 -0.3  4.2 -0.5  4.7 -0.7  5.2 -1.0  5.7 -1.2  6.2 -1.5  6.9 -1.9  6.8 -1.8  6.1 -1.5
5.4 -1.0  5.1 -0.6  5.7 -0.8  6.1 -1.4
UPPER WIND16 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.8 -1.0  2.2 -1.6  3.0 -2.7  3.9 -3.8  3.6 -3.3
3.5 -2.7  3.7 -2.0  4.0 -0.9  4.3  0.1
UPPER WIND16 LAST
UPPER WIND17 7221   1.0  2.3  2.3  3.1  2.2  3.2  0.6  3.4  0.3  3.6  0.0  3.8 -0.4  5.6 -1.4  5.6 -1.5  5.5 -1.6  5.4 -1.7
5.8 -1.3  5.5 -1.2  4.7 -1.3  3.5 -1.5
UPPER WIND17 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  2.7  0.7  2.6  0.6  2.5  0.3  2.3 -0.1  2.3 -0.2
2.2 -0.3  1.7 -0.1  1.9  0.4  2.6  1.0
UPPER WIND17 7231   1.0  3.9 -0.1  4.0 -0.2  4.1 -0.3  4.6 -0.5  5.1 -0.7  5.6 -0.8  6.1 -1.0  6.9 -1.2  6.9 -1.2  6.4 -1.0
5.8 -0.7  5.4 -0.4  5.8 -0.7  6.1 -1.2
UPPER WIND17 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.0 -1.3  2.3 -1.7  2.9 -2.6  3.5 -3.5  3.3 -3.0
3.2 -2.3  3.4 -1.6  3.8 -0.7  4.3  0.2
UPPER WIND17 LAST
UPPER WIND18 7221   1.0  2.3  2.3  3.1  2.2  3.1  0.4  3.2  0.3  3.3  0.2  3.4  0.1  5.3 -0.9  5.3 -1.0  5.2 -1.0  5.2 -1.1
5.8 -0.7  5.5 -0.7  4.8 -0.9  3.5 -1.2
UPPER WIND18 7222   1.0 -1.2 -1.6 -0.4 -2.1  0.9 -3.0  2.6 -4.1  4.3 -5.2  2.5  1.3  2.4  1.2  2.3  0.9  2.1  0.4  2.1  0.2
2.0  0.1  1.4  0.2  1.7  0.6  2.6  1.2
UPPER WIND18 7231   1.0  3.9 -0.1  4.0 -0.1  4.1 -0.2  4.5 -0.2  5.0 -0.3  5.5 -0.4  6.0 -0.5  6.8 -0.6  6.9 -0.6  6.7 -0.5
```

EXHIBIT 3-4. Continued.

```
6.2 -0.3  5.7 -0.2  5.9 -0.5  6.2 -1.1
UPPER WIND18 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.1 -1.6  2.3 -1.9  2.7 -2.5  3.2 -3.1  3.0 -2.6
2.9 -1.9  3.1 -1.3  3.6 -0.4  4.2  0.4
UPPER WIND18 LAST
UPPER WIND19 7221   1.0  0.4  0.1  1.3  0.3  3.0  0.3  3.0  0.3  3.0  0.4  3.0  0.5  5.0 -0.4  5.0 -0.4  5.0 -0.4  5.1 -0.4
5.8 -0.1  5.6 -0.2  4.8 -0.5  3.5 -0.8
UPPER WIND19 7222   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.3  1.9  2.2  1.8  2.1  1.4  1.9  0.9  1.9  0.7
1.8  0.5  1.1  0.5  1.5  0.9  2.6  1.5
UPPER WIND19 7231   1.0  4.0  0.0  4.0  0.0  4.0  0.0  4.4  0.0  4.9  0.0  5.4  0.0  6.0  0.0  6.7  0.0  7.0  0.0  7.0  0.0
6.6  0.0  6.0  0.0  6.0 -0.4  6.3 -1.0
UPPER WIND19 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.3 -1.9  2.4 -2.1  2.6 -2.4  2.8 -2.8  2.6 -2.2
2.6 -1.5  2.8 -0.9  3.5 -0.2  4.1  0.5
UPPER WIND19 LAST
UPPER WIND20 7221   1.0  0.4  0.1  1.3  0.3  3.0  0.3  3.0  0.3  3.1  0.3  3.2  0.3  5.1 -0.7  5.0 -0.7  5.0 -0.7  5.0 -0.7
5.5 -0.4  5.3 -0.4  4.6 -0.5  3.4 -0.7
UPPER WIND20 7222   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.2  2.0  2.1  1.9  2.0  1.5  1.9  1.1  1.9  0.8
1.8  0.6  1.2  0.6  1.5  0.9  2.6  1.5
UPPER WIND20 7231   1.0  3.8 -0.1  3.8 -0.1  3.8 -0.1  4.1 -0.1  4.6 -0.2  5.0 -0.2  5.4 -0.2  6.0 -0.2  6.3 -0.2  6.3 -0.1
5.9  0.0  5.4  0.0  5.5 -0.3  5.9 -0.9
UPPER WIND20 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.1 -1.8  2.1 -1.9  2.3 -2.1  2.5 -2.3  2.4 -1.9
2.5 -1.3  2.8 -0.7  3.4  0.0  4.0  0.6
UPPER WIND20 LAST
UPPER WIND21 7221   1.0  0.4  0.1  1.3  0.3  2.9  0.3  3.1  0.3  3.2  0.2  3.4  0.1  5.2 -0.9  5.1 -0.9  5.0 -1.0  4.9 -1.0
5.2 -0.7  5.0 -0.5  4.4 -0.5  3.3 -0.5
UPPER WIND21 7222   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.1  2.1  2.1  1.9  2.0  1.6  1.9  1.2  1.8  0.9
1.8  0.6  1.2  0.6  1.6  1.0  2.5  1.6
UPPER WIND21 7231   1.0  3.6 -0.2  3.6 -0.2  3.5 -0.3  3.8 -0.3  4.2 -0.3  4.5 -0.3  4.9 -0.4  5.4 -0.4  5.6 -0.3  5.5 -0.2
5.2  0.0  4.7  0.0  5.0 -0.2  5.6 -0.8
UPPER WIND21 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.8 -1.7  1.9 -1.7  2.0 -1.8  2.2 -1.9  2.2 -1.5
2.4 -1.0  2.8 -0.5  3.4  0.1  4.0  0.8
UPPER WIND21 LAST
UPPER WIND22 7221   1.0  0.4  0.1  1.3  0.3  2.9  0.4  3.2  0.2  3.4  0.0  3.6 -0.2  5.3 -1.1  5.2 -1.2  5.0 -1.3  4.8 -1.3
4.9 -1.0  4.7 -0.7  4.1 -0.5  3.2 -0.4
UPPER WIND22 7222   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  2.0  2.2  2.0  2.0  1.9  1.7  1.8  1.3  1.8  1.0
1.8  0.7  1.3  0.7  1.6  1.0  2.5  1.6
UPPER WIND22 7231   1.0  3.4 -0.3  3.4 -0.3  3.3 -0.4  3.5 -0.4  3.8 -0.5  4.0 -0.5  4.3 -0.6  4.7 -0.6  4.8 -0.5  4.8 -0.3
4.4 -0.1  4.1  0.1  4.5 -0.2  5.2 -0.6
UPPER WIND22 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.6 -1.6  1.6 -1.6  1.7 -1.5  1.8 -1.4  2.0 -1.2
2.3 -0.8  2.8 -0.4  3.4  0.3  3.9  0.9
UPPER WIND22 LAST
UPPER WIND23 7221   1.0  0.4  0.1  1.3  0.3  2.8  0.4  3.2  0.2  3.5 -0.1  3.9 -0.4  5.4 -1.3  5.2 -1.4  5.0 -1.5  4.7 -1.7
4.7 -1.3  4.4 -0.9  3.9 -0.5  3.1 -0.2
UPPER WIND23 7222   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.9  2.2  1.9  2.1  1.9  1.8  1.8  1.4  1.8  1.1
1.7  0.8  1.3  0.7  1.6  1.1  2.5  1.7
UPPER WIND23 7231   1.0  3.2 -0.4  3.2 -0.4  3.1 -0.5  3.2 -0.6  3.4 -0.6  3.6 -0.7  3.8 -0.8  4.0 -0.8  4.1 -0.7  4.1 -0.4
3.7 -0.1  3.4  0.1  4.0 -0.1  4.8 -0.5
UPPER WIND23 7232   1.0999.0999.0999.0999.0999.0999.0999.0999.0999.0999.0  1.3 -1.5  1.3 -1.4  1.4 -1.2  1.5 -1.0  1.8 -0.8
2.3 -0.6  2.7 -0.2  3.3  0.4  3.8  1.0
UPPER WIND23 LAST
```

EXHIBIT 3-4. Concluded.

4 GENERATING WIND FIELDS WITH THE WIND MODEL

4.1 UNITS, COORDINATES AND TIME CONVENTIONS

All calculations are performed in the SI units given in Table 4-1. Terrain heights, which are initially specified in non-SI units, are converted to meters. The Universal Transverse Mercator (UTM) coordinate system is used to define the horizontal grid. The vertical coordinate is terrain following. Time is specified according to the 0 - 2400 hour clock.

4.2 INPUTS

Five files supply the following inputs for the Diagnostic Wind Model: (1) parameters that govern the simulation, (2) gridded terrain heights, (3) gridded surface-type indicators, (4) hourly surface data, including station identifiers and locations from the surface data preprocessor, PRESFC, and (5) hourly upper-air data, including station identifiers and locations, from the upper-air data preprocessor, PREUPR. The flow of information for executing the DWM is illustrated in Figure 4-1.

4.2.1 Simulation-Specific Data

The controlling parameters for the Diagnostic Wind Model are specified in the primary input file. These parameters are listed and described in Table 4-2 and an example parameter input file is presented in Exhibit 4-1. Some guidelines for the specification of the parameters are given here.

In the first record a descriptive identifier for the simulation (TITLE) is provided. The next eight records supply information about the grid, including the grid dimensions (NX, NY, NZ), the grid-cell size in km (DXK, DYK), the vertical-layer interface heights in meters (CELLZB), and the grid origin in UTM coordinates (UTMXOR, UTMYOR). The vertical-layer interface heights are given in terrain-following coordinates beginning with 0 for the surface. Next the initial time (TSTART), the final time (TEND), and the time increment (TINC) for the simulation are specified. The next two records contain the total number of surface and upper-air stations (NWIND) and the number of upper-air stations (NUPPER). ZSWIND is the estimated height of the surface wind measurements.

TABLE 4-1. Diagnostic Wind Model internal units.

Parameter	Units
Height (vertical)	Meters
Distance (horizontal)	Kilometers
Time	Hours, minutes, seconds
Temperature	Degrees Kelvin

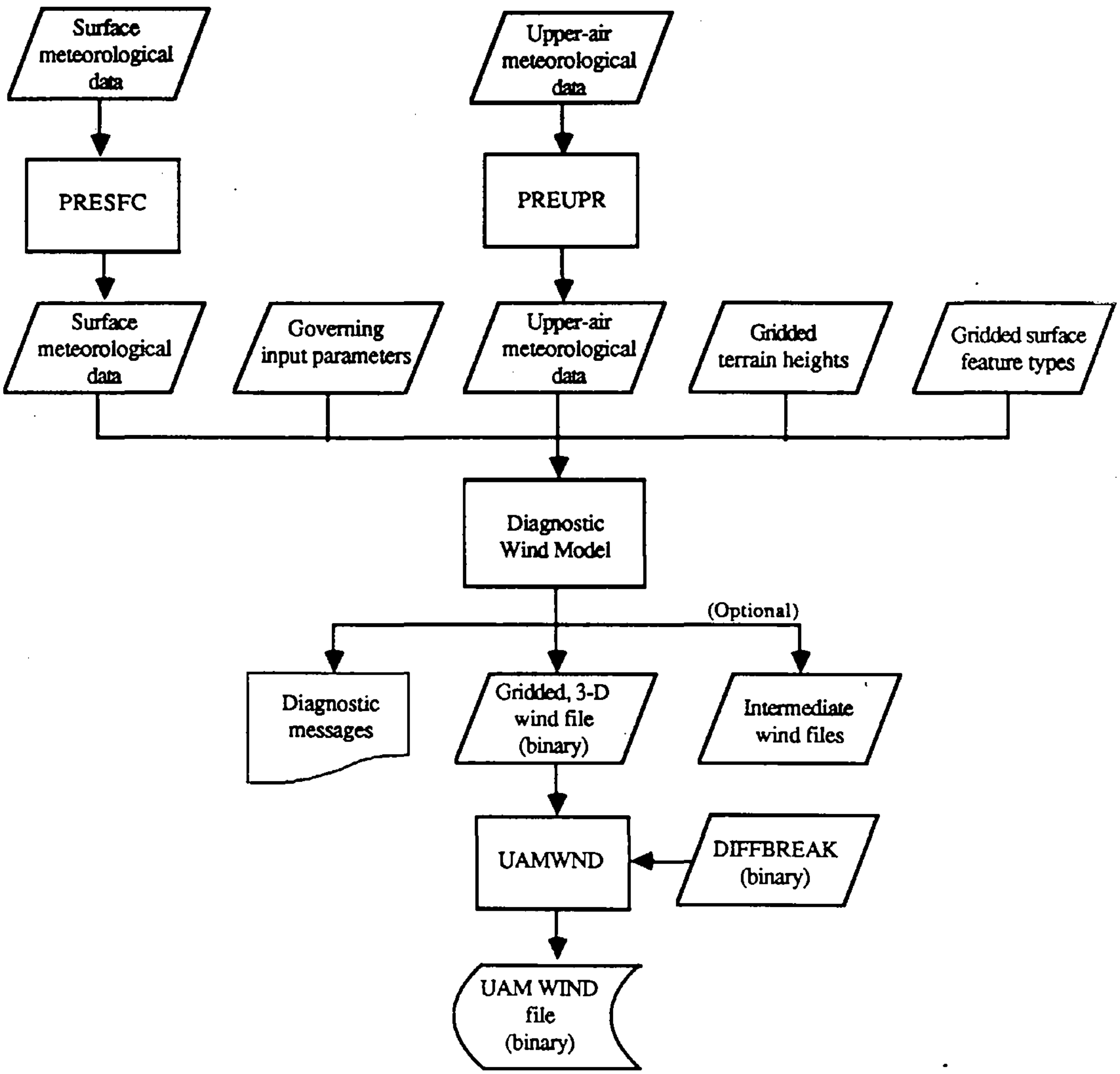

FIGURE 4-1. Flow diagram for using the Diagnostic Wind Model.

TABLE 4-2. Diagnostic Wind Model input parameter control file.

Parameter	Description	Fortran Format
TITLE	Descriptive identifier	(A20)
NX	Number of grid points in the x-direction	(10X,I5)
NY	Number of grid points in the y-direction	(10X,I5)
NZ	Number of vertical layers	(10X,I5)
DXK	Grid cell size in the x-direction (km)	(10X,F6.0)
DYK	Grid cell size in the y-direction (km)	(10X,F6.0)
CELLZB	Heights of vertical layer interfaces in terrain-following coordinates beginning with 0 for the surface (m)	(10X,10F6.0)
UTMXOR	Easting UTM coordinate of origin (southwest corner) of grid (km)	(10X,F6.0)
UTMYOR	Northing UTM coordinate of origin of grid (km)	(10X,F6.0)
TSTART	Initial time (Specified as hour on the 2400-hour clock)	(10X,F6.0)
TEND	Final time	(10X,F6.0)
TINC	Time increment	(10X,F6.0)
NWIND	Total number of wind stations	(10X,I5).
NUPPER	Number of upper-air wind stations	(10X,I5)
ZSWIND	Height of surface wind measurements (m)	(10X,F6.0)

continued

TABLE 4-2. continued

Parameter	Description	Fortran Format
RMIN	Minimum radius of influence used in the interpolation (km)	(10X,F6.0)
RMAX1	Maximum radius of influence over land in the surface layer (km)	(10X,F6.0)
RMAX2	Maximum radius of influence over land aloft (km)	(10X,F6.0)
RMAX3	Maximum radius of influence over water (km)	(10X,F6.0)
R1	Weighting parameter for the diagnostic wind field at the surface (km)	(10X,F6.0)
R2	Weighting parameter for the diagnostic wind field aloft (km)	(10X,F6.0)
NINTRP	Maximum number of stations used in the interpolation of data to a grid point	(10X,10I5)
NZPRNT	Number of levels, starting at the surface, used for printing	(10X,I5)
IPRO	Flag for printing the interpolated wind component fields (set >0)	(10X,I5)
IPR1	Flag for printing the terrain-adjusted surface-wind component fields (used only with objective analysis) (set >0)	(10X,I5)
IPR2	Flag for printing the smoothed wind component and initial divergence fields (set >0)	(10X,I5)

continued

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TABLE 4-2. continued

Parameter	Description	Fortran Format
IPR3	Flag for printing the final wind speed and direction fields (set >0)	(10X,I5)
IPR4	Flag for printing the final divergence field (set >0)	(10X,I5)
IPR5	Flag for printing the wind fields after the kinematic effects are calculated (set >0)	(10X,I5)
IPR6	Flag for printing the wind fields after the slope flows are added (set >0)	(10X,I5)
IPR7	Flag for printing the wind fields after the Froude number adjustment is complete (set >0)	(10X,I5)
ICALC	Flag for calculating the wind fields. It can be turned off (set ≤0) in a preliminary run to ensure that the data are being read correctly, then turned on (set >0) in a subsequent run to perform the calculations	(10X,I5)
IOUTD	Flag for writing the computed wind fields to disk	(10X,I5)
HTFAC	Multiplicative factor used to convert terrain heights to meters	(10X,F10.4)
NITER	Maximum number of iterations for the divergence minimization procedure	(10X,I5)
DIVLIM	The convergence criteria for the divergence minimization procedure (typical values are 1.E-7 to 1.E-5)	(10X,E10.1)

continued

TABLE 4-2. continued

Parameter	Description	Fortran Format
IOBR	Flag for using the O'Brien vertical-velocity adjustment procedure (set >0)	(10X,I5)
NUMBAR	Number of barriers to interpolation	(10X,I5)
I3DCTW	1 = run the diagnostic wind model 0 = run the objective analysis	(10X,I5)
NSMTH	Number of smoothing passes	(10X,I5)
IEXTRP	Vertical extrapolation control variable. When ABS(IEXTRP) = 1, there is no extrapolation from the surface wind data; when ABS(IEXTRP) = 2, extrapolation is done using a power law profile; when ABS(IEXTRP) ≥3, the extrapolation is done using the values provided for FEXTRP. When IEXTRP <0, the layer 1 data at the upper-air stations is ignored	(10X,I5)
FEXTRP	Extrapolation values for layers 2 through NZ	(10X,10F6.0)

The following nine parameters are necessary if only step 1 of the Diagnostic Wind Model is being run (i.e., no observational data are included). For an objective analysis (step 2), do not include these inputs.

Parameter	Description	Fortran Format
GAMMA	Domain-averaged temperature lapse-rate for each hour of the simulation day, beginning at 0 and ending at 2300 (K/km)	(10X,8F5.1)
CRITFN	Critical Froude number (recommended value: 1.0)	(10X,F5.1)
TERRAD	Radius of influence of terrain features (km)	(10X,F5.1)

continued

TABLE 4-2. concluded

Parameter	Description	Fortran Format
TINF	Estimated surface temperature	(10X,F5.1)
IFRADJ	Flag for calculating Froude number adjustment effects (set at 1)	(10X,I3)
IKINE	Flag for calculating kinematic effects (set at 1)	(10X,I3)
ALPHA	Empirical parameter that controls the influence of the kinematic effects (recommended values 0.1 - 0.3)	(10X,F5.1)
UM	U-component of the domain-mean wind for each hour of the simulation day, beginning at 0 and ending at 2300 (m/s)	(10X,8F5.1)
VM	V-component of the domain-mean wind for each hour of the simulation day, beginning at 0 and ending at 2300 (m/s)	(10X,8F5.1)

The following barrier endpoints need only be specified if NUMBAR > 0.

BARXY	UTM coordinates of the barrier segment endpoints. Specify east and north coordinates of the first end point followed by the east and north coordinates of the second end point.	(30X,4F10.0)

Terrain heights are contained in a separate file.

HTOPO	Gridded terrain heights	(10F6.0)

Surface type is contained in a separate file.

LNDWTR	Gridded surface type; 0 = water, 1 = land.	(30I2)

```
                                                                        Page    1

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NX:            40
NY:            40
NZ:            14
DXK:            4.
DYK:            4.
CELLZB:         0.    25.    50.   100.   150.   200.   250.   300.   400.   500.
              700.   900.  1100.  1300.  1500.
UTMXOR:       660.
UTMYOR:      3665.
TSTART:         0.
TEND:           0.
TINC:           1.
NWIND:          8
NUPPER:         4
ZSWIND:        10.
RMIN:           1.
RMAX1:         40.
RMAX2:        200.
RMAX3:        200.
R1:            20.
R2:           160.
NINTRP:         4     2     2     2     2     2     2     2     2     2
                2     2     2     2
NZPRNT:         1
IPRO:          -1
IPR1:          -1
IPR2:          -1
IPR3:          -1
IPR4:          -1
IPR5:          -1
IPR6:          -1
IPR7:          -1
ICALC:          1
IOUTD:          1
HTFAC:          1.
NITER:         50
DIVLIM:         1.0E-06
IOBR:           0
NUMBAR:         0
I3DCTW:         1
NSMTH:          4
IEXTRP:         1
FEXTRP:         0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
                0.     0.     0.
GAMMA:        2.5   3.5   4.0   5.0   6.0   5.0   4.0   3.7
              3.2   1.0  -3.2  -6.0  -7.6  -9.0  -9.5  -9.8
            -10.0  -9.8  -9.6  -9.3  -8.6  -7.3  -5.0  -0.5
CRITFN:       1.0
TERRAD:      50.0
TINF:       300.0
IFRADJ:       1
IKINE:        1
ALPHA:        0.1
UM:           2.6   2.6   2.6   2.6   2.6   2.6   2.6   2.6
              2.6   2.7   2.7   2.7   2.8   2.8   2.8   2.9
              2.9   2.9   3.0   3.0   2.9   2.8   2.6   2.5
VM:          -1.5  -1.5  -1.5  -1.5  -1.5  -1.5  -1.5  -1.5
             -1.4  -1.3  -1.1  -1.0  -0.9  -0.8  -0.6  -0.5
             -0.4  -0.3  -0.1   0.0   0.1   0.2   0.3   0.4
```

EXHIBIT 4-1. Parameter input file for the Diagnostic Wind Model.

The minimum radius of influence (RMIN) and maximum radii (RMAX) for the interpolation are specified next. The minimum is assigned some small value (e.g. 1 km) to ensure that there is no attempt to divide by zero in the inverse-distance-squared weighting scheme. The maxima vary with height and with type of surface (land or water). RMAX1 is the maximum radius of influence over land areas in the domain at the surface. This value should reflect the limiting influence of terrain features on the interpolation at this level. RMAX2 is the maximum over land and aloft; this value is generally larger than RMAX1 because the terrain effects decrease with height. RMAX3 is the maximum over water at all levels; it must be large enough so that all grid points located over water are influenced by at least one observation. For an objective analysis, only RMAX1 need be specified. In this case, the value of RMAX1 must be large enough so that every grid point is influenced by at least one observation. If this criterion is not met, the simulation is aborted.

The next parameters (R1 and R2) control the relative weighting of the wind field produced in step 1 of the wind model (hereafter referred to as the first-guess field) and the observations. R1 is applied at the surface and R2 is used aloft. The degree of influence of the first-guess field is inversely related to the values of these parameters. When considering a single surface station in the interpolation at a grid point, R1 is the distance from the station at which the observation and the first-guess field are equally weighted.

The maximum number of stations to be used in the interpolation (NINTRP) is specified next. This allows only the NINTRP closest stations to be included in the interpolation at a grid point and can be more restrictive than the RMAX parameters. The NINTRP closest stations are used in the interpolation only if they are located within the maximum radius of influence of the grid point. This parameter is a function of observation density. The effect of increasing NINTRP is similar to smoothing, except that by increasing NINTRP the observations are represented more accurately in the resulting wind field.

The next nine parameters control the formatted output from the DWM. The user first specifies the number of levels for which output is to be printed (NZPRNT) and then sets flags to generate output during various stages of the simulation. If the IPR0 option is invoked, the interpolated u and v wind component fields are printed for each hour of the simulation. If the IPR1 option is invoked, the terrain-adjusted surface wind component fields are printed (this procedure is used only with the objective analysis). If the IPR2 option is invoked, the smoothed wind component fields and the initial divergence fields are printed. If the IPR3 option is invoked, the final wind speed and direction fields (calculated from the u- and v-component fields) are printed. If the IPR4 option is invoked, the final divergence field is printed. IPR5, IPR6, and IPR7 control the printing of the three-dimensional wind fields during step 1 of the diagnostic wind model. Output can be generated after the kinematic effects have been calculated, after the slope flows have been added, or after the Froude number adjustment has been applied. These three flags also control the generation of binary output files that can be used to examine each of these complex-terrain effects. IPR8 controls the printing of the final three-dimensional wind field.

Two additional flags follow. ICALC determines whether the wind fields are to be calculated. A preliminary run, in which the ICALC option is not invoked, can be used to ensure that the data are being read properly. IOUTD controls whether the computed wind fields are written to disk. The next parameter (HTFAC) is a multiplicative factor for converting terrain heights to meters.

The maximum number of iterations to be performed in the divergence-minimization procedure (NITER) is specified next. This value is normally set at 50. The maximum acceptable divergence (DIVLIM) is also specified; a typical range for this parameter is 1.0E-7 to 1.0E-5. If the IOBR option is invoked, the O'Brien adjustment procedure is used to adjust the vertical velocity profile. The number of barriers to interpolation (NUMBAR) is specified next. If the I3DCTW option is invoked, the full diagnostic wind model is exercised.

The number of smoothing passes (NSMTH) is then specified for each vertical layer. Smoothing can reduce the discontinuities that result from the interpolation and can also enhance the divergence-minimization procedure. It is important, however, not to overuse smoothing since this reduces the accuracy with which the data are represented in the analyzed field. A maximum of two smoothing passes are applied to the surface layer wind fields. More smoothing may be applied aloft, where less variability is expected.

This is followed by the vertical extrapolation parameters. IEXTRP is the control parameter for the vertical extrapolation of surface winds to upper levels. The available options are summarized in Table 4-2. If IEXTRP equals ± 3 (surface winds are extrapolated), the surface wind is multiplied by the values of FEXTRP (one for each level above level 1) to estimate the upper-level winds. This option may be used, for example, when there are very few upper-air soundings available for an area and the surface data are extrapolated in the vertical with a specified wind profile (e.g., logarithmic wind profile). Use of this option is not recommended if the wind fields from DWM are to be post-processed and converted to UAM input format with the UAMWIND conversion program (see Volume II, Section 6.5.2) because the vertical interpolation is performed by UAMWND.

Certain parameters are specified only when step 1 of the DWM is exercised. For an objective analysis only, these can be omitted. The domain-mean lapse rate (GAMMA) is specified for 24 hours beginning at 0000 LST and ending at 2300 LST. This parameter is an estimate of the lapse rate in that region of the domain where the complex-terrain effects are expected to have the most influence. It is used in the calculation of the Froude number and also controls the magnitude of the slope flows.

This is followed by the critical Froude number (CRITFN), which is usually equal to 1. The distance over which terrain features (TERRAD) influence the air flow is given next. This parameter should be governed by the dominant scale of the terrain features. The surface temperature (TINF) is estimated next; it is not necessary to specify this parameter accurately. If the IFRADJ option is invoked, the Froude number adjustment is calculated.

If the IKINE option is invoked, the kinematic effects are calculated. ALPHA is an empirical parameter that controls the magnitude of the kinematic effects. Recommended values for this parameter range between 0.1 and 0.3.

The next two input records contain the u- and v-components (UM, VM) of the domain-mean wind specified for the 24-hour period from 0000 LST to 2300 LST. The domain-mean wind provides the basic flow that is adjusted for complex-terrain effects in step 1 of the DWM. The domain-mean wind can be based upon observations in the region or it can be derived from the National Meteorological Center's Limited-Area Fine-Mesh Model (LFM) boundary-layer winds. The influence of the domain-mean wind is strongest in data-sparse areas over land.

If barriers are used, the UTM coordinates of the barrier endpoints (BARXY) are specified.

The gridded terrain heights for the domain are contained in a separate file. The terrain heights are defined at the grid cell centers.

Surface type is specified for each grid cell in a separate file. In this file '0' indicates that the grid cell is located over water and '1' indicates that the grid cell is located over land.

4.2.2 Hourly Specific Data

The surface data file (refer to Exhibit 3-2) is generated by the surface preprocessing program (PRESFC). This file contains a list of the station identifiers and the UTM coordinates for each surface station, followed by the surface data for each station and for each time increment (usually hour) of the simulation given in terms of the u- and v-components. Missing data are identified by 999. A station identifier, LAST, indicates the end of the data for each hour.

The upper-air data file (refer to Exhibit 3-4) is generated by the upper-air preprocessing program (PREUA). It contains a list of the upper-air station identifiers and the locations of each of these stations. The u and v wind components for each model level are given for each station and for each time increment (usually hour) of the simulation. Missing data are identified by 999. A station identifier LAST indicates the end of the data for each hour.

4.3 FILE STRUCTURE

Table 4-3 lists the logical units that are assigned in the Diagnostic Wind Model code to the various input and output files.

4.4 DATA SPECIFIED WITHIN THE MODEL

Upper limits for the grid dimensions, the number of stations, and the number of barriers are specified in the model through the use of parameter statements. These values are listed in Table 4-4.

4.5 OUTPUT

Three-dimensional hourly fields of the final u and v wind components are output by the DWM. Two-dimensional hourly fields of the wind components during intermediate steps are also output if requested by the user. This is primarily a diagnostic tool with which to examine complex-terrain effects calculated in step 1 of the DWM.

An additional output file contains the input parameters, the input data for each hour, information on the divergence minimization procedure, and a listing of the final wind fields. A sample printed output file is given in Exhibit 4-2. Various output options may be specified to examine other aspects of the simulation.

4.6 Conversion of DWM Files to UAM Input Format

If desired, the program UAMWND may be used to convert the DWM winds to the UAM-compatible input file format (Figure 4-1). Because the layers in the DWM are fixed in time and space, and the layers in the UAM may change temporally and spatially depending on the top of the region (REGIONTOP) and the mixing height (DIFFBREAK), the winds must be converted from DWM layers to UAM layers. Section 6.5.2 of Volume II provides the details regarding the UAMWND conversion program.

TABLE 4-3. Input and output files for the Diagnostic Wind Model.

Logical Unit	File Contents	Format
12	Input parameters	ASCII
7	Surface data	ASCII
8	Upper-air data	ASCII
5	Gridded terrain heights	ASCII
4	Gridded surface-type indicators	ASCII
6	Printed output file	ASCII
9	2-D final gridded wind components for each layer	Binary
11	2-D wind components after kinematic effects have been calculated	Binary
14	2-D wind components after slope flows have been added	Binary
13	2-D wind components after Froude-number adjustment	Binary

TABLE 4-4. Data specified within the DWM.

Parameter	Description	Stored Value
NXMAX	Maximum number of grid points in the x-direction	50
NYMAX	Maximum number of grid points in the y-direction	50
NZMAX	Maximum number of vertical layers	15
NWINDM	Maximum number of wind stations	100
NUPPRM	Maximum number of upper-air wind stations	50
MAXBAR	Maximum number of user-specified barriers	20

```
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    GRID DESCRIPTION
    ----------------
         NX =       40  NY =       40  NZ =         14
         DX =   4000.0  DY =   4000.0  DZ =      25.0     25.0     50.0     50.0     50.0     50.0     50.0    100.0    100.0    200.0
                                       DZ =     200.0    200.0    200.0    200.0
         CELL CENTER HEIGHTS =                12.5     37.5     75.0    125.0    175.0
         CELL CENTER HEIGHTS =               225.0    275.0    350.0    450.0    600.0
         CELL CENTER HEIGHTS =               800.0   1000.0   1200.0   1400.0

    SIMULATION OPTIONS
    ------------------
         NOHRS =     1      NWIND =    8
         NSURF =     4      NUPPER =   4
         IPRO=    -1  IPR1=    -1  IPR2=    -1  IPR3=    -1  IPR4=    -1
         IPR5=    -1  IPR6=    -1  IPR7=    -1  IOUTD=    1  ICALC=    1

    DIVERGENCE MINIMIZATION CRITERIA
    --------------------------------
    MAXIMUM NUMBER OF ITERATIONS =        50

    ACCEPTABLE DIVERGENCE LIMIT =  0.100E-05


    IOBR =      0      I3DCTW =      1

    INTERPOLATION CRITERIA
    ----------------------

    INFLUENCE RADII OF STATION DATA:     MINIMUM =    1.00
    MAXIMUM SURFACE =   40.00     MAXIMUM UPPER =  200.00
    MAXIMUM WATER =  200.00


    NUMBER OF STATIONS USED =      4    2    2    2    2


    NUMBER OF STATIONS USED =      2    2    2    2    2


    NUMBER OF STATIONS USED =      2    2    2    2

    DIAGNOSTIC WIND MODEL PARAMETERS
    --------------------------------

    R SURF =  20.00     R UPPER =  160.00

    GAMMA =  0.003 0.004 0.004 0.005 0.006 0.005 0.004 0.004
             0.003 0.001-0.003-0.006-0.008-0.009-0.010-0.010
            -0.010-0.010-0.010-0.009-0.009-0.007-0.005-0.001
```

EXHIBIT 4-2. Sample printed output file from the diagnostic wind model.

```
TINF =    300.0

CRITFN =      1.0      TERRAD =     50.0

BETA2 = -1.00-1.00-1.00-1.00-1.00-1.00-1.00-1.00
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         1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00

IFRADJ =        1      IKINE =        1      ALPHA =     0.10

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        2.9  2.9  3.0  3.0  2.9  2.8  2.6  2.5

VM =   -1.5 -1.5 -1.5 -1.5 -1.5 -1.5 -1.5 -1.5
       -1.4 -1.3 -1.1 -1.0 -0.9 -0.8 -0.6 -0.5
       -0.4 -0.3 -0.1  0.0  0.1  0.2  0.3  0.4
ATLANTA 840603
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TERRAIN HEIGHTS (M)

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ARRAY HAS BEEN SCALED BY 0.1E+00 FOR PRINTING

HMAX ARRAY

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EXHIBIT 4-2. Continued.

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ARRAY HAS BEEN SCALED BY 0.1E+00 FOR PRINTING

ATLANTA 840603

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EXHIBIT 4-2. Continued.

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8	10	10	10	10

EXHIBIT 4-2. Continued.

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7 I 10 10 10 10
6 I 10 10 10 10
5 I 10 10 10 10
4 I 10 10 10 10
3 I 10 10 10 10
2 I 10 10 10 10
1 I 10 10 10 10
```

ARRAY HAS BEEN SCALED BY 0.1E+02 FOR PRINTING

GRIDDED WIND STATIONS COORDINATES

NO.	IS	JS	NAME
1	18	19	CBA
2	23	22	PTA
3	18	23	DOB
4	24	17	DEK
5	71	-49	7221
6	-44	-5	7222
7	46	24	7231
8	-29	87	7232

SUMMARY OF DIVERGENCE MINIMIZATION

LEVEL	ITERATIONS	MAXIMUM DIVERGENCE (/SEC)
1	30	0.961E-06
2	26	0.979E-06
3	21	0.960E-06
4	13	0.986E-06
5	8	0.962E-06
6	5	0.952E-06
7	4	0.823E-06
8	2	0.788E-06
9	1	0.597E-06
10	1	0.230E-06
11	0	0.267E-06
12	0	0.694E-07
13	0	0.180E-07
14	0	0.469E-08

ATLANTA 840603

INPUT DATA AT TIME = 0. HOURS (SIMULATION HOUR NO. 1)

SURFACE WIND DATA

STATION	U-CMPT M/SEC	V-CMPT M/SEC	WEIGHTING

EXHIBIT 4-2. Continued.

CBA	0.9	0.5	1.00
PTA	999.0	999.0	1.00
008	1.8	-1.0	1.00
OEK	0.8	-0.3	1.00

UPPER AIR WIND DATA

STATION	--- LEVEL U-CMPT M/S	1 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	2 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	3 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	4 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	5 --- V-CMPT M/S
7221	2.3	2.3	3.1	2.2	4.2	2.1	5.6	0.2	6.8	-2.2
7222	-1.2	-1.6	-0.4	-2.1	0.9	-3.0	2.6	-4.1	4.3	-5.2
7231	3.3	-0.8	4.0	-1.3	4.8	-2.0	5.3	-3.0	5.8	-4.0
7232	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0

UPPER AIR WIND DATA

STATION	--- LEVEL U-CMPT M/S	6 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	7 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	8 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	9 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	10 --- V-CMPT M/S
7221	8.1	-4.7	8.9	-6.4	8.4	-6.9	7.8	-7.6	6.9	-8.3
7222	4.5	-5.4	4.5	-5.4	4.5	-5.4	4.5	-5.4	4.4	-4.9
7231	6.3	-5.0	6.8	-5.9	7.6	-7.4	6.2	-7.2	3.3	-6.1
7232	0.3	2.0	1.9	-0.1	4.4	-3.5	7.0	-7.0	6.7	-6.7

UPPER AIR WIND DATA

STATION	--- LEVEL U-CMPT M/S	11 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	12 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	13 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	14 --- V-CMPT M/S	--- LEVEL U-CMPT M/S	V-CMPT M/S
7221	6.1	-7.3	5.1	-6.5	4.0	-5.7	3.9	-4.9		
7222	4.3	-4.1	4.3	-2.9	3.6	-2.2	2.5	-1.7		
7231	2.0	-4.2	2.2	-2.3	4.7	-2.1	5.5	-2.4		
7232	6.3	-6.1	6.2	-5.3	5.5	-3.2	5.0	-1.2		

ATLANTA 840603

FINAL WIND FIELD AT TIME = 0. (SIMULATION HOUR NO. 1)

X-COMPONENT OF WIND (U) AT LEVEL = 1 (M/SEC)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
40	26	26	26	27	28	27	25	22	26	24	20	4	5	15	22	22	14	2	7	15	24	29	29	26	24	26	27	26	26	24	22	23	21	25	26	27
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34	26	24	17.	8	9	21	25	22	14	22	18	8	10	10	22	23	18	24	26	25	24	24	24	18	9	2	1	13	23	24	21	19	21	25	27	27

EXHIBIT 4-2. Continued.

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EXHIBIT 4-2. Continued.

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 4 I 26 26 26 26
 3 I 26 26 26 26
 2 I 26 26 26 26
 1 I 26 26 26 26

     ARRAY HAS BEEN SCALED BY  0.1E+02  FOR PRINTING

  Y-COMPONENT OF WIND (V) AT LEVEL =     1      (M/SEC)
  --------------------------------------------------------

       1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
    I--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
40  I-15-15-15-16-15-10  5 10  7 10  0-20-24-20 -7 11 12-12-22-23-19-18-17-18-20-17-17-17-17-18-21-19-22-19-17-17
39  I-15-15-16-16-15 -8  2 -5  0 -2 -2-17-22-17 -1  8 15  3-14-19-20-19-17-17-18-17-16-16-16-16-18-18-20-18-17-17
38  I-15-15-16-16-14 -7  1 -5  5 -4  1 -5-18-22-12  3 10  4-12-16-18-19-17-16-17-17-16-16-16-16-19-22-21-17-16-16
37  I-15-15-16-16-10  1  4  9 10 -7 -8 -6 -6-21-23-18-14-11-15-16-16-17-17-17-16-16-16-15-15-16-22-23-18-16-16-16
36  I-15-15-16-18-10  3 -1  8  7 -7 -5 -2 -8-18-22-23-20-17-16-15-15-16-16-16-16-17-16-14-11 -8-19-16-12-14-15-16
35  I-15-14-12-12  1  5 -7 -5-10-11-10 -1  4  1 -6-17-19-18-16-13-10-11-13-12-18-23-22-16-15-12-14 -6  0-11-15-16
34  I-14 -9  0 -4-10 -8-12-11-19-15-17-13 -2-10-12-17-21-18-14 -6  6  3 -3  0-15-22-25-21-17-15 -9  7  7-10-14-15
33  I-13-11-13-15-16-15-16-17-18-17-20-23-17-18-17-16-18-16 10  3  7  3  2  6  1 -7-21-19-17-16-14  1 -5-13-15-15
32  I-13 -9-10-17-14-13-15-17-18-20-22-23-19-17-16-14-15-15-12 -1 -7 -9 -2 -9-14-14-17-16-14-13-18-14-15-15-15-15
31  I-10 -4  0 -8 -6 -6-10-18-18-19-23-22-17-15-14-13-13 -7-12 -9-13-15-11-16-22-20-17-15-10  3 -3-14-15-15-15-15
30  I -4 -1  4  2  2 -6-11-15-15-14-18-19-16-14-10 -5-13-10-12-13-13-13-16-21-24-23-18-18-14  2 -7-14-15-15-15-15
29  I-12-10 -6  2  4 -9-13-12 -8 -3 -4-15-16-15-12 -1 -4 -8-10 -9 -2 -3-14-19-21-19-18-21-21-12-14-15-15-15-15-15
28  I-15-15-14-10 -7-10-10 -4  3  3 -3-12-14-15-13 -5 -5 -4 -3 -1  2  0-11-15-17-15-16-18-18-16-15-15-15-15-15-14
27  I-15-15-15-14-10 -4 -5 -4  2  1 -6 -6 -6-13-13 -9 -7 -3 -3 -5 -6 -7-10-12-14-14-15-19-16-15-15-15-15-15-15-14
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25  I-15-15-15-14-13-11 -5-12-13-11 -6 -3 -4 -5 -8 -9 -9 -9 -9 -8 -7 -7 -8 -9 -9-11-12-13-13-14-15-15-15-15-15-14
24  I-15-14-14-14-14-13-10-13-13-11-10 -8 -8 -7 -8 -9 -9 -9 -9 -7 -5 -6 -8 -8 -8 -9-11-12-12-13-14-15-15-15-15-14
23  I-14-14-14-14-15-15-15-14-10 -6 -9 -9 -8 -8 -8 -9 -9 -9 -8 -7 -6 -7 -7 -7 -8 -8-10-11-12-12-13-14-15-15-14-14
22  I-15-15-15-15-15-16-15-14-11 -8 -9 -9 -8 -7 -7 -7 -7 -7 -6 -6 -6 -6 -6 -7 -7 -8 -9-10-11-12-12-13-14-15-15-14
21  I-15-15-15-16-16-16-16-14-11-10 -9 -8 -7 -6 -5 -4 -3 -2 -2 -3 -4 -5 -5 -6 -6 -7 -8-10-11-11-12-13-14-15-15-14
20  I-15-15-15-16-16-16-16-14-11-10 -9 -8 -7 -5 -3 -1  1  2  1 -1 -3 -4 -5 -5 -6 -6 -7 -9-10-11-12-12-13-14-15-15
19  I-15-15-15-16-16-16-15-14-11-10 -9 -8 -6 -5 -3  0  2  3  2 -1 -2 -4 -4 -4 -5 -6 -7 -9-10-11-11-12-13-14-15-15
18  I-15-15-16-16-16-16-15-14-11-10 -9 -8 -7 -5 -3 -1  1  2  1 -1 -3 -3 -4 -4 -4 -5 -6 -8 -9-10-11-12-13-14-15-15
17  I-15-15-16-16-15-15-15-14-12-10 -9 -9 -7 -5 -4 -2 -1 -1 -1 -2 -3 -3 -3 -3 -4 -5 -6 -8 -9-10-11-12-13-14-15-15
16  I-15-15-15-15-15-15-15-14-12-11-10 -9 -7 -6 -5 -4 -3 -3 -3 -3 -4 -4 -4 -4 -4 -5 -6 -8 -9-10-11-12-13-14-15-15
15  I-15-15-15-15-15-15-15-15-14-11-10 -8 -6 -6 -6 -5 -5 -4 -4 -5 -5 -4 -4 -4 -5 -6 -7 -9-10-11-11-12-13-14-15-15
14  I-15-15-15-15-15-15-15-15-15-12-10 -7 -1 -6 -7 -6 -6 -6 -6 -5 -5 -5 -5 -5 -6 -7 -8 -9-10-11-11-12-13-14-15-15
13  I-15-15-15-15-15-15-15-16-16-13-10-12 -7 -8 -8 -7 -7 -6 -6 -6 -6 -6 -6 -6 -7 -8 -9-10-11-11-12-13-14-15-15-15
12  I-15-15-15-15-15-15-15-16 15 -8  1 -9 -9 -9 -9 -8 -8 -7 -7 -7 -7 -7 -7 -8 -9 -9-10-11-11-12-12-13-14-15-15-15
11  I-15-15-15-15-15-15-15-15-14 -6  7  1 -8-10-10  9  9 -8 -8 -8 -8  8 -9 -9 10-10-11-11-12-12-13-14-15-15-15-15
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EXHIBIT 4-2. Continued.

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10 I-15-15-15-16-16-14-13-14-13 -4 -6 -8-12-13-12-11-10-10 -9 -9 -9-10-10-11-11-11-11-12-12-13-14-15-15-15-15-15
 9 I-15-15-16-16-14 -9 -3 -6-12-13-14-14-15-15-14-14-13-12-12-11-11-11-11-11-12-12-12-12-13-14-15-15-15-15-15-15
 8 I-15-15-15-15-11 -3 -8-10-13-15-15-15-15-15-15-15-15-14-14-13-12-12-12-12-12-12-13-13-14-15-15-15-15-15-15-15
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 2 I-15-15-15-14-10 -4-12-14-15-15-15-15-15-15-15-15-15-14-15-15-15-15-15-14-14-14-14-14-14-14-14-14-14-14-14-14
 1 I-15-15-15-15-13-10-14-15-15-15-15-15-15-15-14-14-14-15-15-15-15-14-14-14-14-14-14-14-14-14-14-14-14-14-14-14

     37 38 39 40
   I--+--+--+--+
40 I-16-16-17-18
39 I-16-16-17-18
38 I-16-16-17-17
37 I-16-17-16-16
36 I-17-16-15-15
35 I-16-15-14-14
34 I-15-14-12-10
33 I-14 -9 -4 -1
32 I-15-14-11 -9
31 I-16-17-17-12
30 I-16-17-16-13
29 I-14-15-14-14
28 I-14-14-14-16
27 I-13-12-12-13
26 I-13-13-11 -9
25 I-13-13-12-11
24 I-13-13-12-12
23 I-13-13-12-12
22 I-13-13-13-12
21 I-14-13-13-13
20 I-14-13-13-13
19 I-14-14-13-13
18 I-15-14-13-13
17 I-15-14-14-14
16 I-15-15-15-15
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14 I-15-15-15-15
13 I-15-15-15-15
12 I-15-15-15-15
11 I-15-15-15-15
10 I-15-15-15-15
 9 I-15-15-15-15
 8 I-15-15-15-15
 7 I-15-15-15-15
 6 I-15-15-15-15
 5 I-15-15-15-15
 4 I-15-15-15-15
 3 I-15-15-15-15
 2 I-15-15-15-15
 1 I-15-15-15-15

      ARRAY HAS BEEN SCALED BY  0.1E+02  FOR PRINTING
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EXHIBIT 4-2. Concluded.

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