CALPUFF Numerical Plume Rise Analyzer

CALPUFF Version 6.26 introduces a new feature that allows the details of its numerical plume rise module to be written to a file for subsequent post-processing. A new processor, RISEPOST, reads this file and extracts statistics on the plume vertical velocity at various user-specified heights.

The output file is a text file that can be viewed by any text editor, but is best processed by RISEPOST because it can become very large. The numerical rise module is called every time period of a simulation, and creates a line in the output file for each step along the plume trajectory (nominally at 1m intervals) each time, listing the cross-plume-average properties, such as the vertical velocity. To limit file-size and simplify analysis tasks, CALPUFF will restrict the simulation to a single source whenever this plume rise output option is selected. Note that numerical plume rise can be used for point sources (with or without PRIME downwash), and buoyant line sources.

Three new CALPUFF control-file inputs are related to this option:

- an output control switch to request the numerical rise output file (INRISE)
- the name of the output file with the numerical plume rise data (RISDAT)
- a model control switch to select numerical rise for point sources (MRISE)

INRISE is found within Input Group 5 -- Output Options, as shown in Exhibit 1. By default, it is turned off since this is a specialized diagnostic feature of the model.

RISDAT is found within Input Group 0 -- Input and Output File Names, as shown in Exhibit 2. The input structure for this file name is similar to other CALPUFF files. If the name is not provided in the control file, the default name, RISE.DAT, is used.

MRISE is found within Input Group 2 -- Technical Options, as shown in Exhibit 3. This may be set to either Numerical Rise or Briggs Rise if a buoyant area source is being simulated, but should be set to Numerical Rise if a point source is being simulated.

When configuring CALPUFF using the GUI, these controls are found on the following screens:

INRISE: Output -- Diagnostic Output (see Figure 1)
RISDAT: Output -- Diagnostic Output (see Figure 1)
MRISE: Model Options -- Plume Rise (see Figure 2)

RISEPOST is currently designed to characterize the vertical velocity of the plume during rise. The numerical plume rise solver marches along the axis of the plume during the rise phase, solving for the cross-plume-average properties at each step as the plume entrains ambient air due to shear-induced turbulence and ambient turbulence. These properties

written to the RISE.DAT file are read by RISEPOST which keeps track of the vertical velocity at a number of user-specified heights. For each time period in the simulation, the minimum, maximum, and average vertical plume velocity is tabulated at each height. More information is also provided in the form of velocity exceedence counts at each height. A number of velocity thresholds are configured by the user, and RISEPOST determines the number of periods in the simulation that the plume vertical velocity exceeds each threshold, at each of the heights.

RISEPOST is a FORTRAN program that requires a control file, a data file (RISE.DAT), and produces a list file with the results.

Exhibit 4 shows an example of the RISEPOST control file. It follows the same configuration used in other CALPUFF system control files.

Input Group 0 contains input and output file names, with default names if none are specified. In this case the only names needed are for the input data file and the output list file of results.

Input Group 1 allows the user to define the vertical velocity thresholds for the exceedence counts. The range of velocities is established by a minimum and maximum (WXMIN, WXMAX). The number of thresholds generated within this range is specified by NXBIN. Note that NXBIN must include the minimum and maximum, so the smallest value for NXBIN is 2. The maximum is limited by the FORTRAN parameter MXBINS which is set at the time RISEPOST is compiled. It is specified in the FORTRAN include-file PARAMS.NRISE, and is currently set to 20. If more thresholds are required, this parameter must be increased, and RISEPOST must be recompiled.

Input Groups 2a and 2b configure the heights used. The number of heights is set in 2a, and the values are entered in increasing order in 2b. The maximum number of heights is limited by the FORTRAN parameter MXHTS which is set at the time RISEPOST is compiled. As discussed above, this limit can be increased by editing PARAMS.NRISE and recompiling RISEPOST.

Exhibit 5 shows the list file of results for an example application that simulated a year with 8784 hours. Selected elements of the control file inputs are repeated here for QA purposes and documentation, followed by source information read from the RISE.DAT file, and the results tables for vertical plume velocity.

Exhibit 1.
CALPUFF Control File Variable INRISE Located in Input Group 5

```
INPUT GROUP: 5 -- Output Options
--------------
                                        *                          *
     FILE                        DEFAULT VALUE             VALUE THIS RUN
     ----                        -------------             --------------

   Concentrations (ICON)              1                   !  ICON =  1   !
   Dry Fluxes (IDRY)                  1                   !  IDRY =  0   !
   Wet Fluxes (IWET)                  1                   !  IWET =  0   !
   2D Temperature (IT2D)              0                   !  IT2D =  0   !
   2D Density (IRHO)                  0                   !  IRHO =  0   !
   Relative Humidity (IVIS)           1                   !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                           Default: T         ! LCOMPRS = T !

   *
    0 = Do not create file, 1 = create file


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                       Default: 1         !  IQAPLOT =  1   !
         0 = no
         1 = yes

    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported?
       (IMFLX)                         Default: 0         ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported?
       (IMBAL)                         Default: 0         ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    NUMERICAL RISE OUTPUT OPTION:

       Create a file with plume properties for each rise
       increment, for each model timestep?
       This applies to sources modeled with numerical rise
       and is limited to ONE source in the run.
       (INRISE)                        Default: 0         ! INRISE =  1  !
         0 = no
         1 = yes (RISE.DAT filename is
                  specified in Input Group 0)
```

(Input Group Continues …)

Exhibit 2.
CALPUFF Control File Variable RISDAT Located in Input Group 0

```
INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    * METDAT =             *
    or
ISCMET.DAT    input    ! ISCDAT =ISCEXT.MET   !
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB=             *
-------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =ISCPUF.LST  !
CONC.DAT      output   ! CONDAT =ISCPUF.CON     !
DFLX.DAT      output   * DFDAT  =             *
WFLX.DAT      output   * WFDAT  =             *

VISB.DAT      output   * VISDAT =             *
TK2D.DAT      output   * T2DDAT =             *
RHO2D.DAT     output   * RHODAT =             *
RESTARTE.DAT  output   * RSTARTE=             *
-------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
-------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT  =             *
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
H2O2.DAT      input    * H2O2DAT=             *
HILL.DAT      input    * HILDAT=             *
HILLRCT.DAT   input    * RCTDAT=             *
COASTLN.DAT   input    * CSTDAT=             *
FLUXBDY.DAT   input    * BDYDAT=             *
BCON.DAT      input    * BCNDAT=             *
DEBUG.DAT     output   * DEBUG =             *
MASSFLX.DAT   output   * FLXDAT=             *
MASSBAL.DAT   output   * BALDAT=             *
FOG.DAT       output   * FOGDAT=             *
RISE.DAT      output   ! RISDAT=RISE_Test.DAT     !
-------------------------------------------------------------------------------
```

(Input Group Continues …)

Exhibit 3.
CALPUFF Control File Variable MRISE Located in Input Group 2

```
INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                  Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                             Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                         Default: 0     ! MCTSG =  0   !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated slugs? (MSLUG)             Default: 0     ! MSLUG =  0   !
        0 = no
        1 = yes (slug model used)

     Transitional plume rise modeled?
     (MTRANS)                             Default: 1     ! MTRANS =  1   !
        0 = no  (i.e., final rise only)
        1 = yes (i.e., transitional rise computed)

     Stack tip downwash? (MTIP)           Default: 1     ! MTIP =  1  !
        0 = no  (i.e., no stack tip downwash)
        1 = yes (i.e., use stack tip downwash)

     Method used to compute plume rise for
     point sources not subject to building
     downwash? (MRISE)                    Default: 1     ! MRISE =  2  !
        1 = Briggs plume rise
        2 = Numerical plume rise
```

(Input Group Continues …)

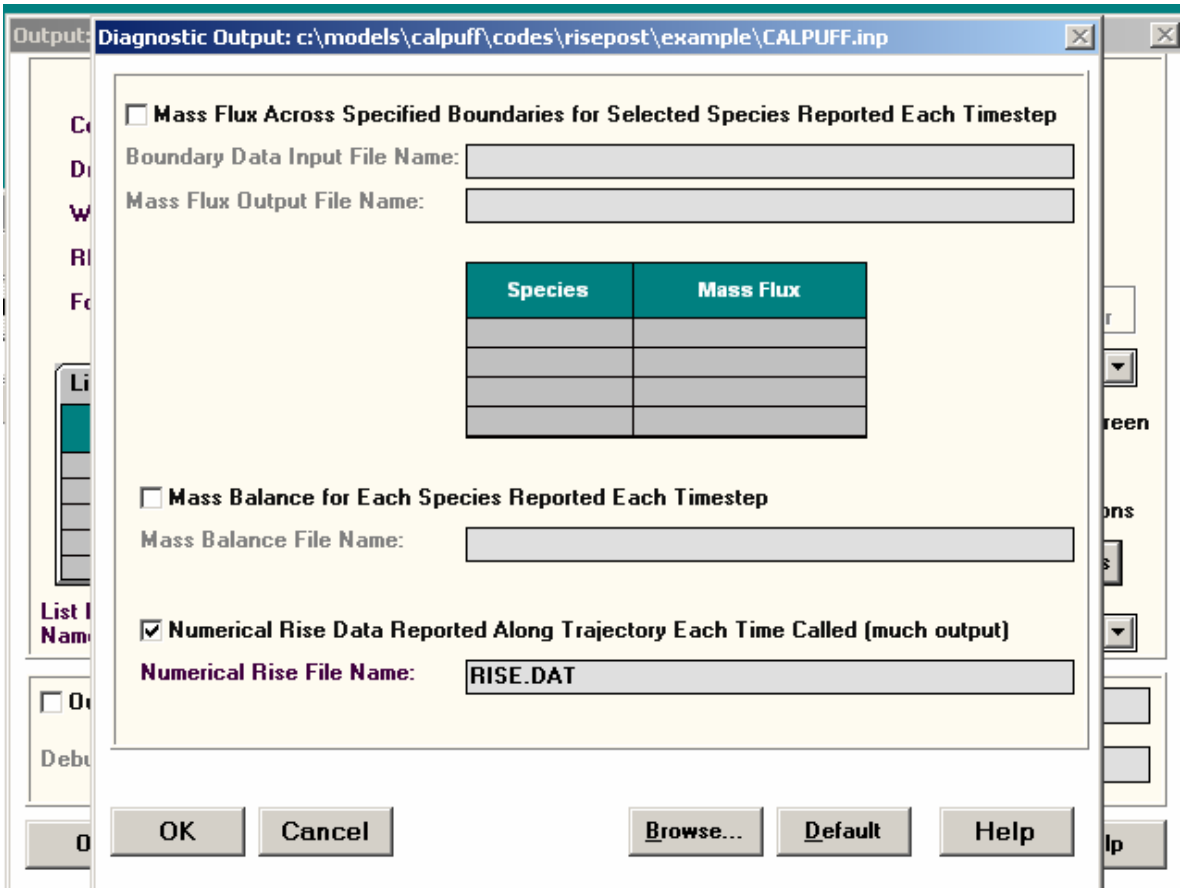

Figure 1. CALPUFF control file variable INRISE is set via the GUI using a check-box selection on the "Output -- Diagnostic Output" screen. The file name field for the output file becomes active when the Numerical Rise Output is selected.

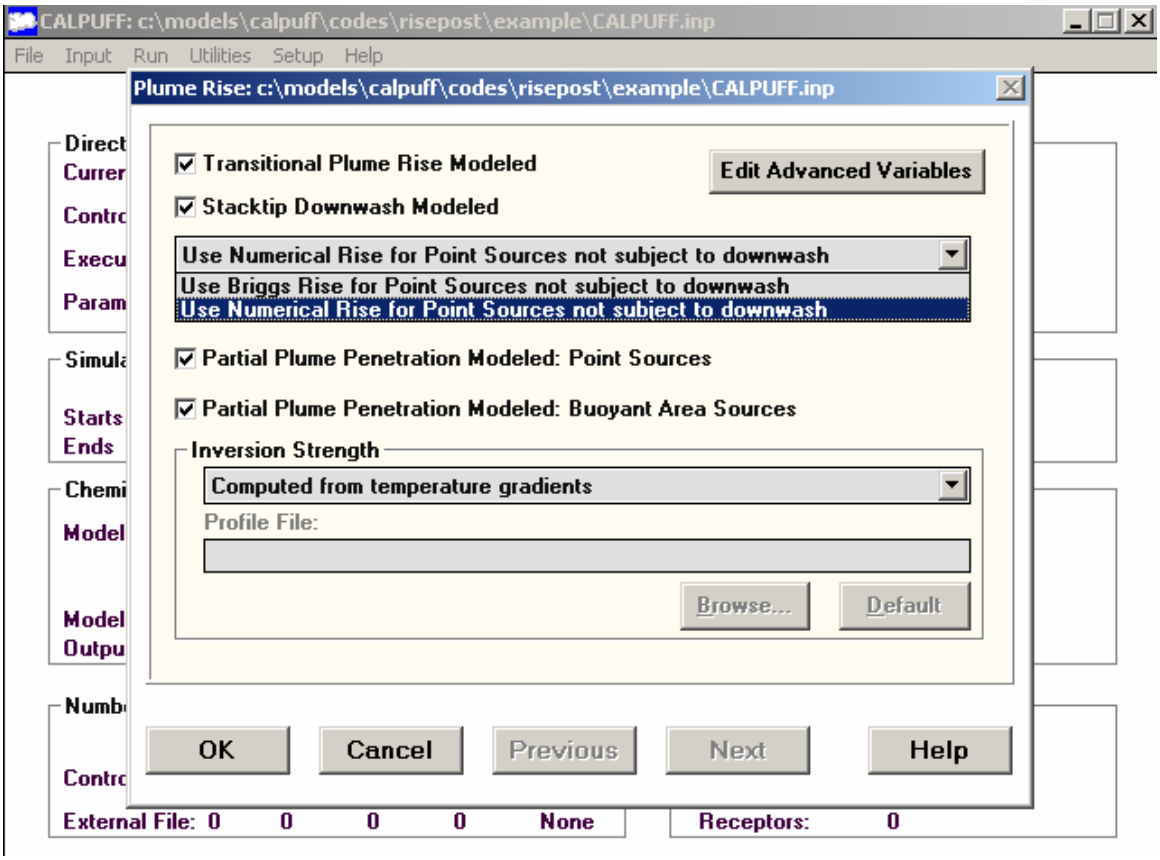

Figure 2. CALPUFF control file variable MRISE is set via the GUI using a pull-down menu selection on the "Model Options -- Plume Rise" screen.

Exhibit 4 (continues).
RISEPOST Control File Example

```
RISEPOST.INP    1.0             Initial Configuration
------------------------------------------------------------------------------

                  RISEPOST Processor CONTROL FILE
                  -------------------------------
PURPOSE
-------
This utility examines a CALPUFF RISE.DAT file of numerical rise output for 1
source and characterizes those data.

------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names
--------------

Input Files
-----------

   Default Name  Type       File Name
   ------------  ----       ---------
   RISE.DAT      output   ! FILEDAT = rise_test.dat !


Output Files
------------

   Default Name  Type       File Name
   ------------  ----       ---------
   RISEPOST.LST  output   ! FILELST = w_vel.lst !


!END!

------------
NOTE: File/path names can be up to 132 characters in length, and are forced
      to be upper case after processing


------------------------------------------------------------------------------
INPUT GROUP: 1 -- Processing Options
--------------

     Minumum vertical velocity (m/s) for
     exceedence counts
     (WXMIN)                              Default: 0.0   ! WXMIN =  0.1   !

     Maximum vertical velocity (m/s) for
     exceedence counts
     (WXMAX)                              Default: 10.0  ! WXMAX =  5.0   !

     Number of vertical velocity  bins for
     exceedence counts
     (NXBIN)                              Default: 10    ! NXBIN =  20   !


!END!
```

Exhibit 4 (concluded).
RISEPOST Control File Example.

```
--------------------------------------------------------------------------------

INPUT GROUPS: 2a & 2b -- Heights for analysis
---------------------

--------------
Subgroup (2a)
--------------

     Number of heights (NHT)              No default  !  NHT =  17   !

!END!

--------------
Subgroup (2b)
--------------
                                          a,b
           HEIGHTS FOR ANALYSIS (m AGL)
          ---------------------------------

                Height
              Above Ground
                  (m)
              ------------
   !    ZHT   =   40.   !  !END!
   !    ZHT   =   50.   !  !END!
   !    ZHT   =   60.   !  !END!
   !    ZHT   =   70.   !  !END!
   !    ZHT   =   80.   !  !END!
   !    ZHT   =   90.   !  !END!
   !    ZHT   =  100.   !  !END!
   !    ZHT   =  110.   !  !END!
   !    ZHT   =  120.   !  !END!
   !    ZHT   =  140.   !  !END!
   !    ZHT   =  160.   !  !END!
   !    ZHT   =  180.   !  !END!
   !    ZHT   =  200.   !  !END!
   !    ZHT   =  250.   !  !END!
   !    ZHT   =  300.   !  !END!
   !    ZHT   =  400.   !  !END!
   !    ZHT   =  500.   !  !END!


-------------
    a
     Input for each height is treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     Heights must increase in the array.
```

Exhibit 5 (continues).
RISEPOST List File Example.

```
                    RISEPOST OUTPUT SUMMARY
                VERSION:  1.0          LEVEL:  080512


-------------------------
    SETUP Information
-------------------------

         Control File Used: w_vel.inp
 Input Numerical Rise File: rise_test.dat
Output Results (List) File: w_vel.lst

Processing Options -----

     Exceedence Counts are requested between
     a minimum vertical velcity     =  0.100000001
     and a maximum vertical velcity =  5.00000000
     using a total number of bins   =  20

Analysis performed for the following heights (m)
     ZHT =  40.0000000
     ZHT =  50.0000000
     ZHT =  60.0000000
     ZHT =  70.0000000
     ZHT =  80.0000000
     ZHT =  90.0000000
     ZHT =  100.000000
     ZHT =  110.000000
     ZHT =  120.000000
     ZHT =  140.000000
     ZHT =  160.000000
     ZHT =  180.000000
     ZHT =  200.000000
     ZHT =  250.000000
     ZHT =  300.000000
     ZHT =  400.000000
     ZHT =  500.000000
```

Exhibit 5 (continues).
RISEPOST List File Example.

```
 ------------------------------------------
 Selected header records from input data file:
 ------------------------------------------

RISE.DAT        1.0             File structure with embedded control file
UTM
  19N
NAS-C   02-21-2003
KM
UTC-0600
 1 1 2 0 3 0 4 0 5 0 6 0 7 0 8 0
 1 PT1



 ------------------------------------------
 Source Information
 ------------------------------------------

   Constant Point      PT1

 Data for last period processed:
 Location            0.749999821 1.00000024
 Elevation (m MSL)   0.00000000E+00
 Release Height (m)  36.0971031
 Temperature (K)     405.000000
 Release Radius (m)  1.06500006
 Exit Velocity (m/s) 5.17999983



 ------------------------------------------------
 Results for Vertical Velocity at Requested Heights
 ------------------------------------------------

 Vertical velocities are from the Numerical Plume
 Rise module within CALPUFF.  This module solves
 for plume rise incrementally along the trajectory
 using plume properties averaged across its
 cross-section.
```

Exhibit 5 (concluded).
RISEPOST List File Example.

Height m(AGL)	Minimum W m/s	Maximum W m/s	Average W m/s	#
500.0	0.0	0.0	0.0	0
400.0	0.4	0.4	0.4	22
300.0	0.4	0.5	0.5	47
250.0	0.5	0.6	0.5	47
200.0	0.6	0.7	0.6	47
180.0	0.6	0.7	0.7	47
160.0	0.4	0.8	0.7	48
140.0	0.4	0.9	0.8	54
120.0	0.4	1.0	0.6	130
110.0	0.3	1.1	0.6	219
100.0	0.4	1.1	0.6	325
90.0	0.2	1.3	0.6	529
80.0	0.2	1.4	0.6	905
70.0	0.2	1.6	0.5	1888
60.0	0.2	1.9	0.5	4064
50.0	0.3	2.3	0.6	7887
40.0	0.4	4.2	1.0	8784

Height m(AGL)	#> 0.1 m/s	#> 0.4 m/s	#> 0.6 m/s	#> 0.9 m/s	#> 1.1 m/s	#> 1.4 m/s	#> 1.6 m/s	#> 1.9 m/s	#> 2.2 m/s	#> 2.4 m/s	#> 2.7 m/s	#> 2.9 m/s	#> 3.2 m/s	#> 3.5 m/s	#> 3.7 m/s	#> 4.0 m/s	#> 4.2 m/s	#> 4.5 m/s	#> 4.7 m/s	#> 5.0 m/s
500.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400.0	22	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300.0	47	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250.0	47	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200.0	47	47	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180.0	47	47	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160.0	48	48	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140.0	54	54	47	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120.0	130	130	47	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110.0	219	207	59	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100.0	325	325	124	51	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90.0	529	528	126	123	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80.0	905	888	136	125	107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70.0	1888	1722	212	125	125	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60.0	4064	3645	477	130	125	125	99	0	0	0	0	0	0	0	0	0	0	0	0	0
50.0	7887	7833	1940	326	135	125	125	125	55	0	0	0	0	0	0	0	0	0	0	0
40.0	8784	8784	7463	3380	1850	1108	881	626	211	183	183	183	135	127	125	125	0	0	0	0