Atmospheric Sciences

Exponent®

Final Report

Technical Memorandum

CALPUFF System Developments for Alberta Flare Modeling

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CALPUFF Flare System Developments for Alberta Flare Modeling

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Contents

List of Figures

List of Tables

1. Introduction

The Atmospheric Sciences team at Exponent, comprising the authors of the CALPUFF modeling suite, has developed new modeling capabilities to model flares. The development work was sponsored by an Alberta Upstream Petroleum Research Fund (AUPRF) grant funded by the Petroleum Technology Alliance Canada (PTAC) under subcontract to Zelt Professional Services Inc.

The new developments include a new CALPUFF source-type, dubbed flare, which is a point source with all arbitrarily-varying emissions parameters, including (potentially) varying location and stack height, for which specific processing flags can be turned on and off, independently of the general processing flags which apply to all other sources in a given CALPUFF simulation. Those flare-specific switches relate to the plume rise method and stack-tip downwash.

Exponent also created a series of new postprocessors to compute time-averages, maxima, n^{th} ranked and percentile concentrations (and deposition fluxes). Those new postprocessors are CALAVE, CALMAX and CALRANK. One of the applications for this new set of CALPUFF postprocessors is to meet emergency flaring impact assessment requirements in general and in the Province of Alberta (Canada) in particular. This new set of processors streamline the computation of maximum (or n^{th} highest, or percentile) impact created by a short-lived event that can occur anytime during the year. This type of situation is typical for emergency events or upset conditions.

The CALPUFF and METSERIES changes can be inserted into the publicly-available official CALPUFF v6.42 and METSERIES v1.81, creating CALPUFF v6.42FL and METSERIES v1.81FL respectively. The new postprocessors, CALAVE, CALMAX and CALRANK are distributed as original Fortran codes.

2. CALPUFF System Enhancements

2.1 CALPUFF Version 6.42FL

The developers of the CALPUFF modeling system (Scire et al., 2000a, 2000b) added a new flare source type to the current existing public version of CALPUFF (Version 6.42 Level 110325). The resulting CALPUFF version is CALPUFF v6.42FL. CALPUFF v6.42FL can be created by inserting the new developments to the publicly available CALPUFF v6.42. The latter is available for download from the CALPUFF web site: www.src.com.

In CALPUFF terms, a flare is a point source with arbitrarily-varying emissions parameters, including (potentially) varying location and stack height, for which specific processing flags can be turned on and off, independently of the general processing flags which apply to all other sources in a given CALPUFF simulation. Those flare-specific flags are:

1) ***MRISE_FL***: determines the plume rise module for flare sources. Available selection is either Briggs plume rise (MRISE_FL=1) or CALPUFF numerical plume rise (MRISE_FL=2). The numerical plume rise model is recommended for flares and set as the default. Indeed, CALPUFF numerical plume rise algorithm should be used for flares because:

- Flares are hot sources and the Boussinesq approximation, one of the Briggs plume rise assumptions, is not valid when the plume density is much smaller than the ambient air density.
- Flares generate highly buoyant plumes and the ambient air stratification and vertical wind shear above stack top should be taken into account during plume rise calculations (Briggs plume rise does not take either into account).

2) ***MTIP_FL***: determines whether stack-tip downwash is applied to the flare sources in CALPUFF. Although stack tip downwash may affect flares, stack-tip downwash should be applied to flare sources in CALPUFF only if it has not been taken into account already when

the effective flare source parameters were computed. In particular, if the flare effective parameters were computed with the Alberta Flare module (either ERCB Flare spreadsheet or soon-to-be-released ABFLARE), in which stack-tip downwash is already taken into account to compute the flame length and effective stack height, stack-tip downwash should be turned-off in CALPUFF to avoid double-counting its effect.

2.2 CALPUFF Input File

Information about the flare source(s), flare source processing options (i.e. stack-tip downwash, numerical plume rise), and flare emission file(s) has to be specified in the CALPUFF input file. To do so, the user has to append a section at the very end of a normal CALPUFF.INP file compatible with v6.42 (i.e. after the discrete receptor information). As usual, the key information must be specified between exclamation point delimiters. A template of the new section in CALPUFF.INP is displayed in Table 2-1.

Note that a CALPUFF.INP file containing the new flare information is compatible with the public code (CALPUFF v6.42), but the section containing the flare information will be ignored by CALPUFF v6.42. Similarly, a CALPUFF.INP file including flare parameters can be loaded in the CALPro Plus GUI (Version 7.12.03_08_2011) but the flare-related section won't be saved by CALPro Plus. **Therefore, CALPro Plus cannot be used to configure or run the new CALPUFF v6.42FL version of the code.** Instead the control file must be configured with a text editor and the v6.42FL code should be run directly from a COMMAND window.

Table 2-1 Flare Source Information Appended to Bottom of CALPUFF.INP

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

INPUT GROUP: FL -- FLARE source control parameters (variable emissions file)
---------------
     Number of flare sources defined in FLREMARB.DAT file(s)
     (NFL2)                                  Default: 0     !  NFL2    =  3 !
     (At least 1 FLREMARB.DAT file is needed if NFL2 > 0)

     Apply stack-tip downwash to FLARE sources?
     (MTIP_FL)                               Default: 0     ! MTIP_FL  =  0 !
        0 = no  (no stack-tip downwash)
        1 = yes (apply stack-tip downwash)

     Plume rise module for FLARE sources
     (MRISE_FL)                              Default: 2     ! MRISE_FL =  2 !
        1 = Briggs module
        2 = Numerical rise module

     Number of FLEMARB.DAT variable emissions files
     Each file contains emissions parameters for the entire period modeled
     for 1 or more sources
      (NFLDAT)                               Default: 0     ! NFLDAT   =  2 !

!END!

------------------------
FLARE Source File Names
------------------------
     Assign NFLDAT filenames between delimiters
     A total of NFLDAT lines is expected with one file name assigned per line
     Each line is treated as an input group and must terminate with END

Default Name  Type          File Name
------------  ----          ---------
 none         input       ! FLDAT=  FLEMARB1.DAT  ! !END!
 none         input       ! FLDAT=  FLEMARB2.DAT  ! !END!
```

2.3 Flare Emission File (FLEMARB.DAT)

CALPUFF v6.42FL accepts a new type of emission source suitable for emergency flare modeling, namely a point source for which all parameters can arbitrarily vary in time. This new format, dubbed FLEMARB.DAT, is an extension of the point-varying emission source format, PTEMARB.DAT.

Flares are treated as arbitrarily-varying point sources with the added flexibility of time-varying location and height in order to track the location of the flame tip. No building downwash is allowed.

The file format is designed to be as general as possible in order to allow additional variables to be taken into account by CALPUFF in the future without a change to the FLEMARB.DAT format. In particular effective exit temperature (T) and exit velocity (u, v, w) have to be specified for each time record but only the temperature and vertical exit velocity are currently taken into account by CALPUFF. An alternative input format in terms of buoyancy (F_b) and momentum (F_{mx}, F_{my}, F_{mz}) fluxes is also possible but not currently supported by CALPUFF.

A FLEMARB.DAT file can contain multiple sources and species, just like a PTEMARB.DAT file. The beginning and ending times of each record are specified in year, Julian: day, hour and seconds, and can be of arbitrarily varying duration. However, as for all other arbitrarily-varying emissions files (PTEMARB, BAEMARB and VOLEMARB), the ending time of one record in FLEMARB.DAT must be equal to the beginning time of the next record and periods of inactivity (zero emission) must be explicitly defined (zero emission rates).

The FLEMARB.DAT record description and format are detailed in Tables 2-2 through 2-5. Not all records in a FLEMARB.DAT file are “free reading” and attention must be paid to the length of each variable, type, and spacing in between them.

Table 2-2 Example Flare Emissions File With Arbitrarily Varying Data (FLEMARB.DAT)

```
FLEMARB.DAT     1.0            Initial configuration
   9
Header records are a mix of formatted and free-format structures
Time-invariant data records are free-format
Time-invariant data records have 8 assignments per source (2-8 are not currently used)
     var1=1: stack inputs are T(K), U, V, W (m/s)
     var1=2: stack inputs are Fb, Fmx, Fmy, Fmz  (i.e., buoyancy and momentum fluxes)
Time-variable data records are free-format
Time-variable data records contain (if var1=1)
     X(km), Y(km), H(mAGL), Elev(mMSL), D(m), T(K), U, V, W, Sigy(m), Sigz(m), Q(g/s)...
Time-variant records contain (if var1=2) --- Not currently available!
UTM
  19N
NAS-C   02-21-2003
  KM
UTC-0500
1990 009  04  0000  1990 009  10 0000
   3   4
'SO2'   'NO'  'NO2'  'PM10'
      30.000      30.000      30.000      30.000
'Source 1'      1.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
'Source 2'      1.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
'Source 3'      1.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
   1990  009  04 0000    1990  009  05 0000
'Source 1'  340.011  4870.443    18.6  160.4  9.754  280.55 0.0   0.0   8.66  1.0   1.0    10.0  4.0  1.0  10.0
'Source 2'  340.486  4870.640    50.1  160.7  4.251  380.4  0.0   0.0   7.66  1.0   1.0    10.0  4.0  1.0  10.0
'Source 3'  341.051  4870.048   35.85  160.9  3.1    289.9  0.0   0.0   2.66  1.0   1.0    10.0  4.0  1.0  10.0
   1990  009  05 0000    1990  009  10 0000
'Source 1'  340.011  4870.443    18.6  160.4  9.754  280.55 0.0   0.0   8.66  1.0   1.0    10.0  4.0  1.0  10.0
'Source 2'  340.486  4870.640    50.1  160.7  4.251  380.4  0.0   0.0   7.66  1.0   1.0    10.0  4.0  1.0  10.0
'Source 3'  341.051  4870.048   35.85  160.9  3.1    289.9  0.0   0.0   2.66  1.0   1.0    10.0  4.0  1.0  10.0
```

Example header records for each map projection (either 2 or 3 records):

Universal Transverse Mercator

```
UTM
  19N
```

Lambert Conformal Conic

```
LCC
40.5N           90.0W           30.0N           60.0N
0.00000000E+00 0.00000000E+00
```

Tangential Transverse Mercator

```
TTM
40.5N           90.0W
0.00000000E+00 0.00000000E+00
```

Polar Stereographic

```
PS
40.5N           90.0W           30.0N
```

Equatorial Mercator

```
EM
0.0N            90.0W
```

Lambert Azimuthal Equal Area

```
LAZA
40.5N           90.0W
0.00000000E+00 0.00000000E+00
```

Table 2-3 Flare Emissions File With Arbitrarily Varying Data (FLEMARB.DAT): Description of Header Variables

FLEMARB.DAT 1.0 Initial configuration	Dataset Name, Dataset Version, Dataset Message (char*16, char*16, char*64) **Format: (2a16,a64)**
9	Number of comment lines to follow (integer) **Free-Format**
Header records are a mix of formatted and free-format structures Time-invariant data records are free-format Time-invariant data records have 8 assignments per source (2-8 are not currently used) var1=1: stack inputs are T(K), U, V, W (m/s) var1=2: stack inputs are Fb, Fmx, Fmy, Fmz (i.e., buoyancy and momentum fluxes) Time-variable data records are free-format Time-variable data records contain (if var1=1) X(km), Y(km), H(mAGL), Elev(mMSL), D(m), T(K), U, V, W, Sigy(m), Sigz(m), Q(g/s).. Time-variant records contain (if var1=2) --- Not currently available!	Comment lines (80 characters per record are read)
UTM **19N**	- Map Projection (char*8) Format: (a8) - UTM Zone, Hemisphere (integer,char*1) **Format: (i4,a1)**
LCC **40.5N 90.0W 30.0N 60.0N** **0.00000000E+00 0.00000000E+00**	- Map Projection (char*8) **Format: (a8)** - Origin Latitude, Origin Longitude, and 2 matching parallels (char*16) **Format: (4a16)** - False Easting and Northing km (real) **Free-Format**
TTM **40.5N 90.0W** **0.00000000E+00 0.00000000E+00**	- Map Projection (char*8) **Format: (a8)** - Origin Latitude, Origin Longitude (char*16) **Format: (2a16)** - False Easting and Northing km (real) **Free-Format**
PS **40.5N 90.0W 30.0N**	- Map Projection (char*8) **Format: (a8)** - Origin Latitude, Origin Longitude, and 1 matching parallel (char*16) **Format: (3a16)**
EM **0.0N 90.0W**	- Map Projection (char*8) **Format: (a8)** - Origin Latitude, Origin Longitude (char*16) **Format: (2a16)**
LAZA **40.5N 90.0W** **0.00000000E+00 0.00000000E+00**	- Map Projection (char*8) **Format: (a8)** - Origin Latitude, Origin Longitude (char*16) **Format: (2a16)** - False Easting and Northing km (real) **Free-Format**
NAS-C 02-21-2003	DATUM code, date (char*8, char*12) **Format: (a8,a12)**
KM	Map units are KM (char*4) **Format: (a4)**
UTC-0500	Time Zone as (UTC+hhmm) (char*8) **Format: (a4)**
1990 009 04 0000 1990 009 10 0000	Start time and end time of data in file as Year, Julian Day, Hour, Second(0-3599) (integer) **Free-Format**
3 4	Number of sources, Number of species (integer) **Free-Format**
'SO2' 'NO' 'NO2' 'PM10'	Species names (char*16) **Free-Format** (quotes required)
30.000 30.000 30.000 30.000	Molecular weights for species (real) **Free-Format**

Table 2-4 Flare Emissions File With Arbitrarily Varying Data (FLEMARB.DAT): Description of Time-Invariant Data

'Source 1' 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 'Source 2' 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 'Source 3' 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Source Name Var1 Var2 Var3 Var4 Var5 Var6 Var7 Var8	Source Name, Var1 - Var8 (char*16, real) **Free-Format** (quotes required on Source Name)
Time-invariant data must be assigned to each of the sources, which are identified by name. In this example, there are 3 sources so there are 3 records. Only the first column of values is currently defined for use, but all 8 columns must have values. Zeros are used for 2-7. Var1 defines the type of source characterization Var1 = 1 : stack inputs are T(K), U, V, W (m/s) Var1 = 2 : stack inputs are Fb, Fmx, Fmy, Fmz (i.e., buoyancy and momentum fluxes)	

Table 2-5 Flare Emissions File With Arbitrarily Varying Data (FLEMARB.DAT): Description of Time-Varying Data

```
   1990  009  04 0000    1990  009  05 0000
'Source 1'  340.011  4870.443    18.6  160.4  9.754  280.55 0.0   0.0   8.66  1.0   1.0    10.0  4.0  1.0  10.0
'Source 2'  340.486  4870.640    50.1  160.7  4.251  380.4  0.0   0.0   7.66  1.0   1.0    10.0  4.0  1.0  10.0
'Source 3'  341.051  4870.048   35.85  160.9  3.1    289.9  0.0   0.0   2.66  1.0   1.0    10.0  4.0  1.0  10.0
```

Source Name	X (KM)	Y (KM)	H (mAGL)	Elev (mMSL)	D (m)	T (K)	U (m/s)	V (m/s)	W (m/s)	Sigmay (m)	Sigmaz (m)	Q1 (g/s)	Q2 (g/s)	Q3 (g/s)	Q4 (4 species here) (g/s)

Time-varying data must be assigned to each of the sources, which are identified by name. These are matched to the names entered in the time-invariant data section. In this example, there are 3 sources and 4 records. The first record contains the start-time and end-time for the period in which the data are valid. The source data follow in the form determined by the value of Var1 entered in the time-invariant data section (current implementation recognizes Var1=1). This set of records is repeated for all time periods in the file.

Record 1: (8 variables)

Start Year, Julian Day, Hour, Second(0-3599), End Year, Julian Day, Hour, Second(0-3599) (integers) **Free-Format**

(Var1=1)
Record 2 through NSRC+1 (NSRC=number of sources):

Source Name, X, Y, H, Elev, D, T, U, V, W, Sigmay, Sigmaz, (Q(n), n=1,NSPEC) (char*16, reals) **Free-Format** (quotes required on Source Name)

- X,Y,H Flare-tip location
- Elev Elevation of the surface above sea level at the flare location
- D Effective flare diameter
- T Effective flare temperature
- U,V,W Effective initial flare velocity components (U along X, V along Y, W vertical)
- Sigmay Initial sigma-y for flare
- Sigmaz Initial sigma-z for flare
- Q(n) Emission rate for each species, in the order defined by the species names in the header

2.4 METSERIES V1.81FL

Modifications to METSERIES v1.81 Level 110308 allow the CALMET surface pressure to be written out in the timeseries output file (TSF file). The code changes can be added to the original v1.81 code by means of a plug-in executable. The resulting code, METSERIES Version 1.81FL, outputs the CALMET surface pressure along with the "OTHER" CALMET micrometeorological variables when the input parameter OTHER is set to 1 in the METSERIES.INP input file. The CALMET surface pressure is flagged by the symbol "SFC_PRESS", written in the last column of the TSF records, and expressed in units of millibars. A timeseries example is displayed in Table 2-6.

With this modification, all the variables that are needed by ABFLARE to compute the flame length, combustion efficiency and flare emissions can be extracted at the flare stack and flame heights and locations by METSERIES, either from a CALMET dataset or from a MM5/WRF file (in M3D format).

Additionally, the plug-in in v1.81FL fixes a bug in v1.81 when METSERIES is used to extract data from a SURF.DAT file with missing records.

Table 2-6 Example TIMESERIES.TSF file (with CALMET surface pressure output)

```
TIMESERIES.TSF  1.3             Full location/date/time documentation
 3      --- comment lines
Created by METSERIES (Version 1.81FL, Level 121201)
Time series from a CALMET.DAT file
NEUTRAL wind profiling method is used
 4      --- station information lines
(11)
CALMET.DAT: Nearest Grid Pt [(I,J)=(    7.000,    7.000)])][(X,Y)km=(   250.000,  4700.000) in MODEL Projection]
Input location:   (X,Y)km=(   250.000  4700.000) in UTM   Projection below
Nearest Grid Pt:  (X,Y)km=(   250.000  4700.000) in UTM   Projection below
UTM
  19N
NAS-C   02-21-2003
KM
UTC-0500
GREGORIAN_YMD
1988  7  7  5 0000 1988  7  7  9 0000    3600
   13     --- measure, units, mol.wt., missing,  Z_m,  X or LON,  Y or LAT
WDIR                 DEGREES   -1.000    9999.000      10.000     250.000    4700.000
WSPEED              M/S                  -1.000    9999.000      10.000     250.000    4700.000
TEMP                K                    -1.000    9999.000      10.000     250.000    4700.000
SHUMID              G/KG                 -1.000    9999.000       1.000     250.000    4700.000
MIXHGT              METERS               -1.000    9999.000       0.000     250.000    4700.000
PRECIP_RATE         MM/HR                -1.000    9999.000       0.000     250.000    4700.000
USTAR                M/S                 -1.000    9999.000       0.000     250.000    4700.000
MONIN_OB            METERS               -1.000    9999.000       0.000     250.000    4700.000
CONV_VEL_S           M/S                 -1.000    9999.000       0.000     250.000    4700.000
SHORT_WAVE          W/M*2                -1.000    9999.000       0.000     250.000    4700.000
STAB_CLASS          CLASS                -1.000    9999.000       0.000     250.000    4700.000
RH_HUMIDITY         %                    -1.000    9999.000       2.000     250.000    4700.000
SFC_PRESS           MB                   -1.000    9999.000       0.000     250.000    4700.000
 1988  7  7  5 0000 1988  7  7  6 0000   262.041     3.376   293.750    12.739   510.963  9999.000     0.599  -6.84096E+02     0.507   123.383         4        82   983.072
 1988  7  7  6 0000 1988  7  7  7 0000   263.098     4.115   295.240    12.960   524.072  9999.000     0.729  -7.50690E+02     0.661   159.348         4        76   983.411
 1988  7  7  7 0000 1988  7  7  8 0000   284.855     3.459   297.105    13.964   446.886  9999.000     0.629  -2.95951E+02     0.846   239.618         4        73   983.749
```

3. Post-Processing

3.1 Overview

Exponent created a series of new postprocessors to compute time-averages, maxima, n^{th} ranked and percentile concentrations (and deposition fluxes). One of the applications for this new set of CALPUFF postprocessors is to meet emergency flaring impact assessment requirements in general and in the Province of Alberta (Canada) in particular.

This new set of processors streamlines the computation of maximum (or n^{th} highest, or percentile) impact created by a short-lived event that can occur anytime during the year. This type of situation is typical for emergency events or upset conditions. In order to assess the potential impact of such an event, ideally 8760 (8784 in a leap year) simulations should be run, averages (if non-hourly averaging times are of interest e.g. daily averages) should be taken for each simulation, maxima should be identified, and then statistics (n^{th} highest, percentile) should be computed across all simulations. The suite of CALAVE-CALMAX-CALRANK processors streamlines this necessary approach as illustrated in Figure 3-1.

For short-lived events (couple of hours) and short-range impacts, it may not be necessary to run 8760 (8784) simulations. The number of simulations could for example be reduced to 24, with each simulation dealing with events starting at one of the 24 hours of the day, and repeating the event at this hour for each day of the year (Simulation 1 would model releases starting during the first hour of each day, Simulation 2 would model releases starting during the second hour of each day, etc.). Because the events and their impacts are short-lived, events on successive days are effectively independent of each other. This approach is often used for the assessment of emergency flaring and is illustrated in Figure 3-2. In any case, whether explicit simulations are run for each possible start time, or whether they are combined, the CALAVE-CALMAX-CALRANK suite can compute the necessary statistics.

Furthermore, any ranked-value or percentile can be computed with CALRANK, which thus extends the CALPOST n^{th} rank capability. Additionally because specific percentile(s) can be

requested explicitly, the user does not have to convert the percentile into an n^{th} rank equivalent before conducting the post-processing.

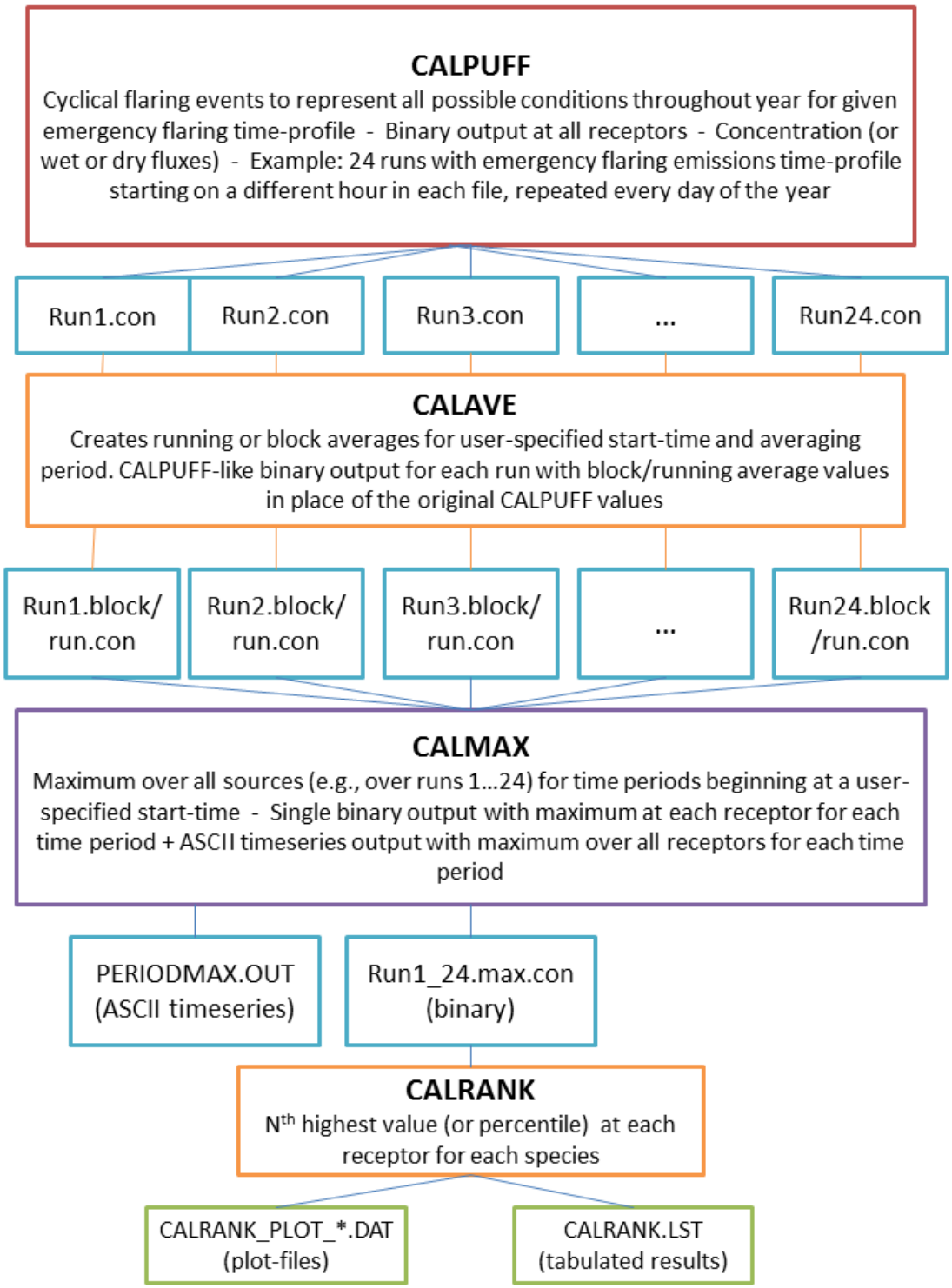

Figure 3-1 Post-Processing Flow

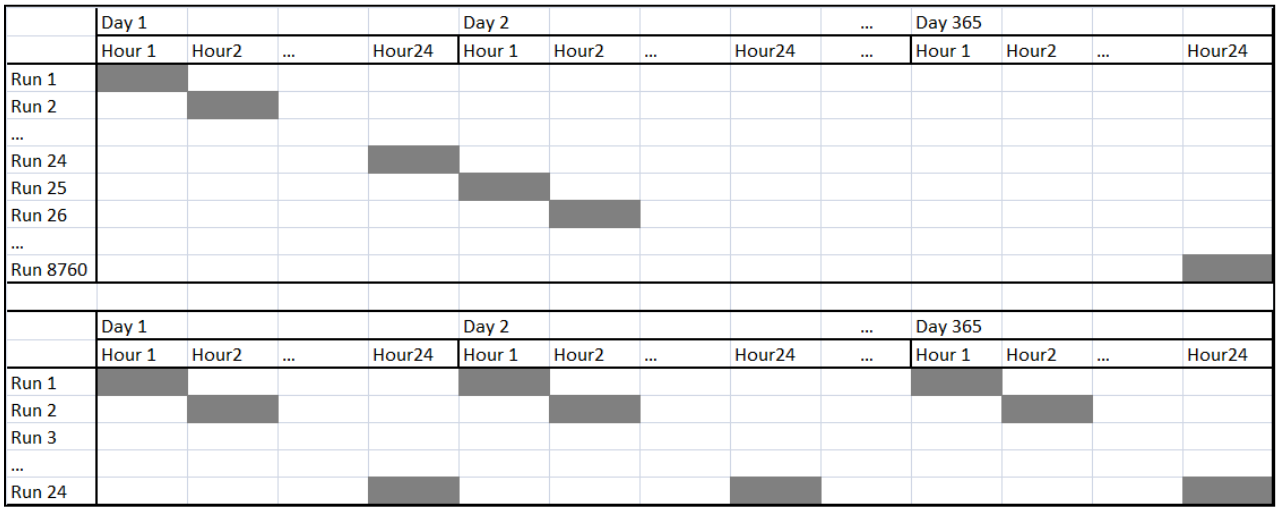

Figure 3-2 Simulation sequence for short-lived, short-range events which can occur any time of the year. Example illustrates 24 simulations with independent events starting every 24 hours in a cyclic fashion can be run instead of 8760 individual runs (hour-long events are shown here).

3.2 CALAVE

CALAVE processes one or more CALPUFF binary output files (dataset v2.1 (CALPUFF output file created by CALPUFF prior to v6.41) or v2.2 (current output format with CALPUFF v6.42 and v6.42FL) and computes either running-averages or block-averages of concentrations, dry deposition fluxes, or wet deposition fluxes for each file. The user instructs CALAVE when to start the averaging and what averaging time to use. A binary output file with a format similar to that of a binary CALPUFF output file is generated for each CALPUFF binary file that is being processed. When blocked averages are produced, the output file is the 'standard' CALPUFF file that can be processed by any of the postprocessors in the CALPUFF system. Running averages use the same format, but because begin and end-times for each average span a duration longer than the interval between the reported values, most of the postprocessors will not accept the running averages.

A sample CALAVE.INP file is included in Appendix A.

3.2.1 Mode 1: Running Averages

In Mode 1, CALAVE reads a CALPUFF output file (CONC, WET, DRY) and creates a running average of its contents. These averages are reported from a specified start-time and are written for each original data-period thereafter.

For example, if 24-hour averages starting at 10 a.m. (start time = 1000) are requested and the original CALPUFF output file contains half-hour values beginning at 0930 on March 13, the following averages will be computed:

1) First 24-hour average: 1000 (March 13) to 1000 (March 14)
2) Second 24-hour average: 1030 (March 13) to 1030 (March 14)
3) Third 24-hour average: 1100 (March 13) to 1100 (March 14)
4) The last 24-hour period will end at the end of the last 30-minute period in the file

3.2.2 Mode 2: Block Averages

In Mode 2, CALAVE reads a CALPUFF output file (CONC, WET, DRY) and creates a blocked average of its contents. These averages are reported from the specified start-time and are written end-to-end thereafter.

For example, if calendar-day 24-hour averages are requested (start time = 0000) and the original CALPUFF output file contains half-hour values beginning at 0930 on March 13, the following averages will be computed:

1) First 24-hour average: 0000 (March 14) to 0000 (March 15)
2) Second 24-hour average: 0000 (March 15) to 0000 (March 16)
3) Third 24-hour average: 0000 (March 16) to 0000 (March 17)
4) The last 24-hour period will end at the end of the last full day in the file

3.3 CALMAX

CALMAX reads a set of CALPUFF-type binary output files either created by CALPUFF directly or averaged with CALAVE, and selects the maximum value at each receptor for each time

period, for each species. The output time periods are contiguous blocks starting at a user-selected date and time, and the averaging time found in the data files determines the length of the block. All input data with a start-time within a block are associated with that block regardless of whether such data include times outside of the block. For example, a 3-hour running-average starting at 0700 covers the period 0700-1000. A CALMAX application with a start-time of 0000 will associate this running-average with the block from 0600-0900.

Many such files can be included without limit and CALMAX will cycle through all, selecting the maximum modeled value for each location and time. Since the main output file from CALMAX is also a CALPUFF-type binary file of "block-averages", CALMAX can be applied sequentially, using a mix of 'regular' CALPUFF files, CALAVE output files, and CALMAX files. The averaging time, receptors and species must be the same in all files.

A CALMAX application creates two output data files:

1. An ASCII timeseries file (PERIODMAX.OUT) of the maximum value over all receptors for each block of time for each species (one value per species per period).
2. A binary CALPUFF-format file of all maximum values (one maximum value at each receptor for each species and 'timestep').

A sample CALMAX input file and PERIODMAX.OUT output file are displayed in Appendix B.

3.4 CALRANK

CALRANK reads a CALPUFF-type concentration/flux output file (Dataset v2.1 or v2.2), ranks the timeseries for each species at each receptor for the entire application period, and identifies the n^{th}-highest values and the percentile values requested in the CALRANK.INP input file. More than one rank or percentile can be requested in a single run, and because of the overhead of ranking all of the values at each receptor, a single application with all desired ranks is normally prepared.

Individual plot-files are created for each requested rank/percentile, and include the location of each receptor, the value of the requested rank/percentile at that receptor, and the date and time at

which that value occurred. If more than one species is in the file, this information is provided for each species. Additionally the largest among all receptors is tabulated for each requested rank/percentile and species in the CALRANK.LST file.

Sample CALRANK.INP (input), CALRANK.LST (output) and CALRANK_PLOT_PCTL-75.00.DAT (75^{th} percentile output) files are displayed in Appendix C

3.5 EXAMPLE

Generate a 90^{th} percentile plot for hourly average impact of an unplanned two-hour long emergency flaring event

Step 1: CALPUFF

Run 24 CALPUFF annual simulations, with 24 FLEMARB.DAT emission files starting on each hour of each day. Each emission profile lasts for 2 hours and is deemed independent and non-interacting with the next one in the same file (starting at the same hour on the following day). The emission profiles are generated with small timesteps and CALPUFF is run with 5 minute timesteps. The set up takes into account the fact that unplanned emergency flaring could start on any hour of the year and the set of meteorological conditions should be taken into account. The 24 CALPUFF simulations are run with the following FLEMARB.DAT emission files and generate the following binary output files (CALPUFF_HH.CON):

1. FLEMARB_00.DAT (CALPUFF Emission starting at 0000 on Days 1, 2, 3 ….Day 365) → CALPUFF_00.CON

2. FLEMARB_01.DAT (CALPUFF Emission starting at 0100 on Days 1, 2, 3 ….Day 365) → CALPUFF_01.CON

   … (2 - 22 removed)

24. FLEMARB_23.DAT (CALPUFF Emission starting at 2300 on Days 1, 2, 3 ….Day 365) → CALPUFF_23.CON

Step 2: CALAVE

Run a single CALAVE simulation which will compute 1 hour block averages for each of the 24 annual CALPUFF simulations at each receptor, and create 24 annual CALPUFF binary output files with hourly timesteps (i.e. the 5 minute concentrations within every hour will be averaged to hourly values). CALAVE should be set up with:

- 24 CALPUFF_HH.CON files as input
- 1 hour averaging period (AVGPD_HH = 1 ; AVGPD_MM = 0)
- Mode =2 (block averages)
- Start time (00)
- → 24 output files:

  CALPUFF_00.CON.1BLOCK

  CALPUFF_01.CON.1BLOCK

  …

  CALPUFF_23.CON.1BLOCK

Step 3: CALMAX

Run a single CALMAX simulation to compute the maximum hourly concentrations at each receptor for each hour of the year. The maximum at each receptor is taken across the 24 CALPUF.CON.1BLOCK files generated by CALAVE.

- Input files: CALPUFF_01.CON.1BLOCK, … CALPUFF_23.CON.1BLOCK
- Output file: CALMAX_1hr.CON

Step 4: CALRANK

Run a single CALRANK simulation requesting the 90^{th} percentile -> 90^{th} percentile at each receptor for each species, date and time at which it occurred

- Input file: CALMAX_1hr.CON
- Statistic parameter: PERCENTILE = 90 (specified in CALRANK.INP)
- Output plot file: PLOT_PCTL-90.000.DAT

Appendix A

Sample CALAVE.INP

CALAVE.INP

```
CALAVE.INP      1.0             Test Configuration
------------------------------------------------------------------------------

                    CALAVE Processor CONTROL FILE
                    -----------------------------
PURPOSE
-------

Mode 1:  Running averages

This utility reads a CALPUFF output file (CONC, WET, DRY) and creates a running
average of its contents.  These averages are reported from a specified start-time
and are written for each data period thereafter.

For example, if 24-hour averages starting at 10AM (start time = 10:00) are
requested and the original CALPUFF output file contains half-hour values
beginning at 0930 on March 13:

  First  24-hour average:  1000 (March 13) to 1000 (March 14)
  Second 24-hour average:  1030 (March 13) to 1030 (March 14)
  Third  24-hour average:  1100 (March 13) to 1100 (March 14)

The last 24-hour period will end at the end of the last 30-minute period in the file.

Mode 2:  Block averages

This utility reads a CALPUFF output file (CONC, WET, DRY) and creates a blocked
average of its contents.  These averages are reported from a specified start-time
and are written end-to-end thereafter.

For example, if calendar-day 24-hour averages are requested (start time = 00:00)
and the original CALPUFF output file contains half-hour values beginning at 0930
on March 13:

  First  24-hour average:  0000 (March 14) to 0000 (March 15)
  Second 24-hour average:  0000 (March 15) to 0000 (March 16)
  Third  24-hour average:  0000 (March 16) to 0000 (March 17)

The last 24-hour period will end at the end of the last full day in the file.

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

 Processing Options
-------------------

     Define the output averaging period in hours and minutes.  Typically, the
     hours will be zero when minutes are non-zero, and minutes will be zero
     when hours are non-zero.

     Averaging Period (hours)             Default: 0     ! AVGPD_HH =   3  !
     Averaging Period (minutes)           Default: 0     ! AVGPD_MM =   0  !


     Mode                                 No Default     ! MODE =  1  !
         1 = Running averages
         2 = Block averages

     Starting time (HHMM)                 Default: 0000  ! START_HHMM =  0000  !




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

   Output files are named by adding characters to the end of the input filenames
   in the form of a new extension.  For example, if an extension '.24_running'
   is entered, the output associated with the first file above would be named
```

```
   'source1.dat.24_running'.  Enter the extension, including any punctuation
   (must resolve to a legal file name) between delimiters:

     Output data file extension            Default: .ave  ! OUT_EXT = .24run !


   Name of output list file for run:

     List-file name               Default: CALAVE.LST     ! LSTFILE = calave.lst !



All file names will be converted to either lower or upper case
         T = lower case       (LCFILES)    Default: F     ! LCFILES = F !
         F = UPPER CASE


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

   Provide one or more filenames for CALPUFF files to process
   (place assignments between delimiters):

      ! INPFILE = source1.dat !
      ! INPFILE = source2.dat !
      ! INPFILE = source3.dat !
      ! INPFILE = source4.dat !
      ! INPFILE = source5.dat !
      ! INPFILE = source6.dat !
```

Appendix B

Sample CALMAX.INP and PERIODMAX.OUT

CALMAX.INP

```
CALMAX.INP      1.0             Test Configuration
------------------------------------------------------------------------------

                    CALMAX Processor CONTROL FILE
                    -----------------------------
PURPOSE
-------

This utility reads a set of CALPUFF-format output files (CONC, WET, or DRY)
and selects the maximum value at each receptor for each block of time.  These
time-blocks start at the beginning of the processing period defined below,
and the length of each block is equal to the averaging time of the data in the
input files (averaging time in all input files must match).  The input data
may consist of block-averages or running-averages.  The start of each average
may be different among the set of input files.  All averages with a start-time
that falls within an output time-block are compared when selecting the maximum
for the time-block.  If the period of data in a file begins later or ends
earlier than the processing period, CALMAX assumes that those data are zero at
these times.

Example:

Time         File 1            File2         Output Block
           (3-hr Avg)        (3-hr Avg)       (3-hr Avg)
-----------------------------------------------------
0000           x                 x               1 (start)
0100           x                 1 (start)       |   File2(1)
0200           x                 |               |
-----------------------------------------------------
0300           x                 |               2
0400           x                 2               |   File2(2)
0500           x                 |               |
-----------------------------------------------------
0600           1 (start)         |               3
0700           |                 3               |   MAX(File1(1),File2(3))
0800           |                 |               |
-----------------------------------------------------
0900           2                 |               4
1000           |                 4               |   MAX(File1(2),File2(4))
1100           |                 |               |
-----------------------------------------------------
1200           3                 |               5
1300           |                 x               |   File1(3)
1200           |                 x               |
-----------------------------------------------------

Many CALPUFF output files can be included without limit and CALMAX will cycle
through all.  Receptors and species must be the same in all files.

CALMAX creates a binary CALPUFF-format file of maximum values for each
species and each receptor for each time-block, which can be processed like any
standard CALPUFF file.  It also creates an ASCII timeseries file of the maximum
across all receptors for each time-block and each species.
------------------------------------------------------------------------------

 Processing Period
-------------------

     Starting date:    Year     (S_YEAR)  --   No default   ! S_YEAR  =  1995  !
                       Month    (S_MONTH) --   No default   ! S_MONTH =  6  !
                       Day      (S_DAY)   --   No default   ! S_DAY   =  30 !
     Starting time:    HH:MM:SS (S_TIME)  --   No default   ! S_TIME  =  16:00:00  !

     Ending date:      Year     (E_YEAR)  --   No default   ! E_YEAR  =  1995  !
                       Month    (E_MONTH) --   No default   ! E_MONTH =  7  !
                       Day      (E_DAY)   --   No default   ! E_DAY   =  31 !
     Ending time:      HH:MM:SS (E_TIME)  --   No default   ! E_TIME  =  20:00:00  !
```

```
Output Files
------------

   ASCII file of Time-Block-Maximum values:

     File name                    No Default             ! PERFILE = calmax_period_blk_s.con !


   Binary CALPUFF-format file of all maximum values:

     File name                    No Default             ! BINFILE = calmax_test_blk_s.bin !


   Name of output list file for run:

     List-file name               Default: CALAVE.LST    ! LSTFILE = calmax_test_blk_s.lst !


All file names will be converted to either lower or upper case
         T = lower case       (LCFILES)    Default: F     ! LCFILES = F !
         F = UPPER CASE


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

   Provide two or more filenames for CALPUFF files to process
   (place assignments between delimiters):

      ! INPFILE = flare.con.01-03blk !
      ! INPFILE = flare.con.02-03blk !
      ! INPFILE = flare.con.03-03blk !
      ! INPFILE = flare.con.04-03blk !
      ! INPFILE = flare.con.05-03blk !
      ! INPFILE = flare.con.06-03blk !
      ! INPFILE = flare.con.07-03blk !
      ! INPFILE = flare.con.08-03blk !
      ! INPFILE = flare.con.09-03blk !
      ! INPFILE = flare.con.10-03blk !
      ! INPFILE = flare.con.11-03blk !
      ! INPFILE = flare.con.12-03blk !
      ! INPFILE = flare.con.13-03blk !
      ! INPFILE = flare.con.14-03blk !
      ! INPFILE = flare.con.15-03blk !
      ! INPFILE = flare.con.16-03blk !
      ! INPFILE = flare.con.17-03blk !
      ! INPFILE = flare.con.18-03blk !
      ! INPFILE = flare.con.19-03blk !
      ! INPFILE = flare.con.20-03blk !
      ! INPFILE = flare.con.21-03blk !
      ! INPFILE = flare.con.22-03blk !
      ! INPFILE = flare.con.23-03blk !
      ! INPFILE = flare.con.24-03blk !
```

PERIODMAX.OUT

```
PERIODMAX.OUT   1.0
  8
--------------------------------------------------------------------------
Prepared by CALMAX Version 1.1          Level 120915
Maxima from a set of CALPUFF output files; information about first is:
Processed by CALAVE Version 1.1          Level 120915
Original CALPUFF output is averaged to    3-hour,  0-minute periods
Averaging Method for Output:  RUNNING
CALPUFF      Version 6.42         Level 110325
--------------------------------------------------------------------------
START(YYYYJJJHHSSSS) =       1995181160000
END  (YYYYJJJHHSSSS) =       1995212190000
NUMBER_PERIODS       =   249
NUMBER_SPECIES       =     2
'SO2           1'    'g/m3           '
'SO4           1'    'g/m3           '
 1995181160000 1995181190000      0.0000000E+00  0.0000000E+00
 1995181190000 1995181220000      0.1236652E-06  0.4296419E-06
 1995181220000 1995182010000      0.1620922E-06  0.4367350E-06
 1995182010000 1995182040000      0.1920760E-06  0.5641223E-06
 1995182040000 1995182070000      0.2449551E-06  0.6999548E-06
 1995182070000 1995182100000      0.2414128E-06  0.7225233E-06
 1995182100000 1995182130000      0.2257391E-06  0.8143888E-06
 1995182130000 1995182160000      0.2091050E-06  0.7982892E-06
 1995182160000 1995182190000      0.1993398E-06  0.7821818E-06
 1995182190000 1995182220000      0.1405862E-06  0.8824974E-06
 1995182220000 1995183010000      0.1541312E-06  0.7509557E-06
 1995183010000 1995183040000      0.1941535E-06  0.7105132E-06
 1995183040000 1995183070000      0.2419434E-06  0.7160419E-06
 1995183070000 1995183100000      0.2379932E-06  0.7245426E-06
 1995183100000 1995183130000      0.2252482E-06  0.7410509E-06
 1995183130000 1995183160000      0.2118052E-06  0.7659141E-06
 1995183160000 1995183190000      0.2213503E-06  0.6943087E-06
 1995183190000 1995183220000      0.2206614E-06  0.7885833E-06
 1995183220000 1995184010000      0.1754233E-06  0.6280415E-06
  . . .  (records removed)
 1995211040000 1995211070000      0.2389819E-06  0.9125792E-06
 1995211070000 1995211100000      0.2448705E-06  0.9817674E-06
 1995211100000 1995211130000      0.2148565E-06  0.9891634E-06
 1995211130000 1995211160000      0.2138693E-06  0.8830513E-06
 1995211160000 1995211190000      0.2050581E-06  0.8602494E-06
 1995211190000 1995211220000      0.1671577E-06  0.8617992E-06
 1995211220000 1995212010000      0.1653654E-06  0.7678133E-06
 1995212010000 1995212040000      0.1733464E-06  0.7147995E-06
 1995212040000 1995212070000      0.2328687E-06  0.7122401E-06
 1995212070000 1995212100000      0.2320222E-06  0.4438733E-06
 1995212100000 1995212130000      0.2211245E-06  0.4894759E-06
 1995212130000 1995212160000      0.2021380E-06  0.5094999E-06
 1995212160000 1995212190000      0.1918380E-06  0.5112856E-06
```

Appendix C

Sample CALRANK.INP, CALRANK.LST, and CALRANK_PLOT_PCTL.DAT

CALRANK.INP

```
CALRANK.INP     1.0             Test Configuration
------------------------------------------------------------------------------

                    CALRANK Processor CONTROL FILE
                    ------------------------------
PURPOSE
-------

This utility reads a CALPUFF-type concentration/flux output file (dataset v2.1
or v2.2), ranks the timeseries for each species at each receptor, and identifies
the nth-highest values and the percentile values requested below.
Plot-files are created for each requested rank/percentile, and the largest among
all receptors is tabulated for each rank/percentile and species.
------------------------------------------------------------------------------


Input File
----------

   File of modeled data (include path if desired):

     File name          No Default             ! DATFILE = CALMAX_TEST_BLK.BIN !


Results File
------------

   Name of output list file of results for run (include path if desired):

     File name          Default: CALRANK.LST    ! LSTFILE = calrank_test_blk.lst !


Plot Files
----------

Plot files are created for each rank/percentile requested, reporting the ranked value
of each species for each receptor with records containing x,y,v(1),v(2),...,v(nspec).
The filenames have a default structure composed of the results file name [LSTFILE]
with the rank or percentile appended.

Nth-Rank Plot File         [LSTFILE]_PLOT_RANK-nnnn.DAT
Pth-Percentile Plot File   [LSTFILE]_PLOT_PCTL-pp.ppp.DAT

All file names will be converted to either lower or upper case
         T = lower case       (LCFILES)    Default: F     ! LCFILES = F !
         F = UPPER CASE
```

```
Processing Options
------------------

   Report values corresponding to the following Nth-highest and percentile values.
      Enter specific ranks using either NTH_HIGHEST or PERCENTILE within
      delimiters (exclamation point), placing one assignment per line

     ! NTH_HIGHEST  =   2  !
     ! NTH_HIGHEST  =   8  !
     ! NTH_HIGHEST  =   12 !


     ! PERCENTILE   =  98  !
     ! PERCENTILE   =  95  !
     ! PERCENTILE   =  90  !
     ! PERCENTILE   =  75  !


   Reported mass units
                            (MASS_UNIT)   Default: 1     ! MASS_UNIT = 3 !

      1:    g/m**3   or    g/m**2/s        grams
      2:   mg/m**3   or   mg/m**2/s   milligrams  (1.0e-03 g)
      3:   ug/m**3   or   ug/m**2/s   micrograms  (1.0e-06 g)
      4:   ng/m**3   or   ng/m**2/s    nanograms  (1.0e-09 g)
      5:   pg/m**3   or   pg/m**2/s    picograms  (1.0e-12 g)


   Peak values that are ranked may be restricted to no more than 1 per calendar
   day (e.g., the calendar-day maximum).  The day in which a value is placed is
   determined by its start-time.

   Report as Calendar-Day maximums?
                             (ICDAY)      Default: 0     ! ICDAY = 0 !
           0 = No  : all values at each receptor are ranked
                     (more than 1 rank may be in same day)
           1 = Yes : peak value in calendar day at each receptor is ranked
```

CALRANK.LST

```
                    CALRANK RESULTS SUMMARY
                VERSION:1.1           LEVEL:120915


 File Processed: CALMAX_TEST_BLK.BIN

 Selected Header Information From File:
--------------------------------------------------------------------------------
Processed by CALMAX Version 1.0          Level 120915
Maxima from the set of CALPUFF output files is obtained
Processed by CALAVE Version 1.0          Level 120915
Original CALPUFF output is averaged to    3-hour,  0-minute periods
Averaging Method for Output:  BLOCK
Produced by CALPUFF Version: 6.42    Level: 110325
--------------------------------------------------------------------------------
 Information about data in file

 Averages (DAY,HH,MM,SS) =   0 3 0 0
 Type of Averaging       =  BLOCK
 Number of averages/day  =  8
 Number of days          =  32
 Number of receptors     =  20
 Number of species       =  6
 First day (YYYYJJJ)     =  1995181     UTC-0700
 Last day (YYYYJJJ)      =  1995212     UTC-0700


 Model data for each receptor are ranked over all times based on magnitude and
 the requested Nth-Highest and/or Percentile values are reported for each receptor
 in the output files:

 CALRANK_TEST_BLK_UG.LST_PLOT_RANK-0002.DAT
 CALRANK_TEST_BLK_UG.LST_PLOT_RANK-0008.DAT
 CALRANK_TEST_BLK_UG.LST_PLOT_RANK-0012.DAT
 CALRANK_TEST_BLK_UG.LST_PLOT_PCTL-98.000.DAT
 CALRANK_TEST_BLK_UG.LST_PLOT_PCTL-95.000.DAT
 CALRANK_TEST_BLK_UG.LST_PLOT_PCTL-90.000.DAT
 CALRANK_TEST_BLK_UG.LST_PLOT_PCTL-75.000.DAT
```

The largest of these for each rank are tabulated below with the location and time

Tabulation for Requested Nth-Highest Values
Results for the Maximum Receptor
All Values in Each Day are Included

N	Percentile	Species - Level	Modeled	Units	Location X (KM)	Location Y (KM)	Starting UTC-0700 Date (YYYY_JJJ)	Starting UTC-0700 Time (HH:MM:SS)
2	99.414	SO2 1	6.4238036E-01	ug/m3	-45.636	17.249	1995_210	09:00:00
8	97.070	SO2 1	5.7844645E-01	ug/m3	-45.636	17.249	1995_190	15:00:00
12	95.508	SO2 1	5.4899251E-01	ug/m3	-22.266	-5.743	1995_190	06:00:00
2	99.414	SO4 1	2.0132611E+00	ug/m3	-49.056	20.559	1995_192	09:00:00
8	97.070	SO4 1	1.3413306E+00	ug/m3	-23.587	19.800	1995_187	21:00:00
12	95.508	SO4 1	1.2776209E+00	ug/m3	-22.266	-5.743	1995_188	00:00:00
2	99.414	NO 1	2.4241890E-01	ug/m3	-86.380	90.776	1995_186	06:00:00
8	97.070	NO 1	2.1577983E-01	ug/m3	-86.380	90.776	1995_205	06:00:00
12	95.508	NO 1	1.7484842E-01	ug/m3	-86.380	90.776	1995_201	06:00:00
2	99.414	NO2 1	5.8553219E-01	ug/m3	-86.380	90.776	1995_208	00:00:00
8	97.070	NO2 1	5.5068791E-01	ug/m3	-86.380	90.776	1995_208	03:00:00
12	95.508	NO2 1	5.4399544E-01	ug/m3	-86.380	90.776	1995_204	00:00:00
2	99.414	HNO3 1	1.6972790E+00	ug/m3	-73.181	19.414	1995_187	15:00:00
8	97.070	HNO3 1	1.5065962E+00	ug/m3	-23.587	19.800	1995_191	15:00:00
12	95.508	HNO3 1	1.4168251E+00	ug/m3	-45.636	17.249	1995_193	15:00:00
2	99.414	NO3 1	2.4409448E-01	ug/m3	-23.587	19.800	1995_200	15:00:00
8	97.070	NO3 1	9.6489988E-02	ug/m3	-36.765	7.793	1995_193	00:00:00
12	95.508	NO3 1	7.0543371E-02	ug/m3	-95.958	46.149	1995_183	00:00:00

Note: number of times in period = 256

Tabulation for Requested Percentile Values
Results for the Maximum Receptor
All Values in Each Day are Included

N	Percentile	Species - Level	Modeled	Units	Location X (KM)	Location Y (KM)	Starting UTC-0700 Date (YYYY_JJJ)	Starting UTC-0700 Time (HH:MM:SS)
6	98.000	SO2 1	6.0360593E-01	ug/m3	-22.266	-5.743	1995_193	09:00:00
14	95.000	SO2 1	5.3457832E-01	ug/m3	-22.266	-5.743	1995_193	12:00:00
27	90.000	SO2 1	4.5703641E-01	ug/m3	-23.587	19.800	1995_191	12:00:00
65	75.000	SO2 1	2.2311690E-01	ug/m3	-45.636	17.249	1995_182	06:00:00
6	98.000	SO4 1	1.3920479E+00	ug/m3	-82.802	31.563	1995_191	03:00:00
14	95.000	SO4 1	1.2384740E+00	ug/m3	-23.587	19.800	1995_190	06:00:00
27	90.000	SO4 1	1.0732707E+00	ug/m3	-56.449	16.810	1995_188	00:00:00
65	75.000	SO4 1	7.2078431E-01	ug/m3	-45.636	17.249	1995_197	09:00:00
6	98.000	NO 1	2.2316346E-01	ug/m3	-86.380	90.776	1995_204	06:00:00
14	95.000	NO 1	1.5821451E-01	ug/m3	-86.380	90.776	1995_198	09:00:00
27	90.000	NO 1	1.3154908E-01	ug/m3	-86.380	90.776	1995_205	09:00:00
65	75.000	NO 1	8.1808403E-02	ug/m3	-86.380	90.776	1995_195	09:00:00
6	98.000	NO2 1	5.5393910E-01	ug/m3	-86.380	90.776	1995_185	21:00:00
14	95.000	NO2 1	5.3284913E-01	ug/m3	-86.380	90.776	1995_210	21:00:00
27	90.000	NO2 1	4.9811035E-01	ug/m3	-86.380	90.776	1995_185	03:00:00
65	75.000	NO2 1	3.8550305E-01	ug/m3	-86.380	90.776	1995_194	03:00:00
6	98.000	HNO3 1	1.5779656E+00	ug/m3	-45.636	17.249	1995_191	15:00:00
14	95.000	HNO3 1	1.3985200E+00	ug/m3	-22.266	-5.743	1995_190	06:00:00
27	90.000	HNO3 1	1.2455554E+00	ug/m3	-22.266	-5.743	1995_193	09:00:00
65	75.000	HNO3 1	1.0136856E+00	ug/m3	-22.266	-5.743	1995_183	09:00:00
6	98.000	NO3 1	1.3482775E-01	ug/m3	-95.958	46.149	1995_193	21:00:00
14	95.000	NO3 1	6.2677436E-02	ug/m3	-56.449	16.810	1995_203	03:00:00
27	90.000	NO3 1	3.5989128E-02	ug/m3	-95.958	46.149	1995_192	12:00:00
65	75.000	NO3 1	2.1382032E-03	ug/m3	-56.449	16.810	1995_197	21:00:00

Note: number of times in period = 256

CALRANK_PLOT_PCTL.DAT

```
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Requested Values for Percentile (%) =  75.000
Corresponding Nth-Highest N         =      65
All Values in Each Day are Included
Number of times in period           =     256
-------------------------------------------
```

Model data for each receptor are ranked over all times based on magnitude and
the requested Nth-Highest and/or Percentile values are reported for each receptor

Location X (KM)	Location Y (KM)	Species - Level SO2 1 ug/m3	Starting UTC-0700 Date (YYYY_JJJ)	Starting UTC-0700 Time (HH:MM:SS)	Species - Level SO4 1 ug/m3	Starting UTC-0700 Date (YYYY_JJJ)	Starting UTC-0700 Time (HH:MM:SS)
-112.534	73.569	2.1135101E-01	1995_208	12:00:00	6.5649730E-01	1995_206	12:00:00
-96.928	42.265	2.1820070E-01	1995_196	09:00:00	6.7459333E-01	1995_198	15:00:00
-22.266	-5.743	2.2265026E-01	1995_187	09:00:00	7.0490843E-01	1995_187	00:00:00
-23.587	19.800	2.1413609E-01	1995_195	09:00:00	6.9981647E-01	1995_194	12:00:00
-86.380	90.776	2.2001354E-01	1995_208	15:00:00	6.5835202E-01	1995_210	03:00:00
-87.952	52.945	2.1083651E-01	1995_183	15:00:00	6.7068070E-01	1995_194	15:00:00
-49.056	20.559	2.1864684E-01	1995_196	09:00:00	7.0782602E-01	1995_211	00:00:00
-48.990	18.439	2.1931919E-01	1995_187	06:00:00	6.8925285E-01	1995_209	12:00:00
-35.131	7.998	2.1881981E-01	1995_194	09:00:00	6.9019318E-01	1995_211	15:00:00
-86.481	69.038	2.1725047E-01	1995_183	15:00:00	6.5713358E-01	1995_206	12:00:00
-61.098	34.721	2.1867444E-01	1995_210	12:00:00	6.8315142E-01	1995_192	00:00:00
-45.636	17.249	2.2311690E-01	1995_182	06:00:00	7.2078431E-01	1995_197	09:00:00
-36.765	7.793	2.1968804E-01	1995_194	09:00:00	6.9777107E-01	1995_206	00:00:00
-100.509	80.586	2.1060951E-01	1995_194	09:00:00	6.5706438E-01	1995_195	15:00:00
-108.462	60.535	2.1599288E-01	1995_208	15:00:00	6.6985178E-01	1995_189	15:00:00
-56.449	16.810	2.1571998E-01	1995_182	06:00:00	7.0858204E-01	1995_211	18:00:00
-82.802	31.563	2.2208786E-01	1995_189	09:00:00	6.7448241E-01	1995_197	15:00:00
-73.181	19.414	2.2289866E-01	1995_183	09:00:00	7.1023667E-01	1995_183	18:00:00
-38.410	4.943	2.1189842E-01	1995_188	03:00:00	6.8579751E-01	1995_209	12:00:00
-95.958	46.149	2.1288925E-01	1995_183	15:00:00	6.7593855E-01	1995_201	12:00:00