# MetCor User Guide

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1.0 Copyright Notice and Disclaimer

DEFINITIONS
1.   "Installation Package" shall mean all files contained in the "MetCor_setup.exe" file.

2.   "Package" shall mean all of the files contained in the Installation Package except those explicitly belonging to the Java Runtime Environment and those under the folder entitled "lib".

3.   "Software" shall mean an installed copy of this Package.

4.   "Modification" shall mean any provisions made to the Software or this Package. Modifications include but are not limited to changes in the Software's source code which change the output and behaviour of the Software.

5.   "Modified Package" shall mean a derivative of the Package created as a result of one or more Modification applied to the Software and/or Package.

6.   "Distribution" shall mean allowing one or more other people to in any way download or receive a copy of this Package, Modified Package or Installation Package.

7.   "Author" shall mean the copyright holder of the Software, Package and Installation Package.

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2.0 Overview

MetCor (**Met**eorological **Cor**relation) contains a suite of tools used in the analysis of data contained in geospatial coordinates. Geospatial coordinates can exist as endpoints in meteorological backward or forward trajectories in the Canadian Meteorological Centre (CMC) 3-dimensional or Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) format. Data is added to these geospatial coordinates on the basis of a unique identifier given to points belonging to the same back trajectory. The identifier in the CMC and the HYSPLIT format is the back trajectory starting date.

In addition to histogram tools and elevations for endpoint analysis, MetCor is mainly used in conjunction with correlated data for the calculation of Particle Source Contribution Function (PSCF) value matrices. These matrices can be visualized by geographical information system (GIS) software.

The following subsection describes how endpoints are organized and how PSCF values are calculated in MetCor.

2.1 Models and Visualization

Upon extracting endpoints from trajectories, MetCor organizes these points into an array of grids with finite area meant to represent all or part of the world. The area of the grid is specified by a single grid's length and width in latitude and longitude degrees, respectively.
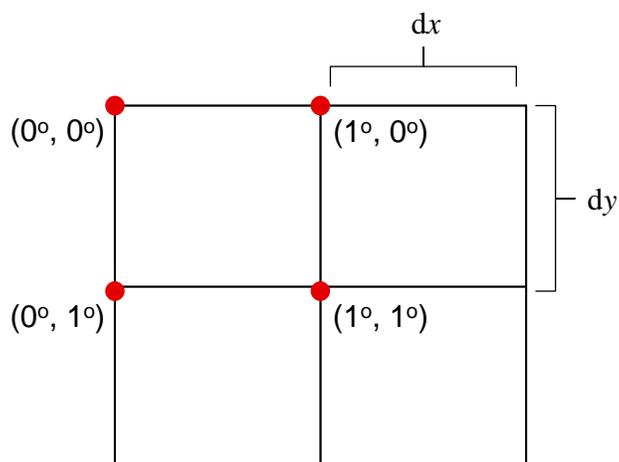
Figure 1: A representation of a part of the world by an array of grids. Latitude and Longitude Degrees are used as units here.

A single grid's geospatial coordinates are represented by the latitude and longitude of its top-left corner. Each grid in the array has a uniform size specified by $\mathrm{d}x$ and $\mathrm{d}y$ such that:

$$\{\mathrm{d}x \in \mathrm{R} \ \wedge \ \mathrm{d}y \in \mathrm{R} \ | \ \mathrm{d}x > 0 \ \wedge \ \mathrm{d}y > 0\}$$

On the basis of their geospatial coordinates, endpoints are abstractly arranged into the appropriate grid representing the world. Each endpoint, P is defined by its geospatial coordinates x and y, an identifier k, an optional starting elevation e and a set of correlated data specific to the identifier, C_k:

$$P_{k,e} = (x_{k,e}, y_{k,e}, C_k)$$

When loading endpoints from trajectories, k is typically the starting date of the back trajectory and data is added to appropriate points on the basis of k. A grid can be defined by the geospatial coordinates x_o and y_o, a set of points $\{P_{k,e}\}$, the grid resolution and the number of points in the grid with a non-empty set C_k, n (also known as the "grid population").

$$G = (x_o, y_o, dx, dy, \{P_{k,e}\}, n). \quad n \in I \mid n > 0$$

The world, W, can be represented by a 2-dimensional matrix of grids with a corner latitude and longitude defined by i and j such that $x_o = i$ and $y_o = j$. W can span all or part of the world, defined by a maximum longitude X and Y such that $0 < X \leq 360$ and $-90 < Y \leq 90$.

$$W = [G_{ij}] = [x_{oij}, y_{oij}, dx, dy, \{P_{k,e}\}_{ij}, n_{ij}]$$

The concentration data for each point, C_k, can be represented as a pair containing the name of the variable, s and its value v, where $\#b$ represents the number of different variables existing in the set C_k.

$$C_k = \{s_b, v_{bk}\}_{b=0}^{\#b}$$

PSCF value for a variable with the name s can be calculated for W the by the expression:

$$[PSCF_{ij}]_{s_b} = w(n_{ij}) \left[\frac{m_{ij}}{n_{ij}} \right] \quad \text{OR} \quad [PSCF_{ij}]_{s_b} = w(\#k, e \text{ in } G_{ij}) \left[\frac{m_{ij}}{n_{ij}} \right]$$

where m_{ij} is the number of points in G_{ij} whose corresponding v_{bk} falls above or at a threshold value v_{bT}. The PSCF value is weighted by a positive, real value w obtained as a function of the grid population or the number of unique identifiers and starting elevations in a grid itself ($\#k,e$ in G_{ij}). In PSCF analyses, only the points with correlated data are considered in all calculations.

The number of PSCF matrices is therefore $\#b$. It is important to note that for a grid with $n_{ij} = 0$ a meaningless no-data value is given to $PSCF_{ij}$. The number of grids in the world and consequently the number of data elements in each PSCF matrix is $\#G$, given by:

$$\#G = \left(\frac{X}{dx} \right)\left(\frac{Y}{dy} \right) \quad \ni \quad X \bmod dx = Y \bmod dy = 0$$

3.0 Installation Procedure

3.1 Minimum Hardware Requirements

According to the requirements of a calculation or "job" as outlined in section 2.0, MetCor required different amounts of computational resources. The memory used depends most significantly on grid resolution (section 4.6) and the number of variables in analysis (section yet also on the number of trajectories being analyzed.

The chart below shows minimum and recommended hardware requirements for MetCor calculations:

	Minimum	Recommended
Processor	800 MHz (single core)	1.0 GHz (multi-core)
Physical Memory (RAM)	512 MB*	3.0 GB
Free Hard Drive Space	500 MB	4 GB
Monitor Resolution	1024 x 768 px.	1280 x 800 px.

*limits calculation jobs to lower grid resolutions and smaller spatial extent

3.2 Supported Operating Systems and Required Libraries

The following operating systems have been tested with MetCor:

Windows-based Operating Systems:
-   Microsoft Windows (Windows 7, Windows Vista, Windows XP, Windows 2000)

Unix-based Operating Systems:
-   Ubuntu Linux (versions 8.04, 8.10, 9.04, 9.10, 10.04)
-   Mac OS X (versions 10.5, 10.6)

Provided that the minimum hardware requirements are met, any operating system which supports the Java Runtime Environment (version 1.6.0) should be able to run MetCor without issue.

Installation instructions for running MetCor each platform can be found in the README file associated with the setup.exe file (for Windows based operating systems) or .tar.gz file (for Unix based operating systems). The same README file is found in the installation directory. It also contains information on setting up shortcuts and launchers for Unix-based operating systems.

The amount of memory which MetCor uses depends on the operating system in use. In Windows based operating systems, MetCor will use anywhere from 25% to 100% of free available memory. The amount of memory installed for Unix-based operating systems is user defined.

4.0 Basic Operation

4.1 Overview and Flowchart

MetCor consists of two components: the implementation of the model described in Section 2.1 as well as a graphical user interface which serves as the implementation's front end. A flowchart describes the typical set up and MetCor's flow of execution (Figure 2).
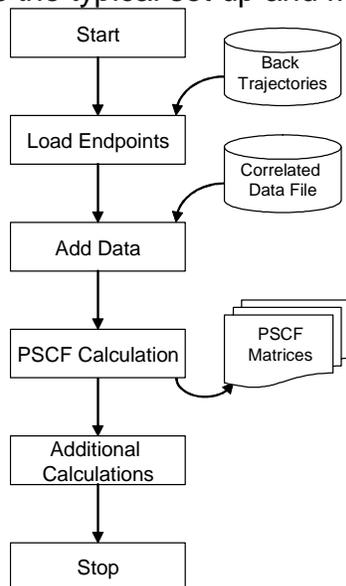
User input provided to MetCor must meet specific formatting requirements for successful analysis and meaningful results

Figure 2: Flow of execution. Trajectories and correlated data files are stored as files on disk. PSCF Matrices and other files generated in "Additional Calculations" are written to disk.

The MetCor interface consists of a single window (Figure G1) with 4 categorical tabs: **File Information, Binning, PSCF** and **Utilities.** Each of the tabs contains fields which must be appropriately filled out to ensure successful results and calculations.
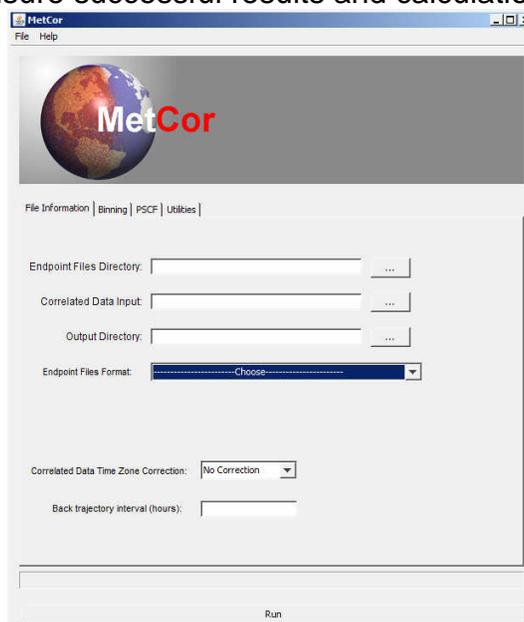
Figure G1: The MetCor user interface.

4.2 Endpoint Files and Directories

MetCor is currently able to extract endpoints from CMC and HYSPLIT formatted trajectories. The trajectory files can exist with any file extension yet must exist in a single directory. The directory must only contain back trajectory files.

An example of a CMC formatted back trajectory is shown in Figure 3.

```
 1     '
 2    Little_Fox_Lake
 3     '
 4           1,'H'           mode et coord
 5    .TRUE.          iretro
 6          3             Nombre de trajectoires
 7        3600.0             Intervalle de temps
 8          42
 9         2007          12          7          6
10     2007120706    61.350    224.370              1138.00
11     2007120706    61.350    224.370    0.864    780.713  1138.000   968.900           0.00   0.00
12     2007120700    61.404    223.315    0.864    758.281  1129.004  1208.355       58038.49   2.69
13     2007120618    61.861    221.908    0.849    743.378  1260.452  1233.172      148067.88   4.17
14     2007120706    61.350    224.370              2000.00
15     2007120706    61.350    224.370    0.772    699.078  2000.000   968.900           0.00   0.00
16     2007120700    62.185    222.069    0.754    665.290  2175.301  1174.217      152622.11   7.07
17     2007120618    62.971    219.747    0.696    647.310  2760.614   791.285      300641.13   6.85
18     2007120612    63.503    216.798    0.664    622.299  3098.094   752.788      459658.25   7.36
19     2007120606    63.628    212.936    0.647    558.338  3252.417  1389.295      652384.63   8.92
20     2007120706    61.350    224.370              3000.00
21     2007120706    61.350    224.370    0.676    613.387  3000.000   968.900           0.00   0.00
22     2007120700    62.352    221.655    0.647    576.685  3318.494  1113.350      180804.41   8.37
23     2007120618    62.966    218.443    0.593    561.303  3949.017   675.207      359541.13   8.27
```

Figure 3: An example of a condensed, CMC formatted back trajectory. All important features of CMC which are required by MetCor are shown.

The back trajectory interval in hours must also be provided by the user to MetCor. This is the fixed amount of time which exists between separate trajectories (in hours). Typically, the interval is 4 to 6 hours.

For version 1.0, CMC formatted trajectories must meet the following requirements:
- The starting date of the back trajectory functions as the unique identifier for all endpoints contained in the same back trajectory file. It must be located on the file's 9th line.
- Elevation headers do not contain a valid endpoint and exist only to denote the starting elevation of endpoints following it. Elevation headers can be on any line yet must contain only 4 values: the back trajectory date, receptor longitude, receptor latitude and elevation.
- Lines of text containing valid endpoints must contain more than 4 values

MetCor reads all HYSPLIT trajectories formatted into blocks of text whose formatting guidelines are specified at http://ready.arl.noaa.gov/HYSPLIT_trajinfo.php. Although forecast and backward trajectories can be read, MetCor cannot extract variable or elevation data from HYSPLIT trajectories as it can with CMC trajectories.

The endpoint directory must be provided to MetCor in the **File Information** tab. This can be done by entering the full path of the folder or choosing it graphically by pressing the "…" button next to the "Endpoint Files Directory" field (Figure G2)
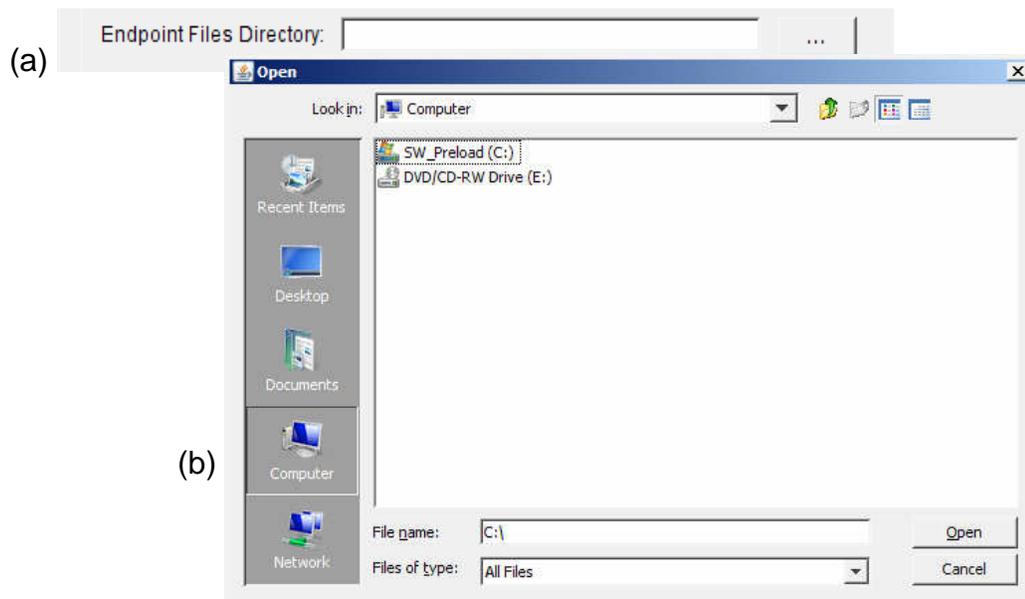
Figure G2: Entering the endpoint directory in MetCor (a). Click the "…" button to open a file dialog (b) which will allow for a graphical selection of the endpoint directory. Once the appropriate folder is selected, click "Open" in the file dialog to return to MetCor's main window.

The format of the endpoint path is dependent on the operating system being used. For example, Windows specifies pathnames as beginning with a drive letter followed by backslashes denoting each subfolder (e.g. C:\Users\EP) whereas in Linux based operating systems, paths start with the root directory and forward slashes (e.g. /users/EP).

4.3 The Correlation Data File

4.3.1 Purpose and Overview
The correlation data file contains data to be associated or "tagged" to specific endpoints which are already loaded from trajectories. For HYSPLIT and CMC back trajectory based analyses, the correlation data file realizes tagging by using the starting back trajectory date as the unique identifier of each endpoint. The correlation data file specifies the date range for a specific set of values. Endpoints with unique identifiers falling between these date ranges are tagged with those values.

4.3.2 Formatting Guidelines and Requirements
The formatting requirements of the correlation data file are highly specific. Proper formatting of the data file is essential in obtaining meaningful results with MetCor. Although the file can be named in any extension, it must be saved in a tab delimited format (Figure 4). Software as Microsoft Excel can be used to construct the correlated data file and save it in this format.

IDATE	ITIME	FDATE	FTIME	FAC1	FAC2	FAC3	FAC4
20070812	1800	20070819	1800	5.26	0	76.1	77.74
20070819	1800	20070825	1800	5.11	18.47	48.14	38.58
20070825	1800	20070826	1800	16.41	0	56.9	296.88
20070826	1800	20070827	1800	22.77	0.25	160.81	326.84
20070827	1800	20070828	1800	27	5.57	80.32	342.89
20070828	1800	20070829	1800	12.09	0.24	44.2	409.26

Figure 4: The contents of the correlated data file. With CMC and HYSPLIT analysis, endpoints of trajectories are assigned data on the basis of the back trajectory date.

Each line of the correlated data file contains:
- **IDATE**, **ITIME**: the starting date and time of the back trajectory to tag (inclusive)
- **FDATE, FTIME:** the ending date and time of the back trajectory to tag (exclusive)
- **Other columns:** representing the variables to be associated with endpoints

The following requirements must be met in order for the correlation data file to be valid:
- IDATE, ITIME, FDATE, FTIME must be listed in the first line of the file
- The dates under the IDATE and FDATE columns must be formatted as*: yyyymmdd*
- The times under the ITIME and FTIME column must be specified and formatted as: *tttt*
- If a line containing user-defined thresholds is specified in the file, "THRESH" must be written under the IDATE column and threshold values under the column of all variables must be specified. The "THRESH" line can be defined anywhere after the first line in the data file.

The correlation data file is provided to MetCor under the **File Information** tab the same way as the endpoint directory is provided. The full path including the file name must be specified either explicitly or graphically.

4.3.3 Time Zone Correction with Daylight Savings Offset
MetCor includes a time-zone correction option if the date ranges specified in the correlation data file are not in the same time zone as the back trajectory dates. Up to 12 hours can be added or subtracted from dates and times of the correlation data file to correspond with back trajectory starting dates and times. Choose the correction time by clicking on the drop-down box under the **File Information Tab** (Figure G3).
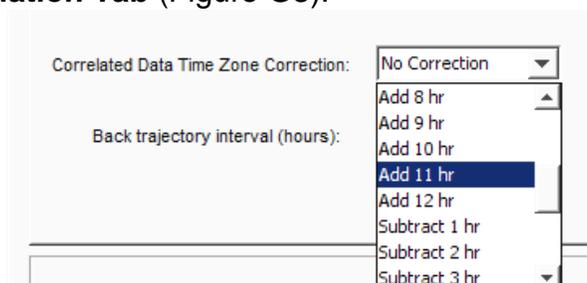
Figure G3: Selecting time zone correction options from a drop down box under the File Information tab. **NOTE** that the subtraction/addition is relative to the dates in the correlation data file. Daylight savings times are automatically added to the files and cannot be adjusted; manual manipulation of the correlation file is required to remove the automatic offset of 1hr for daylight savings time corrections.

4.0 – Basic Operation

4.4 Output Files and Output Directory Structure

MetCor dumps all PSCF matrices and additional data to a single output directory whose structure is shown in Figure 5.

```
                    ┌─────────────────┐
              ┌─────│           HIST  │  -histograms and scatter data
              │     └─────────────────┘
┌──────────┐  │     ┌─────────────────┐
│  OUTPUT  │──┼─────│           ELEV  │  -text files for elevation plots
└──────────┘  │     └─────────────────┘
              │     ┌─────────────────┐
              └─────│  PSCF_MATRICES  │  -PSCF matrices
                    └─────────────────┘
```
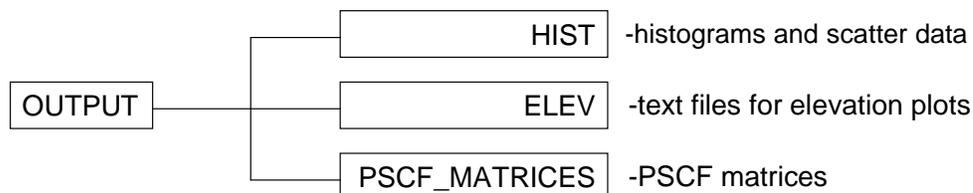
Figure 5: The subfolders of the output directory. The output directory is initially user defined. See section 4.7.3 for details about the format of the PSCF matrices. See section 4.8 for details about the contents of the HIST and ELEV subfolders.

The output directory is provided to MetCor under the **File Information** tab the same way as the endpoint directory is provided. The hard-disk must have enough free space to accommodate the contents of the output file. The output directory will be created if it does not exist or overwritten with new files if it already exists.

4.5 Trajectory Time Intervals

In order to successfully assign data to endpoints loaded by MetCor, the interval between trajectories should be specified in hours. The time interval is required in order for proper tagging of endpoints. If the interval entered is not equal to the actual time interval between the loaded trajectories, accurate assignment of concentration data may not occur and endpoints which should have been associated with concentration data would be neglected.

If the time intervals between trajectories are not known or inconsistent, 1 hour can be entered as the trajectory time interval to ensure that all possible dates and times are considered during tagging.

The time interval setting is found under the **File Information** tab. An integer value representing the back trajectory interval in hours must be entered.

4.6 Spatial Extent and Grid Resolution

The spatial extent represents the total area of the world which the PSCF matrices will ultimately represent. The grid resolution dictates the area of the world which is covered by an individual grid.

MetCor contains a variety of preset settings for spatial extent and grid resolution. It is important to note that as these two settings are made greater, computations will take significantly longer and using MetCor with additional allocated memory may be required (see Section 3.3).

4.6.1 Presets
Preset spatial extents available in MetCor are the northern hemisphere and the entire world. Grid sizes ranging from 0.2 by 0.2 to 10 by 10 degrees are available for each of the two spatial extents. The spatial extent

4.6.2 Customization
Grid sizes are completely customizable and are not required to be completely square. They can be specified by any combination of floating point numbers. Spatial extent can also be specified with integer values representing the maximum longitude and latitude to extend to from 0° latitude and 0° longitude (Figure 6).
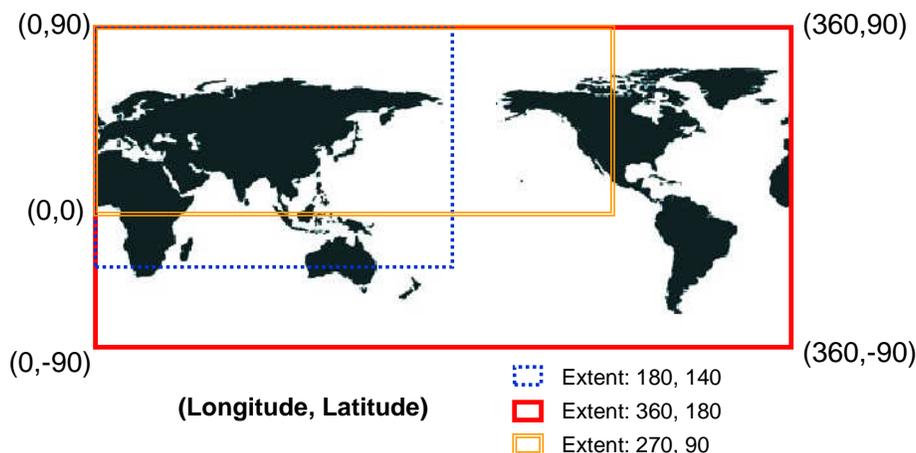
Figure 6: A visual representation of how spatial extents can be customized in MetCor. Note that 360° is equivalent to 0° in the geographical coordinate system

If a spatial extent must extend into the southern hemisphere (where latitude degrees are negative values), this is specified by setting the latitude extent as $90 + |x|$, where x is the minimum latitude desired. Since the extent can only start at 0° latitude and 0° longitude, localization of the grids at a specific part of the world is not possible.

Spatial extent and grid resolution can be chosen from the drop-down box in the **Binning** tab. By selecting "Custom", the fields defining spatial extent and grid resolution can be calculated (Figure G4).

Figure G4: Selecting preset or custom grid spatial extent and resolution in MetCor under the Binning tab. Total longitude and total latitude constitute the spatial extent of the grid, while grid height and grid width define the grid resolution.

4.7 PSCF

<u>4.7.1 Setting Threshold Values</u>
If the threshold concentration line is not found in the correlated data file, MetCor can use one of the following as threshold values for each variable:

1. Average
2. Average + One standard deviation
3. Percentile

The threshold concentration line in the correlated data file takes precedence over any of the above 3 methods: i.e., if the "Average" method is chosen in MetCor and the threshold concentration line is already defined in the file, the threshold values are used.

The average and average + one standard deviation methods use the entire column of values in the data file order to calculate thresholds for each variable.

In an ordered set of concentration data, the percentile method uses a concentration value corresponding to a specific, user-defined percent value. The cut-off percent can be any floating point number in the range [0,100] and will always correspond to a value which exists in the correlated data file. MetCor will round down to the nearest concentration in the case that a given percentile does not correspond exactly to a value (Figure 7).
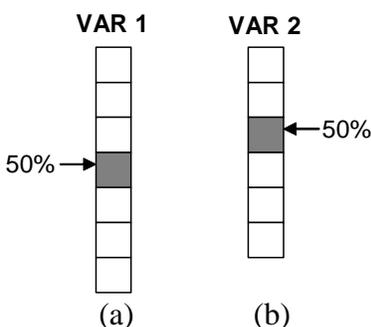
Figure 7: A visual representation of how the percentile method determines thresholds in an unambiguous case (a) and an ambiguous case (b) between two values. In the ambiguous case, the percentile falls between two values and the lower of the two is always chosen.

Threshold options are found in the **PSCF** tab.

<u>4.7.2 Weighting Table and Types of Weighting</u>
As mentioned in section 2.1, PSCF values can be weighted on the basis of the number of unique identifiers or the population of a grid. The analysis of scatter and histogram data for unweighted calculations (section 4.8) is useful in determining a weighting scheme for a specific job.

The weighting table can be entered in the **PSCF** tab. The lower and upper bounds define the range of grid population or unique identifiers to look for, while the weight is added under the third column. If "Use source IDs instead of Grid Population" is checked, the lower and upper

bound represent the range of unique identifiers and starting elevations rather than the default weighting scheme, which is by grid population (see section 2.1 for more information on PSCF weighting). Values which are not in the range of those specified in the weighting table get a default PSCF weighting of 1. The weighting table can also be left empty, in which case the default PSCF is also 1.

The weighting function operates on closed intervals. Therefore, the upper and lower bounds define a closed set of integers. For example, a grid with a population x would carry a PSCF weight of $w(x)$ according to the function:

$$w(x) = \begin{cases} w_1, & l_1 \leq x \leq u_1 \\ w_2, & l_2 \leq x \leq u_2 \\ ... \\ w_{10}, & l_{10} \leq x \leq u_{10} \end{cases}$$

where l and u are integers representing lower and upper bounds of each interval, respectively. A maximum of 10 intervals can be defined in MetCor. The upper and lower bounds can be equal when assigning a weight to only one value of the grid population or number of unique identifiers

4.7.3 PSCF Output Matrices
PSCF matrices are printed as ASCII text files with the ".txt" extension. For further analysis by GIS software, MetCor appends six-line header at the beginning of each PSCF matrix. The coordinate system of the matrix is shown in Figure 8.

0, 90   **359, 90**

0, -90   **359, -90**
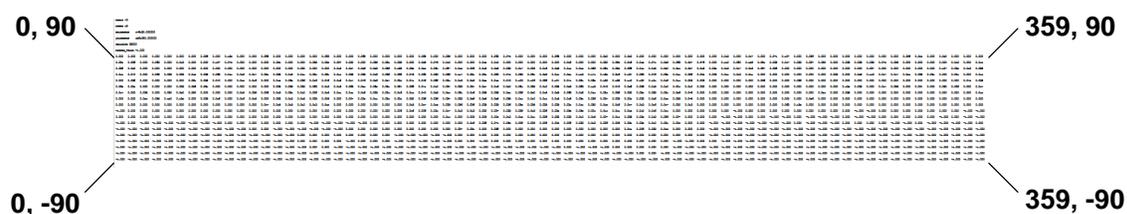
Figure 8: An example of a PSCF matrix with a 5x5 degree grid resolution and a spatial extent spanning the world. Corner grid coordinates are shown. This is useful for reprojection in GIS software.

4.8 Additional Tools
MetCor includes optional tools to print histogram, scatter and elevation data along with PSCF calculations. Elevation data can only be extracted from CMC formatted trajectories and is printed as one simple tab-delimited text file per back trajectory. Histograms and scatter data are also printed as simple, tab delimited text files easily readable by spreadsheet or data processing software.

Options for using the following tools are found under the **Utilities** tab.

4.8.1 Elevation Plot Tool
If this option is selected, one text file per CMC-formatted back trajectory is printed as a tab delimited text file containing only two columns: the forecast date and an associated elevation. If a CMC-formatted file contains more than one elevation, multiple elevations are still plotted

in one file. MetCor is packaged with a Microsoft Excel macro which will iterate through each text file that is saved by the elevation tool and generate one line graph of elevation vs. date per file. Instructions for the use of this macro are printed on the excel file containing the macro itself.

4.8.2 Grid Population and Unique Identifier Histogram Data
If this option is selected, two files containing histogram data are generated upon successful PSCF analysis. The number of classes in the histogram must be an integer value in provided to MetCor.

TaggedFreq_nij.txt contains two columns of data: the first corresponds to grid population while the second lists the frequency of endpoints which fall within a certain range of grid population. *TaggedFreq_sourceID.txt* is saved in a similar format, with the first column representing the number of unique identifiers/starting elevations in a grid and the second column listing the frequency of grids with a certain number of unique identifiers.

The first column of each value represents the horizontal axis of the histogram and defines the lowest value of a histogram class. The upper value of each class can be obtained simply by adding the interval between subsequent classes. Only grids which contain endpoints with correlated data are counted in each of the histograms (Figure 9).

1	1772
3	469
…	…
58	610

1	1977
3	23
…	…
18	1

(a) TaggedFreq_nij.txt   (b) TaggedFreq_sourceID.txt

Figure 9: Examples of the histogram which MetCor prints out.
(a) A grid population histogram. There are 1772 endpoints which fall in grids with a grid population of 1 to 2, 469 endpoints which fall in grids with a grid population of 3 to 4, and 610 endpoints which fall in grids with a grid population of 58 to 59. Endpoints which do not have any correlated data are not counted.
(b) A unique identifier histogram counting the number of grids. There are 1977 grids which have endpoints coming from 1 to 2 unique identifiers. There is only 1 grid which contains endpoints coming from 18 to 19 unique identifiers. Grids with endpoints which do not have any correlated data are not counted.

4.8.3 PSCF Scatter Data
If the option to print scatter data is selected, two files containing all of the PSCF data calculated are printed to disk. In order to remove possible size limitations imposed by the ".txt" extension, the files have no extension.

PSCF_vs_NIJ lists each grid's population and its corresponding PSCF values per variable. *PSCF_vs_SourceID* lists each grid's number of unique identifiers and its corresponding PSCF values for each variable as well. All grids are listed in accordance with the defined spatial extent and grid resolution (section 4.6) regardless of if they contain endpoints with correlated data or not. As a result, the file can be very large if the grid resolution is fine or if the spatial extent is large. Since Microsoft Excel can only plot a finite number of points on its scatter plots, it is best to use a more capable graphical utility to visualize scatter data generated for grids with dimensions smaller than 2 x 2 degrees.

<u>4.8.4 GNUPlot Script for Quick Visualization</u>
For Linux based systems with GNUPlot installed and accessible from a command-line interface, MetCor is bundled with an executable bash script for generating heat-map representations of PSCF matrices. The bash script is executed from the command line and must be placed in the folder containing the PSCF matrices. The header lines (section 4.7.4) must be removed from each of the PSCF matrix files. A heat-map in the form of a portable-network graphics (*.png) formatted image is generated for each of the PSCF matrix files in the folder. An example of such a heat-map is shown in Figure 10 below.
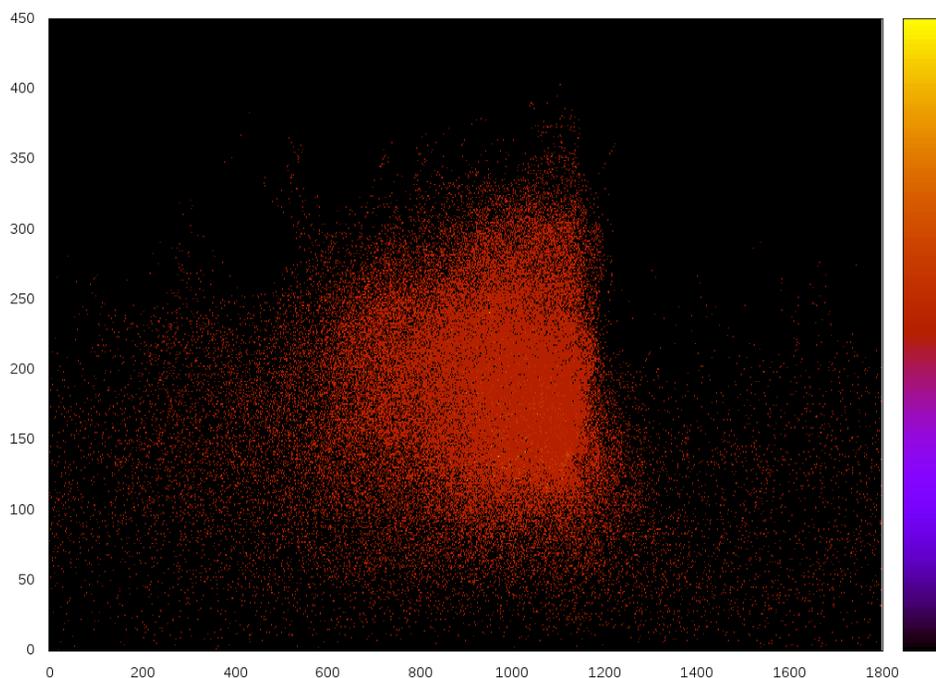
Figure 10: A visual representation of a PSCF matrix generated by MetCor's bundled GNUPlot bash script. This is useful for a quick analysis of the contents of a given PSCF matrix. The *y*-axis represents latitude while the *x*-axis represents longitude. The layout format and coordinate system is the same as that in section 4.7.3.

4.9 Running and Stopping Jobs on MetCor
A job on MetCor can be started by clicking the "RUN" button once all user-input has been appropriately provided. Error message boxes will appear if any user-input is found to be inadmissible or in the wrong format.

To interrupt a calculation, the MetCor must be terminated. This can be done by closing the MetCor window or by the menu option **File → Exit**. If MetCor is interrupted during any file writing process such as printing histogram data or PSCF matrices, the output folder will contain incomplete files. The output directory or files will not be rolled back to a previous state or deleted. This must be done manually.

Multiple instances of MetCor can run on the same computer if the following requirements are met:
- there can be no common output directory (section 4.2, 4.3) shared between the instances of MetCor which are running

4.0 – Basic Operation

- sufficient physical memory required by all the instances of MetCor must be available

5.0 Advanced Tools

Advanced tools available in MetCor include the use of configuration files for quick form loading and use of the program's backend for programming purposes. Configuration files are useful if the same parameters are entered into MetCor multiple times, whereas the MetCor's backend is useful for users with programming knowledge who require more customization.

5.1 Using Configuration (*.cfg) Files
Configuration files are simple text files containing labelled parameters specific to MetCor.

5.1.1 Syntax and Format
The configuration file should be written and saved as a plain text file with the "cfg" extension. MetCor recognizes lines of text beginning with '#' as a comment. The general syntax for setting all parameters except PSCF weights is:

<Parameter-Name>=<Value>

The table below lists parameter names, allowed values and formats. All parameters may be optionally included in the configuration file. If the same parameter is defined twice in one configuration file, the parameter definition closest to the beginning of the file is always chosen.

Name	Description	Values		
EP	Endpoint Directory	<Any File Path>		
OP	Output Directory	<Any File Path>		
IP	Full path of Correlated Data File	<Any File Path>		
Format	Trajectory Format	CMC	-	read CMC Format
		HYSPLIT	-	read 21st century HYSPLIT format
Correct	Time Zone Correction in Hours	<Integer Value>	-	any value from -12 to 12
Hours	Trajectory Interval in Hours	<Integer Value>	-	any value greater than 0
totalLon	Spatial extent in Longitude	<Integer Value>	-	any value from 1 to 360
totalLat	Spatial extent in Latitude	<Integer Value>	-	any value from 1 to 180
dX	Grid Resolution (longitude)	<Floating Point Value>	-	any value greater than 0.0
dY	Grid Resolution (latitude)	<Floating Point Value>	-	any value greater than 0.0
ThreshType	Set thresholds	Avg	-	average
		AvgSD	-	average + standard deviation
		InFile	-	thresholds defined in file
		Percentile	-	percentile method
Percentile	Percentile setting (if applicable)	<Floating Point Value>	-	any value from 1.0 to 100.0
TagType	Domain of weighting function	NIJ	-	use grid population
		SourceID	-	use number of unique identifiers
ELEV	Elevation Plot Tool	ON	-	enable
		OFF or <Any Value>	-	disable
SCAT	Print Scatter Data to Disk	ON	-	enable
		OFF or <Any Value>	-	disable
HIST	Print Histograms to Disk	ON	-	enable
		OFF or <Any Value>	-	disable
HistClasses	Number of Histogram Classes	<Integer Value>	-	any value greater than 0

A PSCF weight table can also be entered into MetCor by writing "WEIGHT:" on one line and writing values which must be separated by tabs. An example is shown below:

```
WEIGHT:
1     21    0.5
22    100   0.75
101   204   0.85
205   205   0.95
```

In the same way as the weighting table in the GUI (section 4.7.2), the first and second column represent lower and upper bounds for either the grid population or number of unique identifiers, respectively. The third column represents the weighting to apply.

5.1.2 Loading a *.cfg File on MetCor
To load a configuration file, select **File → Load Configuration** to use a dialog box and select the configuration file. Once opened, information from the configuration file is loaded onto the form. The calculation must be started manually by the user by clicking "RUN" (section 4.9).

5.0 – Advanced Tools

6.0 Quick GUI Reference

Each component of the MetCor GUI is labelled with the appropriate section to consult in this User Guide.
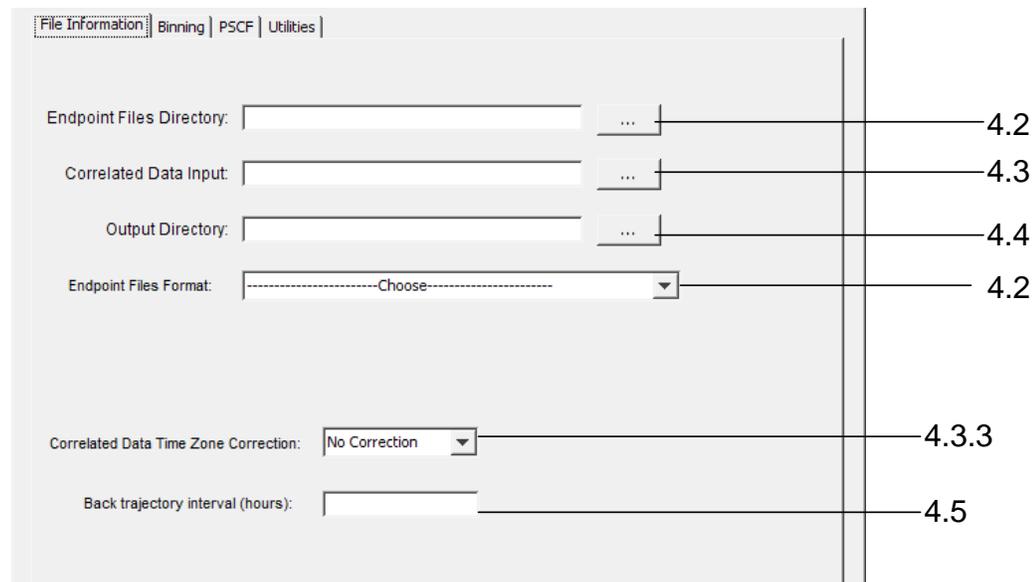
File Information | Binning | PSCF | Utilities |

PSCF Weighting Scheme: ☐ Use Source IDs instead of Grid Population ————— 4.7.2

Lower Bound	Upper Bound	PSCF Weight

————— 4.7.2

Correlated Data Threshold Values: ○ Average
                                     ○ Average + 1 S.D.
                                     ○ Percentile: [   ] %   ————— 4.7.1
                                     ○ Already Defined in File

---

File Information | Binning | PSCF | Utilities |

☐ Extract Elevation Data and Save to Output Directory ————— 4.8.1

☐ Save PSCF Scatter Data to Disk ————— 4.8.3

☐ Save Grid Population and Unique Identifiers Histogram Data to Disk

   Number of Bins: [   ]   ————— 4.8.2

6.0 – Quick GUI Reference
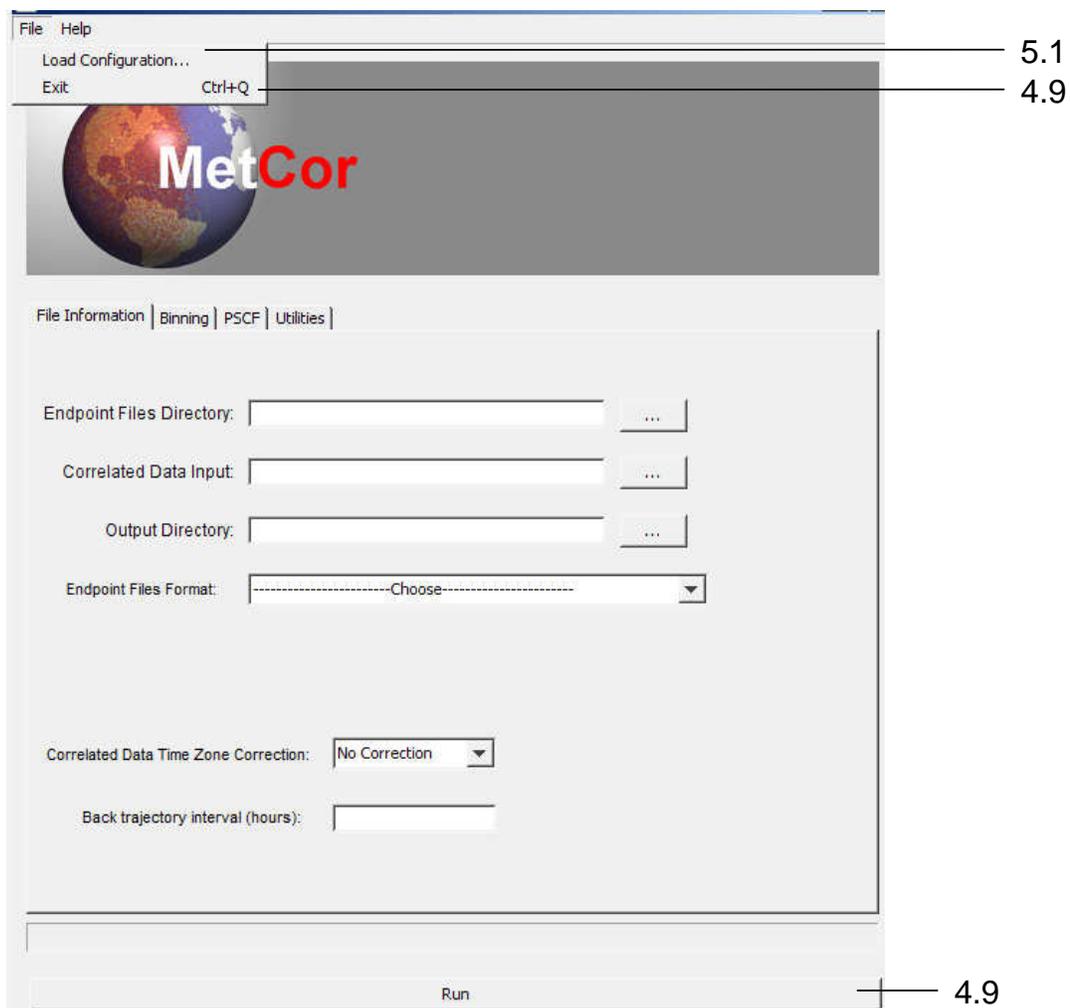
7.0 Examples

By the appropriate use of the correlated data file, PSCF matrices generated by MetCor can represent many types of data. In one application, low resolution grids can be used to map pollution data across the world. In another application, very high resolution grids can be used to plot individual endpoints.

Some of the files used in the examples below are available in MetCor's installation directory. See the README file for more details.

7.1 Mapping Pollution Data
This is the most common application of MetCor. Meteorological data is received as HYSPLIT or CMC formatted trajectories. On the basis of the date and time ranges specified in the correlated data file, endpoints are appropriately tagged. PSCF matrices are then calculated using pre-defined threshold values specific to the concentrations in the data file.

In this example, an analysis of PSCFs of "Pollutant-1" and "Pollutant-2" with CMC-formatted back trajectories is conducted. The identifiers of the CMC-formatted back trajectories span the dates of May 1, 2008 to June 1, 2008. The contents of the correlated data file *example_7_1.txt* are shown below:

```
IDATE      ITIME   FDATE      FTIME   Pollutant_1    Pollutant_2
20080501    1305   20080507    1313          12.33         130.53
20080507    1353   20080513    1822           8.79          76.98
20080514    0600   20080514    2359          12.70          74.11
20080531    1330   20080601    1153          30.76         130.64
```

Rather than defining thresholds in the correlated data file, the "Average" method has been chosen in the PSCF calculations. The following parameters are also used in the PSCF calculations:

- **spatial extent**: Northern Hemisphere
- **grid resolution**: square grids, 1 deg. by 1 deg. Higher grid resolutions would prevent endpoints from being pooled together effectively, whereas lower grid resolutions overcompensate for errors in the back trajectories.
- **weighting scheme**: none; the weighting table is left empty
- **threshold method**: average
- **time-zone correction**: +6 hours is chosen here because the back trajectory time zone is offset by 6 hours from the times defined in the correlated data file.
- **additional plots to generate**: scatter data and histogram data are plotted

7.2 Plotting Individual Trajectories

By using dummy variables in the correlated data file and a fine enough resolution to discriminate between endpoints, PSCF matrices can represent plots of trajectories.

Suppose a series of CMC or HYSPLIT formatted trajectories are loaded onto MetCor spanning May 1, 2008 to May 1, 2010. To plot only those trajectories for the months of May, the correlated data file *example_7_2.txt* contains the following:

```
IDATE      ITIME   FDATE      FTIME              X
20080501    0000   20080531    1800              1
20090501    0000   20100531    1800              1
20100501    0000   20100531    1800              1
     THRESH                                     0.5
```

The variable "X" has no meaning: it is simply used to tag endpoints of trajectories for selected date ranges. By setting the threshold value lower than those used to tag endpoints, PSCF values other than the no-data value (-1) represent a region of a grid containing endpoints of interest.

The following parameters are also used in the PSCF calculations:
- **spatial extent**: Northern Hemisphere
- **grid resolution**: User-defined square grids, 0.1 deg. by 0.1 deg. The high resolution of the grids ensures that one grid represents one endpoint.
- **weighting scheme**: an unweighted calculation would be required in this scenario. This way, each grid which contains a back trajectory endpoint is flagged and gets a PSCF value of 1
- **threshold method:** the thresholds are defined in the correlated data file
- **time-zone correction**: the times specified in the file are in the same time zone as the trajectories. Therefore, the time-zone correction is option is set to "No Correction"
- **additional data**: no other plots are selected

7.0 – Examples

8.0 Troubleshooting

8.1 Form Input Errors

Before starting any calculation, MetCor checks the data which has been entered in the MetCor's textboxes, tables and buttons. Commonly, some of the parameters required for a successful calculation are not entered by the user or are provided in the wrong format. When a calculation attempt is started by the user and such errors are encountered, an error message will appear with details of the problem. The following table shows the error messages which may appear and solutions:

Error Messages	Solution
--The Endpoint Files Directory has not been specified. --The Correlated Data File has not been specified. --The Output Directory has not been specified.	The form fields for these have been left empty. Provide directories or paths for the endpoints, correlated data file and output directory
--The Output Directory could not be created.	The destination where the output folder is stored may be read only. Try specifying the output directory in another destination.
--The Endpoint Files Directory does not exist. --The Correlated Data File does not exist.	These paths and/or directories do not exist. Specify valid directories and paths only.
--A back trajectory format is not specified	Choose CMC or HYSPLIT formatted trajectories from the drop down box under the File Information tab
--The Back trajectory interval is not specified. --The Back trajectory interval specified is a zero or non-integer value.	Enter an integer-valued back trajectory interval, in hours.
--Grid Dimensions and Details are not specified. --Grid Dimensions or Sizes are non-floating point or integer values --The Grid height and/or width are too small	Enter a valid spatial extent and non-zero floating point values for the fields under the Binning tab.
--Threshold data values are not specified	Choose a method of determining thresholds under the PSCF tab
--Percentile data is an inappropriate value	If the percentile method has been chosen as thresholds, enter a percent-value for the percentile *between* 0 and 100.
--PSCF Weighting Factors Contain Non-Floating Point Data	Enter appropriate floating-point weights in the weighting table under the PSCF tab.
--Lower and/or Upper Bound Data contain non-integer data.	Enter integer values for the lower and upper bounds only.
--The number of histogram bins specified is a non-integer value or has not been specified. --The histogram class must be at least 1.	Enter an integer value for the number of histogram classes of at least 1 if the histogram option has been chosen.

8.0 – Troubleshooting

8.2 Errors During Calculations

Errors experienced while calculations are running care usually caused by inconsistencies in the data which MetCor is analyzing. MetCor will terminate the calculation when such errors are encountered. Changes made to the output directory will not be rolled back and must be manually deleted by the user. The following table shows the error messages which may appear during calculations and possible solutions:

Error Messages	Solution
`Input File is not formatted Correctly`	The format of the correlated data file is incorrect. Check to make sure that the proper formatting guidelines (section 4.3.2) are followed.
`MetCor could not load endpoints from disk. Check to make sure that the directory is valid and that back trajectories are formatted correctly.`	Ensure that only trajectory files exist in the endpoint files directory and that all of the trajectory files follow their respective formatting guidelines (section 4.2)
`Runtime Error in Reading Input File. Ensure that it is formatted correctly.`	This usually occurs because the times specified in the input file are in the wrong format. Ensure that they are 4 digits in length
`PSCF Matrix File IO Error.`	Check to make sure that the files in the output directory is not in use. This may also occur if the output directory is made read only.

8.3 Premature Termination

MetCor will unexpectedly terminate a calculation when computer hardware experiences failures or if it resources are too limited. These insufficiencies include but are not limited to low hard disk space or low available memory. MetCor does not explicitly notify users of such errors, yet they often occur if the progress bar reads "Finished" without showing one or any of the steps mentioned in section 4.1. Premature termination will often result in failure to generate any output matrices or additional data. A possible list of solutions to hardware insufficiencies is shown below:

Cause of Premature Termination	Solution
Not enough memory to complete a given MetCor calculation.	- close any programs which might be open in order to free more memory; restart MetCor once this is done (for Windows-based operating systems only) - the grid resolution might be too high; use a lower grid resolution* - lower the number of variables in the correlation data file: or split the variables between two or more correlation data files and run those calculations separately - manually allocate more memory to the instance of MetCor (Unix-based operating systems only)
Not enough free disk space to generate output	- Free disk space - Direct output to a directory of a different drive or partition.

8.0 – Troubleshooting