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# Modeled Attainment Test Software

## User's Manual



March 2009

Prepared for  
Office of Air Quality Planning and  
Standards  
U.S. Environmental Protection Agency  
Research Triangle Park, NC  
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# 1 Welcome to MATS, the Modeled Attainment Test Software

The Modeled Attainment Test Software (MATS) is primarily intended as a tool to implement the modeled attainment tests for particulate matter (PM<sub>2.5</sub>) and ozone (O<sub>3</sub>), and to perform the uniform rate of progress analysis for regional haze (visibility). Detailed information on the attainment tests can be found in U.S. EPA's modeling guidance, "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of the Air Quality Goals for Ozone, PM<sub>2.5</sub>, and Regional Haze." The modeling guidance can be found at [http://www.epa.gov/ttn/scram/guidance\\_sip.htm](http://www.epa.gov/ttn/scram/guidance_sip.htm).

This Chapter provides a brief description of how to use this manual, computer requirements, steps to install and uninstall MATS, and contact information for comments and questions:

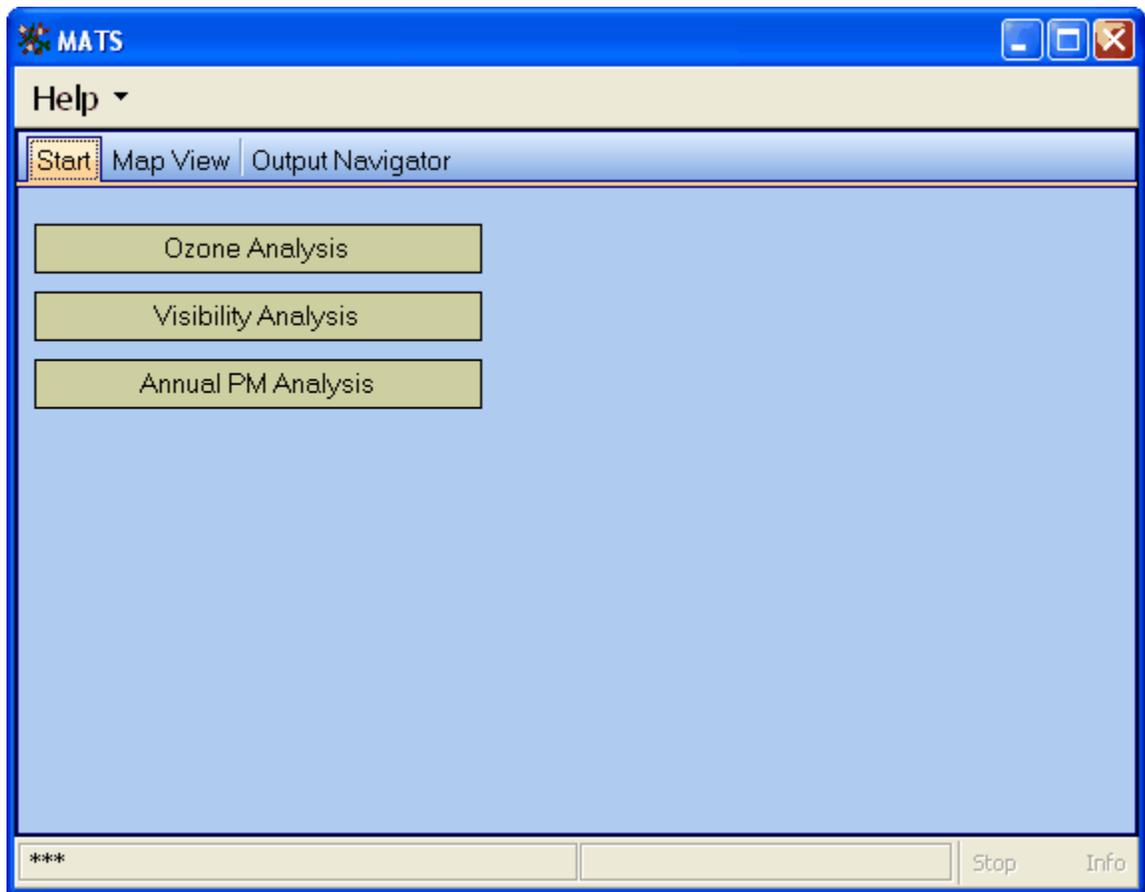
[How to Use this Manual](#)

[Computer Requirements](#)

[Installing MATS](#)

[Uninstalling MATS](#)

[Contact for Comments and Questions.](#)



## 1.1 How to Use this Manual

This manual provides step-by-step instructions on how to use MATS.

New users should start with the [Overview of MATS Components](#) chapter, which is very short, but provides a good overview of the model and how it works. You can then use tutorial chapters to get started using the model. There are separate tutorials for [Particulate Matter \(PM\)](#), [Ozone](#), and [Visibility](#). In addition to these relatively simple tutorials, you can go on to learn more on each subject in the chapters on [PM Analysis: Details](#), [Ozone Analysis: Details](#), and [Visibility Analysis: Details](#). Use the rest of the manual to answer any specific questions you may have. There is a chapter on the [Output Navigator](#), which is the starting point for examining your results. The [Map View](#) chapter details how to map results. Finally, the [Frequently Asked Questions](#) chapter reviews and answers some of the common questions that arise when using MATS.

In sections that provide instructions on navigating the model, the following conventions are observed: menu items, buttons, and tab and selection box labels are in bold type; prompts and messages are enclosed in quotation marks; and drop-down menu items, options to click or check, and items that need to be filled in or selected by the user are italicized. Common terms are defined in the [Terminology and File Types](#) chapter. The [Reference](#) section provides citations for documents relevant to MATS.

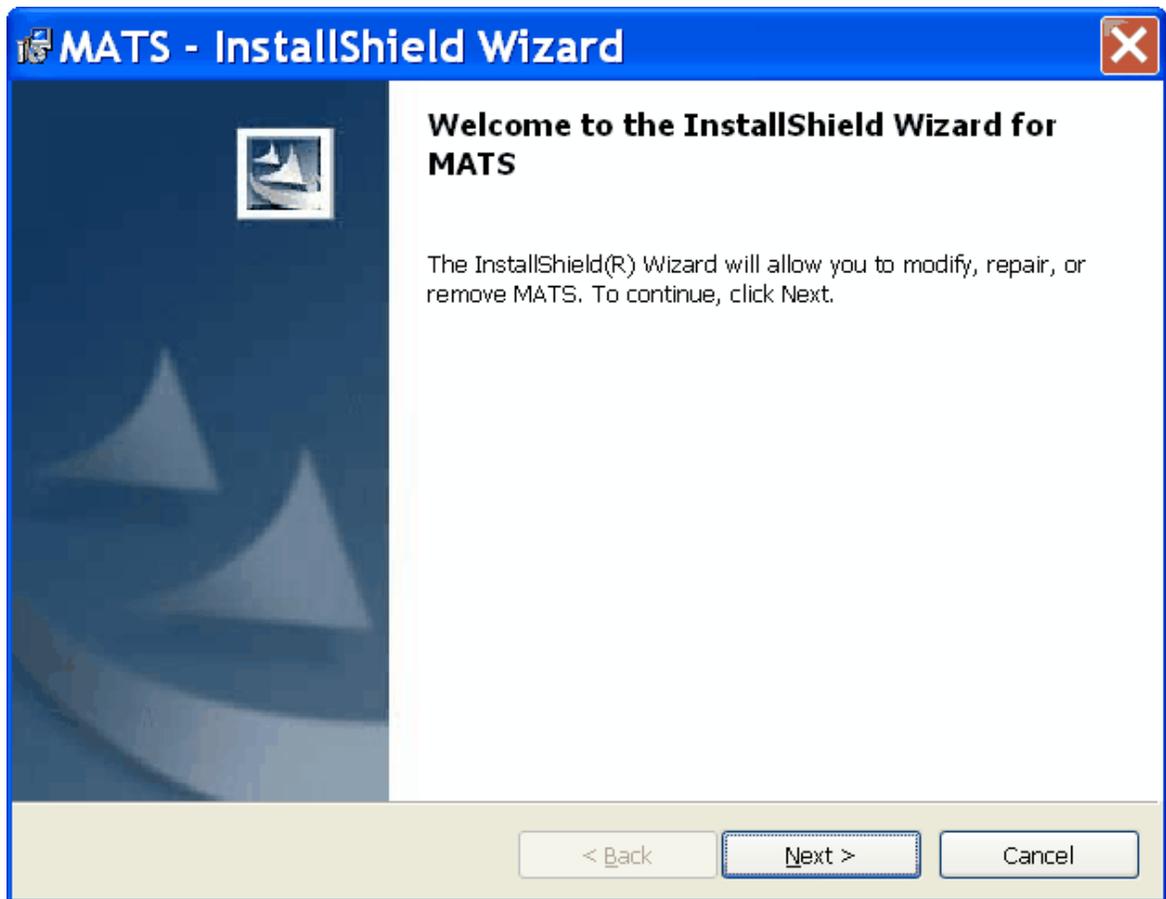
## 1.2 Computer Requirements

MATS requires a Windows platform, and can be used on machines running Windows2000, as well as more recent versions of Windows. In particular, MATS requires a computer with:

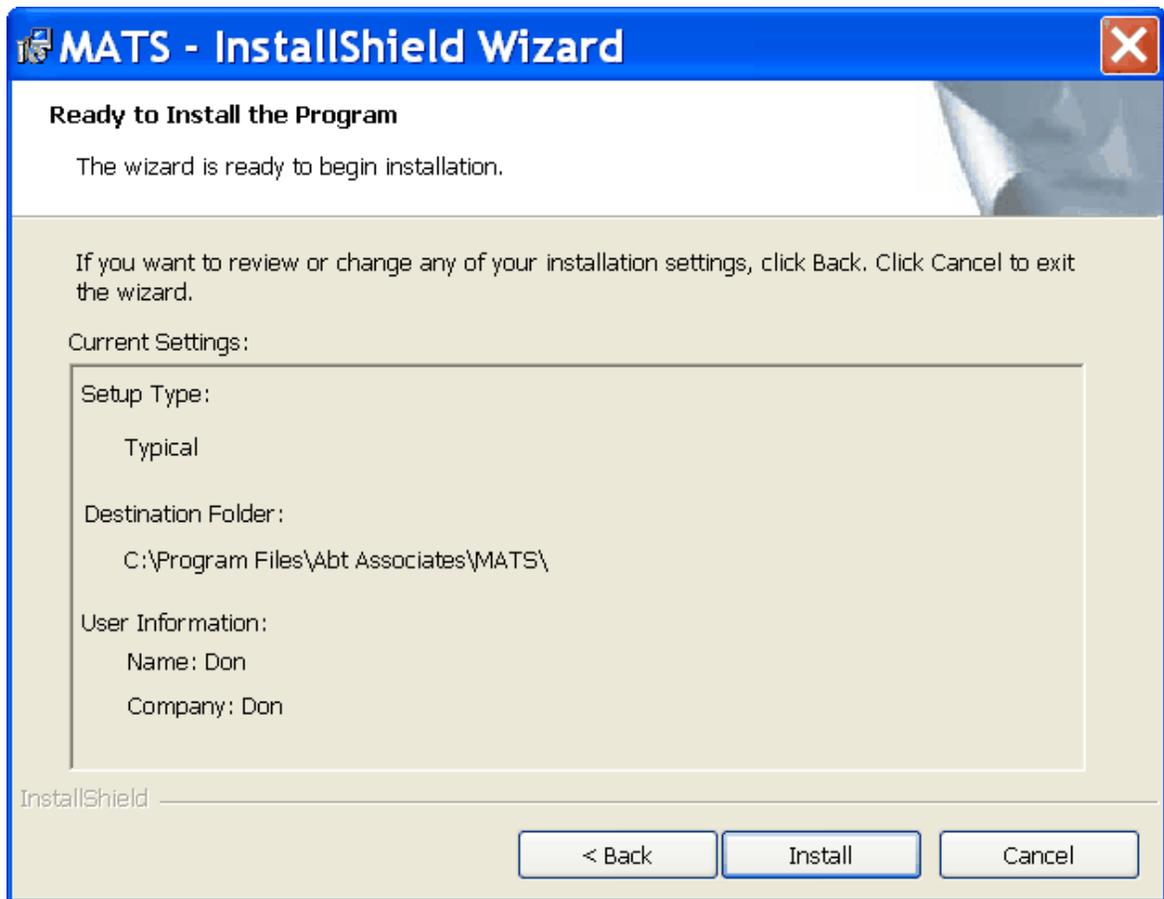
- Windows 2000 or greater.
- 512 megabytes of RAM or greater.
- Intel® or compatible processor, Pentium 166 MHz or higher. 1 GHz processor or greater recommended for optimum performance.
- A CD-ROM drive for CD based installation. Alternatively, a high speed internet connection can be used to download the installer. The installer package can be found at:
  - At least 3 GB free space recommended.

## 1.3 Installing MATS

Load the installation file (MATS\_Setup.exe) onto your hard drive. Double-click the file. This will initiate the installation process, which takes about five to ten minutes, depending on the speed of your computer.



Click the **Next** button. This will bring up the **MATS - InstallShield Wizard**.



Click the **Install** button. After the installation of MATS, a final window will appear to complete the process.



Click the **Finish** button.

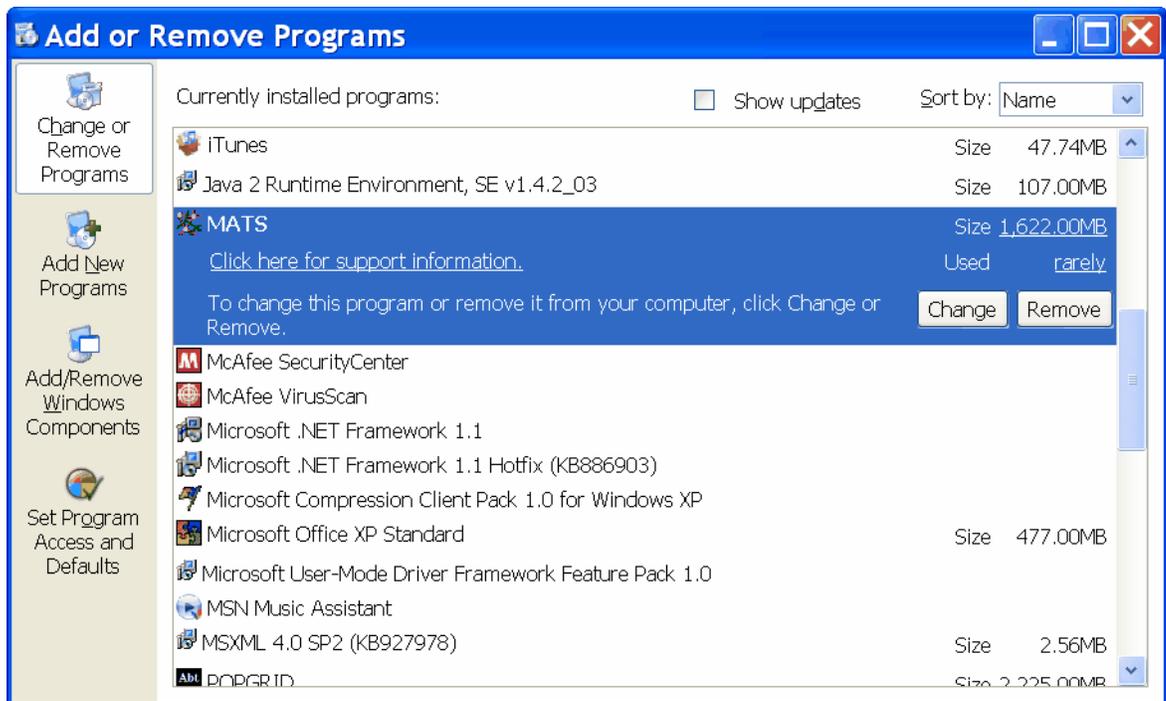
Note that some problems have occurred in the past, when trying to install MATS from a network drive. If this problem occurs, move the MATS\_Setup.exe file to your local hard drive.

## 1.4 Installing an Updated Version of MATS

If a previous version of MATS is already installed on your computer, you will need to uninstall the old version using the Windows Control Panel prior to installing the new version (see next section). Note that uninstalling MATS will not delete your MATS output files.

## 1.5 Uninstalling MATS

To uninstall MATS, go to Control Panel, Add/Remove Programs and highlight MATS.



Click the Remove button. This will bring up a window asking you to confirm the removal.



Note that removing the software will not remove the files that you have generated with MATS. For example, the Output folder will remain with any files (e.g., \*.ASR files) that you have created.

## 1.6 Contact for Comments and Questions

For comments and questions, please contact Brian Timin at the United States Environmental Protection Agency.

Address: C339-01, USEPA Mailroom, Research Triangle Park, NC 27711

Email: [timin.brian@epa.gov](mailto:timin.brian@epa.gov)

Telephone: 919-541-1850.

## 2 Terminology & File Types

The first section of this chapter explains [Common Terms](#) used in this user's manual and in the model, and references, where possible, other sections in this manual to find more detailed information. The second section describes the [File Types](#) used in MATS.

### 2.1 Common Terms

The following include terms commonly used in MATS:

[ASR File](#)

[BMP File](#)

[Class I Area](#)

[Configuration File](#)

[CSV File](#)

[Deciviews](#)

[Design Value](#)

[Domain](#)

[FRM Monitors](#)

[Gradient Adjustment](#)

[IMPROVE Monitors](#)

[Interpolation](#)

[Inverse Distance Weights](#)

[Log File](#)

[Output Navigator](#)

[Output File](#)

[Point Estimate](#)

[RRF](#)

[SANDWICH](#)

[Scenario Name](#)

[SMAT](#)

[Spatial Field](#)

[Spatial Gradient](#)

[STN Monitors](#)

[Temporal Adjustment](#)

[VNA](#)

### 2.1.1 ASR File

An ASR File contains three types of results from a MATS run: [Log File](#), [Configuration File](#), and [Output Files](#). The extension .ASR is used after the [Scenario Name](#). The data in an .ASR file can viewed and extracted using the [Output Navigator](#).

### 2.1.2 BMP File

BMP is a standard file format for computers running the Windows operating system. The format was developed by Microsoft for storing bitmap files in a device-independent bitmap (DIB) format that will allow Windows to display the bitmap on any type of display device. The term "device independent" means that the bitmap specifies pixel color in a form independent of the method used by a display to represent color.\*

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\* See: <http://www.prepressure.com/formats/bmp/fileformat.htm>.

### 2.1.3 Class I Area

A Class I Area is defined by the Clean Air Act to include national parks greater than 6,000 acres, wilderness areas and national memorial parks greater than 5,000 acres, and international parks that existed as of August 1977.\* The Regional Haze rule requires visibility improvements in 156 specific Class I areas. The MATS visibility analysis will calculate visibility values for these areas.

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\* See: <http://vista.cira.colostate.edu/views/Web/General/Glossary.aspx>.

### 2.1.4 Configuration File

A Configuration File stores the choices that you have made when using MATS. A useful feature of a Configuration File is that it is reusable. You can use an existing Configuration File, make some minor changes to generate a new set of results, without having to explicitly set each of the choices you made in the previous Configuration. The section on the [Output Navigator](#) provides additional details on accessing and viewing a Configuration File.

## 2.1.5 CSV File

Is a comma separated values (CSV) file (\*.csv) which can be read using a text editor, or by various spreadsheet and database programs, such as Microsoft Excel.

Note: Detailed formatting in .csv files such as leading zeroes and "" cannot be seen in Excel. To see formatting of MATS input files, open .csv files with a text editor, such as WordPad.

```

DesignValue
_ID, _TYPE, LAT, LONG, POC, DVYEAR, O3, _STATE NAME, _COUNTY NAME
"010030010",,30.497778,-87.881389,1,2001,-9,"Alabama","Baldwin"
"010030010",,30.497778,-87.881389,1,2002,82,"Alabama","Baldwin"
"010030010",,30.497778,-87.881389,1,2003,76,"Alabama","Baldwin"
"010030010",,30.497778,-87.881389,1,2004,76,"Alabama","Baldwin"
"010270001",,33.281111,-85.802222,1,2001,84,"Alabama","Clay"
"010270001",,33.281111,-85.802222,1,2002,82,"Alabama","Clay"
"010270001",,33.281111,-85.802222,1,2003,80,"Alabama","Clay"
"010270001",,33.281111,-85.802222,1,2004,76,"Alabama","Clay"
"010510001",,32.498333,-86.136667,1,2001,79,"Alabama","Elmore"
"010510001",,32.498333,-86.136667,1,2002,80,"Alabama","Elmore"
"010510001",,32.498333,-86.136667,1,2003,76,"Alabama","Elmore"
"010510001",,32.498333,-86.136667,1,2004,74,"Alabama","Elmore"
"010550011",,33.9039,-86.0539,1,2001,-9,"Alabama","Etowah"
"010550011",,33.9039,-86.0539,1,2002,-9,"Alabama","Etowah"
"010550011",,33.9039,-86.0539,1,2003,-9,"Alabama","Etowah"
"010550011",,33.9039,-86.0539,1,2004,75,"Alabama","Etowah"
"010730023",,33.553056,-86.815,1,2001,-9,"Alabama","Jefferson"
"010730023",,33.553056,-86.815,1,2002,82,"Alabama","Jefferson"

```

## 2.1.6 Deciviews

A third measure of visibility is the deciview index, which EPA selected as the standard metric for tracking progress in EPA's regional haze program, largely because it provides a linear scale for perceived visual changes over a wide range of conditions.<sup>1</sup> On a particle-free, pristine day, the deciview index has a value of zero (SVR=391 km). On a relatively clear day in the Great Smoky Mountains the deciview index might be about 16 (SVR=79 km) and on a relatively hazy day the deciview index might be about 31 (SVR=201 km). For each 10 percent increase in light-extinction, the deciview index goes up by one. So, higher deciview values mean worse visibility. Under many scenic conditions, a change of one deciview is considered to be just perceptible by the average person.

### 2.1.7 Design Value

The monitored reading used by EPA to determine an area's air quality status; e.g., for ozone, the 3 year average of the annual fourth highest reading measured at each monitor is the design value. Ozone design values are calculated in accordance with 40 CFR Part 50.10, and Appendix I to Part 50. The calculation of annual and 24-hour average PM<sub>2.5</sub> design values can be found in 40 CFR Part 50, Appendix N.

### 2.1.8 Domain

A Domain (or Model Domain) refers to the coverage of an air quality model, or the area of the country for which there are model values. MATS calculates design values and/or spatial fields for an area encompassed by the coordinates given within a MATS input file.

### 2.1.9 Extinction

Light extinction is the sum of the light scattering and light absorption by particles and gases in the atmosphere, and is measured in inverse megameters (Mm<sup>-1</sup>), relating how much light is extinguished per megameter. Higher extinction values mean worse visibility.

### 2.1.10 FRM Monitors

Federal Reference Method (FRM) monitors used to determine attainment or nonattainment. The term "FRM" is frequently used to describe the network of PM<sub>2.5</sub> mass monitors.

### 2.1.11 Gradient Adjustment

A gradient adjustment is used to scale, or adjust, monitor data when using monitor data to estimate air pollution levels in unmonitored areas. It is calculated as the ratio of the model value in the unmonitored area to the value in the monitored area. In MATS, gradient adjustments can be used for PM Analyses and [Ozone Analyses](#).

### 2.1.12 IMPROVE Monitors

Interagency Monitoring of PROtected Visual Environments (IMPROVE) is a collaborative monitoring program established in the mid-1980s. IMPROVE objectives are to provide data needed to assess the impacts of new emission sources, identify existing man-made visibility impairment, and assess progress toward the national visibility goals that define protection of the 156 Class I areas.\*

---

\* See: <http://vista.cira.colostate.edu/views/Web/General/Glossary.aspx>.

### 2.1.13 Interpolation

Interpolation is the process of estimating the air quality level in an unmonitored area by using one or more nearby air quality monitors. The technique used in MATS is called [Voronoi Neighbor Averaging \(VNA\)](#).

### 2.1.14 Inverse Distance Weights

The weight given to any particular monitor is inversely proportional to its distance from the point of interest.

#### Example, Inverse Distance Weights

Assume there are four monitors (A, B, C, and D) that are a varying distance from a point E. Assume the distances are 10, 15, 15, and 20 kilometers respectively. The weights will be as follows:

$$\text{Weight}_A = 10 / (10+15+15+20) = 10 / 60 = 0.17$$

$$\text{Weight}_B = 15 / (10+15+15+20) = 0.25$$

$$\text{Weight}_C = 15 / (10+15+15+20) = 0.25$$

$$\text{Weight}_D = 20 / (10+15+15+20) = 0.33$$

#### Example, Inverse Distance Squared Weights

Assume there are four monitors (A, B, C, and D) that are a varying distance from a point E. Assume the distances are 10, 15, 15, and 20 kilometers respectively. The weights will be as follows:

$$\text{Weight}_A = 10 / (10^2+15^2+15^2+20^2) = 100 / 950 = 0.11$$

$$\text{Weight}_B = 15 / (10^2+15^2+15^2+20^2) = 0.24$$

$$\text{Weight}_C = 15 / (10^2+15^2+15^2+20^2) = 0.24$$

$$\text{Weight}_D = 20 / (10^2+15^2+15^2+20^2) = 0.42$$

### 2.1.15 Log File

A Log File provides information on a variety of technical aspects regarding how a results file (\*.ASR) was created. This includes the version of MATS, the date and time the [\\*.ASR file](#) was created.

```

Start  Map View  Output Navigator  Run Log
Close

>>>> Start MATS.exe v 1.1.0.4          2007-02-25 22:14:00
~~~~~

Starting iteration 0
Loading Default membership file...0.086 s.
Loading wind profiles file...0.026 s.
Loading Ozone monitor data...0.228 s.
WARNING: Base year of modeling changed to agree with Ozone data
Loading Baseline Model Data...87.966 s.
Calculating metric for Gradients...7.610 s.
Interpolating to spatial fields...13.510 s.
Reading future modeling file: C:\Program Files\Abt Associates\MATS\SampleData\ozone_model_data_2015.csv...91.075 s.
Running future year estimates at monitors...1.040 s.
Spatial interpolations to model cells...53.145 s.
Total execution time: 262.823 s.
~~~~~

<<<< Stop MATS.exe                    2007-02-25 22:18:24
~~~~~

```

### 2.1.16 Output Navigator

The Output Navigator allows you to load results files that you have previously created. You can then view these data in maps and in tables, or export the data to text files, which you can then load into a program such as Excel. Additional details are in the [Output Navigator](#) Chapter.

### 2.1.17 Output File

An Output File is one of the file types within a [\\*.ASR results file](#). The types of Output Files available depend on the type of analysis (PM, [Ozone](#), or [Visibility](#)) and the output choices that you have specified in the [Configuration File](#).

### 2.1.18 Point Estimate

A calculation within MATS that is performed at (or near) the location of ambient air monitors. The output files will contain base and/or future year results at each valid monitoring location.

### 2.1.19 RRF

The relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days).

### 2.1.20 SANDWICH

The SANDWICH process is used to adjust STN and IMPROVE monitor data so that it is

consistent with FRM monitor data. SANDWICH stands for Sulfates, Addjusted Nitrates, Derived Water, Inferrred Carbonaceous mass, and estimated aerosol acidity (H+).\*

\* For more details, see: Frank, N., 2006: "Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities" *J. Air Waste Manage. Assoc.*, 56, 500-511.

### 2.1.21 Scenario Name

The name given to a set of results generated by MATS. The Scenario Name is used in several ways: (1) the results file (\*.ASR) uses the Scenario Name; (2) an output folder, containing results extracted from a \*.ASR file, is given the Scenario Name; and (3) the [Output File](#) names begin with the Scenario Name.

The Scenario Name is specified when choosing the desired output, such as in the case of an ozone analysis.

### 2.1.22 SMAT

The Speciated Modeled Attainment Test (SMAT) is used to forecast  $PM_{2.5}$  values. The main steps are as follows:

- Derive quarterly mean concentrations for each component of PM<sub>2.5</sub> by multiplying FRM PM<sub>2.5</sub> by fractional composition of each species;
- Calculate a model-derived [relative response factor \(RRF\)](#) for each species;
- Multiply each RRF times each ambient PM<sub>2.5</sub> component (for each quarter) to get the future concentrations;
- Sum the future quarterly average components; and
- Average the four mean quarterly future PM<sub>2.5</sub> concentrations.

### 2.1.23 Spatial Field

A Spatial Field refers to air pollution estimates made at the center of each grid cell in a specified modeling domain. For example, MATS might calculate ozone [design values](#) for each grid cell in the modeling domain. Several types of Spatial Fields can be calculated for ozone and PM. (See the sections for [ozone](#) and PM for additional details.)

### 2.1.24 Spatial Gradient

A Spatial Gradient is the ratio of mean model values at an unmonitored location over the mean model values at a monitor. Spatial Gradients can be used in the calculation of [Spatial Fields](#) for ozone and PM. (See the sections for [ozone](#) and PM for additional details.)

### 2.1.25 STN Monitors

In meeting the requirements to monitor and gather data on the chemical makeup of fine particles, EPA established a Speciation Trends Network (STN). These STN monitors were placed at various national air monitoring stations (NAMS) and State and local air monitoring stations (SLAMS) across the Nation.

### 2.1.26 Temporal Adjustment

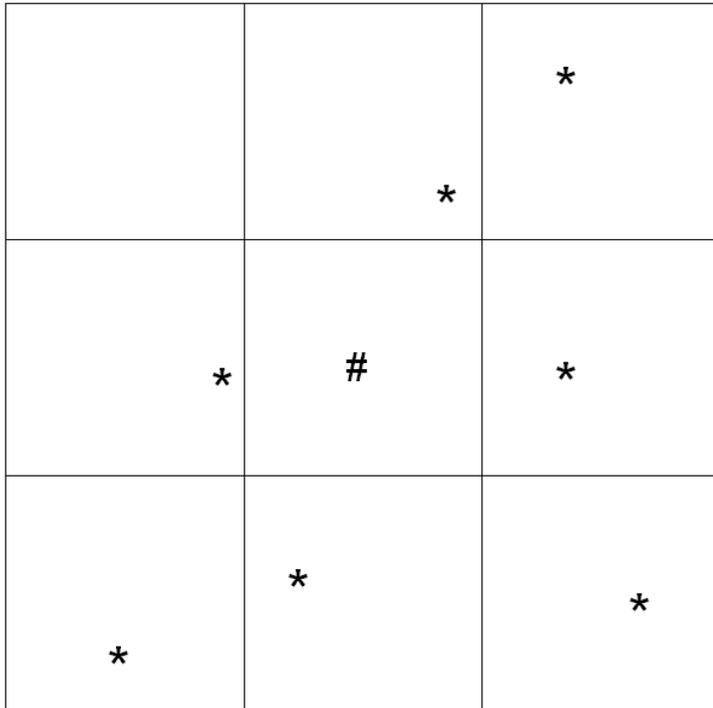
A temporal adjustment refers to multiplying ambient monitor data with a model derived [relative response factor \(RRF\)](#) in order to generate an estimated future year concentration.

### 2.1.27 VNA

Voronoi Neighbor Averaging (VNA) is an algorithm used by MATS to interpolate air quality monitoring data to an unmonitored location. MATS first identifies the set of monitors that best “surround” the center of the population grid cell, and then takes an [inverse-distance weighted average](#) of the monitoring values.

**2.1.27.1 VNA - Detailed Description**

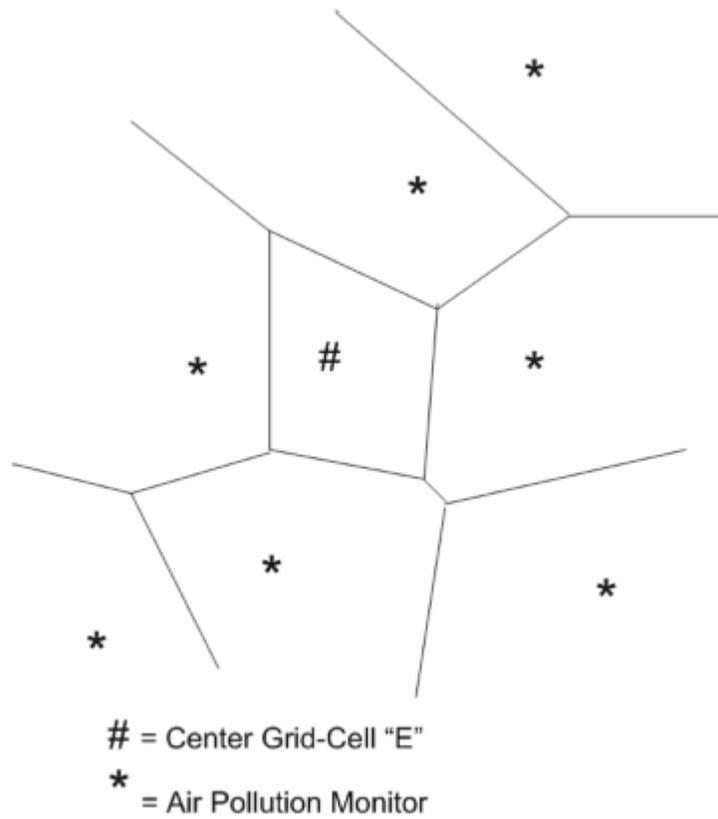
Voronoi Neighbor Averaging (VNA) algorithm uses monitor data directly or in combination with modeling data. MATS first identifies the set of monitors that best “surround” the point of interest.



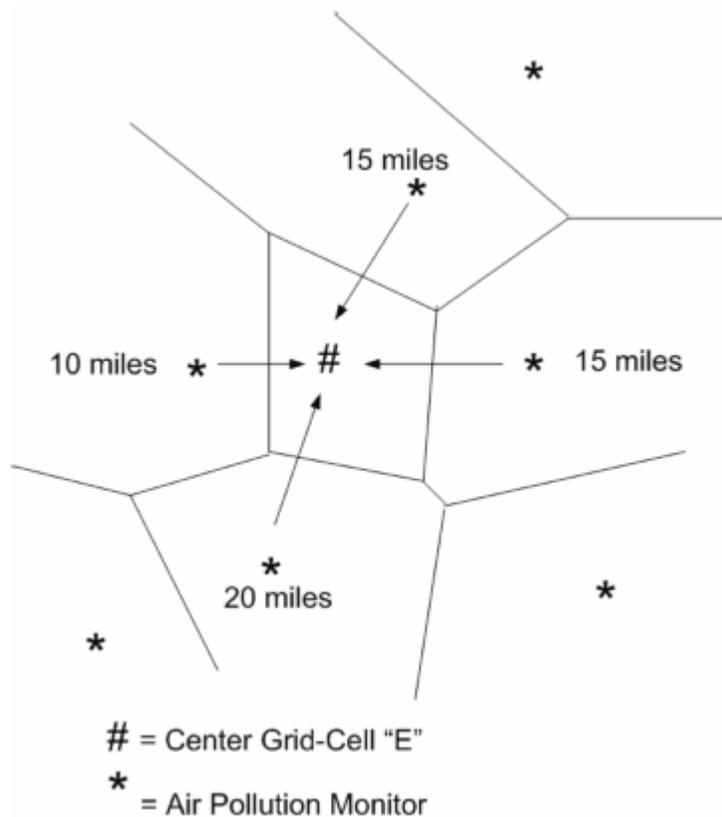
# = Center Grid-Cell “E”

\* = Air Pollution Monitor

In particular, MATS identifies the nearest monitors, or “neighbors,” by drawing a polygon, or “Voronoi” cell, around the center of the point of interest. The polygons have the special property that the boundaries are the same distance from the two closest points.



MATS chooses those monitors that share a boundary with the center of grid-cell "E."  
These are the nearest neighbors, we use these monitors to estimate the air pollution level for this grid-cell.

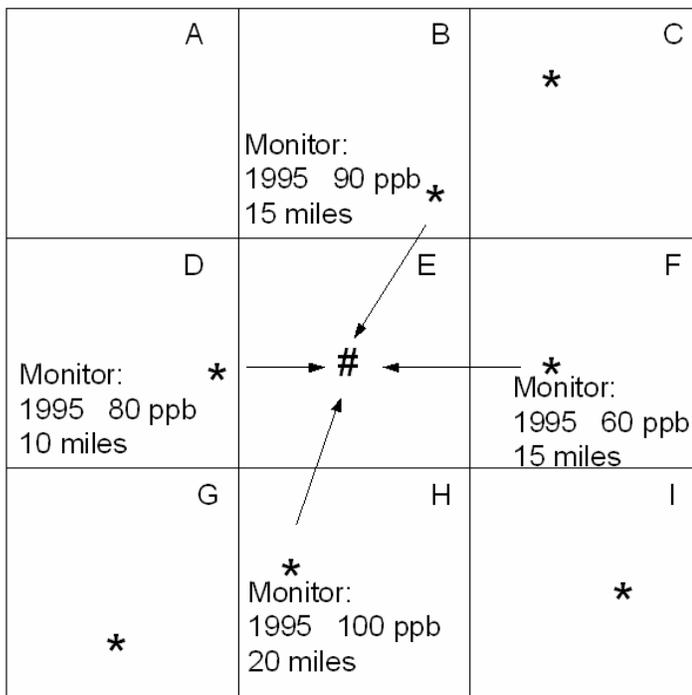


To estimate the air pollution level in each grid-cell, MATS calculates an inverse-distance weighted average of the monitor values. The further the monitor is from the grid cell, the smaller the weight. In the figure below, the weight for the monitor 10 miles from the center of grid-cell E is calculated as follows:

$$d_{i,1} = \frac{\frac{1}{20}}{\left(\frac{1}{20} + \frac{1}{16} + \frac{1}{14}\right)} = 0.27$$

The weights for the other monitors are calculated in a similar fashion. MATS then calculates an inverse-distance weighted average for grid-cell E as follows:

$$\text{Estimate} = 0.35 * 80 \text{ ppb} + 0.24 * 90 \text{ ppb} + 0.24 * 60 \text{ ppb} + 0.18 * 100 \text{ ppb} = 81.2 \text{ ppb}$$



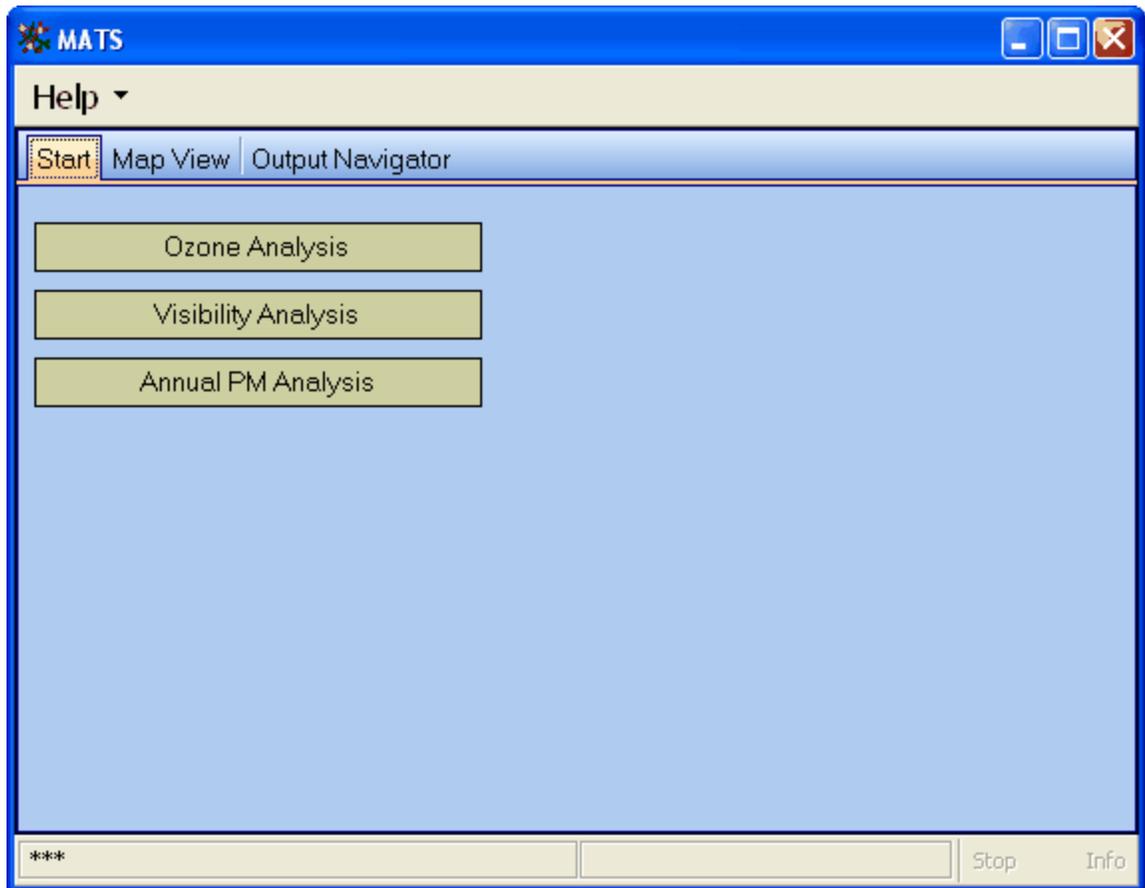
# = Center Grid-Cell "E"  
 \* = Air Pollution Monitor

## 2.2 File Types

The primary results file generated by MATS has a [.ASR](#) extension, which is specific to MATS. To view the results you have generated in other programs (e.g., MS Excel), you can export .CSV files using the [Output Navigator](#).

## 3 Overview of MATS Components

Upon starting MATS for the first time, you will see the following main window.



There are three main tabs: **Start**, **Map View**, and **Output Navigator**. The [Start](#) tab allows you to calculate [Particulate Matter \(PM\)](#), [Ozone](#) and [Visibility](#) levels. The [Map View](#) tab allows to map your results. The [Output Navigator](#) tab allows you to view your results either as tables or maps. Finally, the [Help](#) menu at the top of the main window provides explanations and examples of all of the functionality in MATS.

This Chapter gives a brief description of each of these items. All of these topics are covered in greater detail in subsequent chapters of this manual.

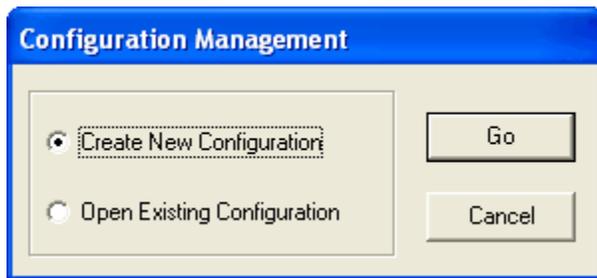
### 3.1 Start

The Start tab gives you the choice to analyze [Particulate Matter \(PM\)](#), [Ozone](#) or [Visibility](#).

To begin, click on one of the three buttons.

One of the key features of MATS is the Configuration. This is a reusable file that stores the choices that you have made when using MATS. You can use an existing Configuration File, make some minor changes to generate a new set of results, without having to explicitly set each of the choices you made in the previous Configuration.

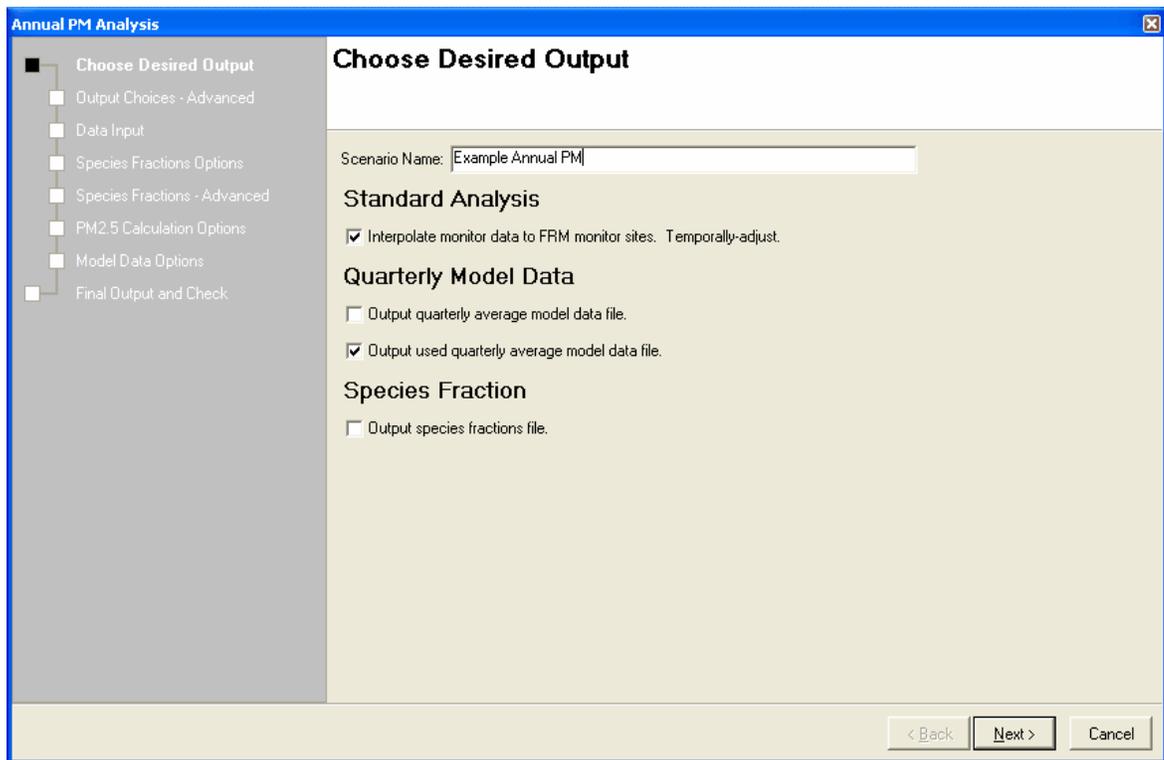
When you click on one of the analysis buttons, you will be asked whether you want to create a new Configuration, or whether you want to use an existing Configuration.



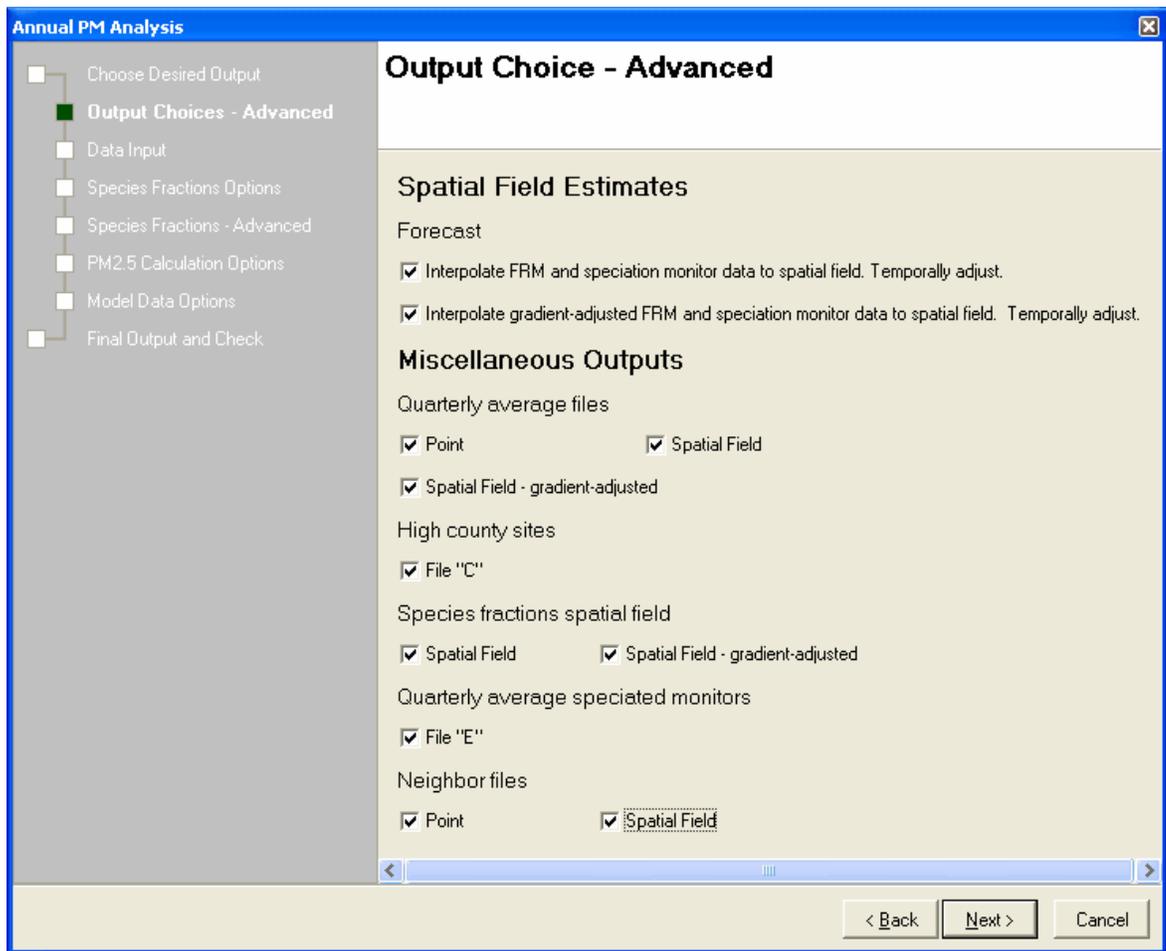
Make your choice and then click **Go**. MATS will then take you through a series of windows specifying the options available for each analysis.

### 3.1.1 PM Analysis

With the Standard Analysis, MATS can forecast annual PM<sub>2.5</sub> design values at monitor locations. MATS can also calculate quarterly model data files and a species fractions file. The **Choose Desired Output** window lets you specify the type of calculation(s) that you would like MATS to perform. These different assumptions are discussed in the [Output Choice](#) section of the [Annual PM Analysis: Details](#) chapter.



In the **Output Choice Advanced** window, MATS lets you choose from among two main options: [Spatial Field Estimates](#) and [Miscellaneous Output](#) that is generally used for quality assurance (QA). Within each of these two main options there are a number of choices. Details regarding these choices are in the [Output Choice - Advanced](#) section of the [Annual PM Analysis: Details](#) chapter.



In the **Data Input** window, you specify the MATS input files that are used in each scenario. There are three main types of files which must be specified. These include ambient PM2.5 species data, ambient total PM2.5 data (FRM and IMPROVE), and gridded model output data (e.g. CMAQ or CAMx data). There is specific terminology that is used on the Data Input page. "Official" data refers to PM2.5 FRM data that can be used to determine official design values for compliance purposes (comparison to the NAAQS). Other datasets which may not have rigid regulatory significance are sometimes referred to as "unofficial" data. The format for the data is in the [Data Input](#) section of the [Annual PM Analysis: Details](#) chapter.

The **Species Fractions Calculation Options** has two main sections. One involving speciated monitor data (e.g., STN and IMPROVE monitors) and the other total PM2.5 monitor data (FRM and IMPROVE). For each type of data you can specify the [years of interest](#), whether you want to [delete certain data](#), and the [minimum amount of data](#) for a monitor to be considered "valid" (and thus included in the calculations). Details on these options are in the [Species Fractions Calculation Options](#) section of the [Annual PM Analysis: Details](#) chapter.

**Annual PM Analysis**

**Species Fractions Calculation Options**

Choose Desired Output

- Output Choices - Advanced
- Data Input
- Species Fractions Options**
- Species Fractions - Advanced
- PM2.5 Calculation Options
- Model Data Options
- Final Output and Check

**IMPROVE-STN Monitor Data**

Monitor Data Years

Start Year: 2002 End Year: 2004

Delete Specified Data Values

EPA-specified deletions from monitor data

User-specified deletions from monitor data

Minimum Data Requirements

Minimum number of valid days per quarter: 11

Minimum number of valid years required for valid season: 1

Minimum number of valid seasons for valid monitor: 1

**PM2.5 Monitor Data**

Monitor Data Years

Start Year: 2002 End Year: 2004

Delete Specified Data Values

EPA-specified deletions from monitor data

User-specified deletions from monitor data

Minimum Data Requirements

Minimum number of valid days per quarter: 11

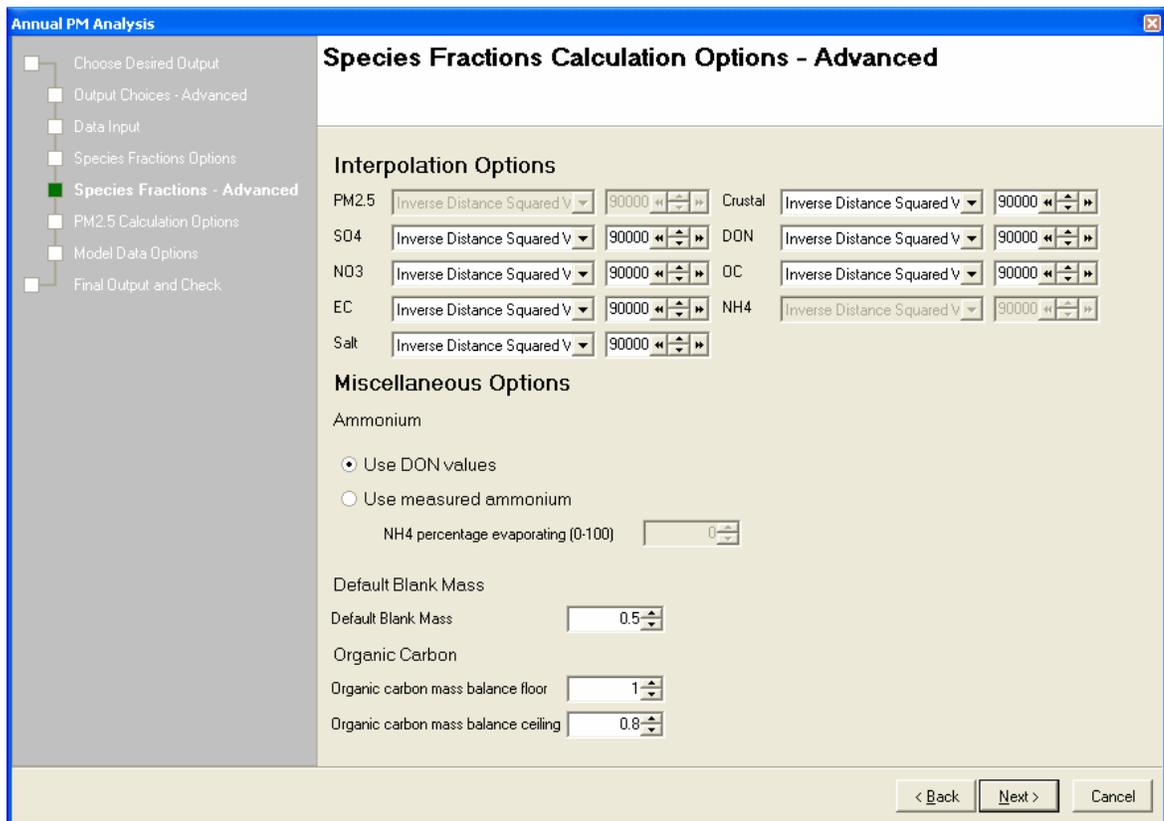
Minimum number of valid years required for valid season: 1

Minimum number of valid seasons for valid monitor (point calculations): 4

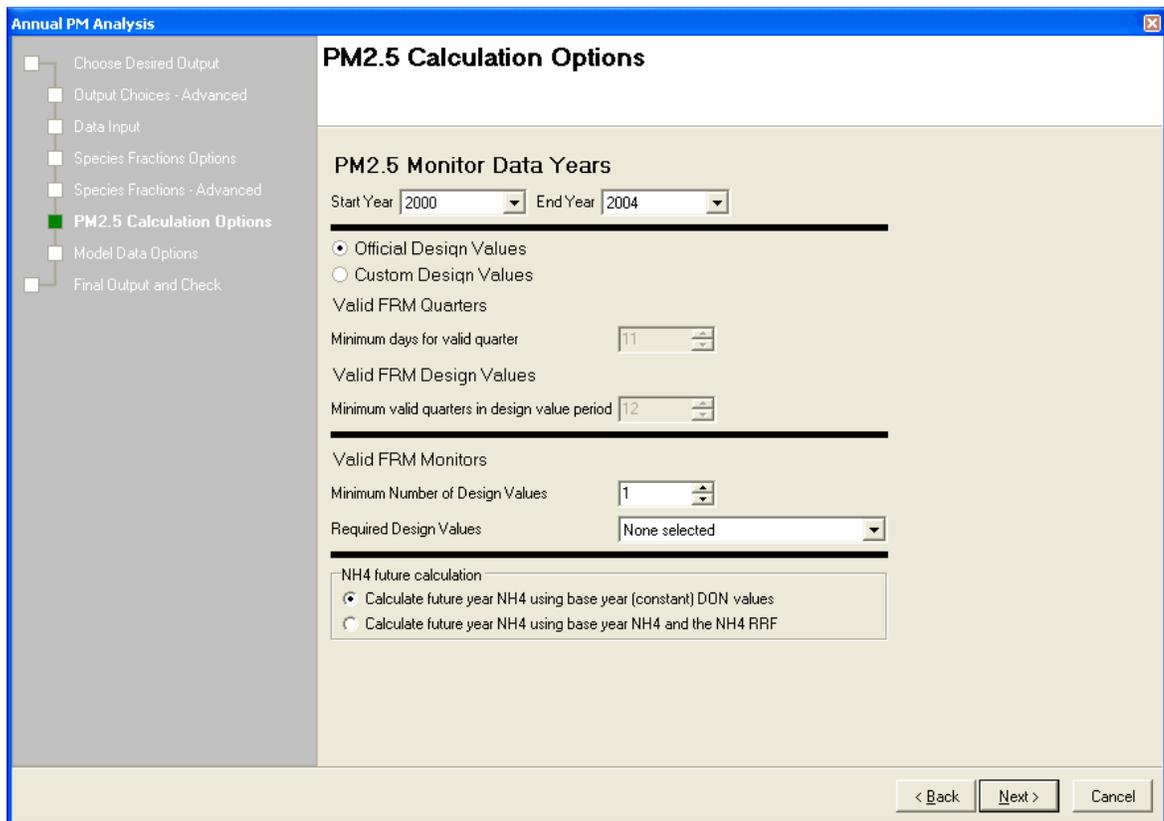
Minimum number of valid seasons for valid monitor (spatial fields calculations): 1

< Back Next > Cancel

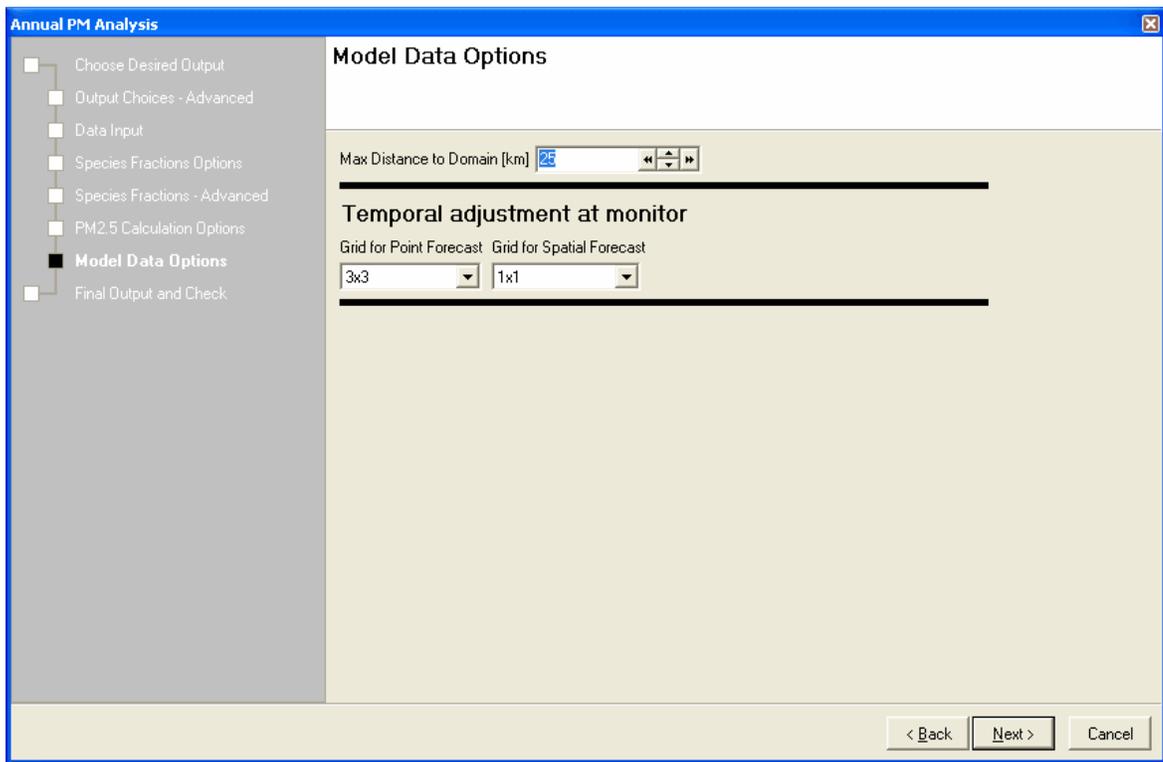
The **Species Fractions Calculation Options - Advanced** screen allows you to make relatively advanced choices for your analysis. Generally speaking, the default options settings are consistent with the EPA modeling guidance document (note: the start and end years should always be set to match the relevant base modeling year). One set of options allows you to specify the interpolation weighting that you want to use and whether the interpolation involves a maximum distance or not. The second set of options involves choices regarding ammonium, blank mass, and organic carbon. Details on these options are in the [Species Fractions Calculation Options - Advanced](#) section of the [Annual PM Analysis: Details](#) chapter.



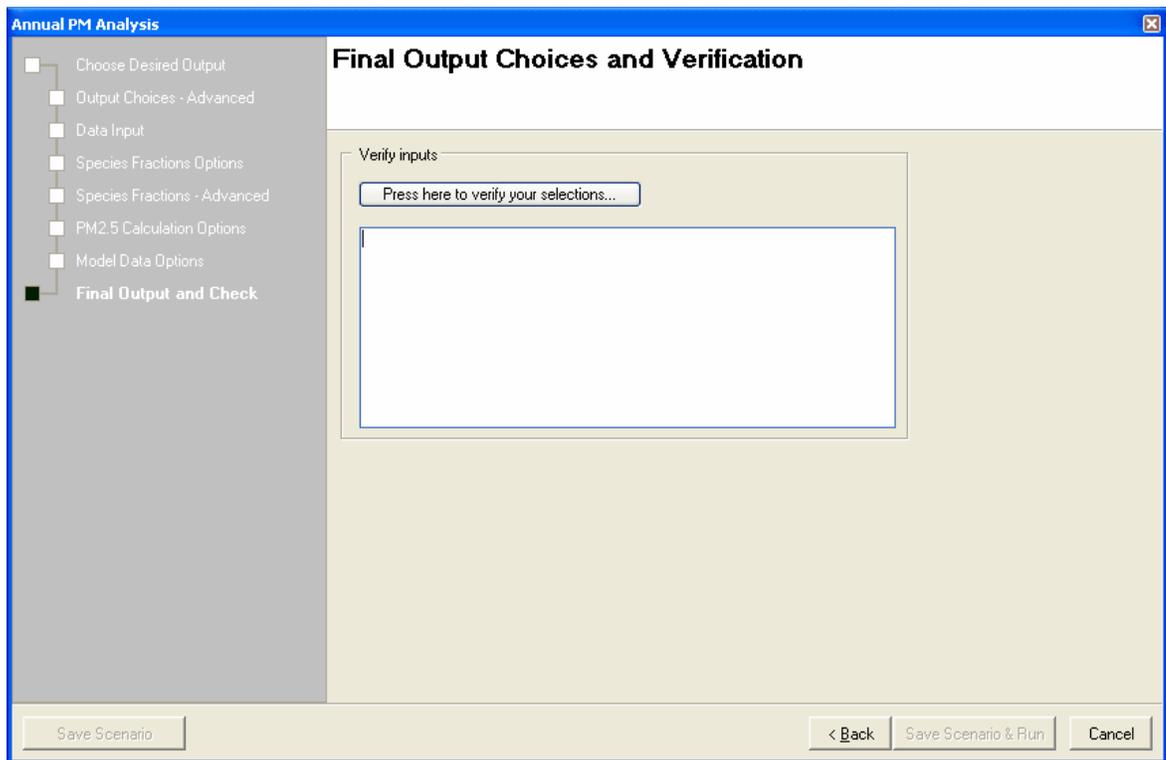
The **PM2.5 Calculation Options** window allows you to specify the particular years of monitor data that you want to use from the input file you specified in the [Data Input section](#). You can also specify a variety of parameters regarding how to determine which data you want to use. Details on these options are in the [PM2.5 Calculation Options](#) section of the [Annual PM Analysis: Details](#) chapter.



You also can use the **Model Data Options** to specify how to use the model data. This is described in the [Model Data Options](#) section of the [Annual PM Analysis: Details](#) chapter.



The last step is to verify the inputs to the analysis.



### 3.1.2 Ozone Analysis

MATS can forecast ozone design values at monitor locations -- these forecasts are referred to as [Point Estimates](#). MATS can also use a variety of approaches to calculate design values for a [Spatial Field](#). The **Choose Desired Output** window lets you specify the type of calculation(s) that you would like MATS to perform. These different assumptions are discussed in the [Choose Desired Output](#) section of the [Ozone Analysis: Details](#) chapter.

**Choose Desired Output**

Scenario Name : Example 03

**Point Estimates**

Forecast

Temporally-adjust ozone levels at monitors.

**Spatial Field**

Baseline

Interpolate monitor data to spatial field

Interpolate gradient-adjusted monitor data to spatial field.

Forecast

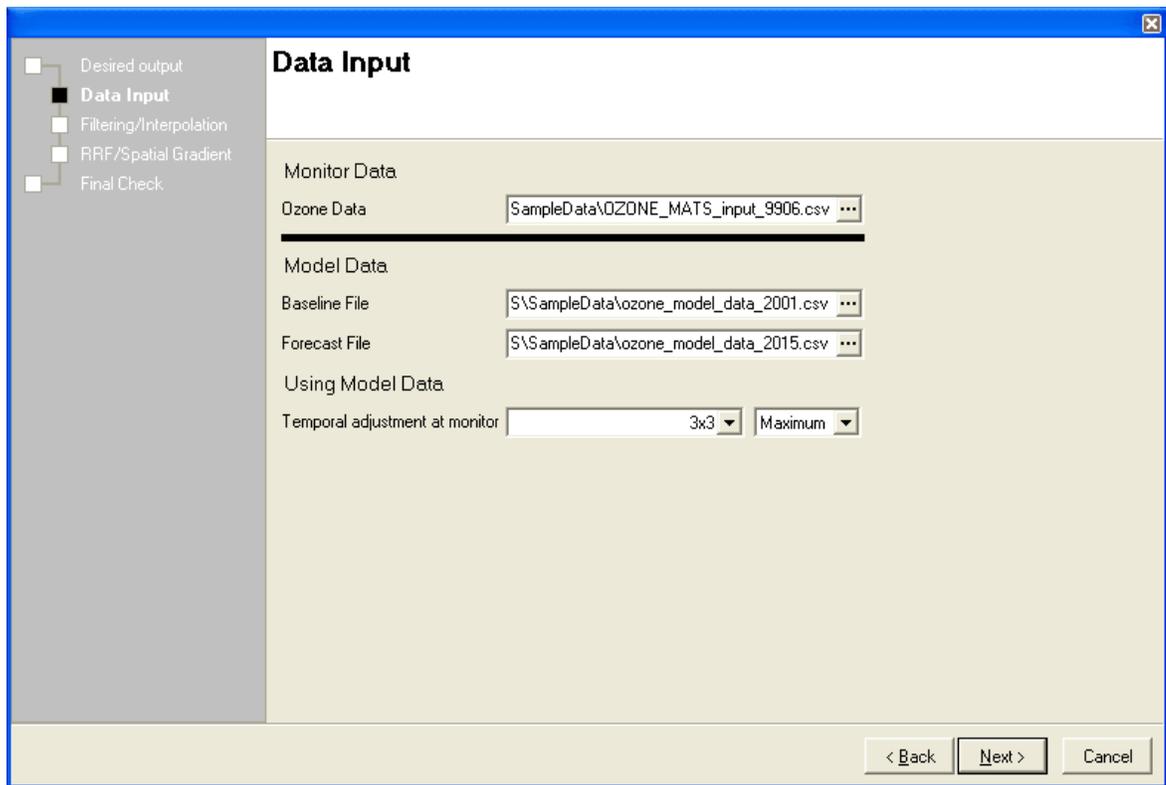
Interpolate monitor data to spatial field. Temporally adjust ozone levels.

Interpolate gradient-adjusted monitor data to spatial field. Temporally adjust...

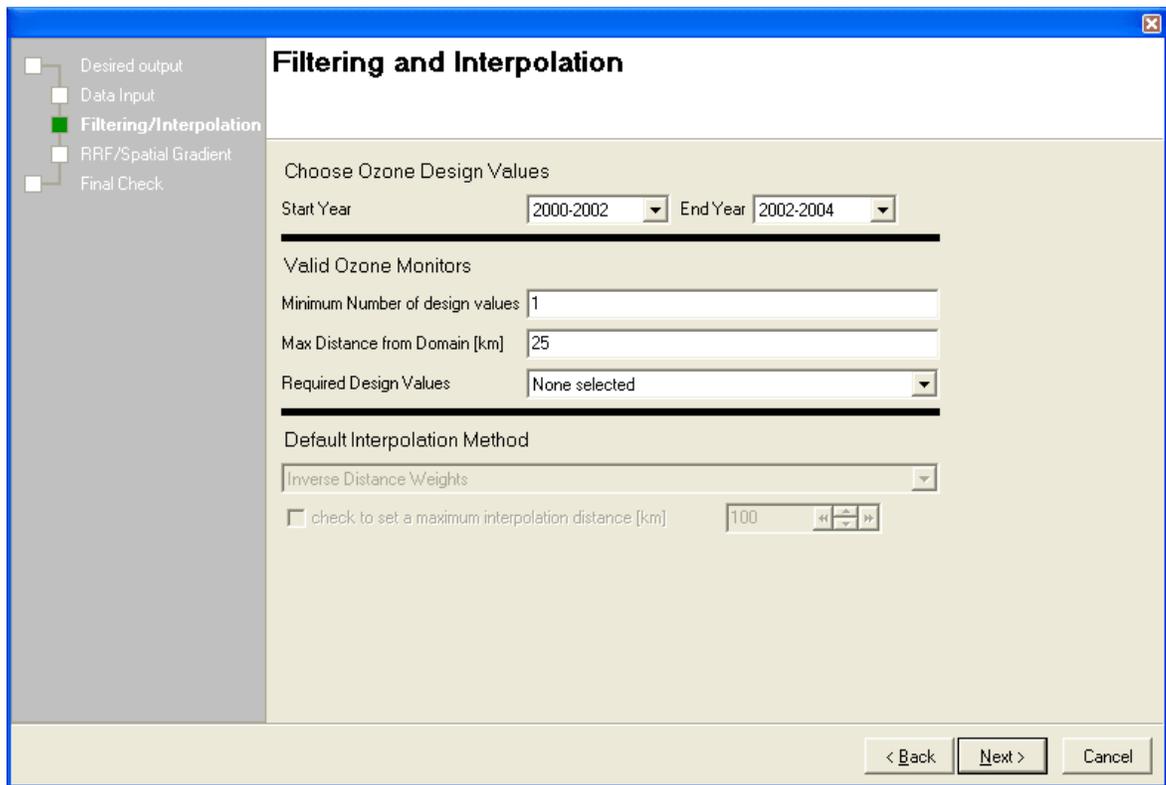
< Back   Next >   Cancel

The **Data Input** window lets you specify the data files that you want to use. MATS comes populated with default data sets, but you can use your own data if you choose. The format for the data is in the [Data Input](#) section of the [Ozone Analysis: Details](#) chapter.

The **Data Input** window also lets you choose how to use model data when calculating a [temporal adjustment](#) at a monitor. This is discussed in detail in the [Using Model Data](#) section of the [Ozone Analysis: Details](#) chapter.



The **Filtering and Interpolation** window lets you specify the years of data that you want to use, any restrictions you want to apply when choosing valid monitors (*i.e.*, monitors that MATS use in its calculations), and options on the [interpolation](#) method. This is discussed in detail in the [Filtering and Interpolation](#) section of the [Ozone Analysis: Details](#) chapter.



The **RRF and Spatial Gradient** window lets you set parameters used in the calculation of [relative response factors \(RRF\)](#) and [spatial gradients](#). This is discussed in detail in the [RRF and Spatial Gradient](#) section of the [Ozone Analysis: Details](#) chapter.

**RRF and Spatial Gradient**

Desired output  
 Data Input  
 Filtering/Interpolation  
**RRF/Spatial Gradient**  
 Final Check

**RRF Setup:**

Initial threshold value (ppb) 85

Minimum number of days in baseline at or above threshold 10

Minimum allowable threshold value (ppb) 70

Min number of days at or above minimum allowable threshold 5

Enable Backstop minimum threshold for spatial fields

Backstop minimum threshold for spatial fields 60

Subrange first day of ozone season used in RRF 1

Subrange last day of ozone season used in RRF 153

Pair days based on high concentration instead of date.

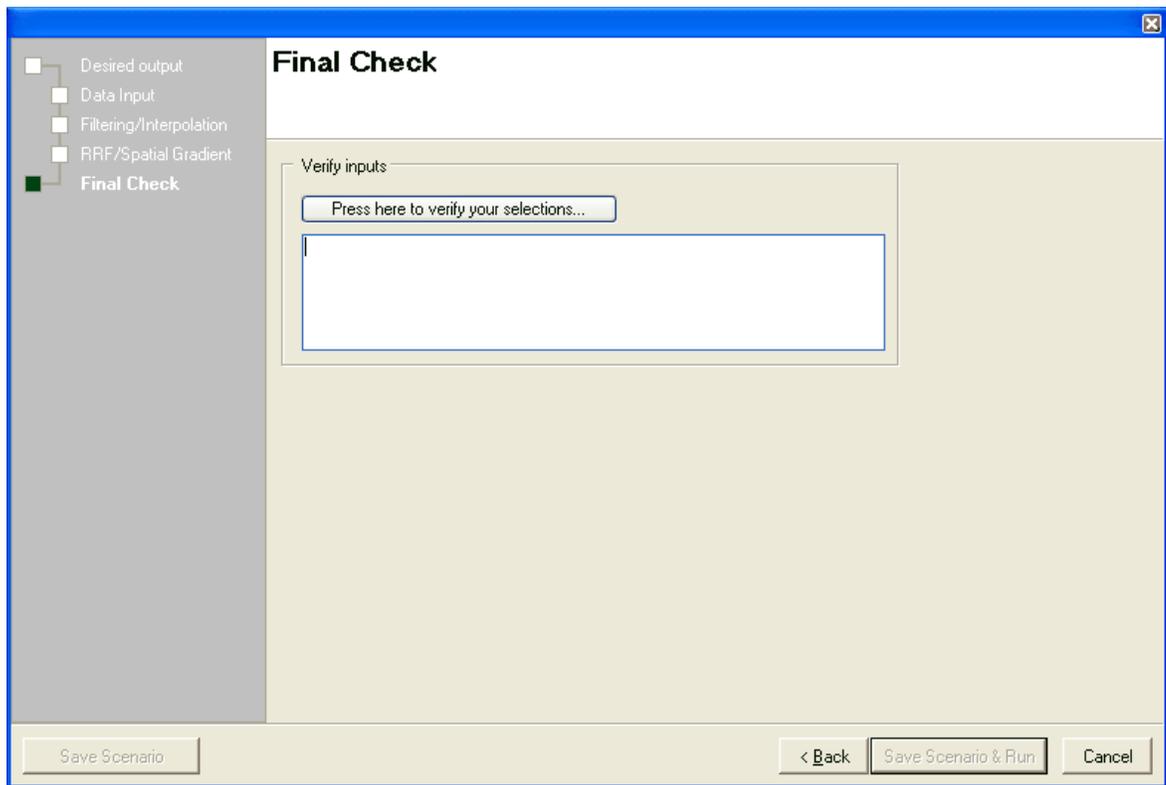
**Spatial Gradient Setup:**

Start Value 1

End Value 5

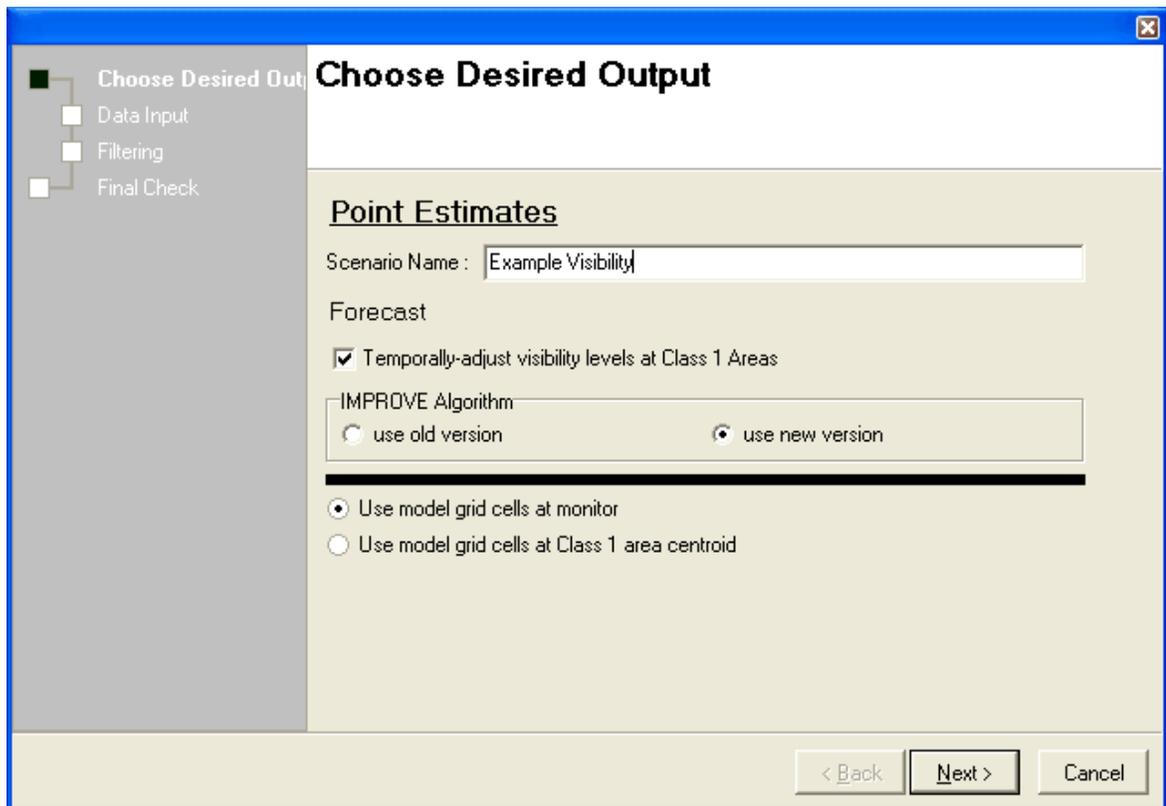
< Back Next > Cancel

The last step is to verify the inputs to the analysis.



### 3.1.3 Visibility Analysis

MATS can forecast visibility in [Class I Areas](#) - these forecasts are referred to as [Point Estimates](#). In addition to specifying the [Scenario Name](#), you can choose the version of the **IMPROVE Algorithm** that you want to use. You can also choose whether to use model data at the monitor linked to each Class I Area, or whether to use model data closest to the Class I Area centroid. These different assumptions are discussed in the [Desired Output](#) section of the [Visibility Analysis: Details](#) chapter.



The **Data Input** window lets you specify the data files that you want to use. MATS comes populated with default input data, but you can use your own data if you choose. The format for the data is in the [Data Input](#) section of the [Visibility Analysis: Details](#) chapter.

The **Data Input** window also lets you choose how to use model data when calculating a [temporal adjustment](#) at a monitor. This is discussed in detail in the [Using Model Data](#) section of the [Visibility Analysis: Details](#) chapter.

**Data Input**

Choose Desired Output  
Data Input  
Filtering  
Final Check

Monitor Data

IMPROVE Monitor Data - Old Algorithm C:\Program Files\Abt Associates\MATS\Samp ...

IMPROVE Monitor Data - New Algorithm 004-daily IMPROVE-all data-new equation.csv ...

Model Data

Baseline File S:\SampleData\2020cc\_EUS\_PM25\_sub.csv ...

Forecast File S:\SampleData\2020cc\_EUS\_PM25\_sub.csv ...

Using Model Data

Temporal adjustment at monitor 3x3

< Back Next > Cancel

The **Filtering** window lets you specify the years of data that you want to use, and any restrictions you want to apply when choosing valid monitors (*i.e.*, monitors that MATS use in its calculations). This is discussed in detail in the [Filtering](#) section of the [Visibility Analysis: Details](#) chapter.

**Filtering**

Choose Visibility Data Years

Start Monitor Year   End Monitor Year   Base Model Year

2000   2004   2002

---

Valid Visibility Monitors

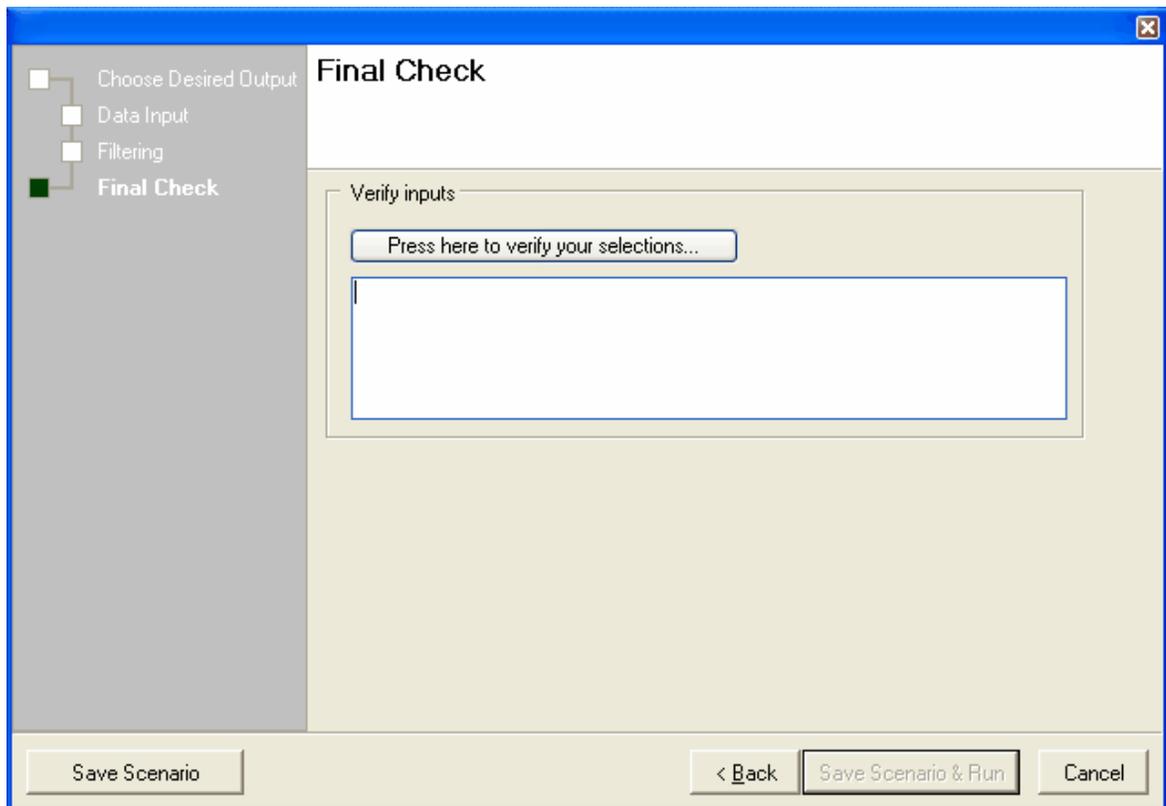
Minimum years required for a valid monitor   3

Max Distance from Centroid to Gridcell Center [km]   25

---

< Back   Next >   Cancel

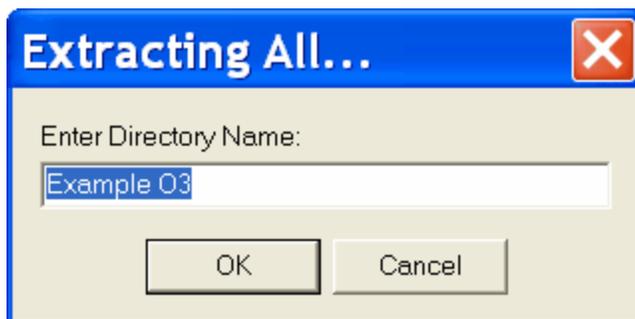
The last step is to verify the inputs to the analysis.



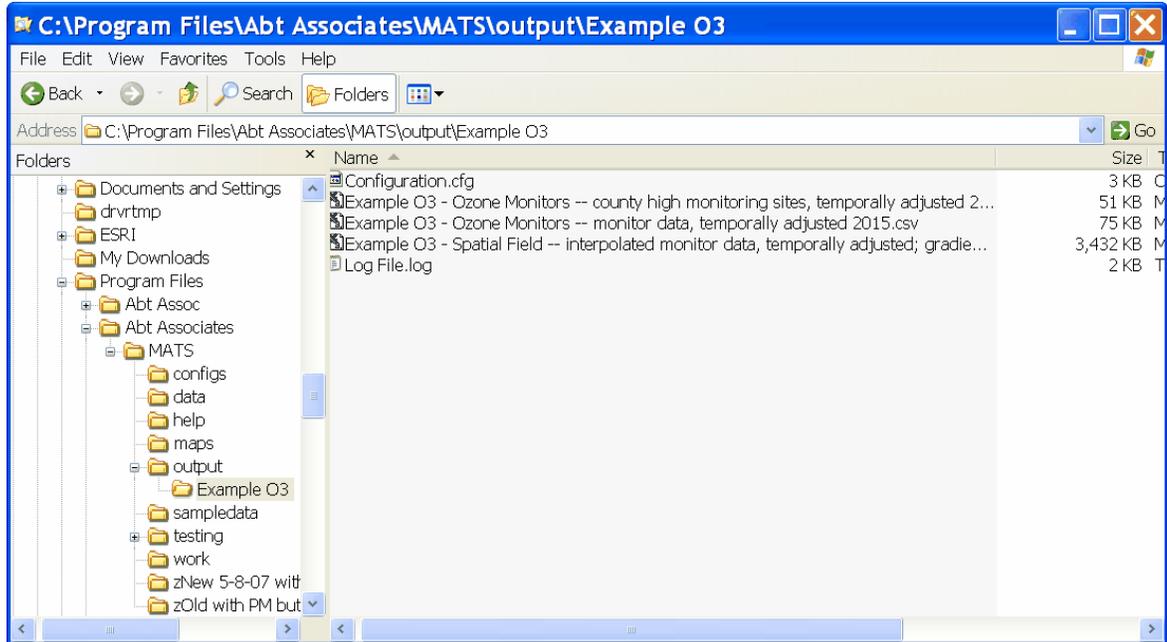
### 3.2 Output Navigator

The **Output Navigator** allows you to load results files (*i.e.*, [ASR files](#)) that you have previously created in MATS. You can view these data in maps and in tables, or export the data to text files that you can then work with in a program such as Excel.

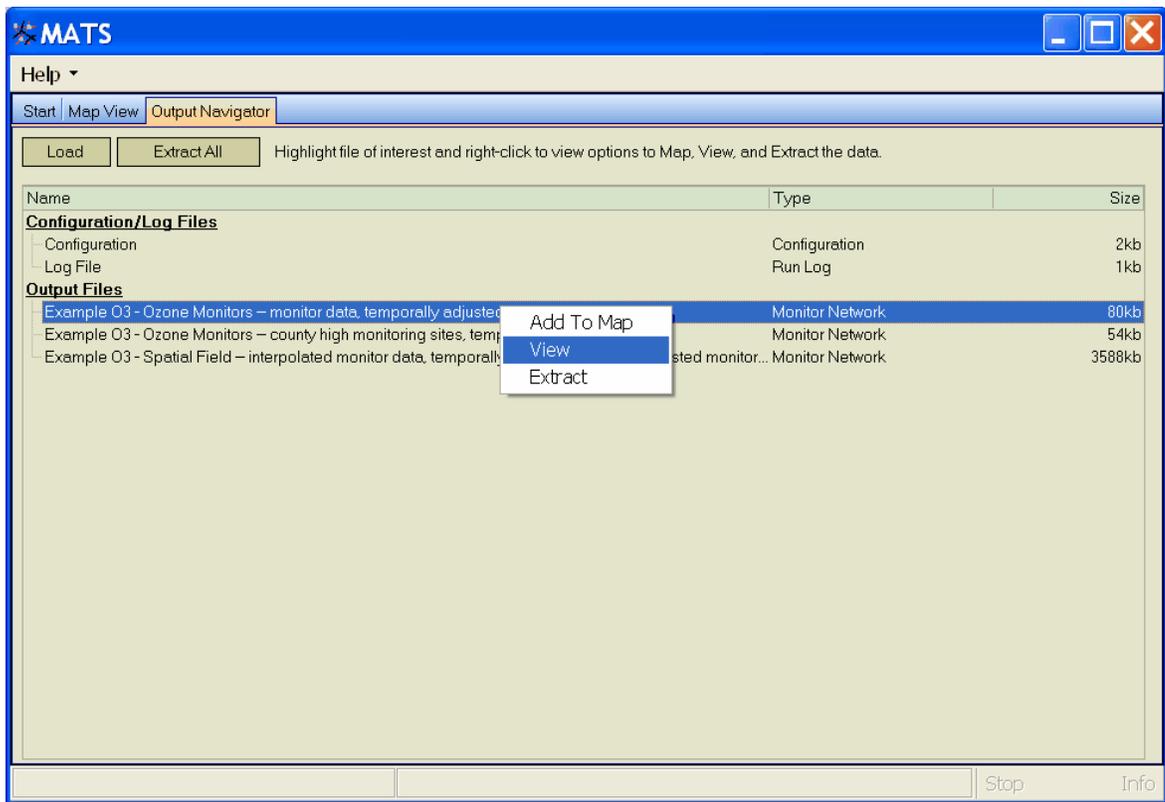
To start, just click on the **Output Navigator** tab. Then click on the **Load** button to choose the file that you want to examine. You can click the **Extract All** button, and MATS will create a folder with all of the files that MATS has generated. (A default name for the folder is the [Scenario Name](#) you have chosen.)



The files generated by MATS are of two types: (1) [Configuration](#) and [Log](#) files; and (2) [Output](#) files containing the results of the MATS calculations.



Another option is to right-click on a particular file, and then you can choose whether to use data to *Add to Map*, *View*, or *Extract*.



The *View* option lets you examine the data and then to export it to a [CSV](#) file, which you can then load into another program such as Microsoft Excel.

Refresh Select location and press refresh to see data... Show All

Select Quantities that must be >= 0

- b\_o3\_dv
- f\_o3\_dv
- referencecell
- rrf
- ppb
- days

Export Export this data to CSV

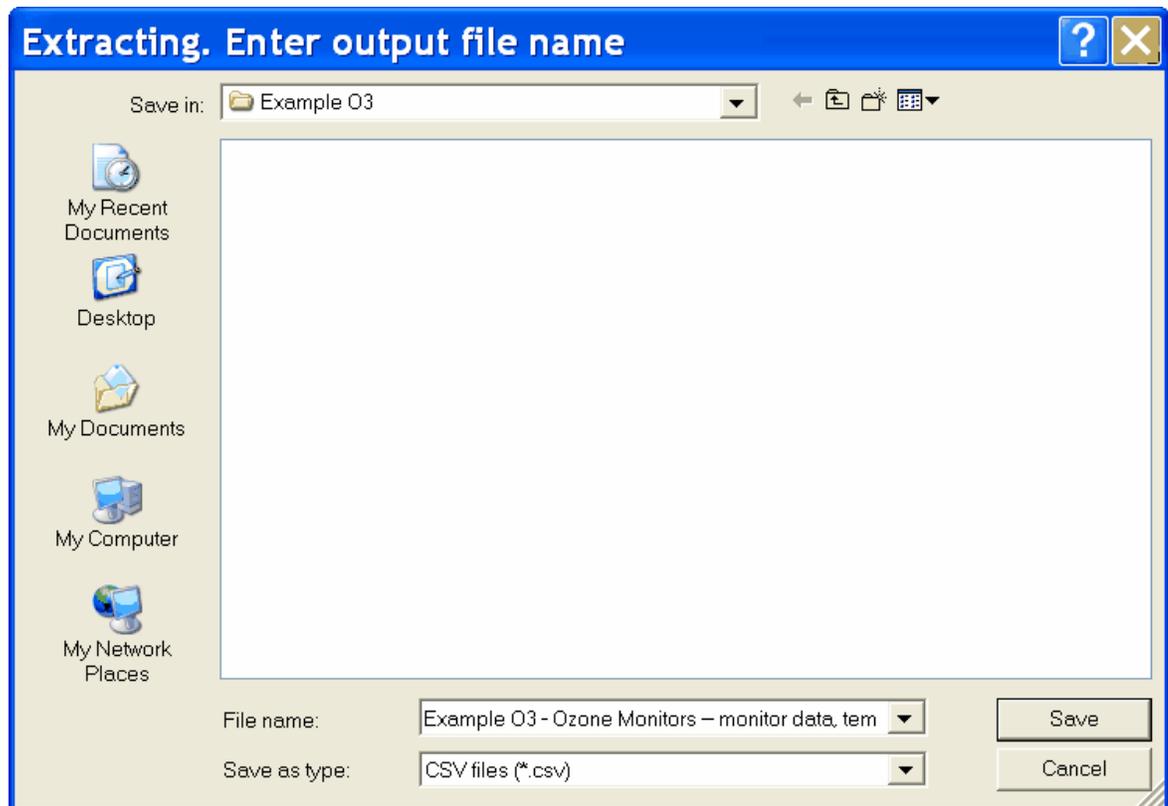
id	type	lat	long
010030010		30.497778	-87.881389
010270001		33.281111	-85.802222
010331002		34.760556	-87.650556
010510001		32.498333	-86.136667
010550011		33.9039	-86.0539
010730023		33.553056	-86.815
010731003		33.485556	-86.915
010731005		32.221111	87.002611

Data

id	date	b_o3_dv	f_o3_dv	referencecell	rrf	ppb	days
010030010	2005	77.7	68.6	95023	0.883	85.0	11.0
010270001	2005	77.7	61.4	108051	0.791	71.0	11.0
010331002	2005	71.0	54.2	92063	0.764	71.0	11.0
010510001	2005	75.0	61.8	106043	0.825	70.0	9.00
010550011	2005	73.0	56.5	105056	0.774	73.0	10.0
010730023	2005	75.7	59.2	100052	0.783	81.0	11.0
010731003	2005	78.0	62.4	99052	0.801	81.0	11.0
010731005	2005	79.2	60.5	99050	0.764	80.0	10.0

Stop Info

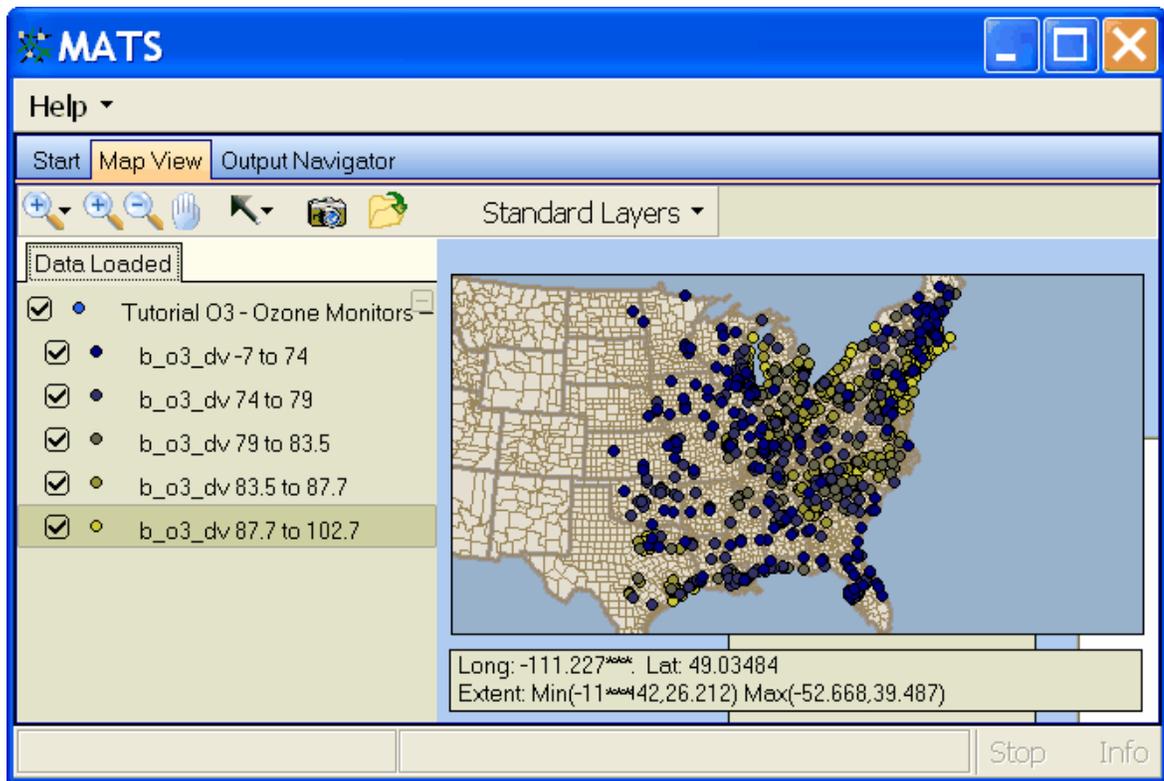
Choosing the *Extract* option will allow you to immediately export the data to a CSV file. The default file name for the CSV file is the same one that you see in the Output Navigator window (e.g., *Example O3 - Ozone Monitors -- monitor data.csv*).



Choosing the *Add to Map* option allows you to create a map of your results.

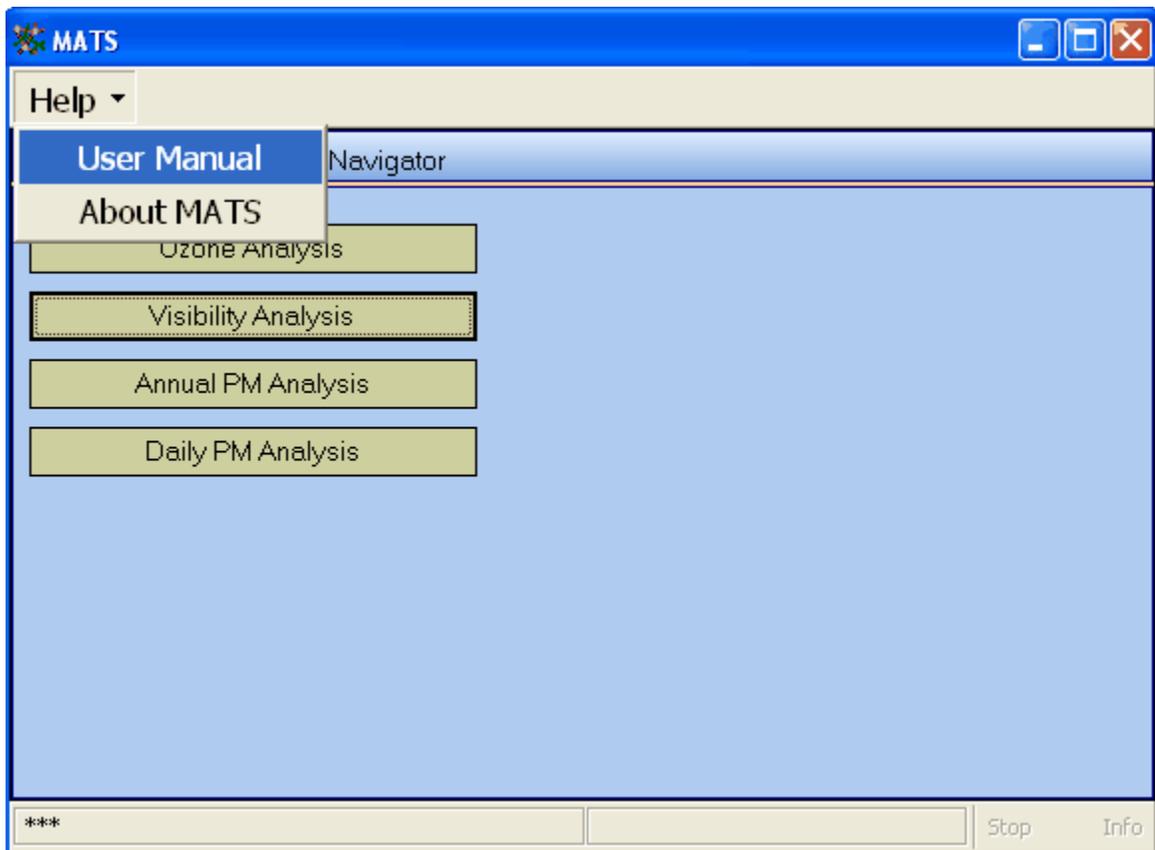
### 3.3 Map View

The **Map View** allows you to perform a variety of mapping tasks. You can zoom in to a particular location; choose particular colors to map your data, export the maps you have created to [BMP files](#), among other things. These various options are discussed in detail in the [Map View](#) chapter.



### 3.4 Help

The Help dropdown menu has the User Manual for MATS and version information.



## 4 Annual PM Analysis: Quick Start Tutorial

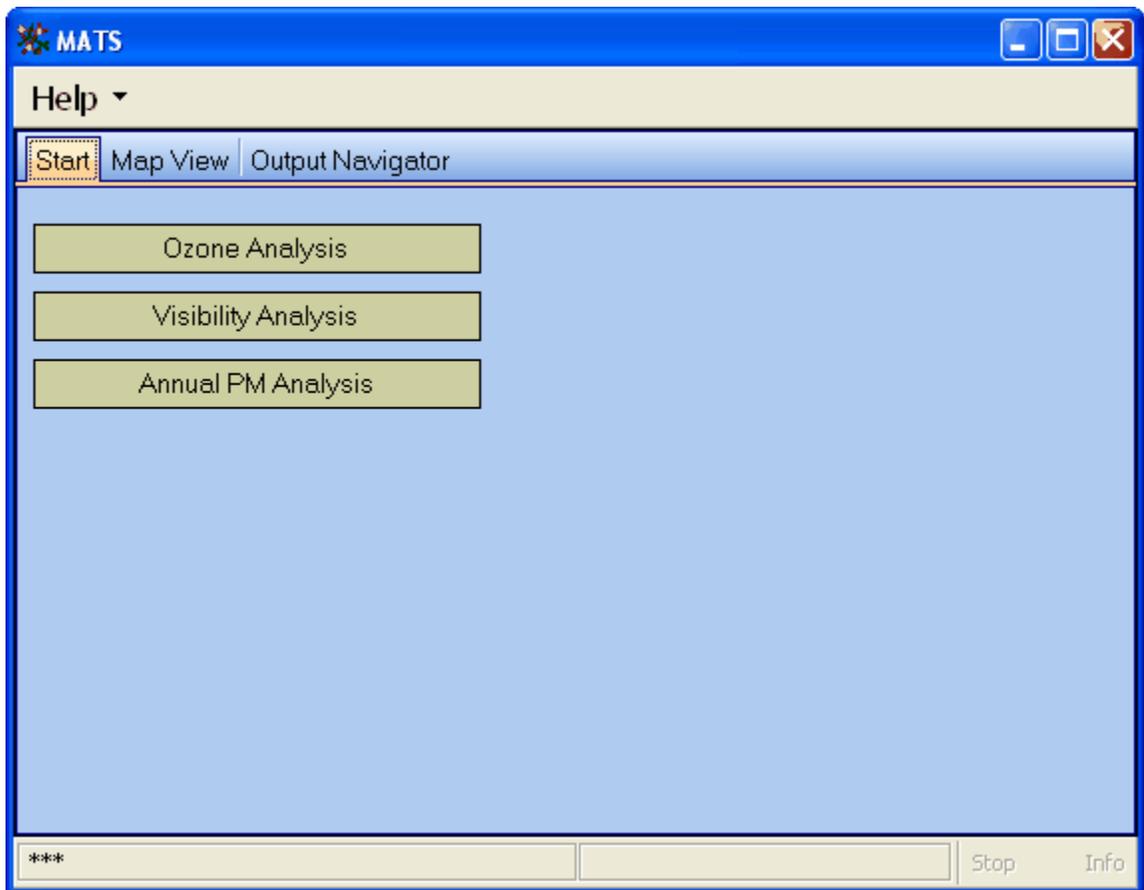
In this tutorial you will forecast annual PM<sub>2.5</sub> [design values](#) at monitors in the Eastern United States. The steps in this analysis are as follows:

- [Step 1. Start MATS](#). Start the MATS program and choose to do an Annual PM analysis.
- [Step 2. Output Choice](#). Choose the output to generate. In this example, you will do two things: forecast annual PM<sub>2.5</sub> levels at monitor locations and output a species fractions file (which you can subsequently reuse, as [discussed here](#)).
- [Step 3. Output Choice - Advanced](#). With these advanced options, you can generate spatial fields and a variety of files useful for quality assurance. Simply review these options and then uncheck them all. (If you are interested, these options are all [described here](#).)
- [Step 4. Data Input](#). Choose the particular years of data and monitors to use in this analysis.
- [Step 5. Species Fractions Calculation Options](#). Specify how to generate the [relative response factors \(RRFs\)](#) used in the forecasts.
- [Step 6. Species Fractions Calculation Options - Advanced](#).
- [Step 7. PM<sub>2.5</sub> Calculation Options](#).
- [Step 8. Model Data Options](#).
- [Step 9. Final Check](#). Verify the choices you have made.
- [Step 10. Load & Map Output](#). Load your output and prepare maps of your forecasts.
- [Step 11. View & Export Output](#). Examine the data in a table format and export these data.

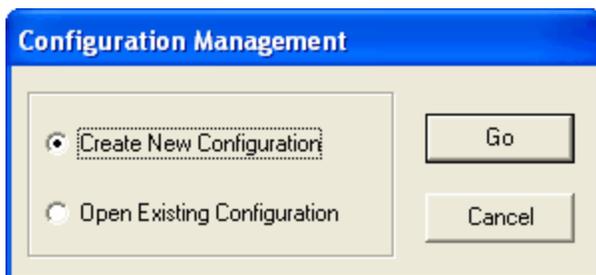
Each step is explained below. Additional details are provided in the section [Annual PM Analysis: Details](#).

### 4.1 Step 1. Start MATS

Double-click on the MATS icon on your desktop, and the following window will appear:



Click the **Annual PM Analysis** button on the main MATS window. This will bring up the **Configuration Management** window.



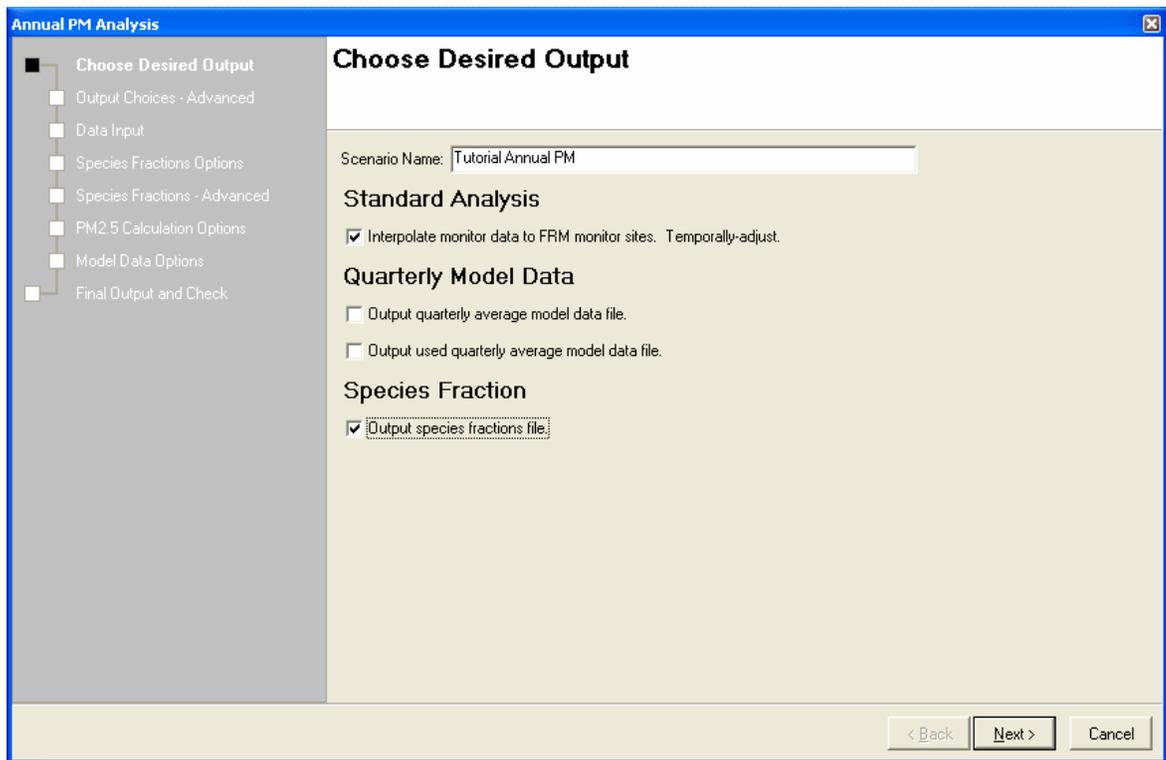
A [Configuration](#) allows you to keep track of the choices that you make when using MATS. For example, after generating results in MATS, you can go back, change one of your choices, rerun your analysis, and then see the impact of this change without having to enter in all of your other choices. For this example, we will start with a *New Configuration*.

Choose **Create New Configuration** and click the **Go** button. This will bring up the [Choose Desired Output](#) window.

## 4.2 Step 2. Output Choice

The **Choose Desired Output** window allows you to choose the output that you would like to generate. MATS allows you to conduct a Standard Analysis (i.e., forecast [Point Estimates](#) at ambient monitors), output quarterly model data, and output a species fractions file.

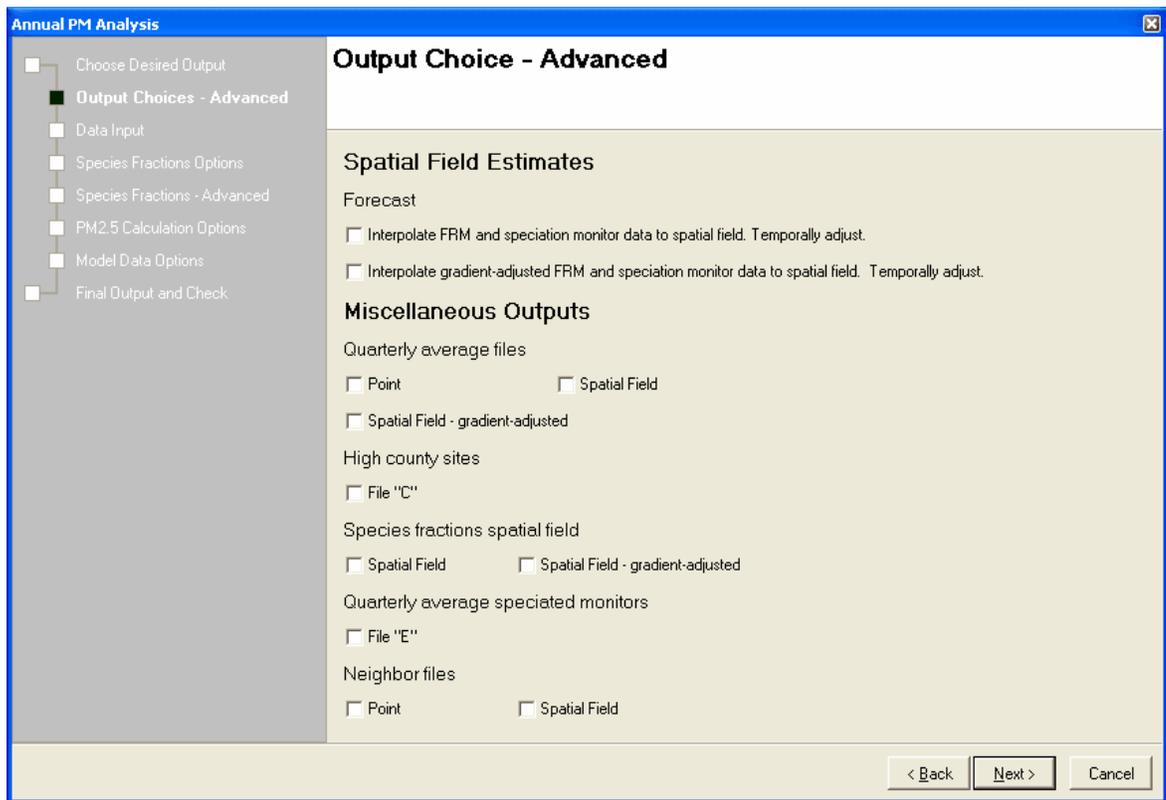
- In the **Scenario Name** box type “*Tutorial Annual PM*” – this will be used to keep track of where your results are stored and the variable names used in your results files.
- **Standard Analysis.** Leave the box checked next to "Interpolate monitor data to FRM monitor sites. Temporally-adjust." MATS will create forecasts for each monitor in the monitor file. (Additional details on the [Standard Analysis are here.](#))
- **Quarterly Model Data.** Uncheck these options. (If checked, MATS generates quarterly model files that MATS generates from daily data that you have provided. This is useful if you want to reuse model files -- the quarterly files are much smaller and MATS will run faster if it can skip the step of creating quarterly data from the daily. These files are [described here.](#))
- **Species Fraction.** Check the box next to Output species fractions file. This will generate a reusable file [described here.](#)



When your window looks like the window above, click **Next**. This will bring you to the [Output Choice - Advanced](#) window.

### 4.3 Step 3. Output Choice - Advanced

With the advanced options in the **Output Choice - Advanced** window, you can generate spatial fields and a variety of files useful for quality assurance. Simply review these options and then uncheck them all. (If you are interested, these options are all [described here](#).)



When your window looks like the window above, click **Next**. This will bring you to the [Data Input](#) window.

#### 4.4 Step 4. Data Input

The **Data Input** window allows you to choose the species and PM2.5 monitor data and the model data that you want to use. As discussed in more detail in the following chapter (see [Standard Analysis](#)), MATS calculates the ratio of the base and future year model data to calculate a relative response factor (**RRF**) for each PM species. MATS uses the unofficial PM2.5 monitor data and interpolated species monitor data to estimate species values at each FRM site, multiplies the species values from the monitor data with the species-specific RRFs, and then estimates a future-year design value. (Additional details on Data Input are available [here](#).)

Use the default settings in the **Data Input** window. The window should look like the following:

When your window looks like the window above, click **Next**. This will bring you to the [Species Fractions Calculation Options](#) window.

## 4.5 Step 5. Species Fractions Calculation Options

The **Species Fractions Calculation Options** window has several functions related to the IMPROVE-STN (species) monitor data and the (unofficial) PM<sub>2.5</sub> monitor data. These functions include identifying the years of monitor data that you want to use, deleting any specific data values, and choosing the minimum data requirements of monitors you want in your analysis.

- **Monitor Data Years.** Choose the years of monitor data that you want to use. The default is to use the three-year period 2002-2004. (That is, for both IMPROVE-STN and PM<sub>2.5</sub> monitor data, the **Start Year** is 2002 and the **End Year** is 2004.)
- **Delete Specified Data Values.** The default is to delete the observations specified by EPA. As described in the [Data Input section](#), valid data are given a value of "0" and observations that should be deleted are given a value of "1" to "10". (Leave unchecked the option for the user to flag data.)
- **Minimum Data Requirements.** There are three sets of minimum data requirements:
  1. Minimum number of valid days per valid quarter. This is the minimum number of site-days per valid quarter. The default is 11 days, which corresponds to >

75% completeness for monitors on a 1 in 6 day schedule. This is a minimum number of samples that is routinely used in calculations of quarterly average concentrations.

2. Minimum number of valid quarters required for valid season. This number of years of data (within the start year and end year specified) for which we have valid quarters for a given season. The default value is 1 year. If the value is set = 2, then there will need to be 2 years of valid data from quarter1 in order for quarter one to be considered complete (and the same for the other 3 quarters).
3. Minimum number of valid seasons required for valid monitor. This is the number of valid seasons that are needed in order for a particular monitor's data to be considered valid. The default is 1 and the range is 1-4. For example, if the value is = 1, then a monitor's data will be used in the species fractions calculations if it has at least one valid season. If the value = 4, then the site must have all 4 seasons of valid data to be used.

Use the default settings pictured in the screenshot below. (All of these options are described in detail [here](#).)

**Annual PM Analysis**

Choose Desired Output

Output Choices - Advanced

Data Input

**Species Fractions Options**

Species Fractions - Advanced

PM2.5 Calculation Options

Model Data Options

Final Output and Check

### Species Fractions Calculation Options

#### IMPROVE-STN Monitor Data

Monitor Data Years

Start Year: 2002 End Year: 2004

Delete Specified Data Values

EPA-specified deletions from monitor data

User-specified deletions from monitor data

Minimum Data Requirements

Minimum number of valid days per quarter: 11

Minimum number of valid years required for valid season: 1

Minimum number of valid seasons for valid monitor: 1

#### PM2.5 Monitor Data

Monitor Data Years

Start Year: 2002 End Year: 2004

Delete Specified Data Values

EPA-specified deletions from monitor data

User-specified deletions from monitor data

Minimum Data Requirements

Minimum number of valid days per quarter: 11

Minimum number of valid years required for valid season: 1

Minimum number of valid seasons for valid monitor (point calculations): 4

Minimum number of valid seasons for valid monitor (spatial fields calculations): 1

< Back Next > Cancel

When your window looks like the window above, click **Next**. This will bring you to the [Species Fractions Calculation Options](#) window.

## 4.6 Step 6. Species Fractions Calculation Options - Advanced

The **Species Fractions Calculation Options - Advanced** screen allows you to make relatively advanced choices for your analysis. Generally speaking, the default options settings are consistent with the EPA modeling guidance document. One set of options allows you to specify the interpolation weighting that you want to use and whether the interpolation involves a maximum distance or not. The second set of options involves choices regarding ammonium, blank mass, and organic carbon.

Use the default settings pictured in the screenshot below. (All of these options are described in detail [here](#).)

**Annual PM Analysis**

Species Fractions Calculation Options - Advanced

Choose Desired Output  
Output Choices - Advanced  
Data Input  
Species Fractions Options  
**Species Fractions - Advanced**  
PM2.5 Calculation Options  
Model Data Options  
Final Output and Check

**Interpolation Options**

PM2.5	Inverse Distance Squared	90000	Crustal	Inverse Distance Squared	90000
SO4	Inverse Distance Squared	90000	DON	Inverse Distance Squared	90000
NO3	Inverse Distance Squared	90000	OC	Inverse Distance Squared	90000
EC	Inverse Distance Squared	90000	NH4	Inverse Distance Squared	90000
Salt	Inverse Distance Squared	90000			

**Miscellaneous Options**

Ammonium

Use DON values  
 Use measured ammonium

NH4 percentage evaporating (0-100)

Default Blank Mass

Default Blank Mass

Organic Carbon

Organic carbon mass balance floor

Organic carbon mass balance ceiling

< Back   Next >   Cancel

When your window looks like the window above, click **Next**. This will bring you to the [PM2.5 Calculation Options](#) window.

## 4.7 Step 7. PM2.5 Calculation Options

The **PM2.5 Calculation Options** window allows you to specify the particular years of monitor data that you want to use from the input file you specified in [Step 4](#) (Data Input). Keep the default settings:

- **PM2.5 Monitor Data Years.** Leave Start Year = 2000 and End Year = 2004.
- **Official vs. Custom Values.** Specify "official" design values, which is the recommended default setting.
- **Valid FRM Monitors.** Keep the minimum number of design values equal to the default value of 1, and do not specify any particular design values for inclusion in the calculations.
- **NH4 Future Calculation.** You can also specify how you want to forecast NH4 values. Use the default approach, which is to use baseline DON values.

Use the default settings pictured in the screenshot below. (All of these options are

described in detail [here](#).)

When your window looks like the window above, click **Next**. This will bring you to the [Model Data Options](#) window.

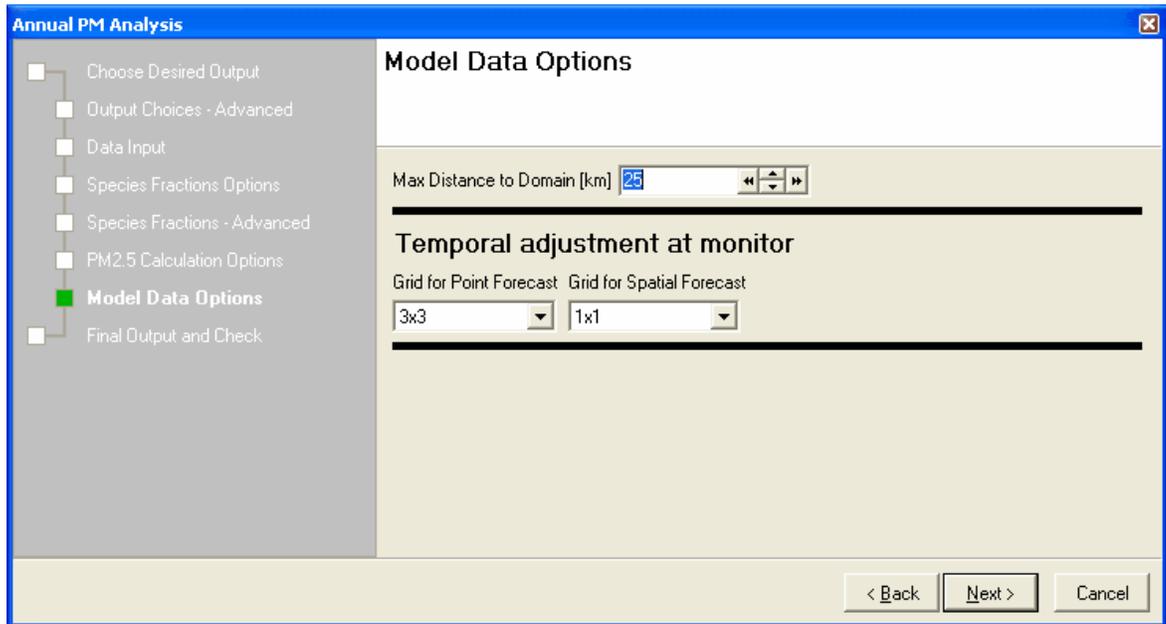
## 4.8 Step 8. Model Data Options

The Model Data Options section allows you to specify:

- **Max Distance to Domain.** This is the maximum distance from a given monitor to the nearest model grid cell (measured in kilometers). If a monitor is further than the specified maximum distance from the center of any grid cell, then MATS will not calculate results for that monitor or use the monitor in any calculations (this effectively eliminates monitors from outside the specified domain from being included in the output files).
- **Temporal Adjustment at Monitor.** This option specifies how many model grid cells to use in the calculation of RRFs for point estimates and for spatial estimates. Use the default option: 3x3 set of grid cells. Note that for PM analyses, MATS calculates **mean**

concentrations across the grid cell array (as compared to maximum concentrations used for ozone analyses).

Use the default settings pictured in the screenshot below. (All of these options are described further [here](#).)

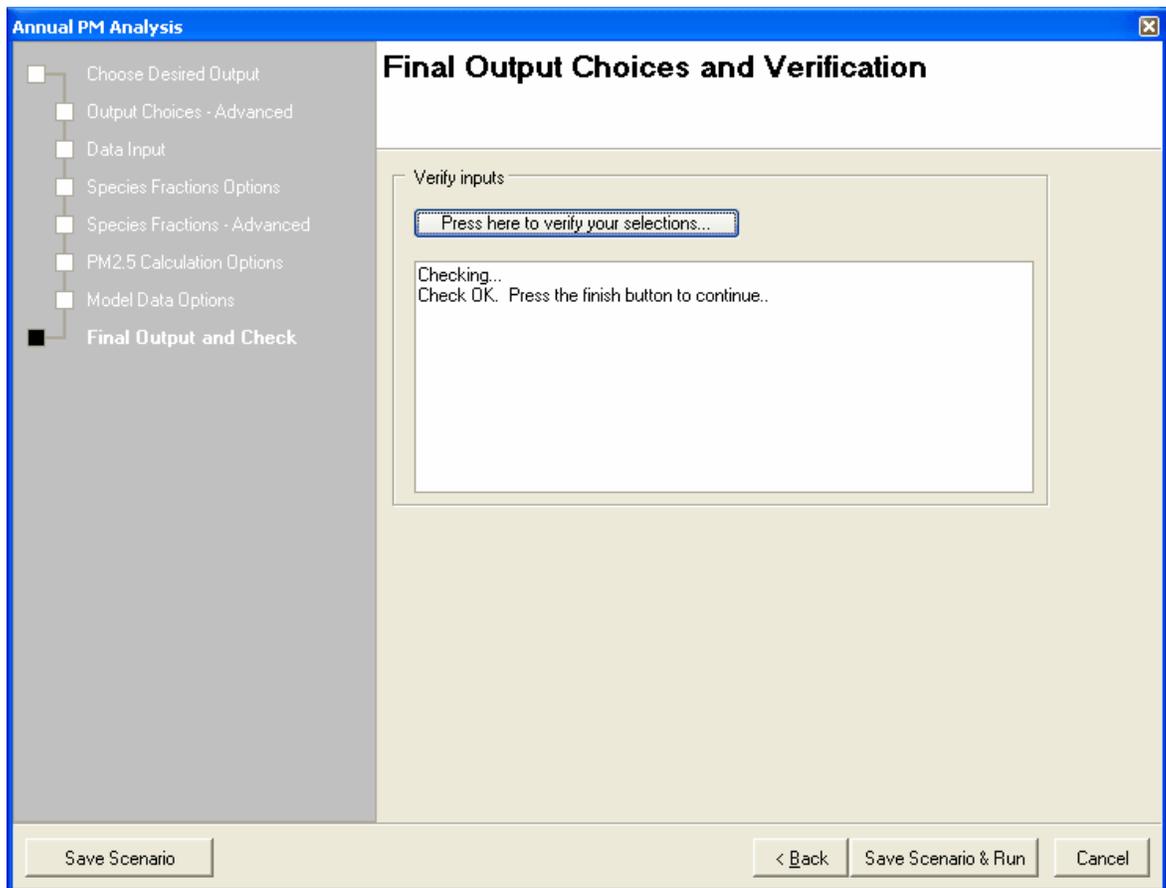


When your window looks like the window above, click **Next**. This will bring you to the [Final Check](#) window.

## 4.9 Step 9. Final Check

The **Final Check** window verifies the choices that you have made. For example, it makes sure that the paths specified to each of the files used in your [Configuration](#) are valid.

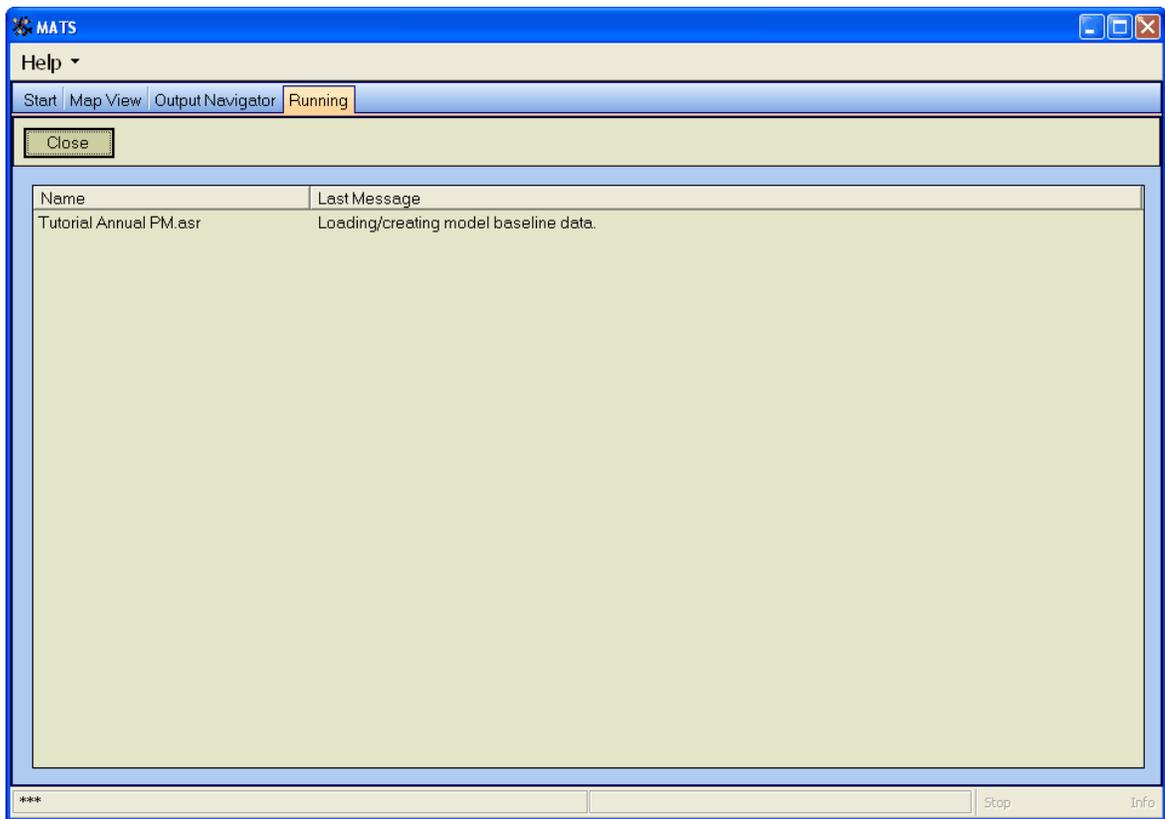
Click on the **Press here to verify selections** button.



If you encounter any errors, go back to the choices you have previously made by clicking on the appropriate part (e.g., [Data Input](#)) of the tree in the left panel, and then make any changes required.

When your window looks like the window above, click either **Save Scenario & Run** or **Save Scenario**. Save Scenario & Run will cause MATS to immediately run the scenario.

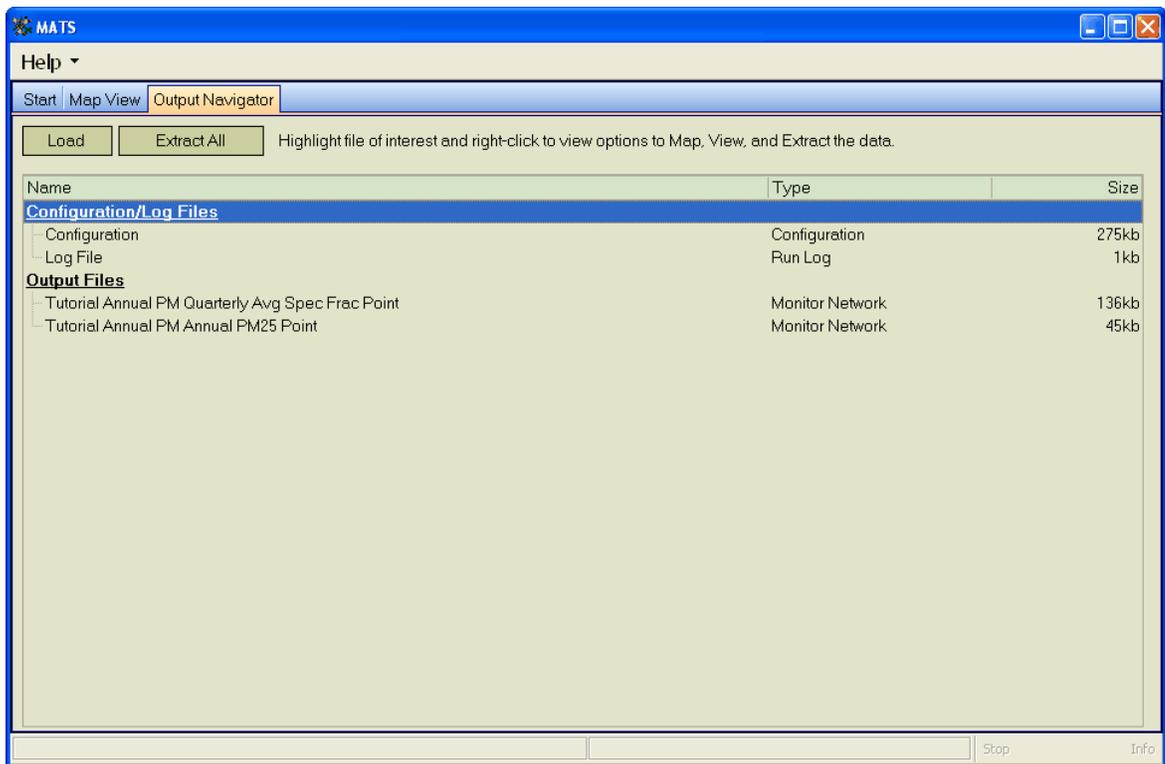
A temporary, new **Running** tab will appear (in addition to the **Start**, [Map View](#) and [Output Navigator](#) tabs).



When the calculations are complete, a small window indicating the results are **Done** will appear. Click **OK**.



After clicking **OK**, the **Output Navigator** tab will be active. (The **Running** tab will no longer be seen.) MATS will automatically load the output files associated with the .asr configuration that just finished running.

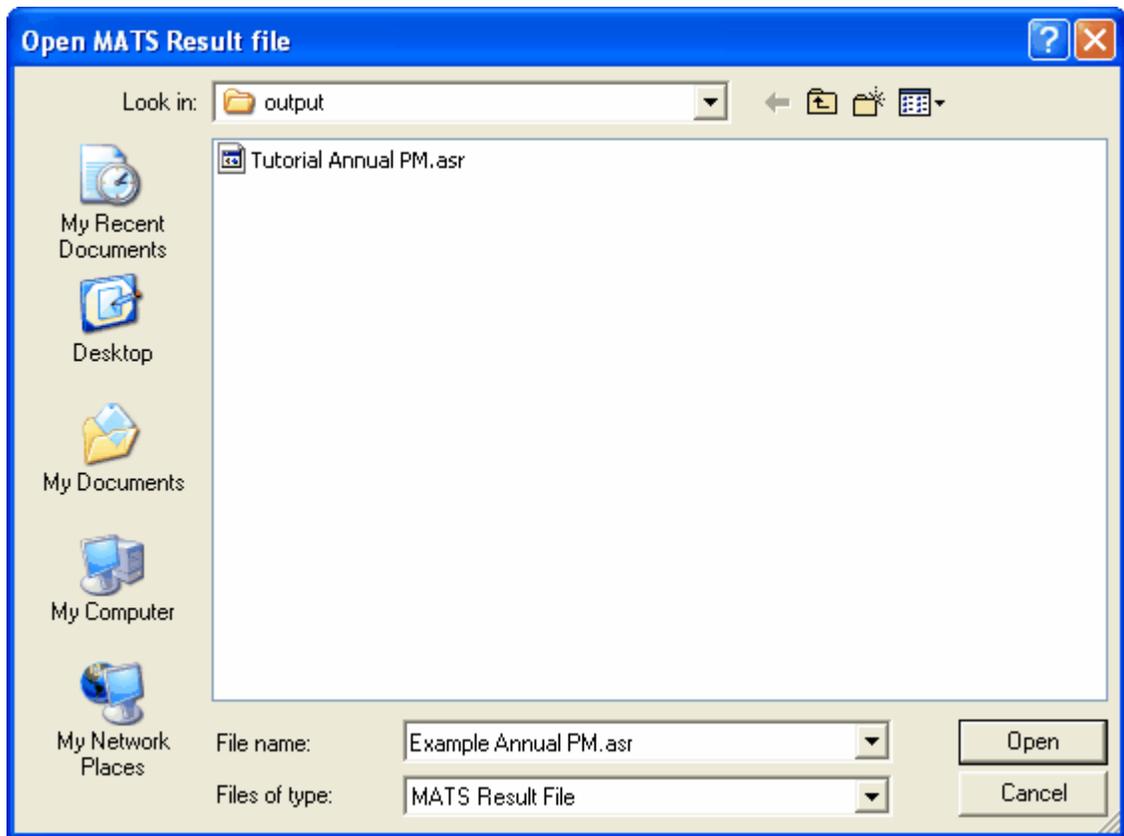


The next step ([click here](#)) shows you how to map your results with the **Output Navigator**. For more details on mapping and other aspects of the **Output Navigator**, there is a separate chapter on the [Output Navigator](#).

#### 4.10 Step 10. Map Output

After generating your results, [Output Navigator](#) can be used to load and/or map them. If a run just finished, the output files will already be loaded into output navigator.

If files from a previous run need to be loaded then click on the **Load** button and choose the *Tutorial Annual PM.asr* file.



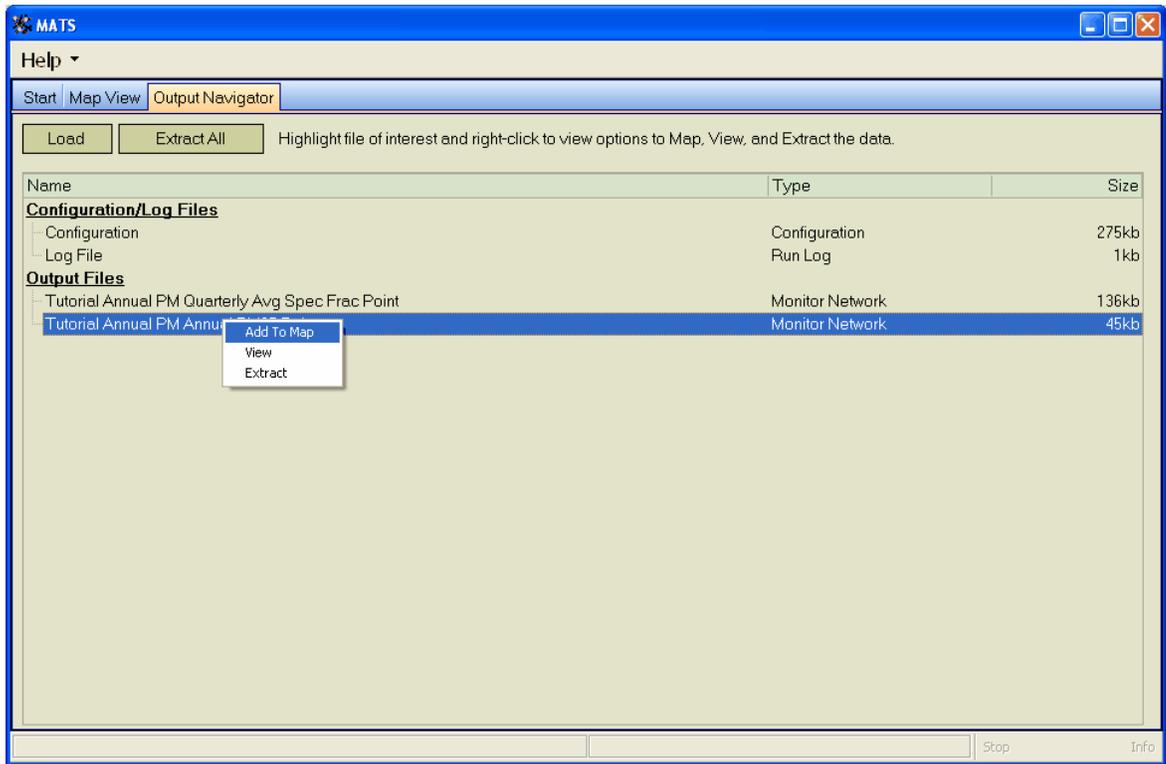
Under **Configuration/Log Files**, you will see two files:

- [Configuration](#): keeps track of the assumptions that you have made in your analysis.
- [Log File](#): provides information on a variety of technical aspects regarding how a results file (\*.ASR) was created.

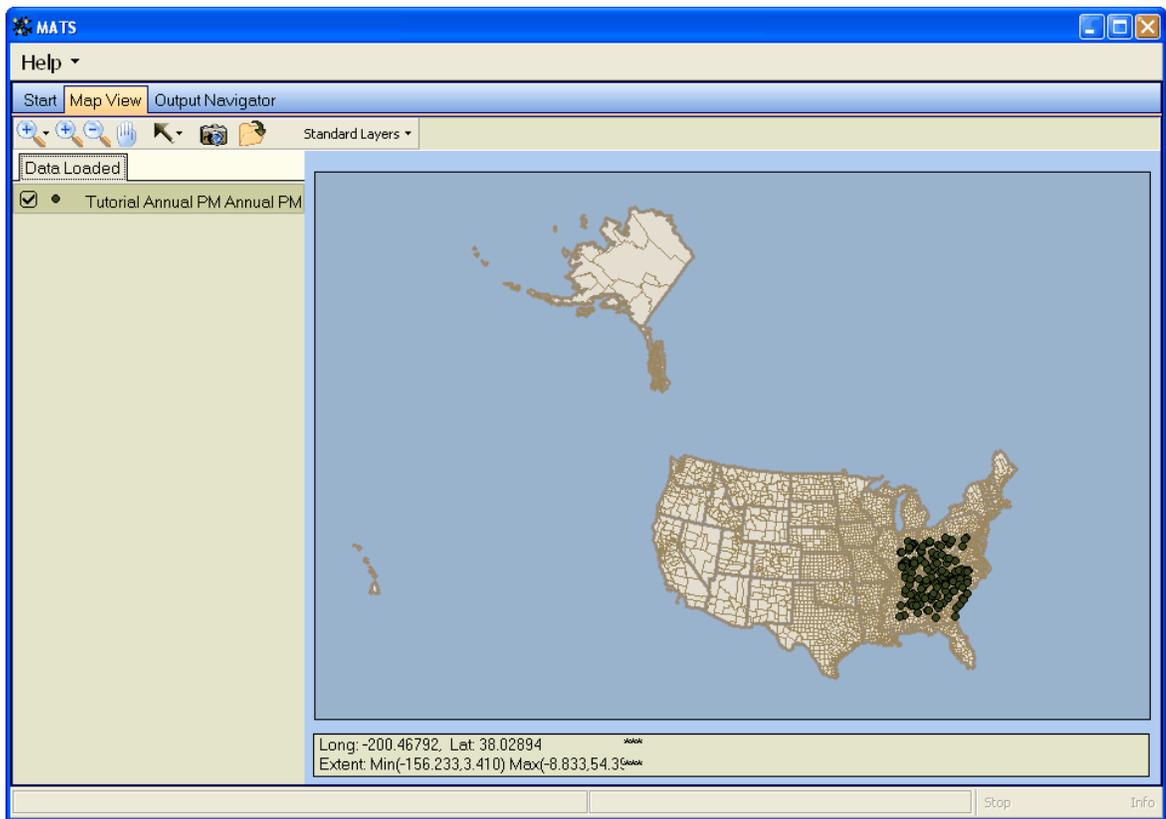
Under **Output Files** you will see:

- *Tutorial Annual PM Quarterly Avg Spec Frac Point*: contains species fractions and interpolated species values. (Note that this is a reusable file that you can load into MATS.)
- *Tutorial Annual PM Annual PM25 Point*: contains base & future PM2.5, species values, and RRFs. (Note that the annual RRFs and annual species values are not used anywhere in the calculation of design values, and here just for information.)

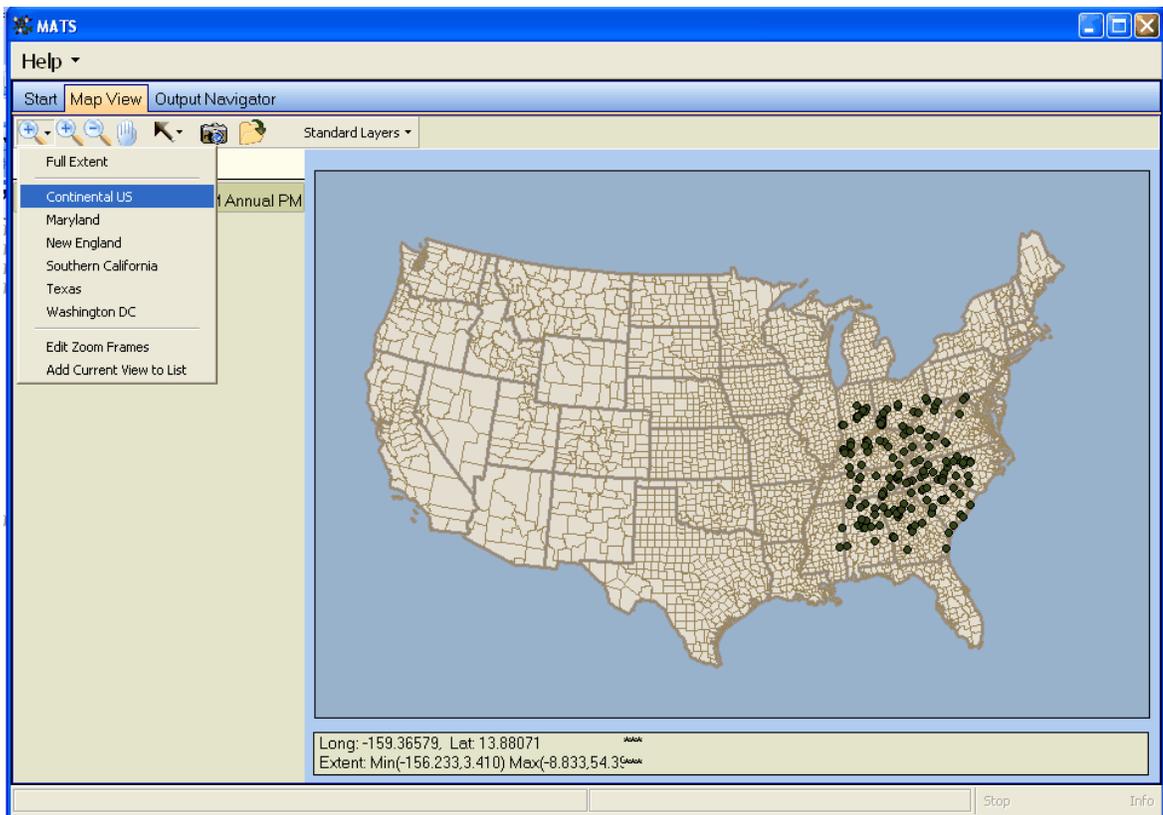
Right-click on the file *Tutorial Annual PM Annual PM25 Point*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *Add to Map* option.



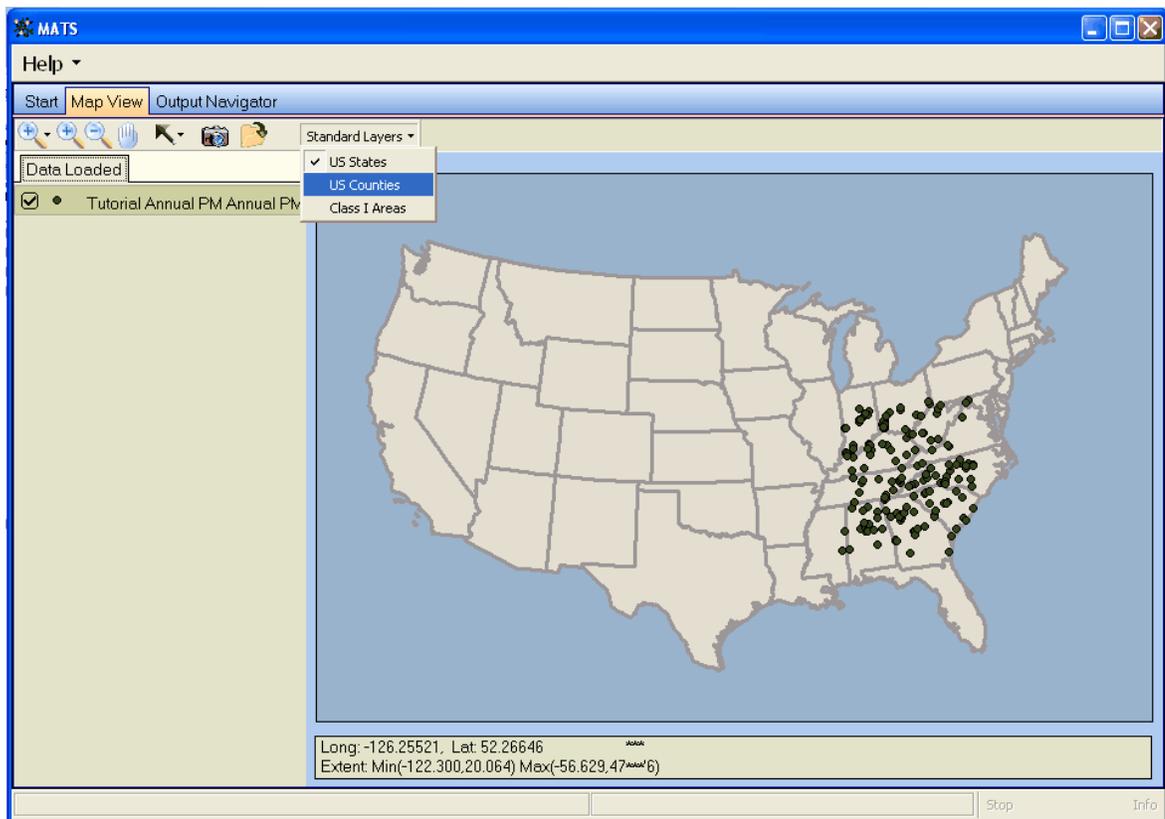
This will bring up the **Map View** tab.



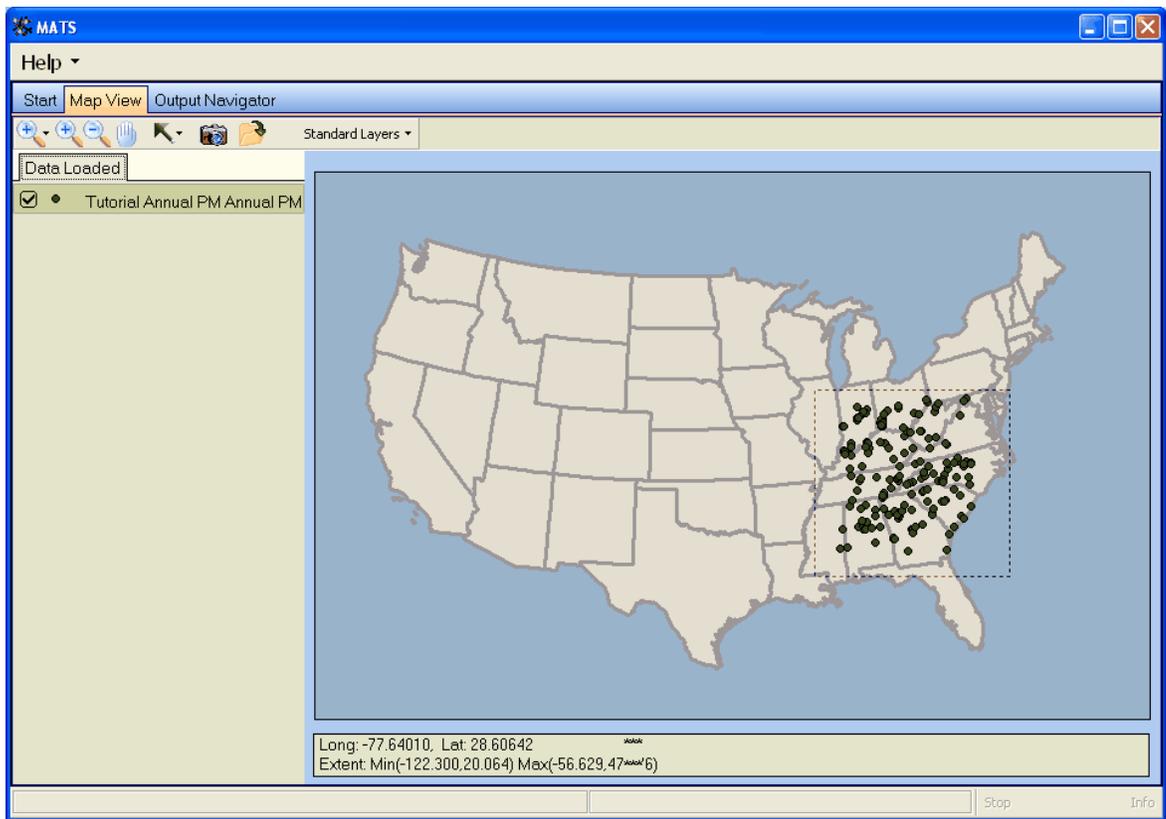
To view an enlarged map, use the **Zoom to an area** Task Bar button on the far left. Choose the *Continental US*.



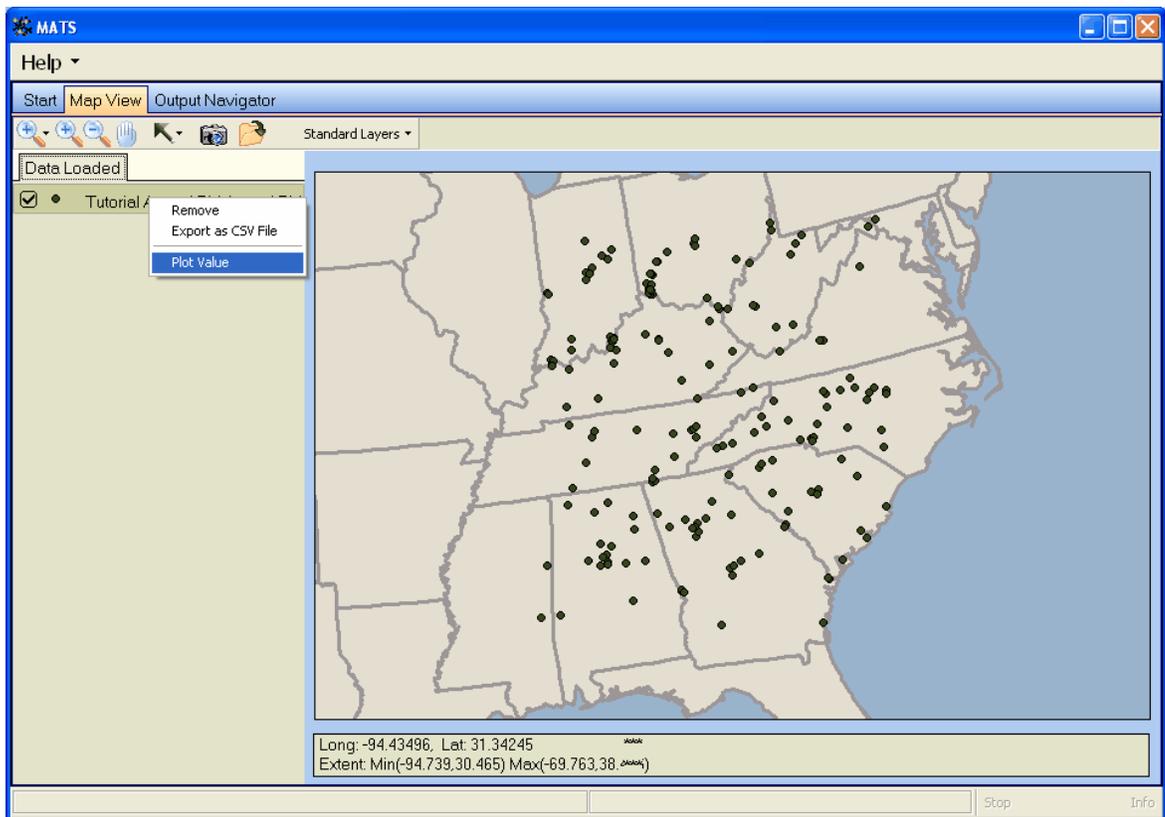
To more easily view the location of monitors in particular states, uncheck *US Counties* using the **Standard Layers** drop down menu on the far right of the Task Bar. Your window should look like the following:



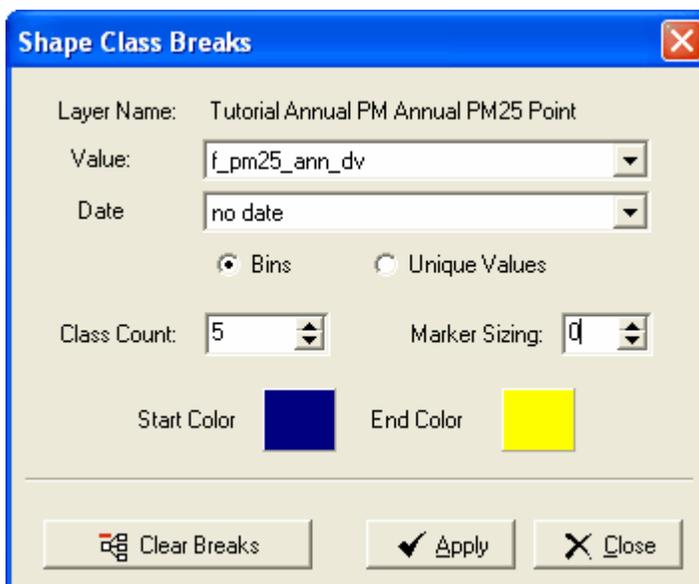
Zoom in further on the Eastern US using the **Zoom in** button on the Task Bar. This allows you to view the results more closely. A dashed line surrounds the area that you have chosen and should look something like the following:



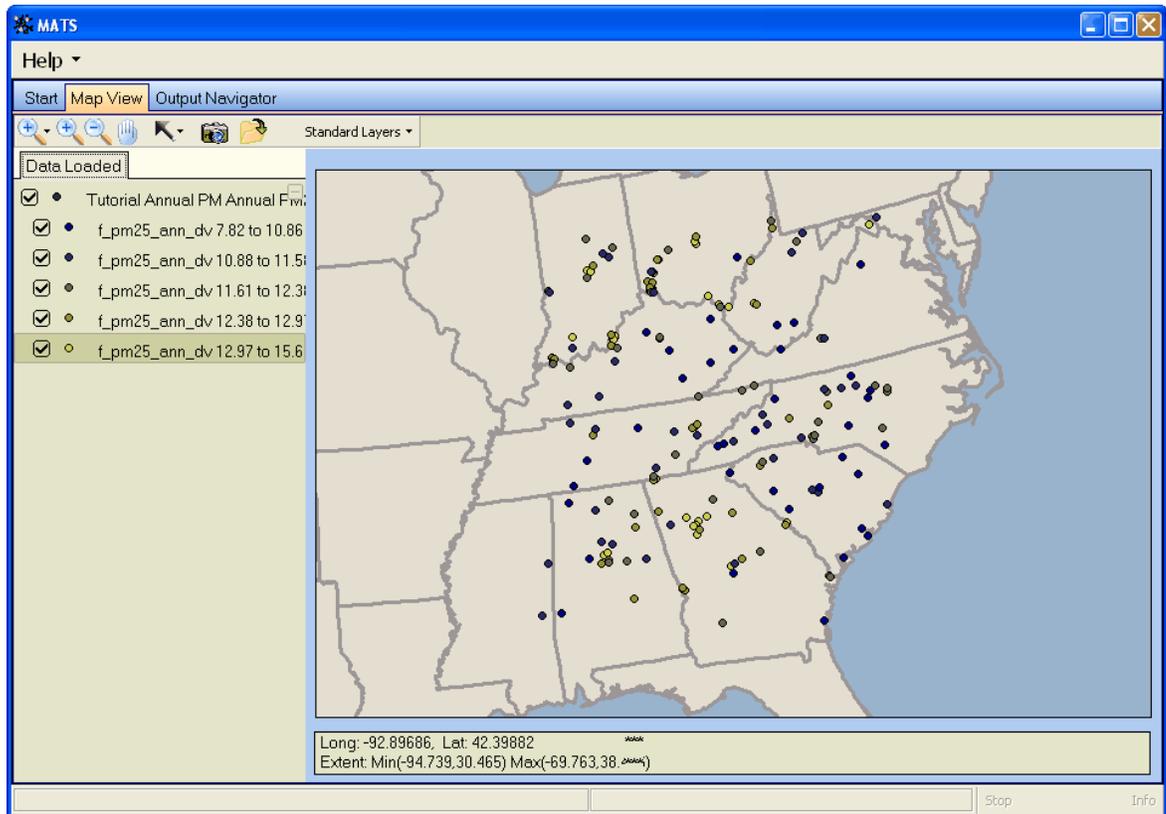
Right click on the "*Tutorial Annual PM Annual PM25 Point*" layer in the panel on the left side of the window. Choose the **Plot Value** option.



This will bring up **Shape Class Breaks** window. In the **Value** drop-down list, choose the variable "*f\_pm25\_ann\_dv*" -- this is forecasted PM2.5 design value.



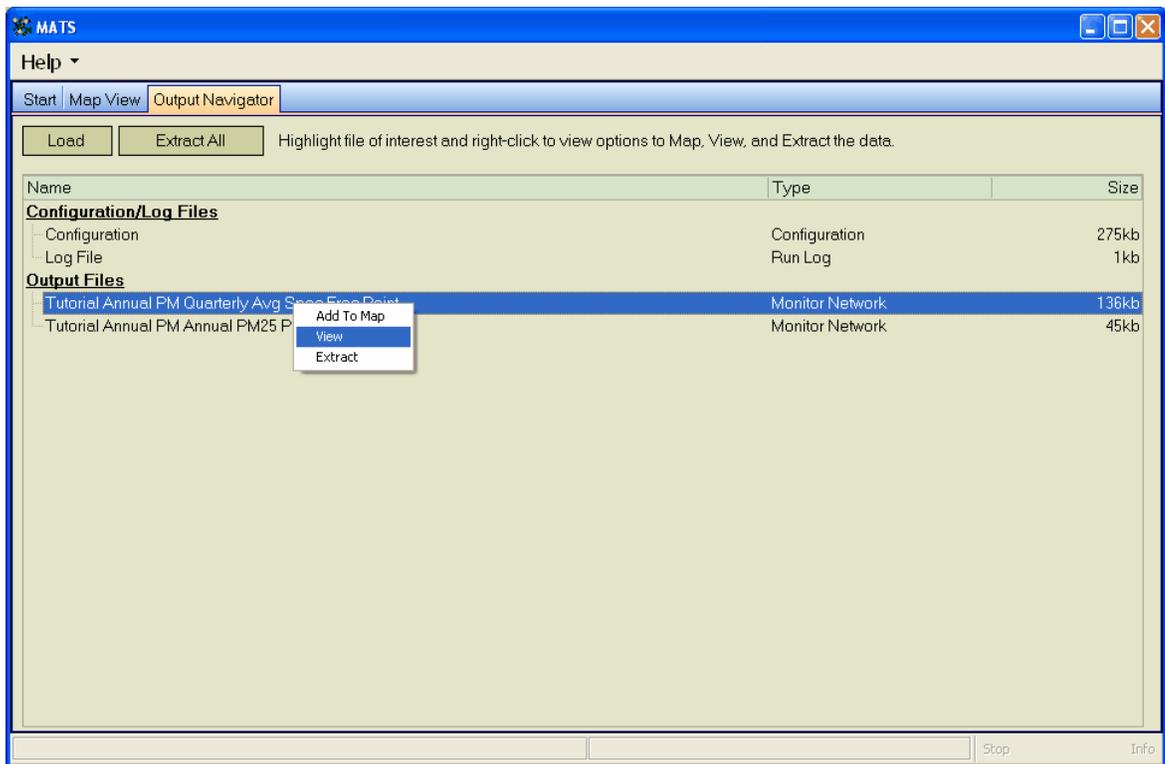
Click **Apply** and then click **Close**. This will bring you back to the **Map View** window.



This is just a brief summary of the mapping possibilities available. For more details, there is a separate chapter on the [Map View](#). The [next step](#) is to go to the **Output Navigator** to view the data in a table format.

## 4.11 Step 11. View Output

After mapping your results, click on the **Output Navigator** tab, so that you can then view the data in a table. Right-click on the file *Tutorial Annual PM Annual PM25 Point*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *View* option.



This will bring up a **Monitor Network Data** tab. The upper left panel allows you to view the ID and latitude and longitude of the monitors in your data -- at the right of this panel there is a scrollbar with which you can locate any particular monitor of interest.

The screenshot shows the MATS software interface. At the top, there is a menu bar with 'Help' and a tab bar with 'Start', 'Map View', 'Output Navigator', and 'Monitor Network Data'. Below the tab bar is a 'Close' button. A section contains a 'Show All' button and the text 'or select a particular location to see data.' To the right is a list of checkboxes for 'Select Quantities that must be >= 0', including 'monitor\_gridcell', 'b\_crusta\_mass', 'b\_ec\_mass', 'b\_ocr\_mass', 'b\_so4\_mass', 'b\_no3\_mass', 'b\_no3r\_mass', and 'b\_salt\_mass'. Below this is an 'Export' button with the text 'Export this data to CSV'. The main area contains a table with columns: id, type, lat, and long. The data rows are as follows:

id	type	lat	long
010050002	STN	31.664137	-85.606234
010730023	STN	33.553056	-86.815
010731009	STN	33.459722	-87.305556
010732003	STN	33.499722	-86.924167
010890014	STN	34.68767	-86.58637
010970003	STN	30.769722	-88.0875
011011002	STN	32.406944	-86.256389
011020011	STN	34.51861	86.976944

Below the table is a 'Data' section with a table that has columns: id, date, monitor\_, b\_crusta, b\_ec\_m, b\_ocr, b\_so4\_r, b\_no3\_r, b\_no3r\_r, and b\_salt\_r. The data rows are as follows:

id	date	monitor_	b_crusta	b_ec_m	b_ocr	b_so4_r	b_no3_r	b_no3r_r	b_salt_r
010050002	Q1	175065	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00
010050002	Q2	175065	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00
010050002	Q3	175065	0.4379	0.1929	3.246	5.951	0.2786	0.00	0.0150
010050002	Q4	175065	0.2243	0.2402	2.296	3.008	0.5832	0.00	0.0169
010730023	Q1	163080	0.7979	1.195	4.042	3.415	1.785	0.7418	0.0656
010730023	Q2	163080	1.63	1.434	4.84	4.951	0.7987	0.0269	0.0463
010730023	Q3	163080	1.808	1.363	5.315	6.693	0.5902	0.00	0.0481

At the bottom right of the interface are 'Stop' and 'Info' buttons.

To view the data for a particular monitor -- in this example, monitor ID = "010050002" -- highlight this monitor. MATS will then display the values for this monitor in the bottom panel.

Close

Show All or select a particular location to see data.

id	type	lat	long
010050002	STN	31.664137	-85.606234
010730023	STN	33.553056	-86.815
010731009	STN	33.459722	-87.305556
010732003	STN	33.499722	-86.924167
010890014	STN	34.68767	-86.58637
010970003	STN	30.769722	-88.0875
011011002	STN	32.406944	-86.256389
011020011	STN	34.51861	86.976944

Select Quantities that must be >= 0

- monitor\_gridcell
- b\_crustal\_mass
- b\_ec\_mass
- b\_ocr\_mass
- b\_so4\_mass
- b\_no3\_mass
- b\_no3r\_mass
- b\_salt\_mass

Export Export this data to CSV

Data

id	date	monitor_	b_crusta	b_ec_m	b_ocr_n	b_so4_r	b_no3_r	b_no3r_r	b_salt_r
010050002	Q1	175065	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00
010050002	Q2	175065	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00	-9.00
010050002	Q3	175065	0.4379	0.1929	3.246	5.951	0.2786	0.00	0.0150
010050002	Q4	175065	0.2243	0.2402	2.296	3.008	0.5832	0.00	0.0169

Stop Info

To view all of the data again, click on the **Show All** button. To then eliminate missing values (denoted by negative numbers in the lower panel), check one or more boxes in the panel in the upper right of the window. For example, to eliminate any monitors that do not have baseline crustal values, check the variable "b\_crustal\_mass."

The screenshot shows the MATS software interface. At the top, there is a menu bar with 'Help' and a tab bar with 'Start', 'Map View', 'Output Navigator', and 'Monitor Network Data'. Below the tab bar is a 'Close' button. A 'Show All' button is followed by the text 'or select a particular location to see data.' To the right is a panel titled 'Select Quantities that must be >= 0' with a list of checkboxes: 'monitor\_gridcell', 'b\_crustal\_mass' (checked), 'b\_ec\_mass', 'b\_ocb\_mass', 'b\_so4\_mass', 'b\_no3\_mass', 'b\_no3r\_mass', and 'b\_salt\_mass'. Below this is an 'Export' button with the text 'Export this data to CSV'. The main data table has columns: 'id', 'type', 'lat', and 'long'. The data rows are as follows:

id	type	lat	long
010050002	STN	31.664137	-85.606234
010730023	STN	33.553056	-86.815
010731009	STN	33.459722	-87.305556
010732003	STN	33.499722	-86.924167
010890014	STN	34.68767	-86.58637
010970003	STN	30.769722	-88.0875
011011002	STN	32.406944	-86.256389
011020011	STN	34.51861	-86.926944

Below the table is a 'Data' section with a table that has columns: 'id', 'date', 'monitor\_', 'b\_crusta', 'b\_ec\_m', 'b\_ocb\_r', 'b\_so4\_r', 'b\_no3\_r', 'b\_no3r\_r', and 'b\_salt\_r'. The data rows are as follows:

id	date	monitor_	b_crusta	b_ec_m	b_ocb_r	b_so4_r	b_no3_r	b_no3r_r	b_salt_r
010050002	Q3	175065	0.4379	0.1929	3.246	5.951	0.2786	0.00	0.0150
010050002	Q4	175065	0.2243	0.2402	2.296	3.008	0.5832	0.00	0.0169
010730023	Q1	163080	0.7979	1.195	4.042	3.415	1.785	0.7418	0.0656
010730023	Q2	163080	1.63	1.434	4.84	4.951	0.7987	0.0269	0.0463
010730023	Q3	163080	1.808	1.363	5.315	6.693	0.5902	0.00	0.0481
010730023	Q4	163080	1.085	1.487	4.842	3.704	1.207	0.2489	0.0944
010731009	Q1	159079	0.3368	0.4159	1.641	3.314	1.382	0.5213	0.0174

At the bottom right of the interface are 'Stop' and 'Info' buttons.

You can save these data that you have just filtered. Click the **Export** button and save the file as "No Negative Forecasts." (It is unnecessary to add an extension. MATS automatically saves the file as a CSV text file and adds a ".csv" extension to your file name.) View this filtered file in Excel.

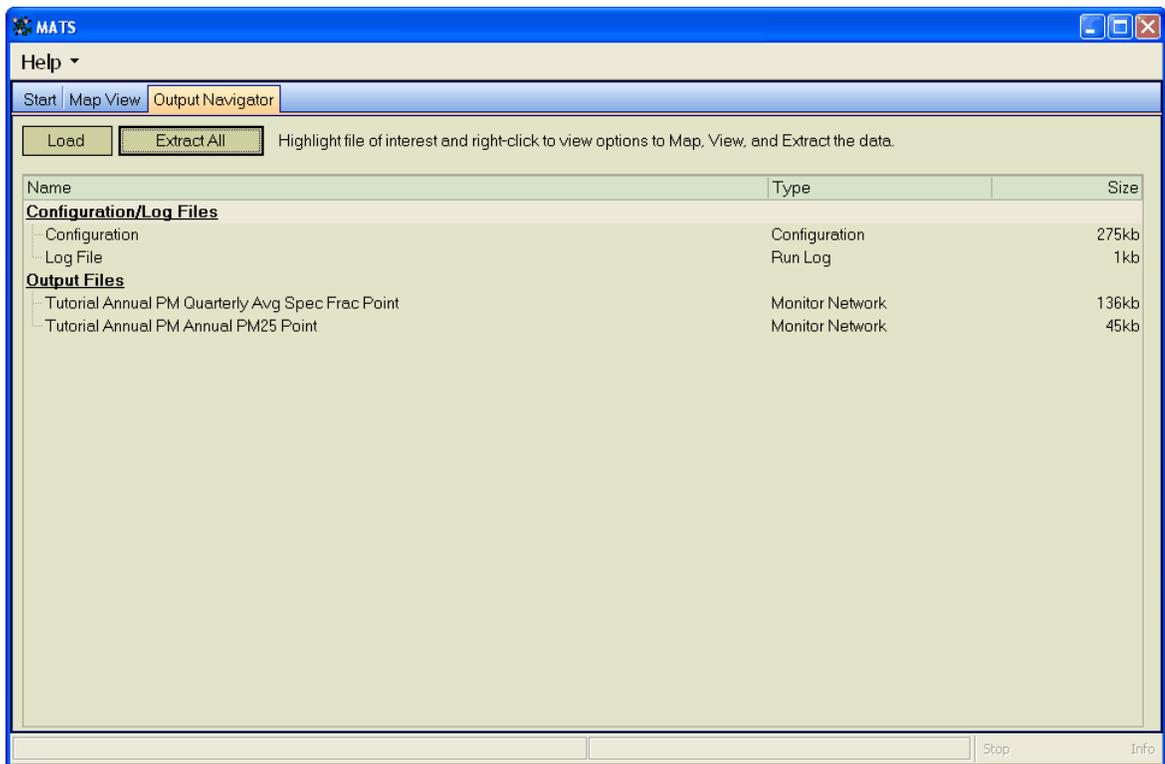
The screenshot shows a Microsoft Excel window titled "Microsoft Excel - No Negative Forecasts.csv". The spreadsheet contains the following data:

	A	B	C	D	E	F	G	H	I	J
1	id	date	b_o3_dv	f_o3_dv	referencecell	rrf	ppb	days		
2	10030010	2005	77.7	68.6	95023	0.883	85	11		
3	10270001	2005	77.7	61.4	108051	0.791	71	11		
4	10331002	2005	71	54.2	92063	0.764	71	11		
5	10510001	2005	75	61.8	106043	0.825	70	9		
6	10550011	2005	73	56.5	105056	0.774	73	10		
7	10730023	2005	75.7	59.2	100052	0.783	81	11		
8	10731003	2005	78	62.4	99052	0.801	81	11		
9	10731005	2005	79.2	60.5	99050	0.764	80	10		
10	10731009	2005	79.2	61.3	96051	0.775	75	11		
11	10731010	2005	72	55.3	102053	0.769	77	11		
12	10732006	2005	82.5	64.2	100051	0.779	81	10		
13	10735002	2005	77.2	60.9	101054	0.79	77	10		

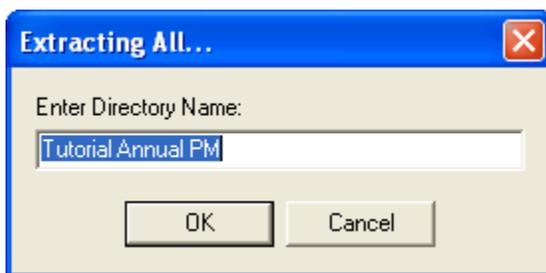
For additional details on generating ozone results, see the chapter on [Annual PM Analysis: Details](#). For additional details on viewing data, see the [View Data](#) section in chapter on the [Output Navigator](#). The [next step](#) is to go to the **Output Navigator** to extract the MATS-generated (unfiltered) output files.

## 4.12 Step 12. Extract Output

After mapping and viewing your results, click on the **Output Navigator** tab, so that you can extract the output that MATS has generated. You have two options. First, you can simply extract all of the files at once by clicking on the **Extract All** button. Alternatively, you can right-click on individual files and choose the *Extract* option.



Click the **Extract All** button. This will bring up a window in which you can specify the folder name for your output files. By default this folder is given the name of your configuration file -- you can change this if you want, though it is probably a good idea to leave the name as is, so you can keep better track of your results.

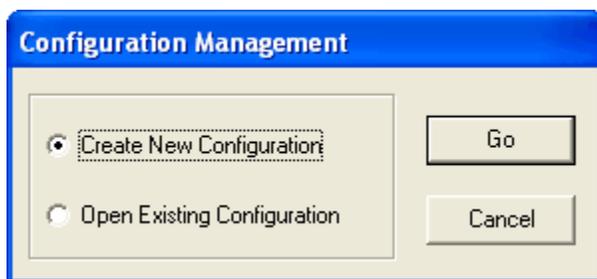


Note that the folder will be saved within the Output folder that MATS creates (C:\Program Files\Abt Associates\MATS\output).

## 5 Annual PM Analysis: Details

MATS can forecast design values at PM2.5 monitor locations -- these forecasts are referred to as [Point Estimates](#). MATS can also use a variety of approaches to calculate design values for a [Spatial Field](#). A *Spatial Field* refers to a set of values comprising calculations for each grid cell in a modeling domain from Eulerian grid models such as CMAQ and CAMx.

The set of choices involved in calculating either *Point Estimates* or a *Spatial Field* can be fairly involved, so MATS keeps track of these choices using a [Configuration](#). When you begin the process of generating PM2.5 estimates, MATS provides an option to start a new Configuration or to open an existing Configuration.



Select your option and then click **Go**.

MATS will then step you through a series of windows with choices for your analysis.

- [Output Choice](#). Choose whether you want to run the Standard Analysis, and whether to output a species fractions file and/or quarterly model data.
- [Output Choice - Advanced](#). This option provides miscellaneous Point Estimate output files, as well as baseline and forecast year Spatial Fields and gradient-adjusted output.
- [Data Input](#). Load species monitoring data or a species fractions file. Load PM2.5 ambient monitoring data. Finally, load the modeling data that you want to use.
- [Species Fractions Calculation Options](#). Choose the years of daily STN-IMPROVE and FRM monitoring data. Identify valid monitors.
- [Species Fractions Calculation Options - Advanced](#). Choose to use all monitor values, or a subset. Choose interpolation options for PM2.5 and species monitoring data. Choose assumptions for the ammonium calculation, default blank mass, and organic carbon.
- [PM2.5 Calculation Options - FRM Monitor Data](#). Choose the years of quarterly FRM monitoring data. Choose whether to use official design values or custom design values. Identify valid monitors.
- [Model Data Options](#). Specify the daily modeling values that will be used in the

calculation of RRFs and spatial gradients. Specify which model grid cells will be used when calculating [RRFs](#) at monitor locations.

- [Final Check](#). Verify the selections that you have made.

## 5.1 Output Choice

In the **Output Choice** window, MATS lets you specify the name of your [Scenario](#), and then to choose up to three options: [Standard Analysis](#), which refer to forecasts made at FRM PM2.5 monitor locations; [Quarterly Model Data](#), which allows you to create quarterly averages from daily model output data (output data from grid models such as CMAQ and CAMx), and then subsequently reuse this file; and [Species Fractions](#), which outputs a reusable species fractions file.

**Standard Analysis.** The [Standard Analysis](#) refers to the calculation of future year PM2.5 design values at FRM monitor locations. This is the main part of the modeled attainment test for PM2.5. There are several calculations involved in this analysis. MATS will interpolate PM2.5 species data, calculate species concentrations at each FRM site and project design values to a future year using gridded model data. Most MATS users will run this analysis and it is therefore checked by default.

**Quarterly Model Data.** MATS requires two types of [data input](#): ambient monitor data and gridded model output data. For the annual PM2.5 calculations, MATS will

accept either MATS formatted daily average gridded model files or quarterly average files. If daily average model files are used as inputs, MATS will calculate quarterly averages from the daily averages and optionally output the quarterly average concentrations into text files (CSV files). The quarterly average text files can then be re-used in subsequent MATS analyses. Quarterly average input files are smaller and run faster than daily average files. There are two options to output quarterly average model concentration CSV files:

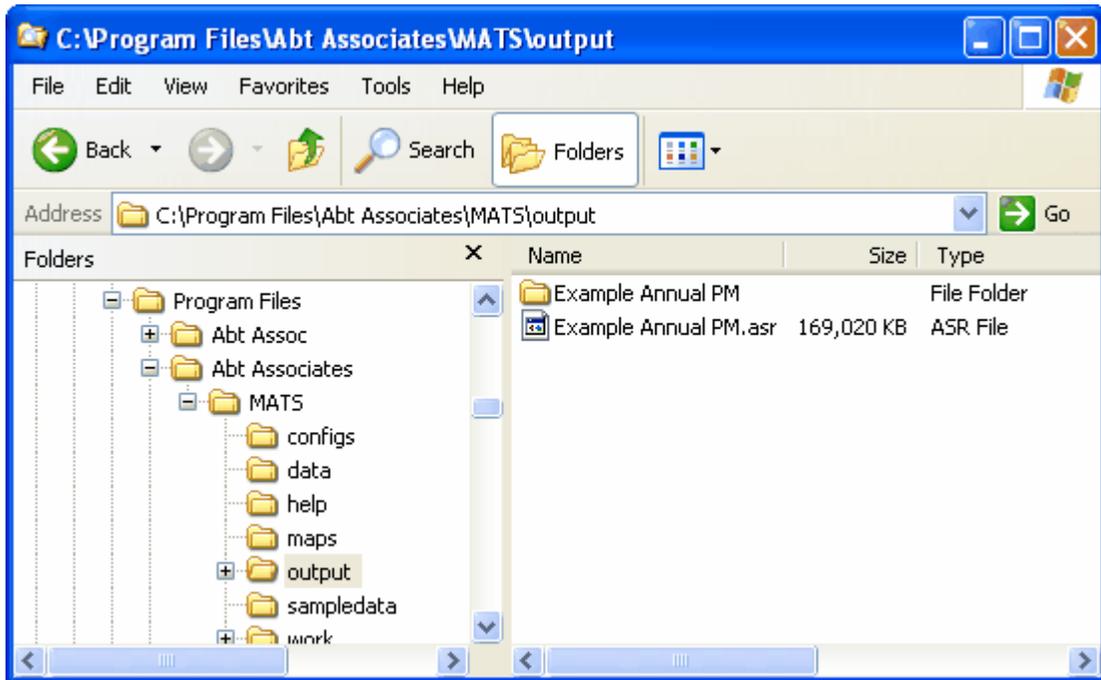
- Check the “Output quarterly average model data file” box to create quarterly average CSV for **all** grid cells in the modeling domain. MATS will create one baseline year file and one future year file. This will create relatively large files, but they will still be ~90 times smaller than daily average files (assuming a full year of model data).
- The second option is to check the “Output used quarterly average model data file”. This option will only output the grid cells that are subsequently **used** in the particular MATS configuration. For example, if MATS calculates future year design values at 20 FRM sites using a 1 X 1 grid array, then MATS will output base and future model values for only 20 grid cells (assuming each monitor is in a unique grid cell). The advantage of these files is that they are extremely small. But if subsequent MATS runs use a different set of monitors or grid arrays, then the files may not contain all of the necessary data to complete the analysis. This option is recommended as a QA tool to examine the grid cells and the model concentrations that MATS is using in the analysis.

**Species Fraction.** Checking the “Output species fraction file” box will create an output file containing the calculated PM<sub>2.5</sub> species fractions at each FRM site used by MATS. This species fraction file can be re-used in MATS as an input file. The species fraction file can be useful for several reasons. One, using a species fraction file saves time because MATS won’t have to interpolate species data and calculate fractions each time it is run. Two, it can provide consistency between MATS runs by ensuring that the same species fractions are used each time. And for the same reason, the species fraction file can be used interchangeably between different users to ensure that multiple groups are using the same species fractions (if that is a goal). And finally, the fractions file can serve as a template for creating a custom species fractions file using whatever data and techniques (e.g. alternative interpolation techniques) are desired by any particular user.

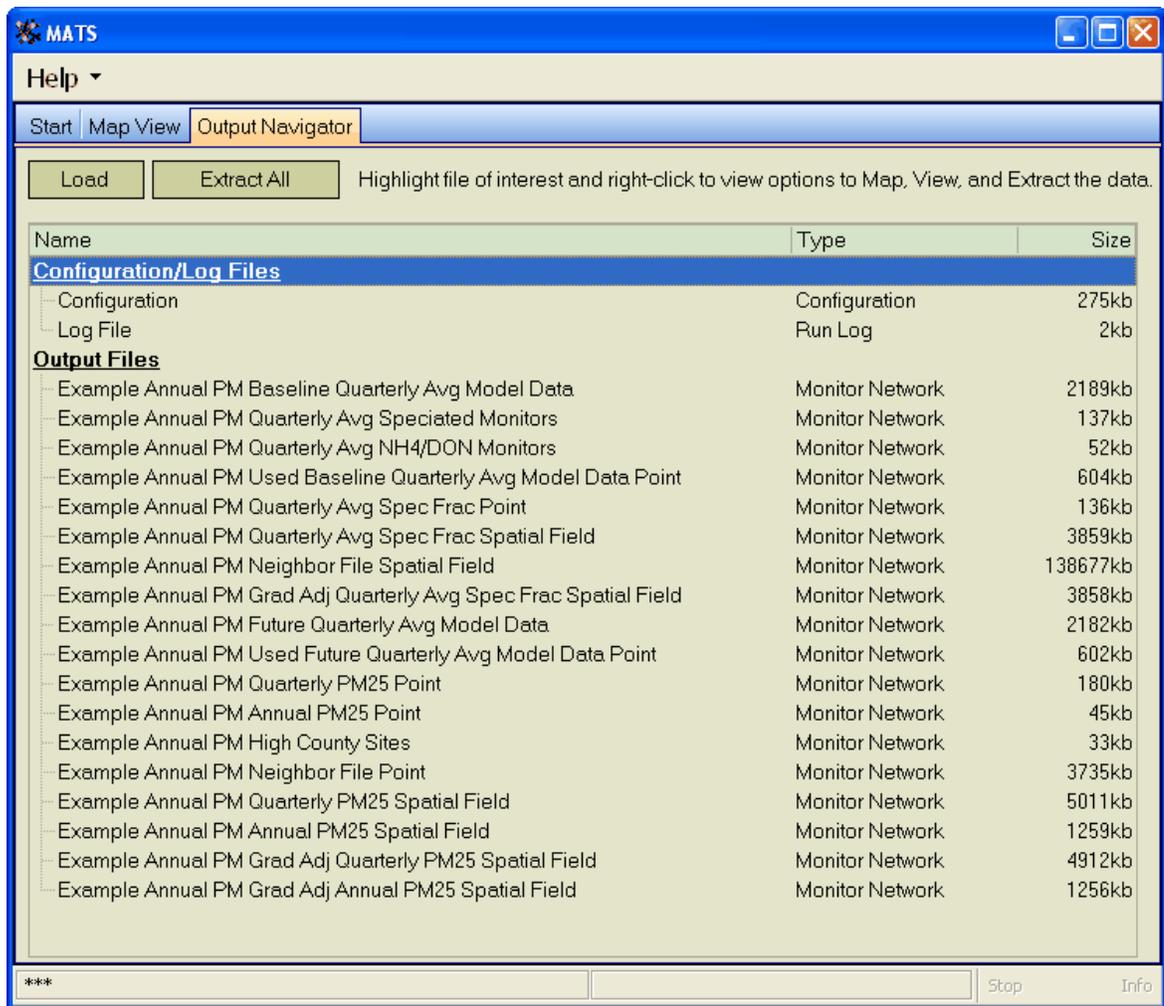
### 5.1.1 Scenario Name

The Scenario Name allows you to uniquely identify each analysis that you conduct. It is used in several ways.

- **Results file name.** The results file is given the **Scenario Name** (e.g., *Tutorial PM.asr*). Note that the extension ([.ASR](#)) is specifically designated just for MATS and can only be used by MATS.
- **Organize output.** In the Output folder, MATS will generate a folder using the [Scenario Name](#). MATS will use this folder as a default location for files generated with this Scenario Name.



- **Output file names.** The output files generated will begin with the Scenario Name.



### 5.1.2 Standard Analysis

Future-year PM<sub>2.5</sub> design values are calculated at each FRM monitoring site through a series of calculations:

- Step 1.** [Quarterly weighted-average baseline PM<sub>2.5</sub> concentration](#) at each FRM monitor site;
- Step 2.** [Baseline species concentrations](#) using the quarterly weighted-average baseline PM<sub>2.5</sub> concentration and species fractions at each FRM monitor site;
- Step 3.** [Forecasted quarterly species averages](#) using relative response factors (RRFs) at each FRM monitor site;
- Step 4.** [Forecasted design values](#) at each FRM monitor site.

In this section, we go into some detail describing these steps. However, you should note that MATS gives you a number of options affecting the exact steps that MATS follows, such as determining which years of monitoring data to use and to choosing which monitors

to include in the calculations. These options are detailed in the [PM2.5 Calculation Options](#) section. The [output from the Standard Analysis is described here](#).

#### 5.1.2.1 Step 1: Baseline PM2.5 Calculation

The first step in the Standard Analysis is to calculate baseline PM2.5 levels using the ("official") quarterly average PM2.5 file (described in the [Data Input section](#)). MATS uses these quarterly values to calculate 3-year averages of consecutive years of data for each quarter, and then to average these averages to get a single PM2.5 estimate for each quarter

##### Example Calculation Baseline PM2.5 Concentration

Starting with the following quarterly values:

Quarter	2000	2001	2002	2003	2004
Q1	11.8188	10.7107	9.7133	10.6966	9.9839
Q2	13.2400	11.1333	9.3138	15.1655	9.6680
Q3	18.7960	11.0700	12.6652	12.0667	14.4964
Q4	14.2579	9.4032	9.7903	10.7414	11.2778

MATS calculates 3-year averages of consecutive years of data for each quarter:

Quarter	2000-2002	2001-2003	2002-2004
Q1	10.7476	10.3735	10.1313
Q2	11.2290	11.8709	11.3824
Q3	14.1771	11.9340	13.0761
Q4	11.1505	9.9783	10.6032

MATS averages the 3-year averages to get a single estimate for each quarter:

Quarter	Avg
Q1	10.4175
Q2	11.4941
Q3	13.0624
Q4	10.5773

#### 5.1.2.2 Step 2: Baseline Species Calculation

Since the FRM monitors do not have speciated data (and the majority of FRM sites are not co-located with a speciation monitor), MATS uses speciated PM2.5 monitor data from other monitoring networks, such as STN and IMPROVE, to estimate the fraction of PM2.5 attributable to the following species: sulfate (SO<sub>4</sub>), nitrate (NO<sub>3</sub>), elemental carbon (EC), organic carbon (OC), crustal matter, particle bound water (PBW), ammonium (NH<sub>4</sub>), and, data permitting, salt.

Note that the process of calculating species fractions is involved and discussed in detail in the [Species Fractions Calculations & Output](#) section of this user manual. Nevertheless,

the use of species fractions to calculate species concentrations is straightforward. The weighted quarterly species average is calculated by multiplying weighted quarterly average FRM baseline values (minus the assumed blank mass, specified by the user) with species fractions that have been estimated for each FRM monitor. The calculation is as follows:

$$Species_{i,q} = SpeciesFraction_{i,q} \cdot (PM_{2.5,q} - BlankMass)$$

where:

$Species_{i,q}$  = weighted quarterly average for a given species "i" (e.g.,  $SO_4$ )

$SpeciesFraction_{i,q}$  = species fraction for species "i"

$PM_{2.5,q}$  = weighted quarterly average  $PM_{2.5}$

$BlankMass$  = assumed monitoring blank mass (e.g.,  $0.5 \mu g / m^3$ )

Note that MATS calculates species fractions from speciated monitors for a limited number of years. As a result, rather than have species fractions specifically calculated for each quarter and each year, MATS uses a single set of species fractions to calculate the weighted quarterly average species concentrations. The species data should be "representative" of the species fractions that occur during the 5 year FRM monitoring period selected in MATS.

### Example Calculation Baseline Species Concentrations

MATS multiplies the (non-blank) baseline quarterly  $PM_{2.5}$  values:

FRM $PM_{2.5}$	Blank Mass	Non-Blank Mass
10.4175	0.5	9.9175
11.4941	0.5	10.9941
13.0624	0.5	12.5624
10.5773	0.5	10.0773

with the species fractions calculated for this particular site:

Quarter	SO4	NO3	OCMMB	EC	PBW	NH4	Crustal	(Salt)
Q1	0.2382	0.1108	0.3346	0.0201	0.1049	0.1209	0.0705	--
Q2	0.2637	0.0727	0.3178	0.0545	0.1095	0.1273	0.0545	--
Q3	0.1432	0.0557	0.5621	0.0238	0.0959	0.0955	0.0238	--
Q4	0.2580	0.1389	0.2756	0.0396	0.1094	0.1190	0.0595	--

The product is the estimated baseline species concentrations by quarter.

Quarter	SO4	NO3	OCMMB	EC	PBW	NH4	Crustal
Q1	2.3623	1.0989	3.3184	0.1993	1.0403	1.1990	0.6992
Q2	2.8991	0.7993	3.4939	0.5992	1.2039	1.3996	0.5992

Q3	1.7989	0.6997	7.0613	0.2990	1.2047	1.1997	0.2990
Q4	2.5999	1.3997	2.7773	0.3991	1.1025	1.1992	0.5996

#### 5.1.2.2.1 Baseline Calculation- General

MATS does several calculations to generate the species concentrations that used to calculate species fractions. In general, calculation of the concentrations of SO<sub>4</sub>, NO<sub>3</sub>, EC, crustal, and salt are straightforward. The concentrations are derived directly from the ambient data file or an interpolation of that data. However, the calculation of ammonium, particle bound water (PBW) and organic carbon (OC) are more complicated. The concentrations for these species re calculated internally in MATS.

MATS uses speciated monitor data to estimate individual species fractions at FRM sites using the “SANDWICH” process (Frank, 2006) (SANDWICH stands for Sulfates, Adjusted Nitrates, Derived Water, Inferred Carbonaceous mass, and estimated aerosol acidity [H<sup>+</sup>]). The [data input](#) to the PM calculations in MATS includes quarterly FRM monitor data and speciated monitor data from STN and IMPROVE sites that has been partially adjusted to match the anomalies in FRM data (e.g., nitrate volatilization).

The default species input data file contains aerosol nitrate data (NO<sub>3r</sub>) that has been adjusted to account for volatilization. Additional SANDWICH adjustments are made within MATS. These include calculation of particle bound water (PBW) and organic carbon by mass balance (OCMmb).

When there is more than one year of speciated data, MATS will create quarterly average species levels for each year at each monitor, and then average the seasonal values across the available years to get a single estimate for each species for each quarter at each monitor. (See the section on [Species Fractions Calculation Options](#) for additional details on how multiple years of speciated monitor data are combined.)

Note that MATS can calculate quarterly species concentrations at FRM monitor sites or a spatial field. MATS will allow you to reuse the species fractions file for point estimates or spatial fields. And in addition to calculating species fractions with monitor data -- on the [Output Choice - Advanced](#) window, you can choose gradient-adjusted species fractions, which are based on monitor *plus* model data.

### Interpolation

About 75 percent of FRM monitors are not co-located with an STN monitor, so the estimation of the quarterly averages of the individual species at those FRM sites depends on the **interpolated** quarterly averages from speciated monitors (e.g., STN). Individual species are interpolated to the latitude and longitude associated with each FRM monitor. (For FRM monitors that *are* co-located with an STN monitor, MATS simply uses the species values from the co-located STN monitor.) You can find details on the interpolation process and different options for interpolation at the section on [Interpolation Options for Species Fractions Calculation](#).

### Calculations After Interpolation

After the interpolation of quarterly averages for retained NO<sub>3</sub> (NO<sub>3r</sub>), SO<sub>4</sub>, OCM, crustal, EC, and DON, a few additional steps are necessary to generate speciated quarterly averages at each FRM monitor site. These include calculating retained NH<sub>4</sub> (NH<sub>4r</sub>), PBW, blank mass, and organic carbon mass (OCMMB), the latter of which is calculated through a mass balance approach.

#### Summary of Calculations After Interpolation of STN & IMPROVE Speciated Monitor Data

Calculation	Description
Calculate Retained Ammonium (NH <sub>4r</sub> )	Calculate ammonium associated with retained nitrate (NO <sub>3r</sub> ) and SO <sub>4</sub> . MATS calculates NH <sub>4r</sub> using DON, SO <sub>4</sub> , and NO <sub>3r</sub> . (Alternatively MATS can use directed measured ammonium).
Calculate Particle Bound Water (PBW)	Calculate amount of water associated with ammonium sulfate and ammonium nitrate, which are hygroscopic.
Estimate Blank Mass	Account for contamination in FRM monitors.
Calculate Organic Carbon Mass (OCMMB)	Calculate organic carbon mass with a mass balance approach.
Calculate Species Fractions	Divide species estimates for SO <sub>4</sub> , NO <sub>3r</sub> , OCMMB, EC, crustal material, NH <sub>4r</sub> , and PBW by the non-blank PM <sub>2.5</sub> mass. (The inclusion of salt is optional and is not included in the default MATS data.)

The following sections describe the calculations of ammonium, PBW, and organic carbon (by difference).

##### 5.1.2.2.2 Retained Ammonium Calculation

MATS calculates retained ammonium two different ways. The default approach is to use interpolated degree of neutralization of sulfate (DON) values from the speciated monitors. The alternative approach is to use interpolated NH<sub>4</sub> values from speciated monitors (e.g., STN). In the [Species Fractions Calculations Options - Advanced](#) section, you have the option to choose the approach that you prefer to use. The two approaches are described here.

#### Default approach using measured pre-calculated DON, SO<sub>4</sub>, and retained NO<sub>3</sub> (NO<sub>3r</sub>):

Because of uncertainties in NH<sub>4</sub> speciation measurements, by default MATS calculates ammonium values using the degree of sulfate neutralization (DON). MATS uses pre-calculated daily DON values that are included in the species data input file ("Species-for-fractions-xxxx.csv"). The values for DON are calculated from the amount of ammonium associated with sulfate (NH<sub>4</sub><sub>SO<sub>4</sub></sub>) as follows:

$$DON = \frac{NH_{4,SO_4}}{SO_4}$$

And the estimated NH<sub>4</sub><sub>SO<sub>4</sub></sub> is calculated as follows:

$$NH_{4,SO4} = NH_{4,measured} - 0.29 * NO_{3,retained}$$

where 0.29 is the molar ratio of NH<sub>4</sub> to NO<sub>3</sub> and NH<sub>4,measured</sub> and NO<sub>3,retained</sub> reflect the amounts of NH<sub>4</sub> and NO<sub>3</sub> retained on the FRM filter. The amount of NH<sub>4,SO4</sub> is not allowed to exceed the fully neutralized amount of 0.375 multiplied by the estimated sulfate ion concentration.

MATS then calculates ammonium using interpolated monitor values of DON, SO<sub>4</sub>, and NO<sub>3r</sub> as follows:

$$NH_4 = DON * SO_4 + 0.29 * NO_{3,retained}$$

**Alternative Approach Using Measured Ammonium.** The alternative approach is to use interpolated NH<sub>4</sub> values from STN monitors. This approach has several steps.

First, MATS calculates “adjusted” NH<sub>4</sub>:

$$NH_{4,adjusted} = NH_{4,measured} - (PctEvap * 0.29 * (NO_{3,measured} - NO_{3,retained}))$$

where the PctEvap factor refers to the percentage of ammonium associated with the volatilized nitrate that is also lost. (As discussed in the [Species Fractions Calculation Options - Advanced](#) section, this factor is adjustable from 0 to 100 percent.) The default assumption is that no ammonium is volatilized (0 percent).

Second, MATS calculates NH<sub>4</sub> associated with SO<sub>4</sub>:

$$NH_{4,SO4} = NH_{4,adjusted} - 0.29 * NO_{3,retained}$$

Third, MATS calculates DON:

$$DON_{calculated} = \frac{NH_{4,SO4}}{SO_4}$$

Finally, using the same equation as in the default approach, MATS calculates NH<sub>4r</sub> by substituting the calculated DON for the interpolated (measured) DON value:

$$NH_{4,retained} = DON_{calculated} * SO_4 + 0.29 * NO_{3,retained}$$

#### 5.1.2.2.3 Particle Bound Water Calculation

Because ammoniated sulfate and ammonium nitrate are hygroscopic, the retained sulfate and nitrate mass will include water. Particle bound water (PBW) is estimated using the Aerosol Inorganic Model (AIM) (Clegg, 1998). For computational convenience, a polynomial regression equation was fit to the calculated water mass from AIM and the three input values that fed into AIM (sulfate, nitrate and ammonium). AIM was run with typical FRM filter equilibration conditions of 35% RH and 22 deg C (295 deg K).

MATS calculates particle-bound water (PBW) using levels of SO<sub>4</sub>, NO<sub>3r</sub>, and NH<sub>4r</sub> as follows. (Note that this is the same equation that MATS uses to calculate future-year PBW, the difference being the future-year PBW uses future-year values of SO<sub>4</sub>, NO<sub>3r</sub>, and NH<sub>4r</sub>, and here MATS uses base-year values.)

The calculation uses one of two equations, depending on the acidity of the ammoniated sulfate (represented by DON). S, N, and A in the equations are the relative fraction of SO<sub>4</sub>, NO<sub>3r</sub>, and NH<sub>4r</sub> respectively.

$$S = \text{SO}_4 / (\text{SO}_4 + \text{NO}_{3r} + \text{NH}_{4r});$$

$$N = \text{NO}_{3r} / (\text{SO}_4 + \text{NO}_{3r} + \text{NH}_{4r});$$

$$A = \text{NH}_{4r} / (\text{SO}_4 + \text{NO}_{3r} + \text{NH}_{4r});$$

if DON ≤ 0.225 then

$$\begin{aligned} \text{PBW} = & \{ 595.556 \\ & - 1440.584 * S \\ & - 1126.488 * N \\ & + 283.907 * (S^{**1.5}) \\ & - 13.384 * (N^{**1.5}) \\ & - 1486.711 * (A^{**1.5}) \\ & + 764.229 * (S^{**2}) \\ & + 1501.999 * (N * S) \\ & + 451.873 * (N^{**2}) \\ & - 185.183 * (S^{**2.5}) \\ & - 375.984 * (S^{**1.5}) * N \\ & - 16.895 * (S^{**3}) \\ & - 65.814 * (N^{**1.5}) * S \\ & + 96.825 * (N^{**2.5}) \\ & + 83.037 * (N^{**1.5}) * (S^{**1.5}) \\ & - 4.419 * (N^{**3}) \\ & + 1720.818 * (A^{**1.5}) * S \\ & + 1220.383 * (A^{**1.5}) * N \\ & - 311.496 * (A^{**1.5}) * (S^{**1.5}) \end{aligned}$$

$$+ 148.771*(A^{**1.5})*(N^{**1.5})$$

$$+ 1151.648*(A^{**3}) \} * (SO_4+NO_3r+NH_4);$$

ELSE

$$PBW = \{202048.975$$

$$- 391494.647 *S$$

$$- 390912.147 *N$$

$$+ 442.435 *(S^{**1.5})$$

$$- 155.335 *(N^{**1.5})$$

$$- 293406.827 *(A^{**1.5})$$

$$+ 189277.519 *(S^{**2})$$

$$+ 377992.610 *N*S$$

$$+ 188636.790 *(N^{**2})$$

$$- 447.123 *(S^{**2.5})$$

$$- 507.157 *(S^{**1.5})*N$$

$$- 12.794 *(S^{**3})$$

$$+ 146.221 *(N^{**1.5})*S$$

$$+ 217.197 *(N^{**2.5})$$

$$+ 29.981 *(N^{**1.5})*(S^{**1.5})$$

$$- 18.649 *(N^{**3})$$

$$+ 216266.951 *(A^{**1.5})*S$$

$$+ 215419.876 *(A^{**1.5})*N$$

$$- 621.843 *(A^{**1.5})*(S^{**1.5})$$

$$+ 239.132 *(A^{**1.5})*(N^{**1.5})$$

$$+ 95413.122 *(A^{**3}) \} * (SO_4+NO_3r+NH_4) ;$$

#### 5.1.2.2.4 Organic Carbon Mass Calculation

Measured organic carbon mass is not directly used in the calculation of species fractions in MATS because of (1) many uncertainties in estimating carbonaceous mass from carbon measurements (Turpin, 2001; Chow, 2004) (2) differences in carbon measurement protocol between urban and rural monitoring locations, (3) a relatively “bumpy” surface of urban

carbon concentrations as derived from urban and rural organic carbon measurements and (4) lack of carbon measurements at all FRM locations. The MATS approach estimates carbon by mass balance comparing precisely measured FRM PM<sub>2.5</sub> mass (EPA, 2003) with the sum of its non-carbon components.

Total carbonaceous mass contains both elemental carbon (EC) and organic carbon mass (OCM). We measure EC from the interpolated STN and IMPROVE monitors, while we calculate OCM using a mass balance approach -- and refer to it as OCMMB. To calculate OCMMB, we subtract the other estimated retained species (including EC) from the PM<sub>2.5</sub> level measured at the FRM site as follows:

$$OCM_{MB} = PM_{2.5} - \left( SO_4 + NO_{3,retained} + NH_{4,retained} + PBW + Crustal + EC + Blank\ Mass + (Salt) \right)$$

The value for OCMMB could be very small, or even be calculated as negative (if the sum of the species enclosed in the curly brackets exceeded the FRM PM<sub>2.5</sub> monitor value). To ensure that the OCMMB does not get too small, an OCMMB "mass balance floor" (default) value is set to 1.0 times the interpolated value of blank-adjusted organic carbon (OCb). It is also possible that the value of the floor by itself could exceed the FRM total PM<sub>2.5</sub> value. In this case, MATS imposes a (user-adjustable) "ceiling," such that OCMMB does not exceed a percentage of the total non-blank mass. The default ceiling value is set to 0.8 or 80% of PM<sub>2.5</sub> mass. (You can modify the floor and ceiling assumptions in the [Species Fractions Calculation Options - Advanced](#) window.)

To account for these possibilities, MATS uses the following series of equations to calculate OCMMB:

$$OCM_{MB,Initial} = NonBlankMass - \left( SO_4 + NO_{3,retained} + NH_{4,retained} + PBW + Crustal + EC + Salt \right)$$

$$OCM_{MB,Floor} = Floor * OCb$$

$$OCM_{MB,Intermediate} = Max(OCM_{MB,Floor}, OCM_{MB,Initial})$$

$$OCM_{MB,Ceiling} = Ceiling * NonBlankMass$$

$$OCM_{MB,Final} = Min(OCM_{MB,Ceiling}, OCM_{MB,Intermediate})$$

where the "Floor" variable has a default value in MATS of "1.0" and the "Ceiling" variable has a default value in MATS of "0.8".

There are at least two things to note with this approach. (1) When the final OCMMB value is equal to the "floor," then the sum of the species will exceed the PM<sub>2.5</sub> value at the FRM monitor. To ensure that the sum of the species just equals the FRM PM<sub>2.5</sub> value, MATS reduces all of the species (except OCMMB) by the same percentage until the sum of the species just equals the FRM PM<sub>2.5</sub> value. (2) When the final OCMMB value is equal to the "ceiling," then the sum of the species will be less than the PM<sub>2.5</sub> value at the FRM monitor. In that case, MATS increases all of the species by the same percentage until the sum of the species just equals the FRM PM<sub>2.5</sub> value

## 5.1.2.2.5 Blank Mass Assumption

The field blank typically has a value of between 0.3 and 0.5 ug/m<sup>3</sup>, which appears to result from contamination of the FRM filter. For calculating retained PM<sub>2.5</sub>, MATS uses a default blank mass value of 0.5 ug/m<sup>3</sup>. If desired, you can change the default blank mass value at the [Species Fractions Calculations Options - Advanced](#) window.

## 5.1.2.3 Step 3: Forecasted Species Calculation

To calculate forecasted quarterly species averages for each of the four quarters in a given year, MATS uses weighted average quarterly species concentrations and both baseline and forecasted (e.g., 2020) air quality modeling. Because this calculation involves modeling data from two different years, this is referred to as a "temporal adjustment."

The forecasted weighted quarterly average for each species is calculated by multiplying the baseline weighted quarterly average for each monitor species with the ratio of the modeling data. This process gives forecasted weighted quarterly averages of six species: SO<sub>4</sub>, NO<sub>3</sub>, OCM, EC, crustal material, and NH<sub>4</sub>. The form of the equation is as follows:

$$Species_{i, future Q} = Species_{i, base Q} \cdot \frac{Model_{i, future Q}}{Model_{i, base Q}}$$

where

$Species_{i, future Q}$  = Estimated forecasted species "i" average in quarter Q

$Species_{i, base Q}$  = Monitored baseline species "i" average in quarter Q

$Model_{i, future Q}$  = Modeled forecasted species "i" average in quarter Q

$Model_{i, base Q}$  = Modeled baseline species "i" average in quarter Q

In other words, baseline species concentrations are assumed to change in the same proportion as the model data in the same location from the baseline to the forecasted. These proportions, called relative response factors (RRF), are simply the ratio of the modeled forecasted species to the modeled baseline species.

$$RRF_{i, Q} = \frac{Model_{i, future Q}}{Model_{i, base Q}}$$

where

$RRF_{i, Q}$  = relative response factor for quarter Q

MATS calculates RRFs for each quarter for each of six species: SO<sub>4</sub>, NO<sub>3</sub>, OCM, EC, crustal material, and (optionally) NH<sub>4</sub>. (Additional information on the [calculation of the RRFs can be found here](#).) The calculation of forecasted weighted quarterly average species concentrations can be rewritten as:

$$Species_{i, future Q} = Species_{i, base Q} \cdot RRF_{i, Q}$$

Additional calculations are needed to estimate future-year quarterly averages of NH4 and particle-bound water (PBW), which is calculated using forecasted levels of NH4, NO3, and SO4. (Details on the PBW calculation can be found [here](#).)

Recall that the default base year NH4 calculation is as follows:

$$NH_4 = DON * SO_4 + 0.29 * NO_{3,retained}$$

MATS can calculate the future year NH4 concentration using modeled NH4 RRFs, or by using the the base year DON value combined with future year SO4 and NO3 values (default approach) as follows:

$$NH_{4,future} = DON_{base} * SO_{4,future} + 0.29 * NO_{3,future}$$

The option for choosing which approach to use for calculating future NH4 is given in the [PM2.5 Calculation Options](#) window. Finally, note that PBW is calculated after future year NH4, using the previously identified water equation and future year concentrations of NH4, SO4, and NO3.

### Example Calculation Forecasted Species Concentrations

MATS multiplies the baseline species concentrations:

Quarter	SO4	NO3	OCMMB	EC	PBW	NH4	Crustal
Q1	2.3623	1.0989	3.3184	0.1993	1.0403	1.1990	0.6992
Q2	2.8991	0.7993	3.4939	0.5992	1.2039	1.3996	0.5992
Q3	1.7989	0.6997	7.0613	0.2990	1.2047	1.1997	0.2990
Q4	2.5999	1.3997	2.7773	0.3991	1.1025	1.1992	0.5996

with the RRFs for each quarter and species:

Quarter	SO4	NO3	OCMMB	EC	PBW	NH4	Crustal
Q1	0.9737	0.9873	0.9636	0.9872	--	0.9634	0.9808
Q2	0.9898	0.9991	0.9979	0.9917	--	0.9697	0.9891
Q3	0.9784	0.9775	0.9875	0.9944	--	0.9702	0.9759
Q4	0.9700	0.9800	0.9761	0.9843	--	0.9790	0.9818

The product is the forecasted species concentrations by quarter.

Quarter	SO4	NO3	OCMMB	EC	PBW	NH4	Crustal
Q1	2.3003	1.0849	3.1975	0.1968	--	1.1552	0.6858
Q2	2.8695	0.7985	3.4865	0.5942	--	1.3571	0.5927
Q3	1.7600	0.6840	6.9728	0.2973	--	1.1640	0.2918
Q4	2.5219	1.3717	2.7109	0.3928	--	1.1741	0.5887

#### 5.1.2.4 Step 4: Forecasted Design Value Calculation

The forecasted weighted quarterly averages for the species are then added together to get the estimated forecasted quarterly average PM2.5 level:

$$PM_{2.5,q} = SO_{4,q} + NO_{3,q} + OCM_{q} + EC_{q} + Crustal_{q} + NH_{4,q} + PBW_{q}$$

MATS averages the four quarterly averages these forecasted quarterly average PM2.5 levels to calculate forecasted design values:

$$PM_{2.5} = \sum_{q} \frac{PM_{2.5,q}}{4}$$

where

$$PM_{2.5} = \text{annual average } PM_{2.5} \text{ design value.}$$

The output file containing the results of this Standard Analysis are described [here](#).

#### Example Calculation Forecasted Design Values

Using hypothetical data from the previous example calculation plus PBW values and assumed blank mass, MATS sums the species to get quarterly PM2.5 values.

Quarter	SO4	NO3	OCMMB	EC	PBW	NH4	Crustal	Blank Mass	PM2.5
Q1	2.3003	1.0849	3.1975	0.1968	0.5000	1.1552	0.6858	0.5000	<b>9.6205</b>
Q2	2.8695	0.7985	3.4865	0.5942	0.4000	1.3571	0.5927	0.5000	<b>10.5985</b>
Q3	1.7600	0.6840	6.9728	0.2973	0.6000	1.1640	0.2918	0.5000	<b>12.2699</b>
Q4	2.5219	1.3717	2.7109	0.3928	0.7000	1.1741	0.5887	0.5000	<b>9.9601</b>

MATS then averages the four quarters to get a forecasted design value:

Quarter	PM2.5
Q1	9.6205
Q2	10.5985
Q3	12.2699
Q4	9.9601
<b>Forecasted Design Value</b>	<b>10.61</b>

#### 5.1.2.5 Output Description

The output file is named "Annual PM25 Point.csv" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "Example PM -- Annual PM25 Point 2020.csv"). The table below describes the variables in the output file for the Standard Analysis.

**Note:** The RRF variables in this file are not the actual RRFs used to calculate future year PM2.5 and PM2.5 species. They are the resultant annual average RRFs calculated by dividing the future annual average concentrations (in this file) by the base year annual average concentrations (in this file). The actual RRFs are calculated on a quarterly average basis and are contained in the quarterly average output files. There are no quarterly average RRFs for water or NH4 (if DON, NO3, and SO4 are used to calculate NH4).

**Output file name: "Scenario Name + Annual PM25 Point"**

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_type	FRM data
_STATE_NAME	State name. (This is a character variable.)
_COUNTY_NAM	County name. (This is a character variable.)
E	
monitor_lat	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
monitor_long	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_gridcell	Identifier of grid cell closest to the monitor
b_pm25_ann_DV	Base year 5 year weighted average PM2.5 annual design value
f_pm25_ann_DV	Future year 5 year weighted average PM2.5 annual design value
b_blank_mass	Base year blank mass concentration (ug/m3)
b_crustal_mass	Base year crustal mass concentration (ug/m3)
b_EC_mass	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass	Base year nitrate ion mass concentration (ug/m3)
b_water_mass	Base year water mass concentration (ug/m3)
b_salt_mass	Base year salt mass concentration (ug/m3)
f_blank_mass	Future year blank mass concentration (ug/m3)
f_crustal_mass	Future year crustal mass concentration (ug/m3)
f_EC_mass	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass	Future year ammonium mass concentration (ug/m3)
f_Ocmb_mass	Future year organic carbon mass (by difference) concentration (ug/m3)
f_SO4_mass	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass	Future year nitrate ion mass concentration (ug/m3)
f_water_mass	Future year water mass concentration (ug/m3)
f_salt_mass	Future year salt mass concentration (ug/m3)

rrf_crystal	Resultant annual relative response factor- Crystal Mass
rrf_ec	Resultant annual response factor- Elemental Carbon Mass
rrf_nh4	Resultant annual relative response factor- Ammonium Mass.
rrf_oc	Resultant annual relative response factor- Organic Carbon Mass
rrf_so4	Resultant annual relative response factor- Sulfate Mass
rrf_no3	Resultant annual relative response factor- Nitrate Mass
rrf_water_mass	Resultant annual relative response factor- Water Mass
rrf_salt	Resultant annual relative response factor- Salt Mass (set equal to 1 if modeled salt is not used)

### 5.1.3 Quarterly Model Data

The **Quarterly Model Data** option gives you the option of creating a small, reusable file with quarterly values from a much larger file with daily values. Since annual PM<sub>2.5</sub> MATS works with quarterly values there is no loss of precision. To save time, it is possible to use daily values only for an initial run with MATS and check this **Quarterly Model Data** option. Then for subsequent runs (that use the same modeled data), use the quarterly file that MATS generates. However, this will only work for subsequent MATS runs that use exactly the same base and future year photochemical model data (such as sensitivity runs that test the various ambient data settings in MATS).

Alternatively, you can generate a baseline and future quarterly average model file outside of MATS (using a program such as SAS, STATA, etc), and then load these quarterly files into MATS, bypassing the use of any daily model data in MATS. The format of the quarterly file is described below.

MATS generates two files:

- Base-year file: "*Baseline Quarterly Avg Model Data.csv*" with the Scenario Name (e.g., Example PM Annual) appended at the beginning (e.g., "*Example PM Annual -- Baseline Quarterly Avg Model Data.csv*").
- Future year file (e.g., "*Example PM -- Future Quarterly Avg Model Data.csv*." The format of the two files is the same.

The table below describes the variables in the **Quarterly Model Data** file.

**Output file name: "Scenario Name + Baseline/Future Quarterly Avg Model Data"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
_type	
lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.

long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
date	Year and Quarter (01= 1st quarter, 04= 2nd quarter, etc.)
crustal	Crustal PM
nh4	Ammonium PM
so4	Sulfate PM
ec	Elemental Carbon
no3	Nitrate PM
oc	Organic carbon PM
pm25	PM2.5 mass (only used to gradient adjust PM2.5 for gradient adjusted spatial fields)
cm	Coarse PM (ug/m3) (only used for visibility calculations)

MATS also produces a set of "used" quarterly average model day files (base and future). These have the same format as the quarterly average model data files, but only contain data for the model grid cells that were used in the MATS point calculations. These files can also be re-used and are also useful for QA purposes.

The table below describes the variables in the **Used Quarterly Model Data** file

**Output file name: "Scenario Name + Used Baseline/Future Quarterly Avg Model Data"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
_type	
lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
date	Year and Quarter (01= 1st quarter, 04= 2nd quarter, etc.)
crustal	Crustal PM
nh4	Ammonium PM
so4	Sulfate PM
ec	Elemental Carbon
no3	Nitrate PM
oc	Organic carbon PM
pm25	PM2.5 mass (only used to gradient adjust PM2.5 for gradient adjusted spatial fields)
cm	Coarse PM (ug/m3) (only used for visibility calculations)

## 5.1.4 Species Fractions

Species fractions are simply the fraction of quarterly average PM2.5 at a given monitor attributable to seven (and potentially eight) species: nitrate (NO3), sulfate (SO4), organic carbon (OC), crustal, elemental carbon (EC), ammonium (NH4), and particle-bound water (PBW). (And pending data availability, an eighth species, salt, can be included as well, the default MATS species files include salt data. But salt is an optional species on the model files. If base and future year modeled salt data is supplied, a salt RRF will be calculated. If there is no salt data in the model files, then the salt RRF will be set to 1.)

When you check the Species Fractions option, you get a *reusable* file with species fractions for each FRM monitor. Making the file reusable allows you to generate consistent results and, perhaps most importantly, allows the same file to be used by different MATS users.

### 5.1.4.1 Species Fractions Calculation

After calculating the ambient level of SO4, NO3, OCMMB, EC, PBW, NH4, and crustal, we then divide these ambient levels by the non-blank mass of PM2.5. To get non-blank PM2.5, subtract the blank mass from the FRM PM2.5 value. Then divide each of the species (except blank mass) by non-blank PM2.5.

#### Example Calculation of Species Fractions

The table below gives an example of these calculations. The fraction is calculated by dividing mass (ug/m3) by the Non-blank Mass. Note that salt is optional.

Units	FRM PM2.5	Blank Mass	Non-Blank Mass	SO4	NO3	OCMM B	EC	PBW	NH4	Crusta (Salt) I	
Concentration	10.9175	0.5	10.4175	2.4160	1.1555	3.4847	0.2101	1.1555	1.2605	0.7353	--
Fraction				0.2319	0.1109	0.3345	0.0202	0.1109	0.1210	0.0706	--

### 5.1.4.2 Output Description

The output file is named "*Quarterly Avg Spec Frac Point.csv*" with the [Scenario Name](#) appended at the beginning (e.g., "*Example PM -- Quarterly Avg Spec Frac Point.csv*"). The table below describes the variables in the file.

The interpolated variables (starting with i\_XXX) are created when MATS is run, but are not needed when re-using a fractions file. They are also not needed when running with a user generated fractions file.

#### Output file name: "Scenario Name + Quarterly Avg Spec Frac Point"

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_STATE_NAME	State name. (This is a character variable.)
_COUNTY_NAME	County name. (This is a character variable.)

monitor_lat	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
monitor_long	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
quarter	Quarter
pm25_mass_frac	PM2.5 mass used to calculate species fractions (calculated from the "PM2.5 for fractions" file)
fcr	Crustal fraction of PM2.5 mass
fec	Elemental carbon fraction of PM2.5 mass
fnh4	Ammonium fraction of PM2.5 mass
focm	Organic carbon fraction of PM2.5 mass
fso4	Sulfate ion fraction of PM2.5 mass
fno3	Nitrate ion fraction of PM2.5 mass
fwater	Water fraction of PM2.5 mass
fsalt	Salt fraction of PM2.5 mass
blank_mass	Blank mass
don	Degree of neutralization of sulfate used to calculate ammonium mass (0.000 - 0.375)
i_so4	Interpolated sulfate ion
i_no3r	Interpolated retained nitrate ion
i_ocb	Interpolated blank-adjusted organic carbon
i_ec	Interpolated elemental carbon
i_crustal	Interpolated crustal
i_don	Interpolated degree of neutralization of sulfate (DON).
i_nh4	Interpolated ammonium
i_no3	Interpolated nitrate ion (only used to calculate volatilized ammonium; if option is selected)
i_salt	Interpolated salt

**Notes:**

i\_ocb is only used to calculate the OCMmb "floor".

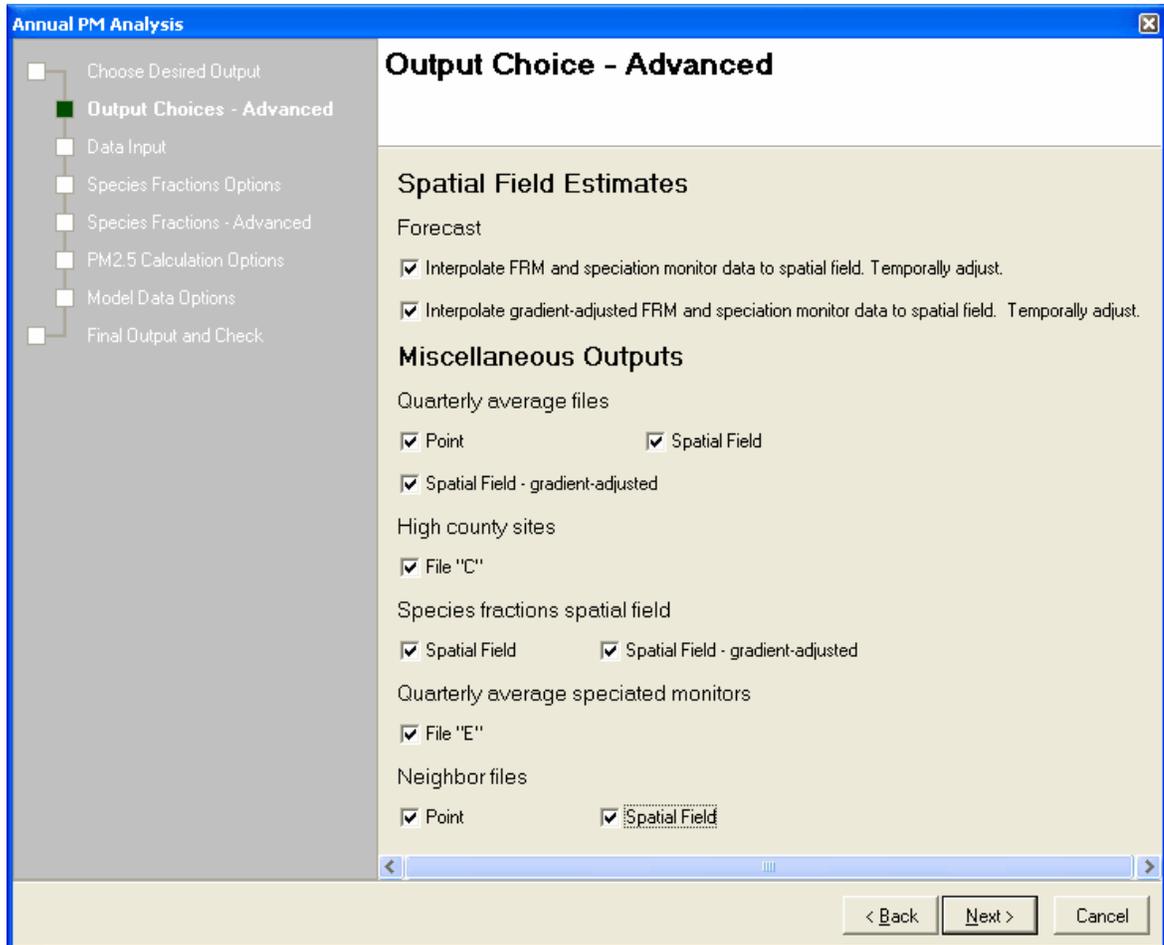
i\_nh4 is not used if DON is used to calculate the ammonium concentration (and fraction).

i\_no3 is only used to calculate the "volatilized ammonium", if the option is selected (not used by default).

## 5.2 Output Choice - Advanced

In the **Output Choice Advanced** window, MATS lets you choose from among two main options: [Spatial Field Estimates](#) and [Miscellaneous Output](#) that is generally used for

quality assurance (QA). Within each of these two main options there are a number of choices.



**Spatial Field Estimates.** This option gives you PM2.5 forecasts for each grid cell in the modeling domain (e.g., CMAQ 36 km).

- The [Interpolate FRM & speciation monitor data to spatial field. Temporally-adjust](#) option calculates interpolated spatial fields that are temporally adjusted. This option creates gridded spatial fields of future year PM2.5 data. To create PM2.5 spatial fields, MATS interpolates both speciation data **and** PM2.5 data (FRM and IMPROVE).
- The [Interpolate gradient-adjusted FRM & speciation monitor data to spatial field. Temporally-adjust](#) option calculates interpolated spatial fields that are temporally adjusted and gradient adjusted. Check this option to create gridded spatial fields of gradient adjusted future year PM2.5 data. To create PM2.5 spatial fields, MATS interpolates both gradient adjusted speciation data and PM2.5 data (FRM and

IMPROVE). This option creates the recommended spatial field for the “Unmonitored Area Analysis” from the PM2.5 modeling guidance.

**Miscellaneous Output.** This provides a variety of output files that can be used to QA the your calculations.

- [Quarterly average files.](#) The MATS default is to output the annual average results for all analyses (point, spatial fields). Checking any one of these boxes will also output the more detailed quarterly average calculations (the quarterly average calculations are the basis of all of the MATS annual PM2.5 calculations).
- [High county sites.](#) The MATS default is to output the point results for all FRM sites. Checking this box will also create a file which contains only the single highest monitor in each County (based on the highest future year value). This dataset is a subset of the all sites file.
- [Species fractions spatial field.](#) This option is the same as the species fraction file created from the standard analysis except it outputs the species fractions file created from a spatial field or gradient adjusted spatial field. The file will contain species fraction data for each quarter for each grid cell.
- [Quarterly average speciated monitors.](#) This file contains the raw quarterly average speciated data that MATS uses to do interpolations (to calculate species fractions). This data is derived from the “species for fractions” input file.
- [Neighbor files.](#) The neighbor files contain the “nearest neighbor” data for the VNA interpolation scheme. The data includes the distance to neighbor monitors and weights used to do the interpolations. There is information for each FRM monitor (for point analyses) or each grid cell (for spatial fields) for each quarter and for each species.

### 5.2.1 Spatial Field Estimates

With the Spatial Field Estimates option you can estimate PM2.5 for each grid cell in a spatial field by interpolating both FRM monitor data and speciated monitor data to the grid cell centroid (identified by latitude and longitude). A key difference between Spatial Field Estimates and [Standard Analysis](#) is that the Spatial Field Estimates requires the interpolation of FRM monitor data. MATS interpolates the "unofficial" daily PM2.5 monitor data from FRM and IMPROVE sites to each grid cell centroid and then averages the values for each quarter from the different PM2.5 sites. (Recall, as discussed in the [Baseline PM2.5 Calculation](#) section, the Standard Analysis uses "official" PM2.5 monitor data.)

The basic form of the spatial calculation is as follows:

$$Gridcell_{E, baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i$$

Gridcell<sub>E, baseline</sub> = estimated quarterly average baseline species concentration at grid cell E;

Weight<sub>i</sub> = inverse distance weight for monitor i;

Monitor<sub>i</sub> = quarterly average baseline species concentration at monitor i.

Note that MATS lets you choose whether to use air quality modeling to scale the interpolation of speciated monitor values to grid cell centroids (spatial fields). This use of modeling data is referred to as a gradient adjustment, and is discussed in the [next section](#).

#### 5.2.1.1 Gradient-Adjustment- ("Fused fields")

Using modeling data for a [gradient adjustment](#) is fairly simple. MATS calculates species fractions using monitor data in basically the same way as in the [species fractions calculation for the Standard Analysis](#), however, MATS includes model data to help inform the calculation. In particular, MATS uses model values for the grid cell of interest and the model values for the grid cells containing the speciated/PM2.5 monitors to be interpolated to cell of interest. (Note that "unofficial" PM2.5 values are used in the interpolation, and they are treated in essentially the same way as monitor data for particular species, such as SO4.)

A general form of the equation for the interpolated species values is as follows:

$$Species_{E, baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i \cdot Gradient\ Adjustment_{i,E}$$

where:

Species<sub>E, baseline</sub> = estimated baseline quarterly average species/PM2.5 concentration at cell E;

Weight<sub>i</sub> = inverse distance weight for monitor i;

Monitor<sub>i</sub> = baseline quarterly average species/PM2.5 concentration at monitor i;

Gradient Adjustment<sub>i, E</sub> = gradient adjustment from monitor i to cell E.

This interpolation calculation can be rewritten somewhat more precisely as:

$$Species_{E, baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i \cdot \frac{Model_{E, baseline}}{Model_{i, baseline}}$$

where:

Model<sub>E, baseline</sub> = modeled quarterly average baseline species/PM2.5 concentration at cell E;

$Model_{i, \text{baseline}}$  = modeled quarterly average baseline species/PM2.5 concentration at monitor site i.

MATS uses this gradient approach for PM2.5 and for most species -- SO4, NO3r, EC, OCb, Crustal, and NH4. However, for DON (degree of neutralization), MATS does not use a gradient adjustment and simply interpolates the estimated DON values as is from each monitor. Options regarding the use of model data are discussed in more detail in the section on [Model Data Options](#).

Once MATS has interpolated quarterly species values at the cell of interest, calculations proceed in exactly the same way as described for [species fractions](#) and [forecasted PM2.5 values](#) for the Standard Analysis.

### Example Calculation for Interpolated Gradient-Adjusted Baseline Species Concentrations

For each quarter, MATS identifies the speciated monitors that are nearby ("neighbors") to a given cell of interest "E", and determines the weight that should be given to each monitor in the interpolation process. Monitors that are nearby get a greater weight.

#### Speciated Monitor Values

Monitor ID	Quarter	SO4	NO3r	EC	OCb	Crustal	NH4	DON	Interpolation Wght
A	Q1	2.30	1.10	3.32	0.20	1.10	1.20	0.21	0.2
B	Q1	2.90	0.80	3.49	0.60	1.20	1.40	0.19	0.4
C	Q1	1.80	0.70	7.06	0.30	1.20	1.20	0.18	0.15
D	Q1	2.60	1.40	2.78	0.40	1.10	1.20	0.32	0.25

MATS then identifies the speciated model values at each of the speciated monitors (A-D) and for the given cell of interest (E):

#### Model Values at Speciated Monitor Sites A-D

Monitor ID	Quarter	SO4	NO3	EC	OC	Crustal	NH4	DON
A	Q1	1.60	1.03	2.99	0.15	0.75	0.86	--
B	Q1	2.54	0.70	3.20	0.47	1.07	1.04	--
C	Q1	1.66	0.59	5.91	0.23	1.13	0.81	--
D	Q1	1.93	1.15	2.13	0.27	1.00	1.12	--

#### Model Values at Cell E

Monitor ID	Quarter	SO4	NO3	EC	OC	Crustal	NH4	DON
E	Q1	2.10	0.98	3.10	0.15	1.00	1.30	--

MATS then calculates the speciated values at cell E using the monitor and model data (and interpolation weights) using the equation above:

**Interpolated Speciated Monitor Values**

Monitor ID	Quarter	SO4	NO3r	EC	OCb	Crustal	NH4	DON
A	Q1	3.02	1.04	3.44	0.20	1.46	1.82	0.21
B	Q1	2.40	1.12	3.38	0.19	1.13	1.75	0.19
C	Q1	2.27	1.16	3.71	0.19	1.06	1.93	0.18
D	Q1	2.83	1.19	4.05	0.22	1.10	1.39	0.32
<b>Wght. Avg.</b>	Q1	<b>2.61</b>	<b>1.13</b>	<b>3.61</b>	<b>0.20</b>	<b>1.18</b>	<b>1.70</b>	<b>0.23</b>

Note that MATS does a similar calculation (not shown) when interpolating "unofficial" PM2.5 values to the given cell of interest, denoted "E".

**5.2.1.2 Output Description - Interpolate FRM & Speciation Monitor Data to Spatial Field**

The output file is named "*Annual PM25 Spatial Field*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- Annual PM25 Spatial Field 2020.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Annual PM25 Spatial Field"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
b_pm25_ann_DV	Base year interpolated PM2.5 from unofficial data file
f_pm25_ann_DV	Future year interpolated PM2.5
b_blank_mass	Base year blank mass concentration (ug/m3)
b_crustal_mass	Base year crustal mass concentration (ug/m3)
b_EC_mass	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass	Base year nitrate ion mass concentration (ug/m3)
b_water_mass	Base year water mass concentration (ug/m3)
b_salt_mass	Base year salt mass concentration (ug/m3)
f_blank_mass	Future year blank mass concentration (ug/m3)
f_crustal_mass	Future year crustal mass concentration (ug/m3)
f_EC_mass	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass	Future year ammonium mass concentration (ug/m3)
f_Ocmb_mass	Future year organic carbon mass (by difference) concentration (ug/m3)

f_SO4_mass	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass	Future year nitrate ion mass concentration (ug/m3)
f_water_mass	Future year water mass concentration (ug/m3)
f_salt_mass	Future year salt mass concentration (ug/m3)
rff_crustal	Resultant annual relative response factor- Crustal Mass
rff_ec	Resultant annual response factor- Elemental Carbon Mass
rff_nh4	Resultant annual relative response factor- Ammonium Mass.
rff_oc	Resultant annual relative response factor- Organic Carbon Mass
rff_so4	Resultant annual relative response factor- Sulfate Mass
rff_no3	Resultant annual relative response factor- Nitrate Mass
rff_water_mass	Resultant annual relative response factor- Water Mass
rff_salt	Resultant annual relative response factor- Salt Mass

### 5.2.1.3 Output Description - Interpolate Gradient-Adjusted FRM & Speciation Monitor Data to Spatial Field

The output file is named "*Grad Adj Annual PM25 Spatial Field*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- Grad Adj Annual PM25 Spatial Field 2020.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Grad Adj Annual PM25 Spatial Field"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
b_pm25_ann_DV_ga	Base year gradient adjusted interpolated PM2.5 from unofficial data file
f_pm25_ann_DV_ga	Future year gradient adjusted interpolated PM2.5
b_blank_mass_ga	Base year blank mass concentration (ug/m3)
b_crustal_mass_ga	Base year crustal mass concentration (ug/m3)
b_EC_mass_ga	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass_ga	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass_ga	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass_ga	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass_ga	Base year nitrate ion mass concentration (ug/m3)
b_water_mass_ga	Base year water mass concentration (ug/m3)
b_salt_mass_ga	Base year salt mass concentration (ug/m3)
f_blank_mass_ga	Future year blank mass concentration (ug/m3)

f_crustal_mass_ga	Future year crustal mass concentration (ug/m3)
f_EC_mass_ga	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass_ga	Future year ammonium mass concentration (ug/m3)
f_Ocmb_mass_ga	Future year organic carbon mass (by difference) concentration (ug/m3)
f_SO4_mass_ga	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass_ga	Future year nitrate ion mass concentration (ug/m3)
f_water_mass_ga	Future year water mass concentration (ug/m3)
f_salt_mass_ga	Future year salt mass concentration (ug/m3)
rff_crustal	Resultant annual relative response factor- Crustal Mass
rff_ec	Resultant annual response factor- Elemental Carbon Mass
rff_nh4	Resultant annual relative response factor- Ammonium Mass.
rff_oc	Resultant annual relative response factor- Organic Carbon Mass
rff_so4	Resultant annual relative response factor- Sulfate Mass
rff_no3	Resultant annual relative response factor- Nitrate Mass
rff_water_mass	Resultant annual relative response factor- Water Mass
rff_salt	Resultant annual relative response factor- Salt Mass

## 5.2.2 Miscellaneous Output

MATS gives you ability to generate a number of specialized files for quality assurance, identify the monitor in each county with the highest forecast, and other reasons. These files include:

- [Quarterly Average Files](#). Contain baseline PM2.5 and species concentrations, RRFs, forecasted PM2.5 and species concentrations. Available for point estimates and spatial fields, as well as gradient-adjusted spatial fields. These files are important because all of the basic PM2.5 calculations in MATS occur on a quarterly average basis. The "true" RRFs and PM2.5 and species concentrations are found in the quarterly average files.
- [High County Sites](#). Monitor chosen in county based on highest future-year value. Contains baseline PM2.5 and species concentrations, RRFs, forecasted PM2.5 and species. File only available for the Standard Analysis (point) results.
- [Species Fractions for Spatial Fields](#). Contains quarterly species fractions and interpolated species values (with or without gradient-adjustment) for spatial fields.
- [Quarterly Average Speciated Monitors](#). Contains baseline quarterly average monitored species concentrations at STN and IMPROVE sites. This is the subset of species data that MATS uses for each particular scenario (based on the MATS inputs and configuration settings).
- [Neighbor Files](#). Contains neighbor identifiers for interpolation to both FRM sites or to spatial fields.

### 5.2.2.1 Quarterly Average Files

The Quarterly Average Files provide intermediate calculations performed by MATS. In particular, these files have the weighted quarterly average baseline and future values for PM2.5 and its constituent species. In addition it gives the speciated RRFs. There are potentially three Quarterly Average Files: one for Point Estimates and two for Spatial Field Estimates (with and without gradient adjustment).

#### 5.2.2.1.1 Output Description - Quarterly Average Point

The output file is named "*Quarterly PM25 Point*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- Quarterly PM25 Point 2020.csv*"). The table below describes the variables in the output file.

#### Output file name: "Scenario Name + Quarterly PM25 Point + Year"

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_type	FRM data
_state_name	State name. (This is a character variable.)
_county_name	County name. (This is a character variable.)
monitor_lat	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
monitor_long	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_gridcell	Identifier of grid cell closest to the monitor
quarter	Quarter
b_pm25_ann_q_DV	Base year 5 year weighted average PM2.5 (quarter) design value
f_pm25_ann_q_DV	Future year 5 year weighted average PM2.5 (quarter) design value
b_blank_mass_q	Base year blank mass concentration (ug/m3)
b_crustal_mass_q	Base year crustal mass concentration (ug/m3)
b_EC_mass_q	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass_q	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass_q	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass_q	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass_q	Base year nitrate ion mass concentration (ug/m3)
b_water_mass_q	Base year water mass concentration (ug/m3)
f_blank_mass_q	Future year blank mass concentration (ug/m3)
f_crustal_mass_q	Future year crustal mass concentration (ug/m3)
f_EC_mass_q	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass_q	Future year ammonium mass concentration (ug/m3)
f_Ocmb_mass_q	Future year organic carbon mass (by difference) concentration (ug/m3)

f_SO4_mass_q	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass_q	Future year nitrate ion mass concentration (ug/m3)
f_water_mass_q	Future year water mass concentration (ug/m3)
rrf_crustal	Relative response factor- Crustal Mass
rrf_ec	Relative response factor- Elemental Carbon Mass
rrf_nh4	Relative response factor- Ammonium Mass. (Only calculated if ammonium in model data and measured ammonium ["NH4"] used in calculations.)
rrf_oc	Relative response factor- Organic Carbon Mass
rrf_so4	Relative response factor- Sulfate Mass
rrf_no3	Relative response factor- Nitrate Mass

## 5.2.2.1.2 Output Description - Quarterly Average Spatial Field

The output file is named "*Quarterly PM25 Spatial Field*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- Quarterly PM25 Spatial Field 2020.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Quarterly PM25 Spatial Field + Year"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
quarter	Quarter
b_pm25_ann_q_DV	Base year 5 year weighted average PM2.5 (quarter) design value
f_pm25_ann_q_DV	Future year 5 year weighted average PM2.5 (quarter) design value
b_blank_mass_q	Base year blank mass concentration (ug/m3)
b_crustal_mass_q	Base year crustal mass concentration (ug/m3)
b_EC_mass_q	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass_q	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass_q	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass_q	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass_q	Base year nitrate ion mass concentration (ug/m3)
b_water_mass_q	Base year water mass concentration (ug/m3)
f_blank_mass_q	Future year blank mass concentration (ug/m3)
f_crustal_mass_q	Future year crustal mass concentration (ug/m3)
f_EC_mass_q	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass_q	Future year ammonium mass concentration (ug/m3)
f_Ocmb_mass_q	Future year organic carbon mass (by difference) concentration

	(ug/m3)
f_SO4_mass_q	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass_q	Future year nitrate ion mass concentration (ug/m3)
f_water_mass_q	Future year water mass concentration (ug/m3)
rff_crustal	Relative response factor- Crustal Mass
rff_ec	Relative response factor- Elemental Carbon Mass
rff_nh4	Relative response factor- Ammonium Mass. (Only calculated if ammonium in model data and measured ammonium ["NH4"] used in calculations.)
rff_oc	Relative response factor- Organic Carbon Mass
rff_so4	Relative response factor- Sulfate Mass
rff_no3	Relative response factor- Nitrate Mass

## 5.2.2.1.3 Output Description - Quarterly Average Spatial Field - Gradient Adjusted

The output file is named "*Grad Adj Quarterly PM25 Spatial Field*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- Grad Adj Quarterly PM25 Spatial Field 2020.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Grad Adj Quarterly PM25 Spatial Field + Year"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
quarter	Quarter
b_pm25_ann_q_DV_ga	Base year 5 year weighted average PM2.5 (quarter) design value
f_pm25_ann_q_DV_ga	Future year 5 year weighted average PM2.5 (quarter) design value
b_blank_mass_q_ga	Base year blank mass concentration (ug/m3)
b_crustal_mass_q_ga	Base year crustal mass concentration (ug/m3)
b_EC_mass_q_ga	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass_q_ga	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass_q_ga	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass_q_ga	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass_q_ga	Base year nitrate ion mass concentration (ug/m3)
b_water_mass_q_ga	Base year water mass concentration (ug/m3)
f_blank_mass_q_ga	Future year blank mass concentration (ug/m3)
f_crustal_mass_q_ga	Future year crustal mass concentration (ug/m3)
f_EC_mass_q_ga	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass_q_ga	Future year ammonium mass concentration (ug/m3)

f_Ocmb_mass_q_ga	Future year organic carbon mass (by difference) concentration (ug/m3)
f_SO4_mass_q_ga	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass_q_ga	Future year nitrate ion mass concentration (ug/m3)
f_water_mass_q_ga	Future year water mass concentration (ug/m3)
rff_crustal_ga	Relative response factor- Crustal Mass
rff_ec_ga	Relative response factor- Elemental Carbon Mass
rff_nh4_ga	Relative response factor- Ammonium Mass. (Only calculated if ammonium in model data and measured ammonium ["NH4"] used in calculations.)
rff_oc_ga	Relative response factor- Organic Carbon Mass
rff_so4_ga	Relative response factor- Sulfate Mass
rff_no3_ga	Relative response factor- Nitrate Mass

### 5.2.2.2 Output Description - High County Sites

In this file, MATS reports the monitor with the highest forecasted PM2.5 design value in each county. The name of this file is "*High County Sites*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- High County Sites 2020.csv*"). The table below describes the variables in the output file.

#### Output file name: "Scenario Name + High County Sites + Year"

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_type	FRM data
_state_name	State name. (This is a character variable.)
_county_name	County name. (This is a character variable.)
monitor_lat	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
monitor_long	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_gridcell	Identifier of grid cell closest to the monitor
b_pm25_ann_DV	Base year 5 year weighted average PM2.5 annual design value
f_pm25_ann_DV	Future year 5 year weighted average PM2.5 annual design value
b_blank_mass	Base year blank mass concentration (ug/m3)
b_crustal_mass	Base year crustal mass concentration (ug/m3)
b_EC_mass	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass	Base year sulfate ion mass concentration (ug/m3)

b_NO3_mass	Base year nitrate ion mass concentration (ug/m3)
b_water_mass	Base year water mass concentration (ug/m3)
f_blank_mass	Future year blank mass concentration (ug/m3)
f_crustal_mass	Future year crustal mass concentration (ug/m3)
f_EC_mass	Future year elemental carbon mass concentration (ug/m3)
f_NH4_mass	Future year ammonium mass concentration (ug/m3)
f_Ocmb_mass	Future year organic carbon mass (by difference) concentration (ug/m3)
f_SO4_mass	Future year sulfate ion mass concentration (ug/m3)
f_NO3_mass	Future year nitrate ion mass concentration (ug/m3)
f_water_mass	Future year water mass concentration (ug/m3)

### 5.2.2.3 Species Fractions Spatial Field

Contains quarterly species fractions and interpolated species values (with or without gradient-adjustment) for spatial fields. (Note that you cannot currently load this file into MATS, and instead this file is currently only for information. A future version of MATS may allow loading in species fractions for spatial fields.)

#### 5.2.2.3.1 Output Description - Species Fractions Spatial Field

In this file, MATS reports the quarterly species fractions. The name of this file is "*Quarterly Avg Spec Frac Spatial Field*" with the [Scenario Name](#) appended at the beginning (e.g., "*Example PM -- Quarterly Avg Spec Frac Spatial Field.csv*"). The table below describes the variables in the output file.

#### Output file name: "Scenario Name + Quarterly Avg Spec Frac Spatial Field"

Variable	Description
_ID	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
quarter	Quarter
PM25_mass_frac	PM2.5 mass used to calculate species fractions (calculated from the "PM2.5 for fractions" file)
fcr	Crustal fraction of PM2.5 mass
fec	Elemental carbon fraction of PM2.5 mass
fnh4	Ammonium fraction of PM2.5 mass
focm	Organic carbon fraction of PM2.5 mass
fso4	Sulfate ion fraction of PM2.5 mass
fno3	Nitrate ion fraction of PM2.5 mass
fwater	Water fraction of PM2.5 mass

fsalt	Salt fraction of PM2.5 mass
blank_mass	Blank mass
don	Degree of neutralization of sulfate used to calculate ammonium mass (0.000 - 0.375)
i_SO4	Interpolated sulfate ion
i_NO3R	Interpolated nitrate ion
i_OCB	Interpolated blank-adjusted organic carbon
i_EC	Interpolated elemental carbon
i_CRUSTAL	Interpolated crustal
i_DON	Interpolated degree of neutralization of sulfate (DON).
i_SALT	Interpolated salt
i_NH4	Interpolated ammonium

## 5.2.2.3.2 Output Description - Gradient-Adjusted Species Fractions Spatial Field

In this file, MATS reports the gradient adjusted quarterly species fractions. The name of this file is "*Grad Adj Quarterly Avg Spec Frac Spatial Field*" with the [Scenario Name](#) appended at the beginning (e.g., "*Example PM -- Grad Adj Quarterly Avg Spec Frac Spatial Field.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Grad Adj Quarterly Avg Spec Frac Spatial Field"**

Variable	Description
_ID	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
quarter	Quarter
PM25_mass_frac_ga	PM2.5 mass used to calculate species fractions (calculated from the "PM2.5 for fractions" file)
fcr_ga	Crustal fraction of PM2.5 mass
fec_ga	Elemental carbon fraction of PM2.5 mass
fnh4_ga	Ammonium fraction of PM2.5 mass
focm_ga	Organic carbon fraction of PM2.5 mass
fso4_ga	Sulfate ion fraction of PM2.5 mass
fno3_ga	Nitrate ion fraction of PM2.5 mass
fwater_ga	Water fraction of PM2.5 mass
fsalt_ga	Salt fraction of PM2.5 mass
blank_mass_ga	Blank mass
don_ga	Degree of neutralization of sulfate used to calculate ammonium mass (0.000 - 0.375)
i_SO4_ga	Interpolated sulfate ion
i_NO3R_ga	Interpolated nitrate ion

i_OCB_ga	Interpolated blank-adjusted organic carbon
i_EC_ga	Interpolated elemental carbon
i_CRUSTAL_ga	Interpolated crustal
i_DON	Interpolated degree of neutralization of sulfate (DON). Note that DON is not gradient-adjusted.
i_SALT_ga	Interpolated salt
i_NH4_ga	Interpolated ammonium

#### 5.2.2.4 Output Description - Quarterly Average Speciated Monitors

In this file, MATS reports the quarterly averages at the speciated monitors. The name of this file is "*Quarterly Avg Speciated Monitors*" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "*Example PM -- Quarterly Avg Speciated Monitors.csv*"). The table below describes the variables in the output file.

#### Output file name: "Scenario Name + Quarterly Avg Speciated Monitors"

Variable	Description
_id	IMPROVE/STN Site Code
_type	
_state_name	State name. (This is a character variable.)
_county_name	County name. (This is a character variable.)
monitor_lat	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
monitor_long	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_gridcell	Identifier of grid cell closest to the monitor
quarter	Quarter
b_crustal_mass	Base year crustal mass concentration (ug/m3)
b_EC_mass	Base year elemental carbon mass concentration (ug/m3)
b_NH4_mass	Base year ammonium mass concentration (ug/m3)
b_Ocmb_mass	Base year organic carbon mass (by difference) concentration (ug/m3)
b_SO4_mass	Base year sulfate ion mass concentration (ug/m3)
b_NO3_mass	Base year nitrate ion mass concentration (ug/m3)
b_water_mass	Base year water mass concentration (ug/m3)

#### 5.2.2.5 Neighbor Files

MATS calculates the nearby monitors or "neighbors" separately for each species when interpolating to points, and similarly for interpolating to spatial fields, which also involves interpolation of PM monitors.

- [Neighbors for Interpolating Species to Points.](#)
- [Neighbors for Interpolating PM2.5 & Species to Spatial Fields.](#)

## 5.2.2.5.1 Output Description - Neighbors for Interpolating Species to Points

In this file, MATS reports the neighbors involved in interpolating species values (except NH<sub>4</sub> and DON) to the FRM monitor sites. The name of this file is "*Neighbor File Point*" with the [Scenario Name](#) appended at the beginning (e.g., "*Example PM -- Neighbor File Point.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Neighbor File Point"**

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_state_name	State name. (This is a character variable.)
_county_name	County name. (This is a character variable.)
monitor_lat	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
monitor_long	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_gridcell	Identifier of grid cell closest to the monitor
quarter	Quarter
_neighbor	IMPROVE/STN Site Code. (This is a character variable.)
neighbor_gridcell	Identifier of grid cell closest to the neighbor
distance	Distance in kilometers from FRM monitor site and IMPROVE/STN/SPECTRE neighbor.
weightdistance	Inverse-distance weight
weightdistancesquared	Inverse-distance-squared weight
pollutant	Pollutant (e.g., SO <sub>4</sub> ). Note interpolation approach can vary by pollutant

## 5.2.2.5.2 Output Description - Neighbors for Interpoatling PM &amp; Species to Spatial Field

In this file, MATS reports the neighbors involved in interpolating NH<sub>4</sub> and DON to the Spatial Field. The name of this file is "*Neighbor File Spatial Field - PM*" with the [Scenario Name](#) appended at the beginning (e.g., "*Example PM -- Neighbor File Spatial Field - PM.csv*"). The table below describes the variables in the output file.

**Output file name: "Scenario Name + Neighbor File Spatial Field"**

Variable	Description
_id	The ID is a unique identifier for each model grid cell. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.

quarter	Quarter
_neighbor	IMPROVE/STN Site Code. (This is a character variable.)
neighbor_gridcell	Identifier of grid cell closest to the neighbor
distance	Distance in kilometers from FRM monitor site and IMPROVE/STN/SPECTRE neighbor.
weight	Inverse-distance weight
Interpolation method	Inverse-distance-squared weight
pollutant	Pollutant (e.g., SO4). Note interpolation approach can vary by pollutant

### 5.3 Data Input

In the **Data Input** window, you specify the MATS input files that are used in each scenario. There are three main types of files which must be specified. These include ambient PM2.5 species data, ambient total PM2.5 data (FRM and IMPROVE), and gridded model output data (e.g. CMAQ or CAMx data). There is specific terminology that is used on the Data Input page. "Official" data refers to PM2.5 FRM data that can be used to determine official design values for compliance purposes (comparison to the NAAQS). Other datasets which may not have rigid regulatory significance are sometimes referred to as "unofficial" data. The individual input file choices are explained below.

**Species Data.** MATS needs ambient PM2.5 species data to calculate species concentrations at FRM monitoring sites and spatial fields. Users have a choice of supplying a “Species Monitor Data File” or a “Species Fractions File”.

- [Species Monitor Data File](#). The default is to provide a species monitor data file. MATS is populated with daily average species data from STN and IMPROVE sites across the country. However, users can also provide their own ambient data file. MATS uses the daily average species data to calculate species fractions at each FRM monitor (or at each grid cell, in the case of spatial fields). The species fraction data is combined with the “unofficial daily average PM2.5 data” to calculate species concentrations. The default MATS species data file contains all available data. However, there is a data flag to indicate site days that are recommended to be removed from the species fractions calculations. This is not necessarily the same data flags that have been identified by State agencies. We have incorporated flagging routines that remove data that are considered to be outliers and/or incomplete data. (A description of the flags is provided in the section on [Species Fractions Calculation Options](#).)
- [Species Fraction File](#). Alternatively, the user can choose to use a pre-calculated species fractions file which contains quarterly species information for the FRM monitors of interest. MATS can also re-use a species fractions file (either "point" or "spatial fields") that has previously been generated by MATS. To re-use a previously created fractions file, simply supply the correct path to the file. When re-using spatial fields species fractions files, either "spatial field" or gradient adjusted spatial fields" must be selected from the drop-down box. MATS cannot use both types of spatial fields species fractions files at the same time. (The calculation of [species fractions is discussed here](#).)

**PM2.5 Monitor Data.** MATS uses both "official" and "unofficial" data in its calculations.

- [Unofficial Daily Average PM2.5 Data File](#). The “unofficial daily average PM2.5” file contains the PM2.5 data that is needed to calculate species fractions. It is used in combination with the “species monitor data file” from above. The unofficial daily average PM2.5 file is not needed if the user supplies a pre-calculated species fractions file.

Similar to the species monitor data file from above, the “unofficial” PM2.5 data file contains a data flag to indicate site days that are recommended to be removed from the species fractions calculations. The flagged data is matched between the species file and the PM2.5 file so that the same site days are removed. However, the PM2.5 data file contains additional data (sites that don’t contain speciation measurements) and therefore has additional flagged site days. These are not the same data flags that have been identified by State agencies. We have incorporated flagging routines that remove data that are considered to be outliers and/or incomplete data. (A description of the flags is provided in the section on [Species Fractions Calculation Options](#).) The user is free to

unflag existing data or add flags as necessary and appropriate.

- [Official Quarterly Average FRM Data File](#). The “official quarterly average file” contains all of the “official” quarterly average FRM data that has been used to calculate PM<sub>2.5</sub> design values. It is used to calculate design values and 5 year weighted average design values as part of the attainment test.

The default data file in MATS was created by the Air Quality Analysis Group within OAQPS. In most cases, the data should not be altered, however in some cases (e.g. sensitivity analyses) there may be a need to add or remove data.

**Model Data.** The “model data” refers to gridded model output from models such as CMAQ or CAMx. The user can choose either [daily model data input](#) or [quarterly model data input](#) (which is just a quarterly average of the daily model data). Either will work for annual PM<sub>2.5</sub>. The default setting is daily average data. Recall that MATS can generate quarterly average model data (which can then be re-used in subsequent MATS runs).

Model data must be selected for all MATS runs. The size of the modeling grid defines the outputs for point estimates and for spatial fields. For point estimates, MATS will output the results for all specified monitors within the domain. For spatial fields, MATS will create spatial fields that match the size of the gridded model domain.

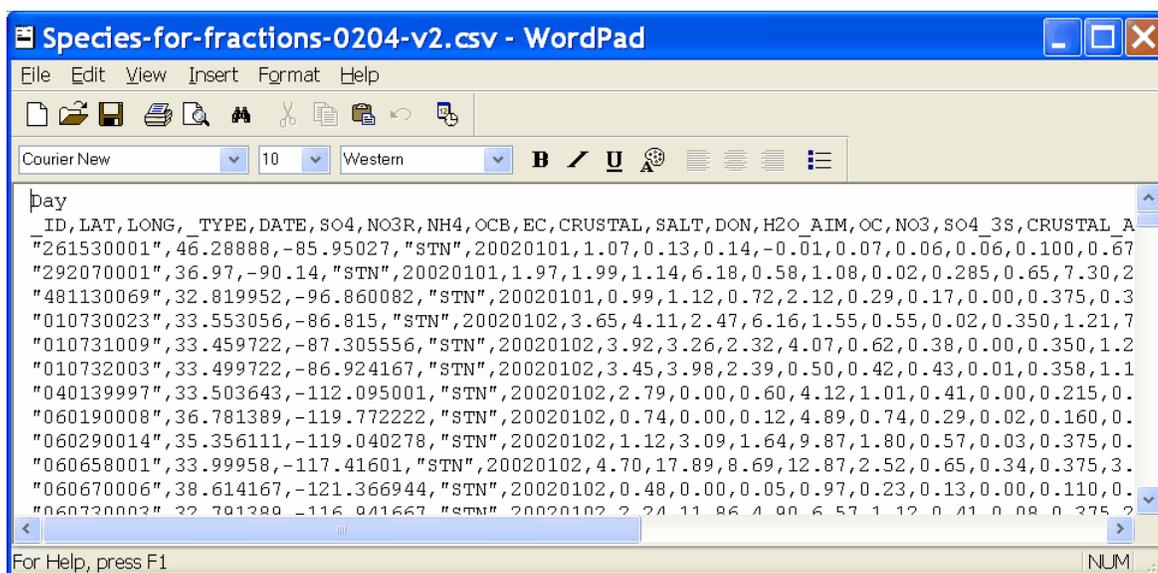
Note that you need to specify both a [Baseline File](#) and a [Forecast File](#). The baseline file should be consistent with the historical monitor data that you use, and the forecast year is the future-year of interest.

### 5.3.1 Species Data Input

The species data may be in form of monitor data (specified below) that MATS then uses to calculate species fractions, or it may be in the form of species fractions directly ([specified here](#)).

Monitor data should be in the form of a simple text file. The first row specifies the frequency of the data (e.g., day). The second row presents comma-separated variable names. The third row begins the data values. Below is an example of the monitor data file format and descriptions of the variables in the file.

#### Format of Speciated Monitor Data



## Speciated Monitor Data Variable Descriptions

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. (This is a character variable.)
LAT	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
LONG	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
_TYPE	STN or IMPROVE network data
DATE	Date of daily average ambient data with YYYYMMDD format (This is a numeric variable)
SO4	Measured sulfate ion
NO3R	Estimated nitrate retained on FRM filter, using measured nitrate, hourly T and RH
NH4	Measured NH4+ ion
OCB	OC blank adjusted, STN uses constant blank value per sampler type, IMPROVE uses backup filter methodology
EC	Measured EC
CRUSTAL	Using IMPROVE algorithm, Crustal, aka "Fine Soil" = $2.2 \times [Al] + 2.49 \times [Si] + 1.63 \times [Ca] + 2.42 \times [Fe] + 1.94 \times [Ti]$
SALT	Estimated salt using Cl (Salt=1.8*Cl), where Cl is elemental chloride
DON	Degree of neutralization of SO4 (0-0.375)
H2O_AIM	Calculated water using AIM and measured SO4, adjusted NO3 and measured NH4
OC	Measured OC
NO3	Measured nitrate ion
SO4_3S	Sulfate value derived from S, as per IMPROVE protocol. i.e. $SO4\_3S = 3*S$ .

CRUSTAL_ALT	Alternative Crustal calculation using measured Si, Fe, Ca, Ti (modified formula without Al) = $3.73 \times [\text{Si}] + 1.63 \times [\text{Ca}] + 2.42 \times [\text{Fe}] + 1.94 \times [\text{Ti}]$
FRM_MASS	FRM mass
MEASURED_FM	STN or IMPROVE sampler measured fine mass (Teflon filter)
RCFM	Reconstructed Fine Mass using IMPROVE protocol, RCFM = [Amm_Sulfate] + [Amm_Nitrate] + [OCM] + [EC] + [Fine Soil]
Al	Measured Al
Ca	Measured Ca
Fe	Measured Fe
Ti	Measured Ti
Si	Measured Si
EPA_FLAG	Flag to indicate data that EPA recommends to be removed from the species fractions calculations. 0 = valid data, 1 or greater = data that has been flagged and should be removed
USER_FLAG	Flag to indicate additional data that the user wants to remove from the species fractions calculations. 0 = valid data, 1 or greater = data that has been flagged and should be removed

**Notes:** Some variables are supplied for QA purposes only and are either not used by MATS or are calculated internally by MATS. For example, "OC" is not used by MATS (OCb is used) and H2O\_AIM is calculated internally. Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

### 5.3.2 PM2.5 Monitor Data Input

MATS uses the "unofficial" daily PM2.5 file for the calculation of all species fractions files (both point and spatial field) and in the calculation of PM2.5 levels in spatial fields. MATS uses the "official" quarterly PM2.5 file for point estimates.

#### 5.3.2.1 Unofficial Daily PM2.5 Monitor Data Input

Monitor data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, day). The second row presents comma-separated variable names. The third row begins the data values. Below is an example of the monitor data file format and descriptions of the variables in the file.

#### Format of Unofficial PM2.5 Monitor Data

```

Day
_ID, _TYPE, LAT, LONG, DATE, PM25, EPA_FLAG, USER_FLAG
"010030010", "FRM", 30.497778, -87.881389, 20000116, 5.9, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000119, 11.0, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000122, 8.6, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000125, 6.2, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000128, 7.6, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000131, 9.1, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000203, 14.0, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000206, 13.9, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000209, 20.8, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000310, 14.3, 0,
"010030010", "FRM", 30.497778, -87.881389, 20000313, 9.5, 0,

```

### Unofficial PM2.5 Monitor Data Variable Descriptions

Variable	Description
_ID	The ID is a unique name for each monitor in a particular location. (This is a character variable.)
_TYPE	FRM, IMPROVE, or other "special" data -- may include dummy sites. (This is a character variable.)
LAT	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
LONG	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
DATE	Date of daily average ambient data with YYYYMMDD format (This is a numeric variable)
PM25	Measured PM2.5 mass (ug/m3)
EPA_FLAG	Flag to indicate data that EPA recommends to be removed from the species fractions calculations. 0 = valid data, 1 = data that has been flagged and should be removed
USER_FLAG	Flag to indicate additional data that the user wants to remove from the species fractions calculations. 0 = valid data, 1 or greater = data that has been flagged and should be removed.

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

#### 5.3.2.2 Official Quarterly PM2.5 Monitor Data Input

Monitor data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, quarter). The second row presents comma-separated variable names. The third row begins the data values. Below is an example of the monitor data file

format and descriptions of the variables in the file.

### Format of Official PM2.5 Monitor Data

```

quarter
_ID, _TYPE, LAT, LONG, DATE, PM25, NDAYS, _SUBSTITUTION_CODE, COMPLETION_CODE, _STATE_NAME, _COUNTY_NAME
"010030010", "FRM", 30.497778, -87.881389, 19990101, -9, -9, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 19990401, -9, -9, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 19990701, -9, -9, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 19991001, -9, -9, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20000101, 11.81875, 16, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20000401, 13.24, 25, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20000701, 18.796, 25, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20001001, 14.257894737, 19, "", -9, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20010101, 10.710714286, 28, "", 4, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20010401, 11.133333333, 27, "", 4, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20010701, 11.07, 30, "", 4, "Alabama", "Baldwin"
"010030010", "FRM", 30.497778, -87.881389, 20011001, 9.4032258065, 31, "", 4, "Alabama", "Baldwin"

```

### Official PM2.5 Monitor Data Variable Descriptions

Variable	Description
<u>_ID</u>	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
<u>_TYPE</u>	Leave blank
<u>LAT</u>	Latitude at the monitor site in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
<u>LONG</u>	Longitude at the monitor site in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
<u>DATE</u>	Date of quarterly average ambient data with YYYYMMDD format. The date represents the first day of each quarter. (This is a numeric variable)
<u>PM25</u>	PM2.5 mass
<u>NDAYS</u>	Number of complete days in each quarter
<u>_SUBSTITUTION_CODE</u>	Indicates whether the design value period was determined to be complete by using substitution procedures.
<u>COMPLETION_CODE</u>	Official design value completion codes (1, 2, 3, 4, or 5). Codes are valid for the end year of each 3 year design value period.
<u>_STATE_NAME</u>	State name. (This is a character variable.)
<u>_COUNTY_NAME</u>	County name. (This is a character variable.)

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

### 5.3.3 Model Data Input

Model data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, day). The second row presents comma-separated variable names. The third row begins the data values. Below is an example of the model data file format and descriptions of the variables in the file. Note that there is both a base year and a future year model file. The format for both is the same.

Note that you can load in either daily model data or quarterly model data.

### Model Data

Daily model data input     
  Quarterly model data input

Baseline File

Forecast File

#### Format of Model Data

```

DAY
_ID, _TYPE, LAT, LONG, DATE, CRUSTAL, NH4, SO4, EC, NO3, OC, PM25, CM
1001, "", 28.471949, -99.489582, 20010101, 1.0109, 0.2824, 0.9765, 0.0912, 0.0164, 0.3124, 2.8249, 0.8978
1001, "", 28.471949, -99.489582, 20010102, 2.8108, 1.0958, 2.7710, 0.2289, 0.3444, 0.8092, 8.4251, 1.1180
1001, "", 28.471949, -99.489582, 20010103, 2.3401, 0.9529, 3.1398, 0.1826, 0.0001, 0.7121, 7.6542, 1.3048
1001, "", 28.471949, -99.489582, 20010104, 2.0181, 0.5711, 2.1170, 0.1382, 0.0322, 0.5955, 5.7402, 1.5992
1001, "", 28.471949, -99.489582, 20010105, 1.4976, 0.4863, 1.4446, 0.1229, 0.0097, 0.4955, 4.2749, 1.5466
1001, "", 28.471949, -99.489582, 20010106, 2.3727, 0.4759, 0.9909, 0.2058, 0.4538, 0.8122, 5.6640, 2.2531
1001, "", 28.471949, -99.489582, 20010107, 2.2806, 0.5864, 1.2852, 0.2268, 0.4051, 0.8344, 5.9948, 1.5827
1001, "", 28.471949, -99.489582, 20010108, 1.6657, 0.1600, 0.3930, 0.1123, 0.0502, 0.4535, 3.0330, 0.8604
1001, "", 28.471949, -99.489582, 20010109, 1.3391, 0.3094, 0.6555, 0.1386, 0.2596, 0.4678, 3.3762, 1.1703
1001, "", 28.471949, -99.489582, 20010110, 0.4216, 0.1147, 0.4267, 0.0438, 0.0077, 0.1330, 1.2061, 0.3809
1001, "", 28.471949, -99.489582, 20010111, 0.7091, 0.2885, 1.4738, 0.0497, 0.0867, 0.1813, 2.8685, 0.9395
1001, "", 28.471949, -99.489582, 20010112, 1.3101, 0.5146, 1.5635, 0.1210, 0.1901, 0.4141, 4.2979, 1.1250
1001, "", 28.471949, -99.489582, 20010113, 0.3476, 0.1573, 0.6827, 0.0365, 0.0017, 0.1127, 1.3884, 0.4123
1001, "", 28.471949, -99.489582, 20010114, 0.7833, 0.2313, 0.6184, 0.0747, 0.0200, 0.2884, 2.1420, 1.2354
  
```

#### Model Data Variable Descriptions

Variable	Description
_ID	The ID is a unique name for each monitor in a particular location. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
_TYPE	Leave blank
LAT	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.

LONG	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
DATE	Date of daily average model value with YYYYMMDD format (This is a numeric variable)
CM	Coarse PM mass (ug/m3)
CRUSTAL	Crustal PM2.5 mass
NH4	Ammonium mass
SO4	Sulfate PM
EC	Elemental carbon
NO3	Nitrate PM
OC	Organic mass PM
PM25	PM2.5 mass
SALT	Salt

**NOTE:** The "PM25" mass variable is used to calculate PM2.5 model "gradients" for gradient adjusted spatial fields. It is up to the user to provide a modeled PM2.5 mass concentration using an appropriate definition of modeled PM2.5 mass.

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

## 5.4 Species Fractions Calculation Options

The **Species Fractions Calculation Options** has two main sections. One involving speciated monitor data (e.g., STN and IMPROVE monitors) and the other total PM2.5 monitor data (FRM and IMPROVE). For each type of data you can specify the [years of interest](#), whether you want to [delete certain data](#), and the [minimum amount of data](#) for a monitor to be considered "valid" (and thus included in the calculations). In the next sections, we describe each of these three options in more detail. Note that these options apply more or less in the same way for both speciated monitor data and total PM2.5 monitor data. Also note that these options are no longer relevant if you have loaded a [species fractions file](#).

- **IMPROVE-STN Monitor Data.** The speciation data from STN and IMPROVE monitors are interpolated by MATS in order to provide species data for any point in a modeling domain. The interpolated species data is used to calculate species fractions at FRM monitors (point estimates) and/or species fractions at all grid cells (spatial fields). Note that you do not need to have values for all species for a monitor to be considered valid, as each species is considered individually. However, the "EPA\_Flag" variable in the default "species for fractions" file has been set so that all monitor days that do not have complete species data are not used in the calculations (flag = 1). If the user wants to use the incomplete species data, the flag can be changed to "0".
- **PM2.5 Monitor Data.** The total PM2.5 data from FRM are used by MATS to calculate species fractions for point estimates (in conjunction with the interpolated speciation data from STN and IMPROVE monitors). The interpolated species data is used to calculate species fractions at FRM monitors (point estimates) and/or species fractions at all grid

cells (spatial fields).

**Annual PM Analysis**

**Species Fractions Calculation Options**

Choose Desired Output

- Output Choices - Advanced
- Data Input
- Species Fractions Options**
- Species Fractions - Advanced
- PM2.5 Calculation Options
- Model Data Options
- Final Output and Check

**IMPROVE-STN Monitor Data**

Monitor Data Years

Start Year: 2002 End Year: 2004

Delete Specified Data Values

EPA-specified deletions from monitor data

User-specified deletions from monitor data

Minimum Data Requirements

Minimum number of valid days per quarter: 11

Minimum number of valid years required for valid season: 1

Minimum number of valid seasons for valid monitor: 1

**PM2.5 Monitor Data**

Monitor Data Years

Start Year: 2002 End Year: 2004

Delete Specified Data Values

EPA-specified deletions from monitor data

User-specified deletions from monitor data

Minimum Data Requirements

Minimum number of valid days per quarter: 11

Minimum number of valid years required for valid season: 1

Minimum number of valid seasons for valid monitor (point calculations): 4

Minimum number of valid seasons for valid monitor (spatial fields calculations): 1

< Back Next > Cancel

### 5.4.1 Monitor Data Years

Using the **Start Year** and **End Year** drop-down menu options, you can choose more than one year of speciated data for the calculation of species fractions. The default approach in MATS is to use three years of data.

**Monitor Data Years**

Start Year: 2002 End Year: 2004

2002  
2003  
2004

**Delete Specified Data Values**

deletions from monitor data

MATS handles multiple years of data by calculating averages for each species by quarter and year. MATS then averages the quarterly values across the years (e.g., average quarter 1 values of SO<sub>4</sub> across two years to get a single "quarter 1" estimate). After completing this step, MATS will have four quarterly estimates for each species at each speciated monitor. These quarterly values are then ready to be interpolated to FRM sites or to grid cell centroids in spatial fields.

#### 5.4.2 Delete Specified Data Values

The default is to delete the observations specified by EPA. (That is, these observations are excluded from a particular analysis, while they of course remain in the database.) As described in the [Data Input section](#), valid data are given a value of "0" and observations that are deleted are given a value of "1" to "10", as follows:

0. Data is OK to use
1. Important species is missing (e.g. no<sub>3</sub>, so<sub>4</sub>, oc, etc)
2. Constructed mass < 30% total mass
3. Constructed mass > 2 times total mass
4. Fire event
5. total mass < so<sub>4</sub>
6. total mass < crustal
7. OC is outside QA criteria
8. Soil is outside QA criteria
9. Both OC and soil are outside QA criteria
10. Regional concurrence on exceptional event

There is also an option for the user to flag data, using the same convention of "0" for valid data and "1" to "10" for data marked for deletion. If both the **EPA-specified** and **User-specified** flags are checked, then MATS deletes any observations that are marked for deletion by either the EPA or the user. This makes it easy for the user to flag additional data for removal from the calculations (without deleting the actual record from the ambient data file).

#### Delete Specified Data Values

- EPA-specified deletions from monitor data
- User-specified deletions from monitor data

#### 5.4.3 Minimum Data Requirements

There are three sets of minimum data requirements:

- Minimum number of valid days per valid quarter. This is the minimum number of site-days per valid quarter. The default is 11 days, which corresponds to > 75% completeness for monitors on a 1 in 6 day schedule. This is a minimum number of

samples that is routinely used in calculations of quarterly average concentrations.

- **Minimum number of valid quarters required for valid season.** This is the number of years of data (within the start year and end year specified) for which we have valid quarters for a given season. The default value is 1 year. If the value is set = 2, then there will need to be 2 years of valid data from quarter1 in order for quarter one to be considered complete (and the same for the other 3 quarters).
- **Minimum number of valid seasons required for valid monitor.** This is the number of valid seasons that are needed in order for a particular monitor's data to be considered valid. The default is 1 and the range is 1-4. For example, if the value is = 1, then a monitor's data will be used in the species fractions calculations if it has at least one valid season. If the value = 4, then the site must have all 4 seasons of valid data to be used.

Minimum Data Requirements	
Minimum number of valid days per quarter	<input type="text" value="11"/>
Minimum number of valid years required for valid season	<input type="text" value="1"/>
Minimum number of valid seasons for valid monitor (point calculations)	<input type="text" value="4"/>
Minimum number of valid seasons for valid monitor (spatial fields calculations)	<input type="text" value="1"/>

### Example 1: Minimum Days = 11, Minimum Years = 1, Minimum Seasons = 1

Consider the default assumptions and the following data from three monitors:

Year	Quarter	Monitor 1		Monitor 2		Monitor 3	
		# Obs.	Avg (ug/m <sup>3</sup> )	# Obs.	Avg (ug/m <sup>3</sup> )	# Obs.	Avg (ug/m <sup>3</sup> )
2002	1	8	10.2	11	10.8	11	10.4
	2	6	13.3	13	13.2	8	13.7
	3	11	10.7	4	11.2	12	12.9
	4	5	12.4	12	13.7	8	11.5
2003	1	11	12.7	10	13.4	9	12.1
	2	9	12.0	11	13.0	12	10.4
	3	12	14.5	13	14.2	10	10.7
	4	6	11.5	12	13.4	9	12.5
2004	1	6	13.8	15	14.2	12	14.9
	2	7	14.1	11	14.5	10	12.0
	3	12	14.9	12	14.6	10	10.1
	4	13	12.6	9	12.1	12	14.1

With the default assumptions, MATS would then use the highlighted observations and calculate averages for each quarter at each monitor in the following way:

	Monitor 1	Monitor 2	Monitor 3
Quarter	Avg (ug/m <sup>3</sup> )	Avg (ug/m <sup>3</sup> )	Avg (ug/m <sup>3</sup> )
1	12.7	12.5	12.6
2	--	13.6	10.4
3	12.5	14.4	12.9
4	12.6	13.6	14.1

Note that MATS would not calculate an average in quarter 2 for Monitor 1.

### Example 2: Minimum Days = 11, Minimum Years = 2, Minimum Seasons = 1

Assuming the following data from three monitors:

Year	Quarter	Monitor 1		Monitor 2		Monitor 3	
		# Obs.	Avg (ug/m <sup>3</sup> )	# Obs.	Avg (ug/m <sup>3</sup> )	# Obs.	Avg (ug/m <sup>3</sup> )
2002	1	8	10.2	11	10.8	11	10.4
	2	6	13.3	13	13.2	8	13.7
	3	11	10.7	4	11.2	12	12.9
	4	5	12.4	12	13.7	8	11.5
2003	1	11	12.7	10	13.4	9	12.1
	2	9	12.0	11	13.0	12	10.4
	3	12	14.5	13	14.2	10	10.7
	4	6	11.5	12	13.4	9	12.5
2004	1	6	13.8	15	14.2	12	14.9
	2	7	14.1	11	14.5	10	12.0
	3	12	14.9	12	14.6	10	10.1
	4	13	12.6	9	12.1	12	14.1

Assuming that a minimum of two years of data for each season, MATS would then use the highlighted observations highlighted and calculate averages for each quarter at each monitor in the following way:

	Monitor 1	Monitor 2	Monitor 3
Quarter	Avg (ug/m <sup>3</sup> )	Avg (ug/m <sup>3</sup> )	Avg (ug/m <sup>3</sup> )
1	--	12.5	12.6
2	--	13.6	--
3	12.5	14.4	--
4	--	13.6	--

Note that the requirement of 2 years, reduces to a single quarter the seasonal averages calculated for Monitors 1 and 3. If you had further required that a monitor needed, say, 4 seasons, then MATS would have only calculated averages for Monitor 2.

## 5.5 Species Fractions Calculation Options - Advanced

The **Species Fractions Calculation Options - Advanced** screen allows you to make relatively advanced choices for your analysis. Generally speaking, the default options settings are consistent with the EPA modeling guidance document. One set of options allows you to specify the interpolation weighting that you want to use and whether the

interpolation involves a maximum distance or not. The second set of options involves choices regarding ammonium, blank mass, and organic carbon.

### 5.5.1 Interpolation Options for Species Fractions Calculation

The **Interpolation Options** panel allows you to choose how you will [interpolate](#), or combine, the values from different monitors. One approach is to use [Inverse Distance Weights](#). This means that the weight given to any particular monitor is inversely proportional to its distance from the point of interest. A second approach is Inverse Distance Squared Weights, which means that the weights are inversely proportional to the square of the distance. And the third approach is Equal Weighting of Monitors. The default approach for PM is Inverse Distance Squared Weights.

When interpolating monitor values, MATS allows you to identify the monitors you want to use based on their distance away from the point of interest (*e.g.*, the center of a grid cell). The first step in the interpolation process is to identify the monitors that are nearby, or neighbors, for each point of interest. The next step is to determine the distance (in kilometers) from the nearby monitors to the point of interest.

The default approach is to include all valid monitors (*i.e.*, those that satisfy the three criteria in the [Species Fractions Calculation Options](#) panel), regardless of distance. If you want to limit the use of monitors based on distance, type in the distance you want to use (*e.g.*, 100) next to the pollutant of interest.

**Interpolation Options**

PM2.5	Inverse Distance Squared \	900000	Crustal	Inverse Distance Squared \	900000
SO4	Inverse Distance Squared \	100	DON	Inverse Distance Squared \	900000
NOx	Inverse Distance Squared \	900000	OC	Inverse Distance Squared \	900000
EC	Inverse Distance Squared \	900000	NH4	Inverse Distance Squared \	900000
Salt	Inverse Distance Squared \	900000			

You can also change the number using the arrows. The double arrow on the right increases the number in units of 100:

and the double arrow on the left decreases the number in units of 100. The upper arrow increases the number in single digits:

and the lower arrow reduces the number in single digits.

Note that a distance of one hundred (100) kilometers means that any monitors further than 100 kilometers can no longer be used in the interpolation. If a point of interest has no monitors within the specified distance, then no value is calculated.

## 5.5.2 Miscellaneous Options

The Miscellaneous Options panel lets you make choices regarding:

- **Ammonium.** This allows you to specify whether MATS uses degree of neutralization (DON) values to calculate ammonium (NH<sub>4</sub>) or whether it uses measured ammonium in conjunction with an assumption about the percentage of NH<sub>4</sub> that evaporates. The default option is to use DON values. If you want to use measured ammonium, you need to click the button and choose a NH<sub>4</sub> percentage evaporating (*e.g.*, 50). The default is

"0", which assumes that no ammonium evaporates from the FRM filters. The calculations underlying the default and alternative ammonium calculations are discussed in detail in the section on [species fractions calculations](#).

- **Default Blank Mass.** The Default Blank Mass option simply allows you to set default blank mass to the desired level. The default is 0.5. You can type desired value, or use the arrows to increase or decrease the value.
- **Organic Carbon.** This allows you to set the "floor" and the "ceiling" for the mass balance calculation for organic carbon. The calculations involved are discussed in detail in the section on [species fractions calculations](#).

**Miscellaneous Options**

Ammonium

Use DON values

Use measured ammonium

NH4 percentage evaporating (0-100)

Default Blank Mass

Default Blank Mass

Organic Carbon

Organic carbon mass balance floor

Organic carbon mass balance ceiling

## 5.6 PM2.5 Calculation Options

The **PM2.5 Calculation Options** window allows you to specify the particular years of monitor data that you want to use from the input file you specified in the [Data Input section](#). You can also specify the following:

- [Official vs. Custom Values](#). You can specify whether to use "official" design values, which are generally recommended, or use "custom" design values. If you choose to use custom design values, then you specify the minimum number of days of observations each valid quarter and the minimum number of valid quarters.
- [Valid FRM Monitors](#). You can also specify the minimum number of design values (the default is 1) and whether you want to make sure that particular design values have to be used in the calculations.
- [NH4 Future Calculation](#). You can also specify how you want to forecast NH4 values. The default approach is to use baseline DON values, and the alternative is to use baseline NH4 and a RRF value for NH4.

### 5.6.1 PM2.5 Monitor Data Years

Using the **Start Year** and **End Year** drop-down menu options, you can choose more than one year of official PM monitor data for the calculation of future PM2.5 values. The default approach in MATS is to use five years of data.

MATS handles multiple years of data as described in the [Baseline PM2.5 Calculation](#) section.

### 5.6.2 Design Values

MATS gives you option to choose "official" design values, which are generally

recommended, or to choose "custom" design values. If you choose to use custom design values, then you need to specify the minimum number of days of observations each valid quarter and the minimum number of valid quarters.

- **Minimum days for valid quarter.** This is the minimum number of site-days per valid quarter. The default is 11 days, which corresponds to > 75% completeness for monitors on a 1 in 6 day schedule. This is a minimum number of samples that is routinely used in calculations of quarterly average concentrations.
- **Minimum valid quarters in design value period.** This is the number of quarters for which we have data within three consecutive design value periods. The default value is 12 quarters. If the value is set = 11, then there will need to be at least 11 valid quarters (i.e., two years must have 4 valid quarters and one year must have at least 3 valid quarters.)

Official Design Values  
 Custom Design Values  
 Valid FRM Quarters  
 Minimum days for valid quarter: 11  
 Valid FRM Design Values  
 Minimum valid quarters in design value period: 12

### 5.6.2.1 Completion Code Use

The Completion Code is a variable in the official quarterly PM<sub>2.5</sub> monitor datafile that MATS uses to identify valid data. As noted in the section on [Official Quarterly PM<sub>2.5</sub> Monitor Data Input](#), the completion code has values of: 1, 2, 3, 4, or 5; and the codes are valid for the end year of each 3 year design value period. MATS uses the Completion Code variable somewhat differently when using official design values and when using custom design values.

- When using official data, MATS will only use completion codes: 1 and 2.
- When using custom data, MATS will potentially use completion codes: 1, 2, 3, and 4 (if the user specified completion criteria are met).

The following is an explanation of the official EPA completion codes:

Code "1"- complete data and violates the NAAQS

Code "2"- complete data that is below the NAAQS

Code "3"- incomplete data and violates the NAAQS

Code "4" - incomplete data that is below the NAAQS

Code "5" - data that is not comparable to the NAAQS and should not be used. For example, FRM data collected at a micro-scale site cannot be compared to to the annual

PM2.5 NAAQS.

### 5.6.3 Valid FRM Monitors

By default, MATS assumes that there only need to be one design value for a monitor to be considered valid. In addition, MATS assumes that no particular design value is required, so different monitors with different years of data could be used. For example, if you specify the start year and end year as 2000 and 2004 (giving potential design values of 2002, 2003, and 2004), then one monitor could have data for, say, 2002 and another monitor data for 2003, and both monitors would be used.

Valid FRM Monitors

Minimum Number of Design Values: 1

Required Design Values: None selected

### 5.6.4 NH4 Future Calculation

As described in the section on [Forecasted Species Calculation](#), MATS can forecast NH4 using two different approaches. The default approach is to use base year DON values.

NH4 future calculation

Calculate future year NH4 using base year (constant) DON values

Calculate future year NH4 using base year NH4 and the NH4 RRF

## 5.7 Model Data Options

The **Model Data Options** section allows you to specify:

- **Max Distance to Domain.** This is the maximum distance from a given monitor to the nearest model grid cell (measured in kilometers). If a monitor is further than the specified maximum distance from the center of any grid cell, then MATS will not calculate results for that monitor or use the monitor in any calculations (this effectively eliminates monitors from outside the specified domain from being included in the output files).
- **Temporal Adjustment at Monitor.** This option specifies how many model grid cells to use in the calculation of RRFs for point estimates and for spatial estimates. Using the drop-down menu, you can choose 1x1, 3x3, 5x5, and 7x7. (The default for a 12 kilometer by 12 kilometer grid is to use a 3x3 set of grid cells. The choice of grid size is discussed in the following EPA guidance: <http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf>) For PM analyses, MATS calculates **mean** concentrations across the grid cell array (as compared

to maximum concentrations used for ozone analyses).

**Annual PM Analysis**

- Choose Desired Output
  - Output Choices - Advanced
  - Data Input
  - Species Fractions Options
  - Species Fractions - Advanced
  - PM2.5 Calculation Options
  - Model Data Options**
  - Final Output and Check

**Model Data Options**

Max Distance to Domain [km] 25

**Temporal adjustment at monitor**

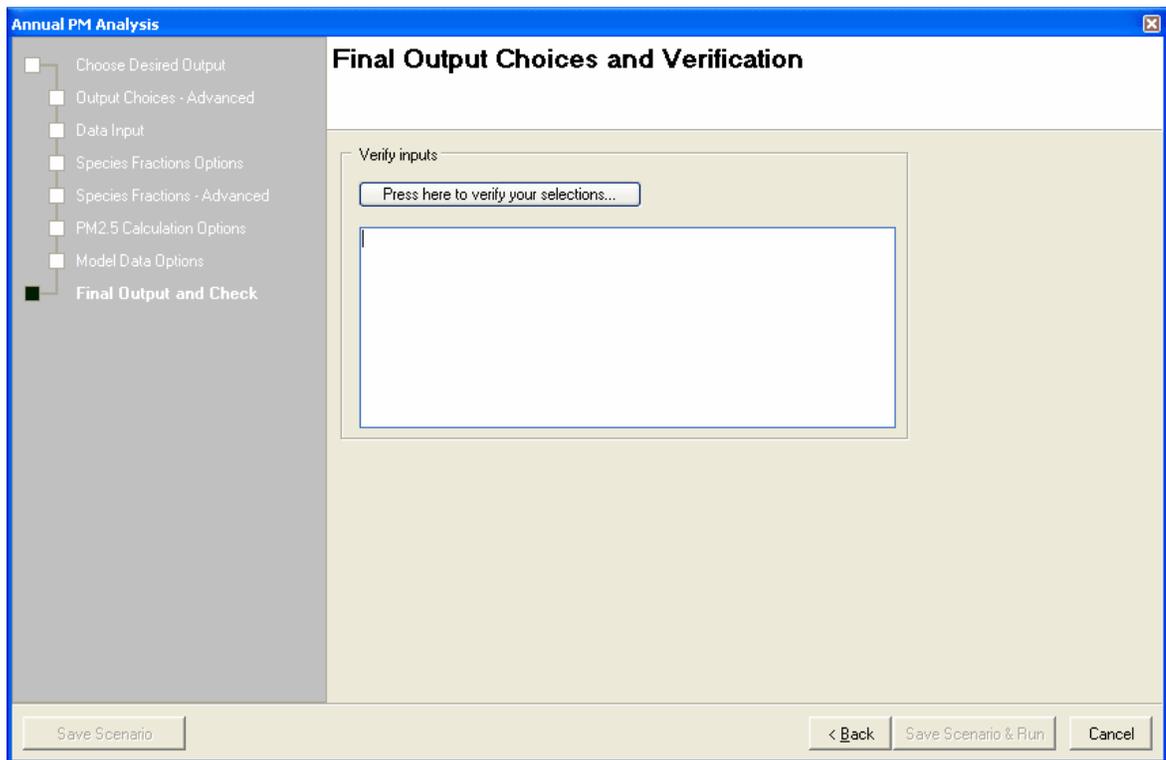
Grid for Point Forecast Grid for Spatial Forecast

3x3 1x1

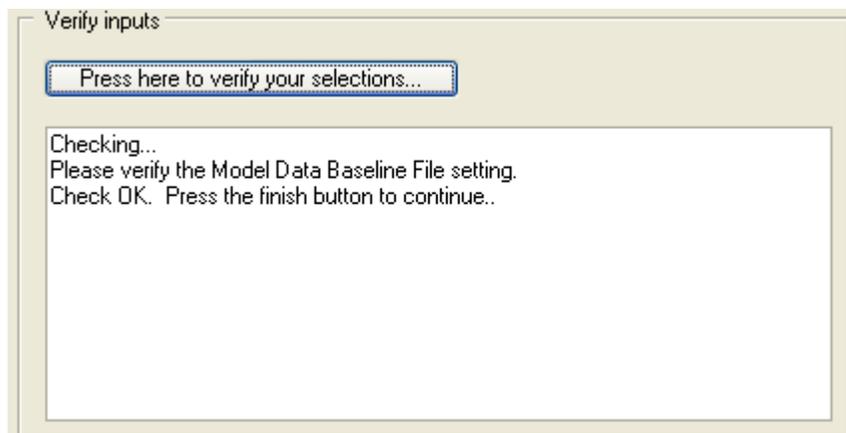
< Back Next > Cancel

## 5.8 Final Check

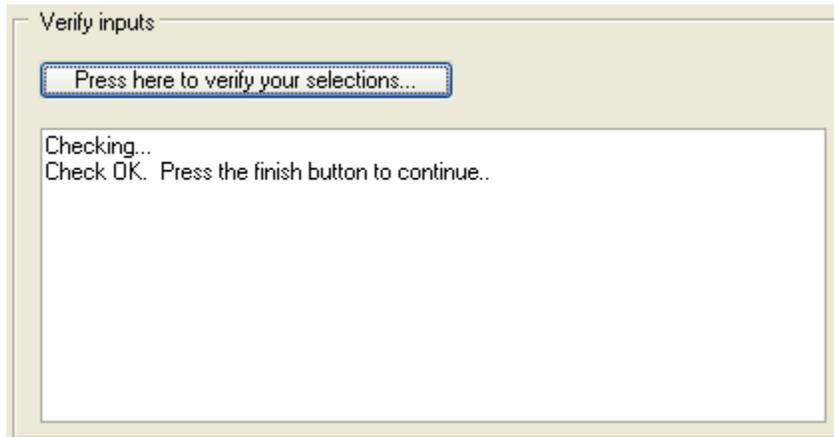
The **Final Check** window verifies the selections that you have made.



Click the button **Press here to verify your selections**. If there are any errors, MATS will present a message letting you know. For example, if the path to a model file is invalid -- perhaps you misspelled the file name -- you would get the following error:

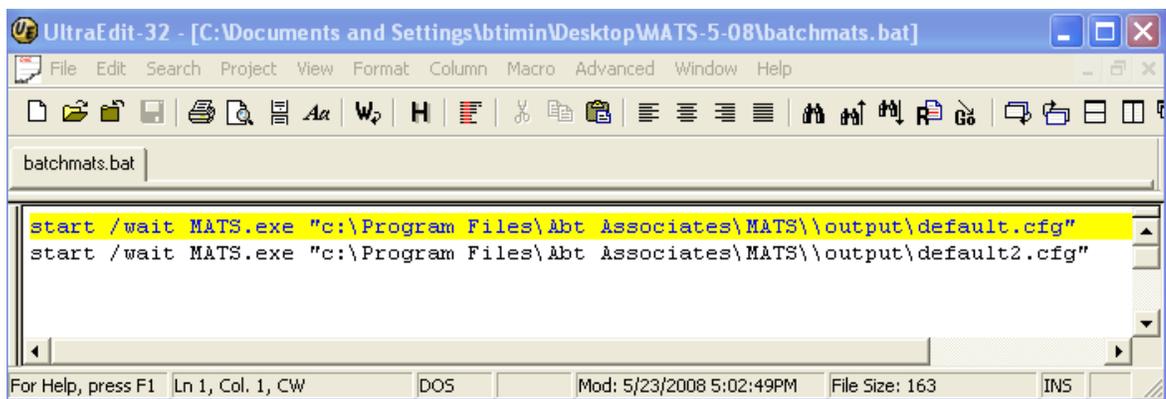


After making the necessary correction, click the button **Press here to verify your selections**. Then click the **Finish** button.



### 5.8.1 Running MATS in Batch Mode

The **Save Scenario** button will save the scenario as a configuration file (.cfg file). The "\*.cfg" file will be saved in the .\MATS\output directory. Several .cfg files can be created with the MATS interface and run later in batch mode. To do this, edit the default batch file located in the .\MATS directory. The file "batchmats.bat" should be edited with a text editor to point to the name and location of the .cfg files that will be run in batch mode.



After editing the batchmats.bat file, simply run the .bat file. MATS will start and run in the background.

## 6 Ozone Analysis: Quick Start Tutorial

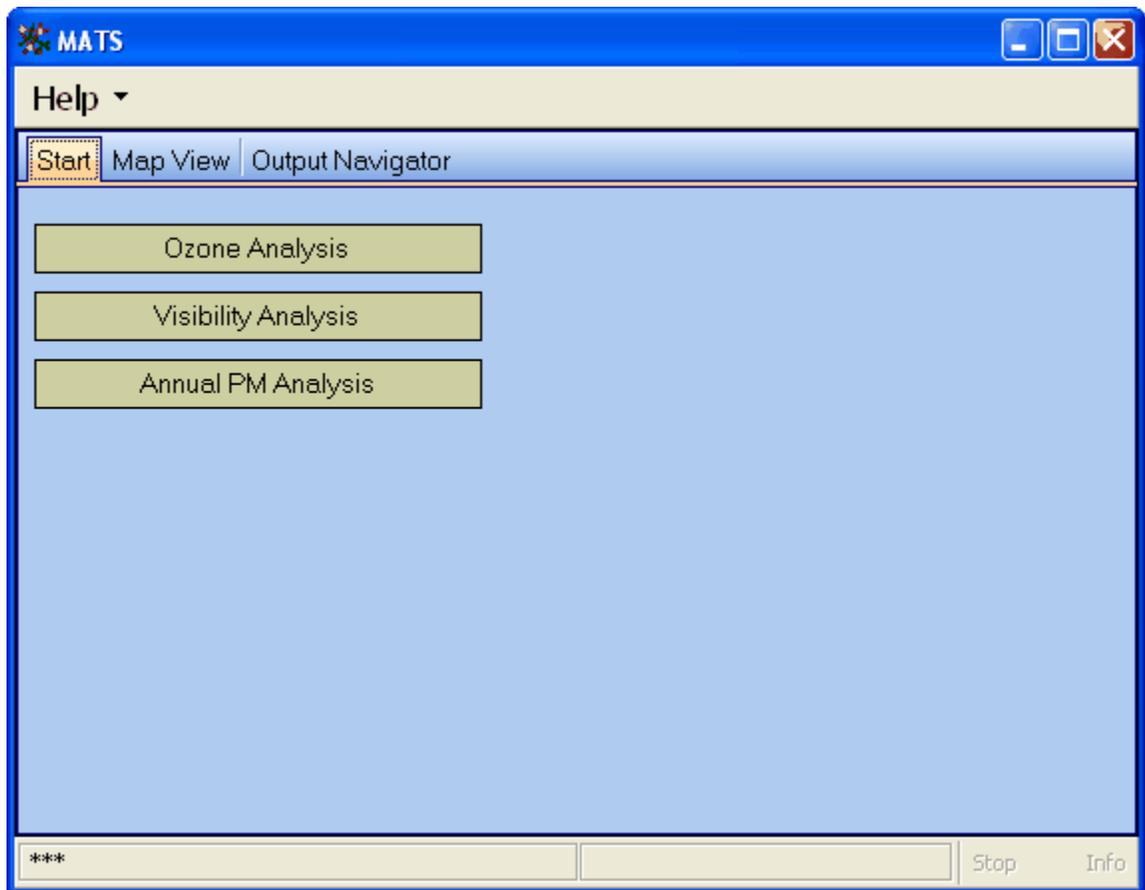
In this tutorial you will forecast ozone [design values](#) at monitors in the Eastern United States. The steps in this analysis are as follows:

- [Step 1. Start MATS](#). Start the MATS program and choose to do an Ozone analysis.
- [Step 2. Output Choice](#). Choose the output to generate. In this example, you will forecast ozone levels at monitor locations.
- [Step 3. Data Input](#). Choose the data files for input to MATS.
- [Step 4. Filtering & Interpolation](#). Choose the particular years of data and monitors to use in this analysis.
- [Step 5. RRF & Spatial Gradient](#). Specify how to generate the [relative response factors \(RRFs\)](#) used in the forecasts.
- [Step 6. Final Check](#). Verify the choices you have made.
- [Step 7. Load & Map Output](#). Load your output and prepare maps of your forecasts.
- [Step 8. View & Export Output](#). Examine the data in a table format and export these data.

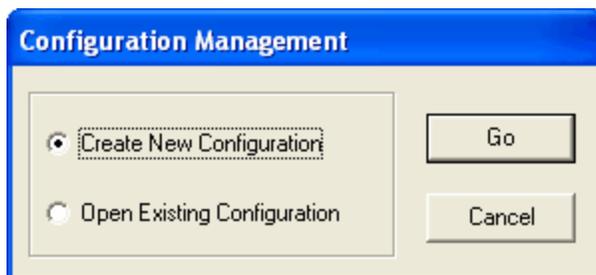
Each step is explained below. Additional details are provided in the section [Ozone Analysis: Details](#).

### 6.1 Step 1. Start MATS

Double-click on the MATS icon on your desktop, and the following window will appear:



Click the **Ozone Analysis** button on the main MATS window. This will bring up the **Configuration Management** window.



A [Configuration](#) allows you to keep track of the choices that you make when using MATS. For example, after generating results in MATS, you can go back, change one of your choices, rerun your analysis, and then see the impact of this change without having to enter in all of your other choices. For this example, we will start with a *New Configuration*.

Choose **Create New Configuration** and click the **Go** button. This will bring up the [Choose Desired Output](#) window.

## 6.2 Step 2. Output Choice

The **Choose Desired Output** window allows you to choose the output that you would like to generate. MATS allows you to forecast [Point Estimates](#) (at ambient monitors) or to generate a [Spatial Field](#) of either Baseline values or Forecast values.

In the **Scenario Name** box type “*Tutorial O3*” – this will be used to keep track of where your results are stored and the variable names used in your results files. Leave the box checked next to [Temporally-adjust ozone levels at monitors](#). MATS will create forecasts for each monitor in the monitor file.

**Choose Desired Output**

Scenario Name : Tutorial O3

**Point Estimates**

**Forecast**

Temporally-adjust ozone levels at monitors.

**Spatial Field**

**Baseline**

Interpolate monitor data to spatial field

Interpolate gradient-adjusted monitor data to spatial field.

**Forecast**

Interpolate monitor data to spatial field. Temporally adjust ozone levels.

Interpolate gradient-adjusted monitor data to spatial field. Temporally adjust.

< Back   Next >   Cancel

When your window looks like the window above, click **Next**. This will bring you to the [Data Input](#) window.

### 6.3 Step 3. Data Input

The **Data Input** window allows you to choose the monitor data and the model data that you want to use. As discussed in more detail in the following chapter (see [RRF Setup](#)), MATS calculates the ratio of the base and future year model data to calculate a relative response factor ([RRF](#)). MATS then multiplies the [design value](#) from the monitor data with the RRF to calculate a future-year design value.

MATS currently comes loaded with ozone design values for the period from 1997-2005 (1997-1999, 1998-2000, 1999-2001, 2000-2002, 2001-2003, 2002-2004, and 2003-2005); and it comes loaded with example ozone model data for 2001 and 2015. These are the files needed to calculate the [Point Estimates](#) and [Spatial Fields](#) listed in the [Desired Output](#) window.

Use the default settings in the **Data Input** window. The window should look like the following:

The screenshot shows the 'Data Input' window. On the left is a sidebar with a tree view containing the following items: 'Desired output', 'Data Input' (which is selected and highlighted in green), 'Filtering/Interpolation', 'RRF/Spatial Gradient', and 'Final Check'. The main window area is titled 'Data Input' and contains the following settings:

- Monitor Data**
  - Ozone Data: MATS\SampleData\OZONE\_ASIP\_input.csv
- Model Data**
  - Baseline File: \\SampleData\ozone\_model\_data\_2001.csv
  - Forecast File: \\SampleData\ozone\_model\_data\_2015.csv
- Using Model Data**
  - Temporal adjustment at monitor: 3x3 (dropdown menu) | Maximum (dropdown menu)

At the bottom of the window are three buttons: '< Back', 'Next >', and 'Cancel'.

Note that MATS gives you the option to use model data in different ways when calculating forecasts at each monitor. The user can choose to use the model results from the single grid cell that contains the monitor or select a grid cell array of 3x3, 5x5, or 7x7 model cells

around each monitor. The example model output dataset contained in MATS is at 12km resolution. Therefore, for this example, a 3x3 grid cell array should be used (see section 3.2 of the modeling guidance). The default for ozone analysis is to choose the maximum value each day in the array for the calculation. This is described in more detail in the [Using Model Data](#) section of the [Ozone Analysis: Details](#) chapter.

When your window looks like the window above, click **Next**. This will bring you to the [Filtering and Interpolation](#) window.

## 6.4 Step 4. Filtering and Interpolation

The **Filtering and Interpolation** window has several functions. These include identifying the years of monitor data that you want to use, choosing the particular monitors in these data that you want in your analysis, and (when calculating [spatial fields](#)) specifying the [interpolation](#) method. Use the default settings pictured in the screenshot below.

- [Choose Ozone Design Values](#). Choose the years of [design values](#) that you want to use. The default is to use a 5 year period (3 design values) that is centered about the base emissions year. The default in MATS assumes an emissions year of 2002. Therefore, the design value would be based on data from 2000-2002 up through a design value based on data from 2002-2004. (That is, the **Start Year** is 2000-2002 and the **End Year** is 2002-2004.)
- [Valid Ozone Monitors](#). Identify "valid" monitors -- that is, those monitors that you want to include in the analysis. The defaults are that monitors should have at least one valid design value period; and, are within 25 kilometers of a model grid cell. You can also specify that a monitor must have a particular design value (*e.g.*, 2000-2002) to be valid, however the default is to require none in particular.
- [Default Interpolation Method](#). Choose the interpolation method -- that is, the method to combine the design values from different monitors into a single estimated design value. This option is only used when generating estimates for a Spatial Field. Since we are only generating [Point Estimates](#), this set of options is not active.

When your window looks like the window above, click **Next**. This will bring you to the [RRF & Spatial Gradient](#) window, where you can set parameters for the calculation of [RRFs](#) and [spatial gradients](#).

## 6.5 Step 5. RRF & Spatial Gradient

The [RRF and Spatial Gradient](#) window has two sets of options.

- The **RRF Setup** uses threshold values in the model data to identify the days to be used in the calculation of relative response factors ([RRFs](#)). The details of this process are somewhat involved and are described in detail in the next chapter. (See: the [example calculations](#).) A brief summary is the following: The default threshold is set to 85 ppb.\* If there are fewer than 10 model days at or above 85 ppb in the baseline scenario, then MATS will lower the threshold in increments of 1 ppb, until there are at least 10 days at or above this new, lower threshold. This process is continued, if needed, until a threshold of 70 ppb is reached. By default, this is the lowest allowable threshold. If there are fewer than 5 days at or above this threshold of 70 ppb, then the monitor site will be dropped.
- The **Spatial Gradient Setup** identifies the model values that will be used in the calculation of a [Spatial Field](#). Since we are only generating [Point Estimates](#), this set of options is not active.

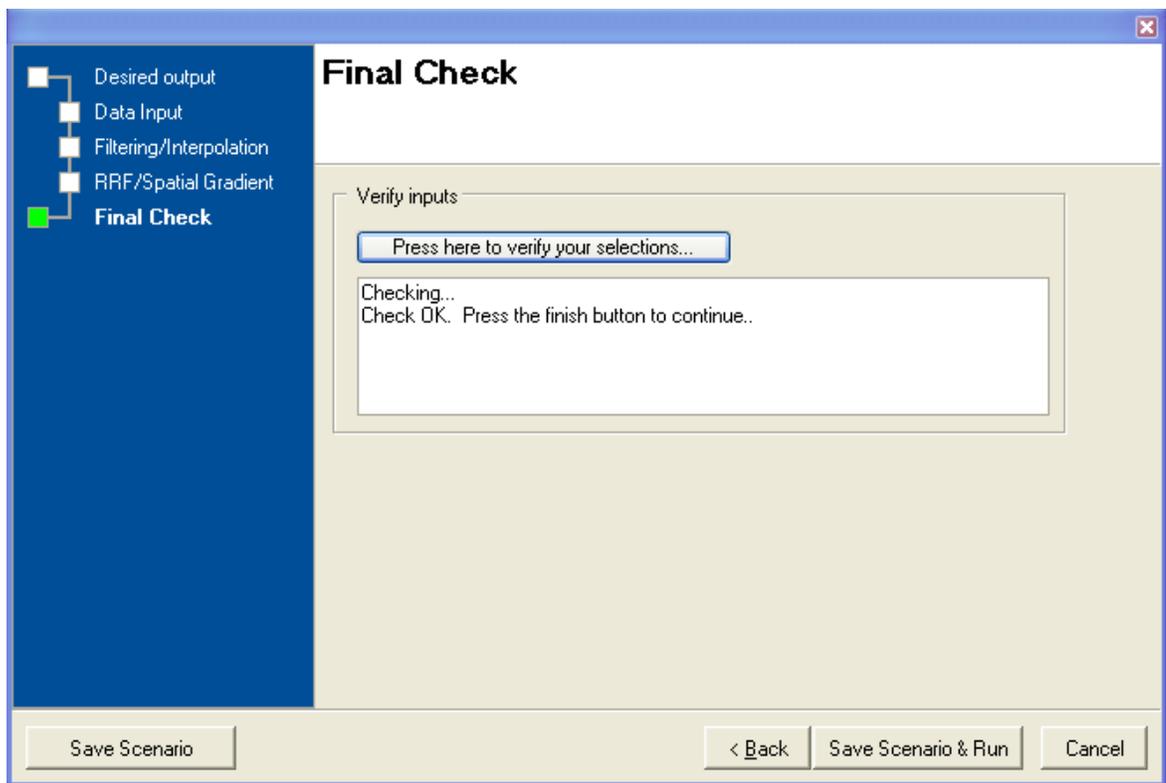
When your window looks like the window above, click **Next**. This will take you to the [Final Check](#) window, where you can verify the choices that you have made.

\* The default values in MATS are consistent with the recommended values in the EPA modeling guidance (see section 14.1.1).

## 6.6 Step 6. Final Check

The **Final Check** window verifies the choices that you have made. For example, it makes sure that the paths specified to each of the files used in your [Configuration](#) are valid.

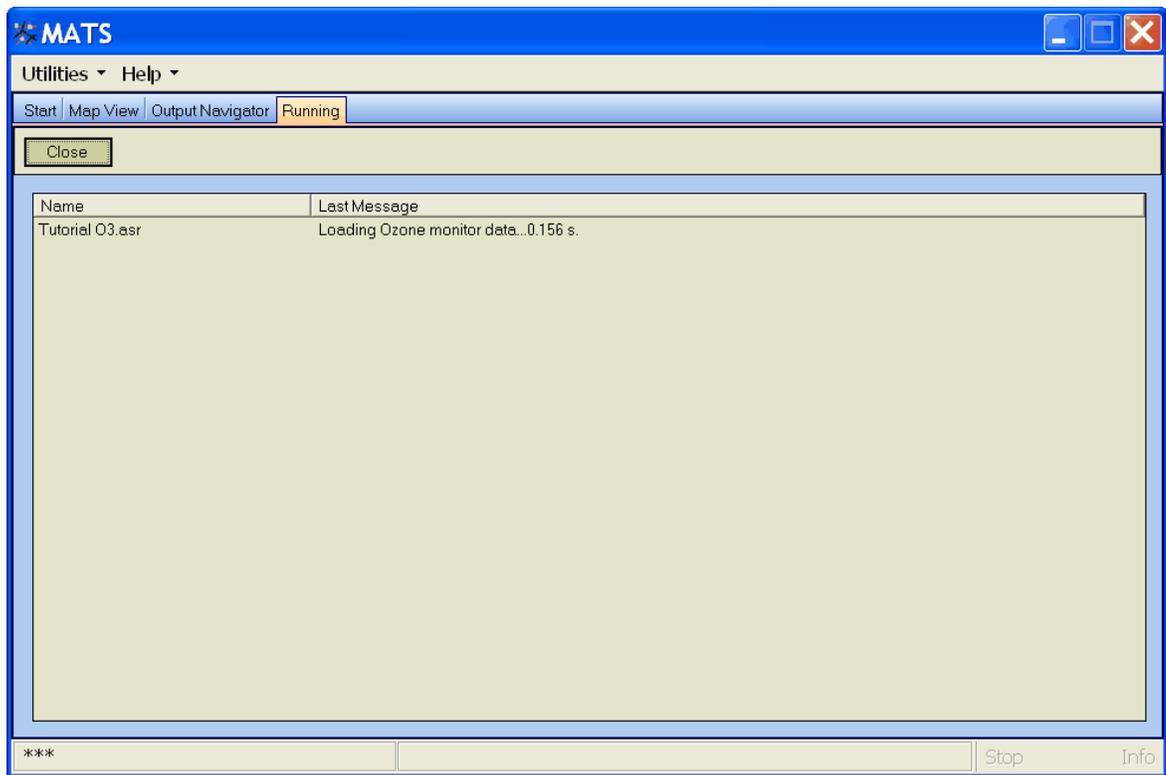
Click on the **Press here to verify selections** button.



If you encounter any errors, go back to the choices you have previously made by clicking on the appropriate part (e.g., [Data Input](#)) of the tree in the left panel, and then make any changes required.

When your window looks like the window above, click either **Save Scenario & Run** or **Save Scenario**. Save Scenario & Run will cause MATS to immediately run the scenario.

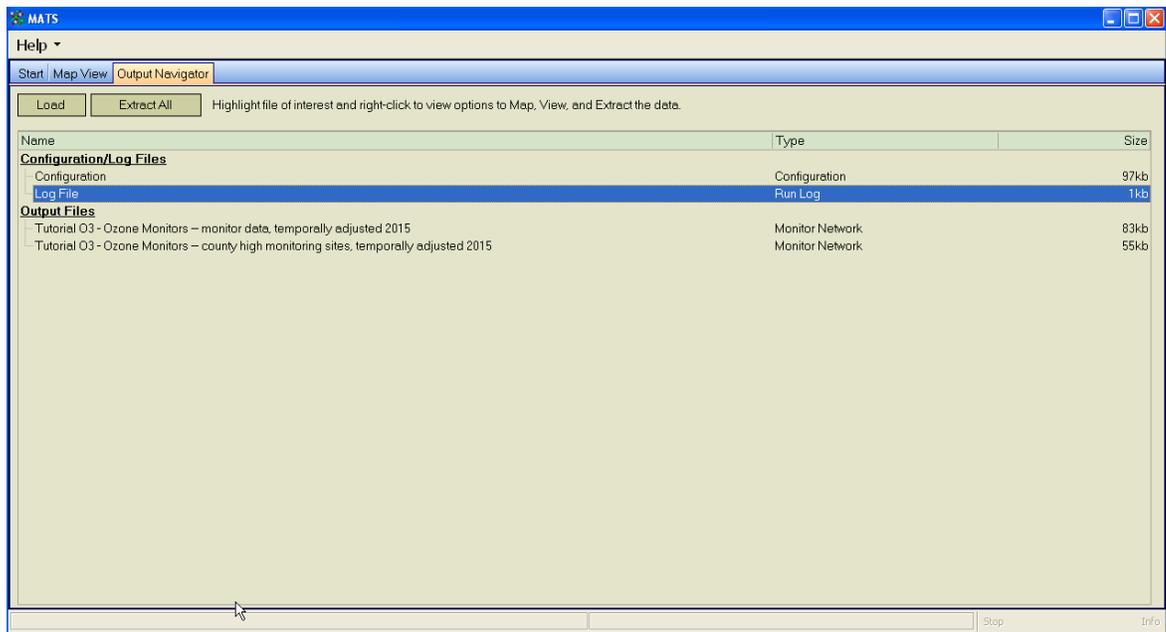
A temporary, new **Running** tab will appear (in addition to the **Start**, [Map View](#) and [Output Navigator](#) tabs).



When the calculations are complete, a small window indicating the results are **Done** will appear. Click **OK**.



After clicking **OK**, the **Output Navigator** tab will be active. (The **Running** tab will no longer be seen.) MATS will automatically load the output files associated with the .asr configuration that just finished running.

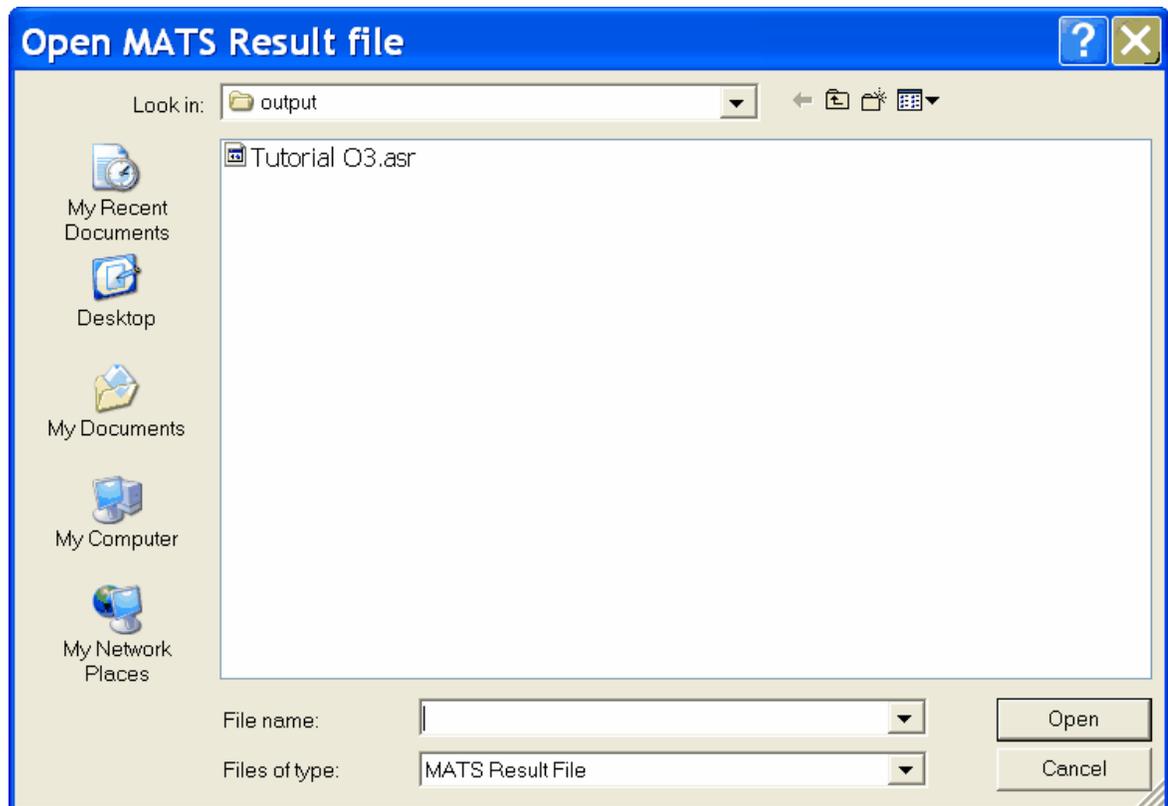


The next step ([click here](#)) shows you how to map your results with the **Output Navigator**. For more details on mapping and other aspects of the **Output Navigator**, there is a separate chapter on the [Output Navigator](#).

## 6.7 Step 7. Load & Map Output

After generating your results, [Output Navigator](#) can be used to load and/or map them. If a run just finished, the output files will already be loaded into output navigator.

If files from a previous run need to be loaded then click on the **Load** button and choose the *Tutorial O3.asr* file.



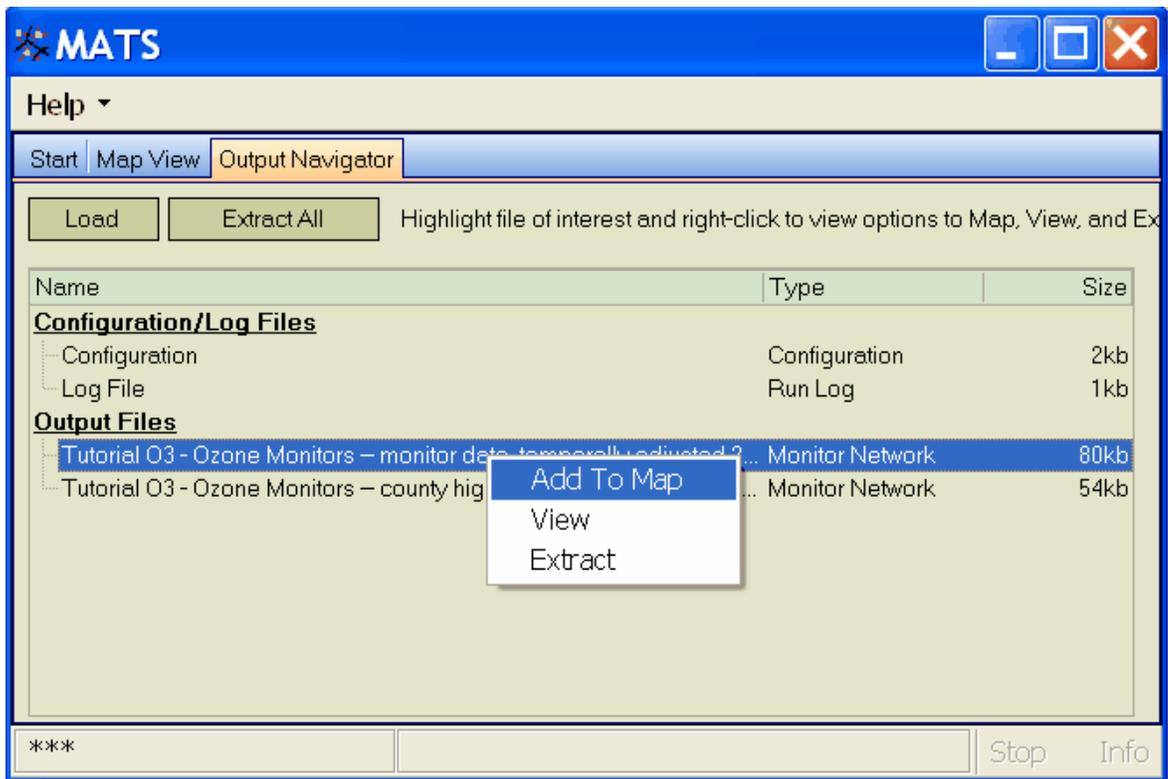
Under **Configuration/Log Files**, you will see two files:

- [Configuration](#): keeps track of the assumptions that you have made in your analysis.
- [Log File](#): provides information on a variety of technical aspects regarding how a results file (\*.ASR) was created.

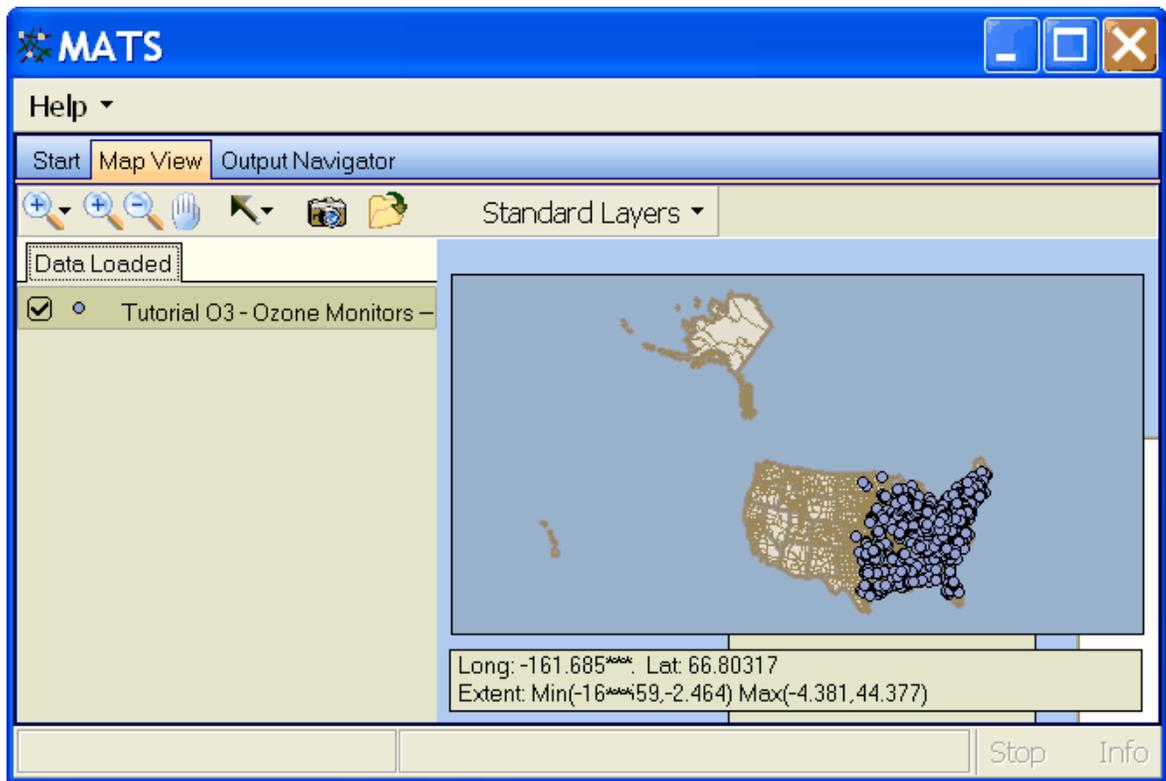
Under **Output Files** you will see:

- *Tutorial O3 - Ozone Monitors - monitor data, temporally adjusted 2015*: contains forecasted values and the monitor data used.
- *Tutorial O3 - Ozone Monitors - county high monitoring sites, temporally adjusted 2015*: contains forecasted values and the monitor data used for the monitor with the highest levels in the county.

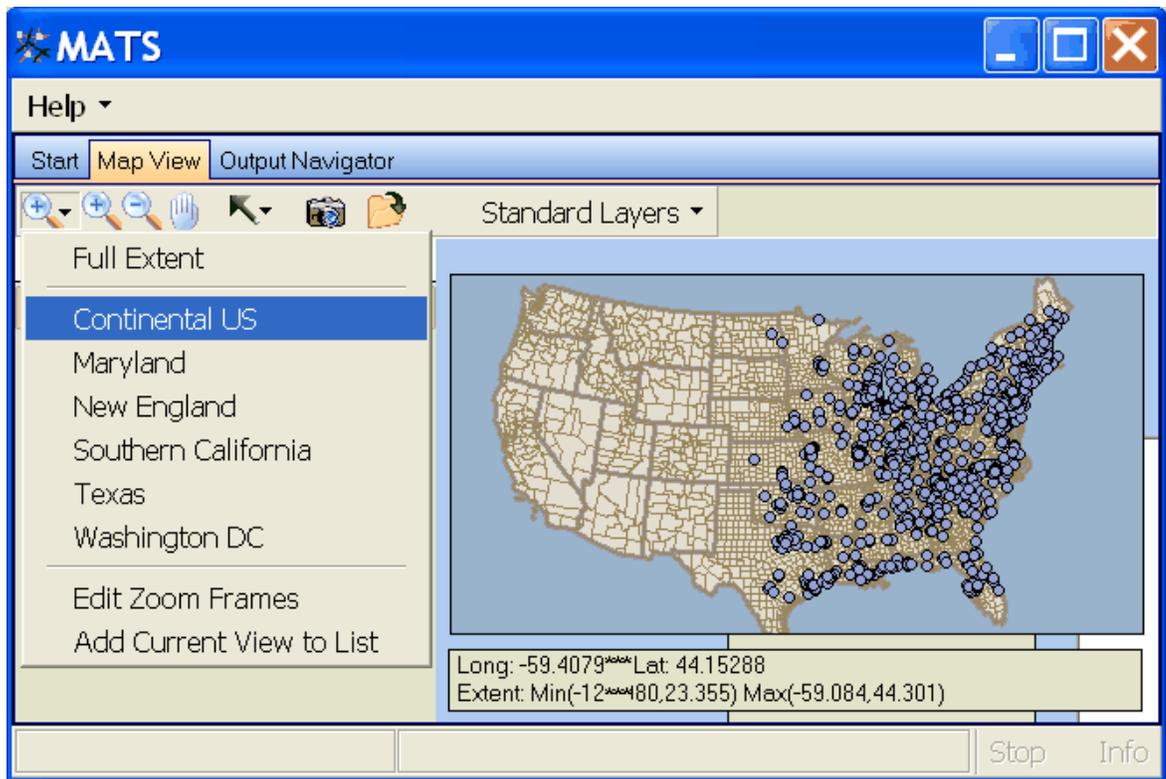
Right-click on the file *Tutorial O3 - Ozone Monitors - monitor data temporally adjusted 2015*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *Add to Map* option.



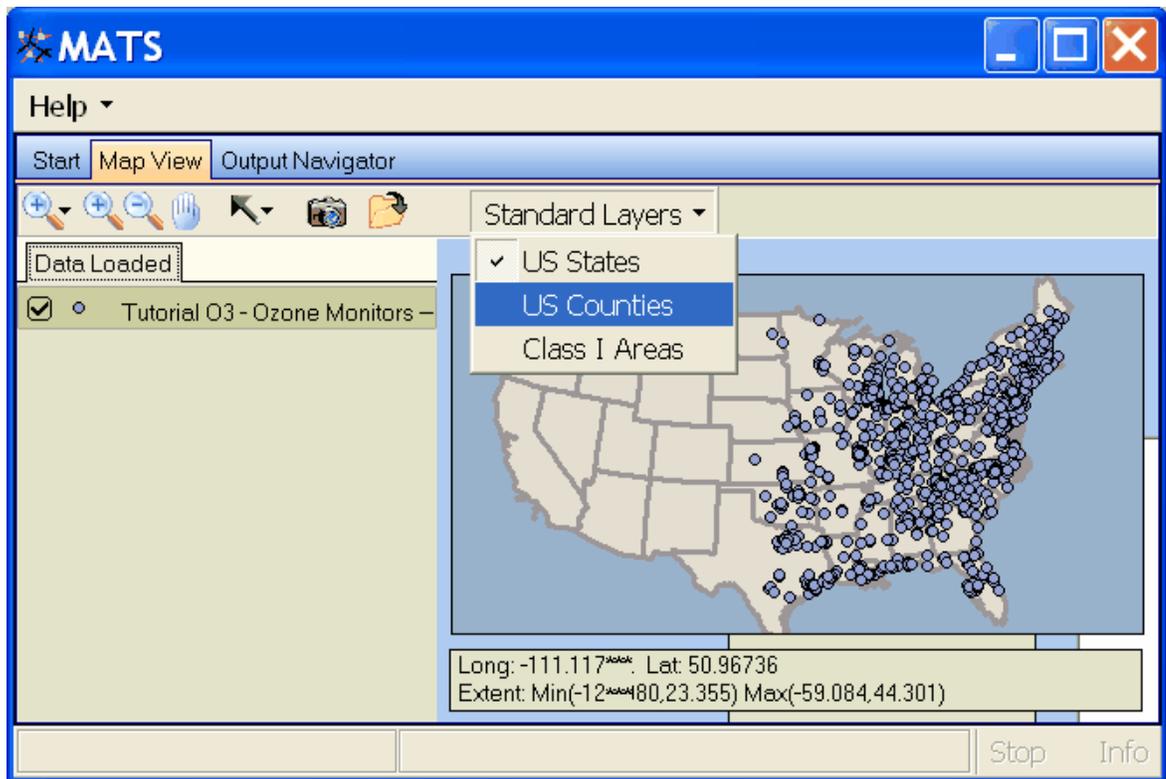
This will bring up the **Map View** tab.



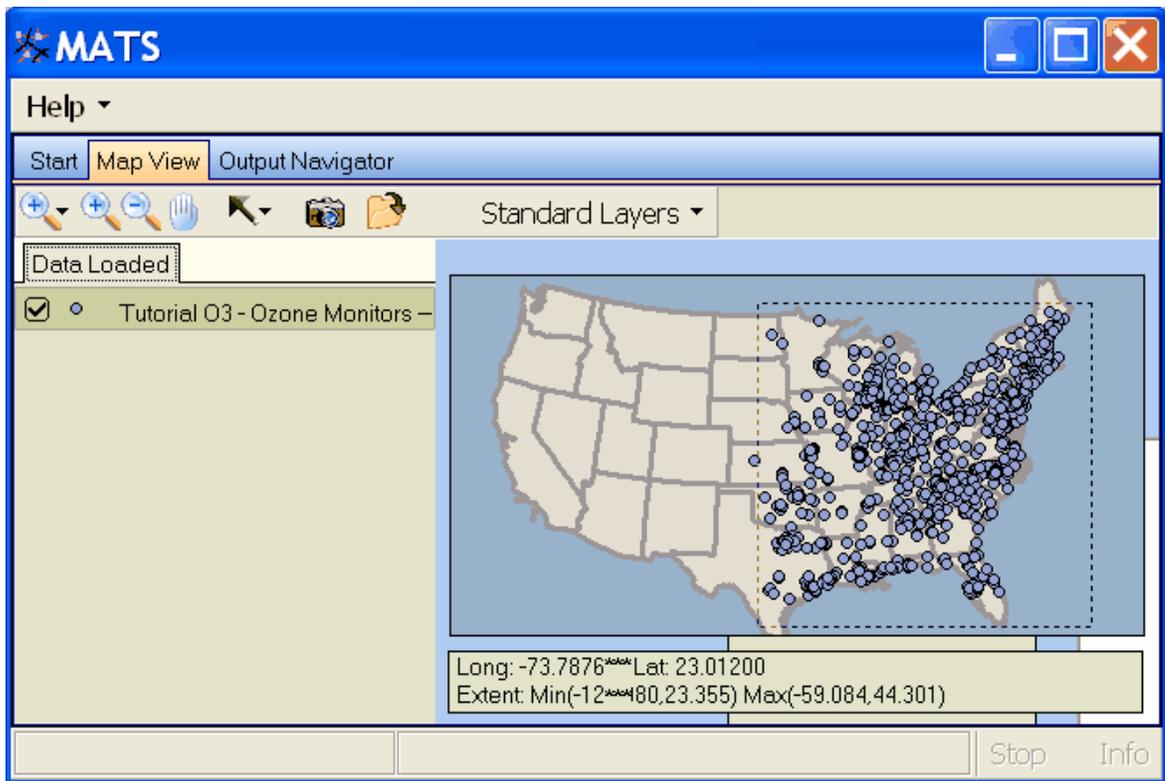
To view an enlarged map, use the **Zoom to an area** Task Bar button on the far left. Choose the *Continental US*.



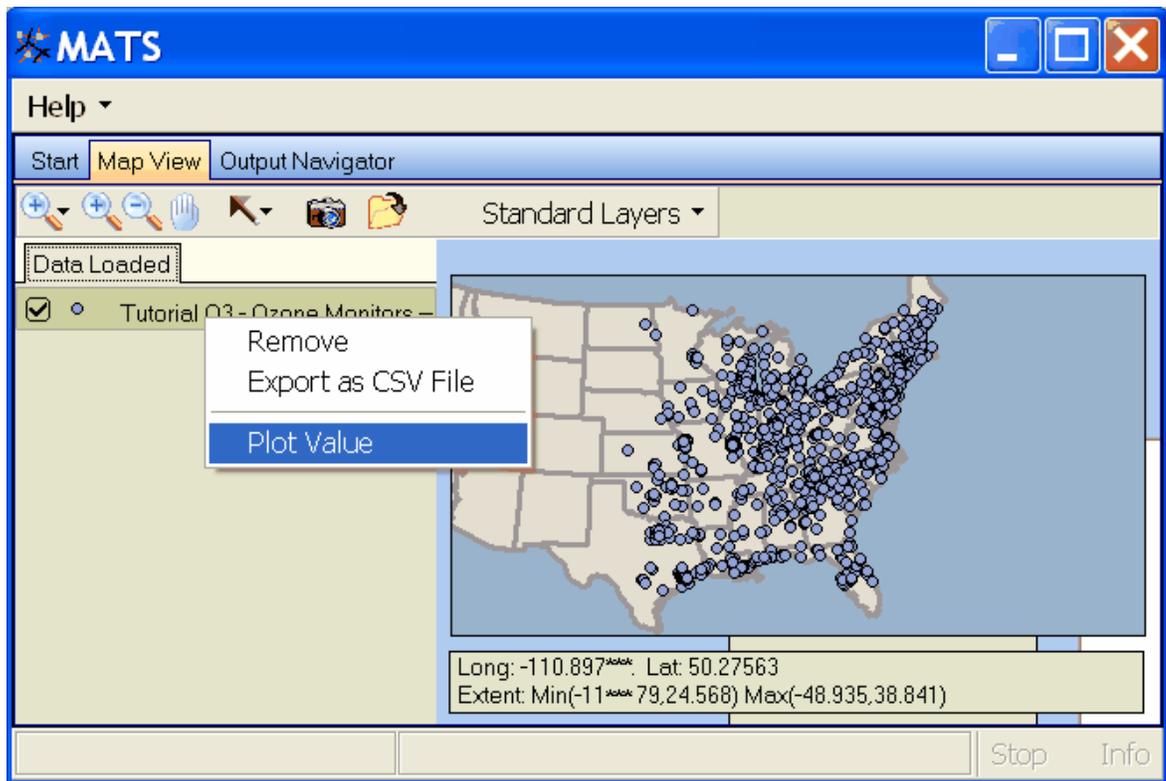
To more easily view the location of monitors in particular states, uncheck *US Counties* using the **Standard Layers** drop down menu on the far right of the Task Bar. Your window should look like the following:



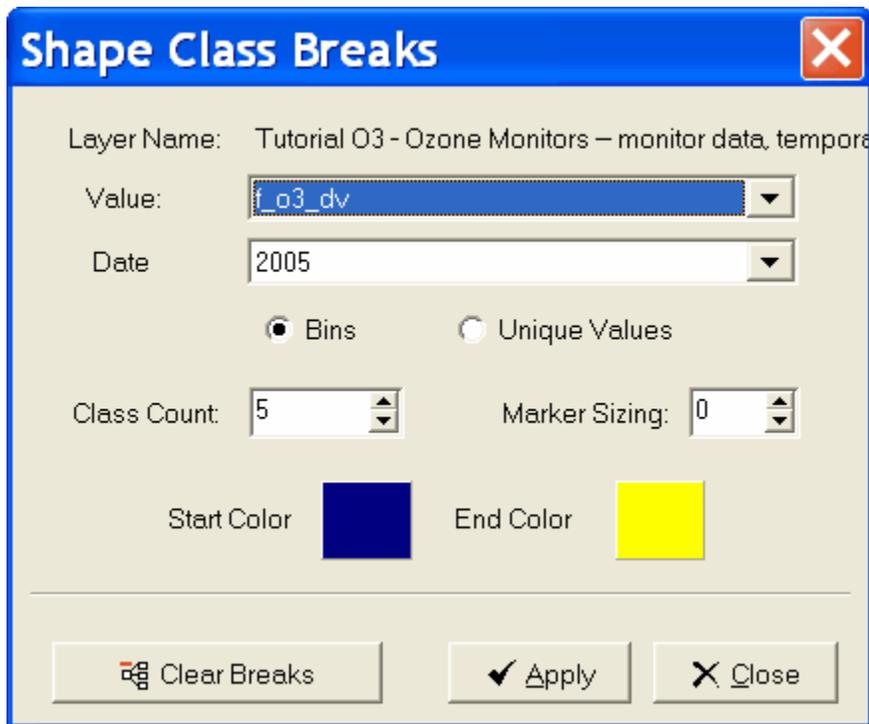
Zoom in further on the Eastern US using the **Zoom in** button on the Task Bar. This allows you to view the results more closely. A dashed line surrounds the area that you have chosen and should look something like the following:



Right click on the "*Tutorial O3 - Ozone Monitors* -"layer in the panel on the left side of the window. Choose the **Plot Value** option.

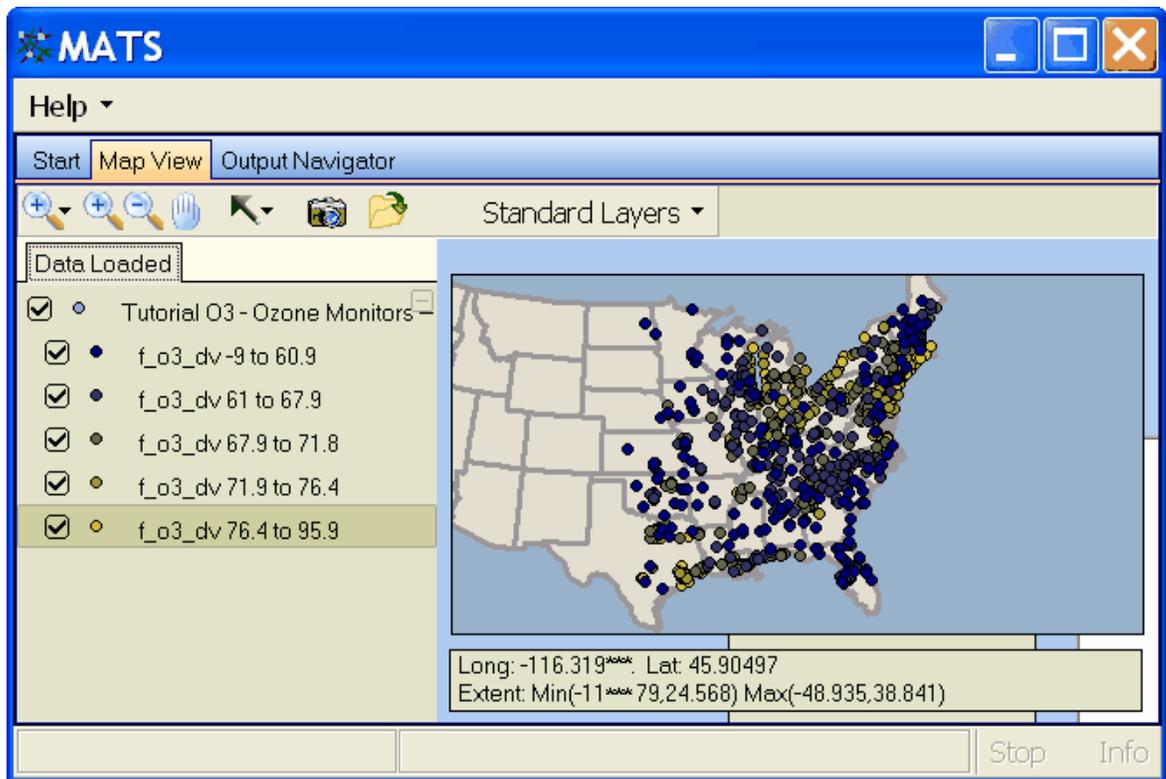


This will bring up **Shape Class Breaks** window. In the **Value** drop-down list, choose the variable "*f\_o3\_dv*" -- this is forecasted ozone design value for 2015.



The image shows a dialog box titled "Shape Class Breaks" with a blue header and a red close button. The dialog is set for a layer named "Tutorial O3 - Ozone Monitors – monitor data, tempora". The "Value" dropdown is set to "o3\_dv" and the "Date" dropdown is set to "2005". The "Bins" radio button is selected, and the "Class Count" is set to 5. The "Marker Sizing" is set to 0. The "Start Color" is a dark blue square and the "End Color" is a yellow square. At the bottom, there are three buttons: "Clear Breaks" (with a grid icon), "Apply" (with a checkmark icon), and "Close" (with an X icon).

Click **Apply** and then click **Close**. This will bring you back to the **Map View** window.



Examine the other variables:

*b\_o3\_dv*: baseline ozone design value;

*rrf*: relative response factor used to forecast the ozone design value;

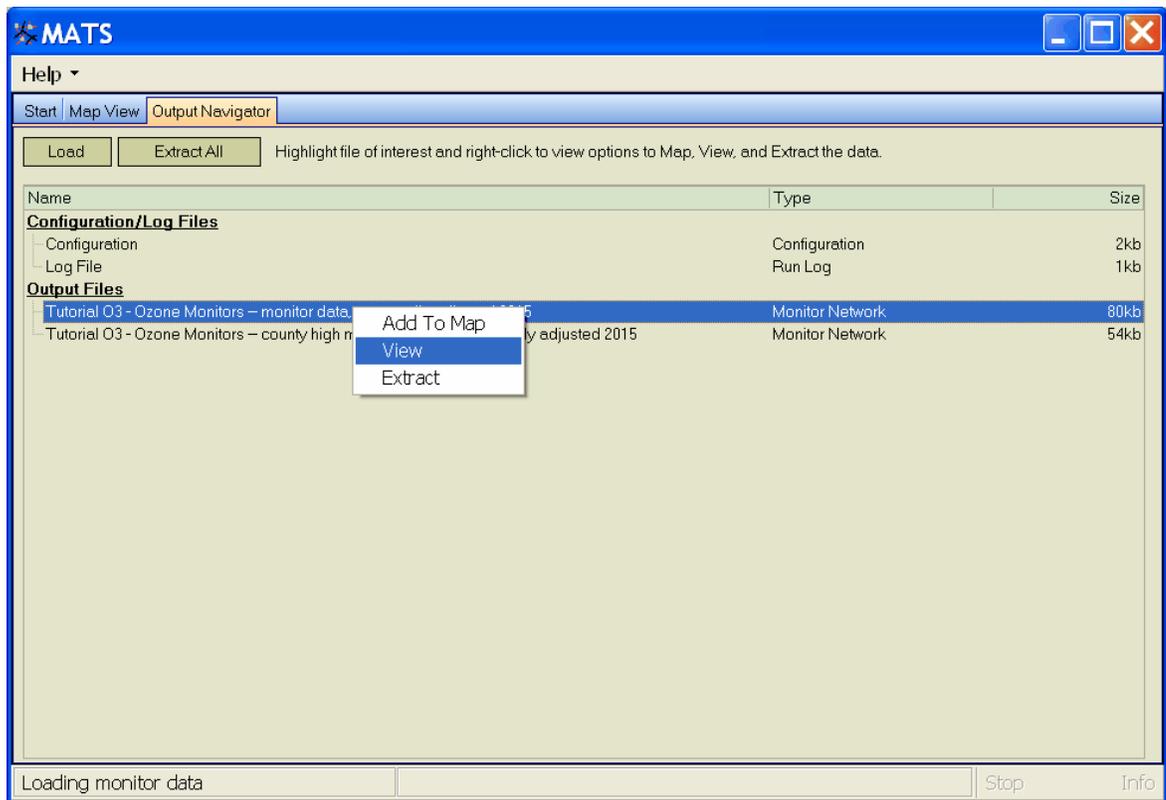
*ppb*: value of the threshold used;

*day*: number of days at or above the threshold.

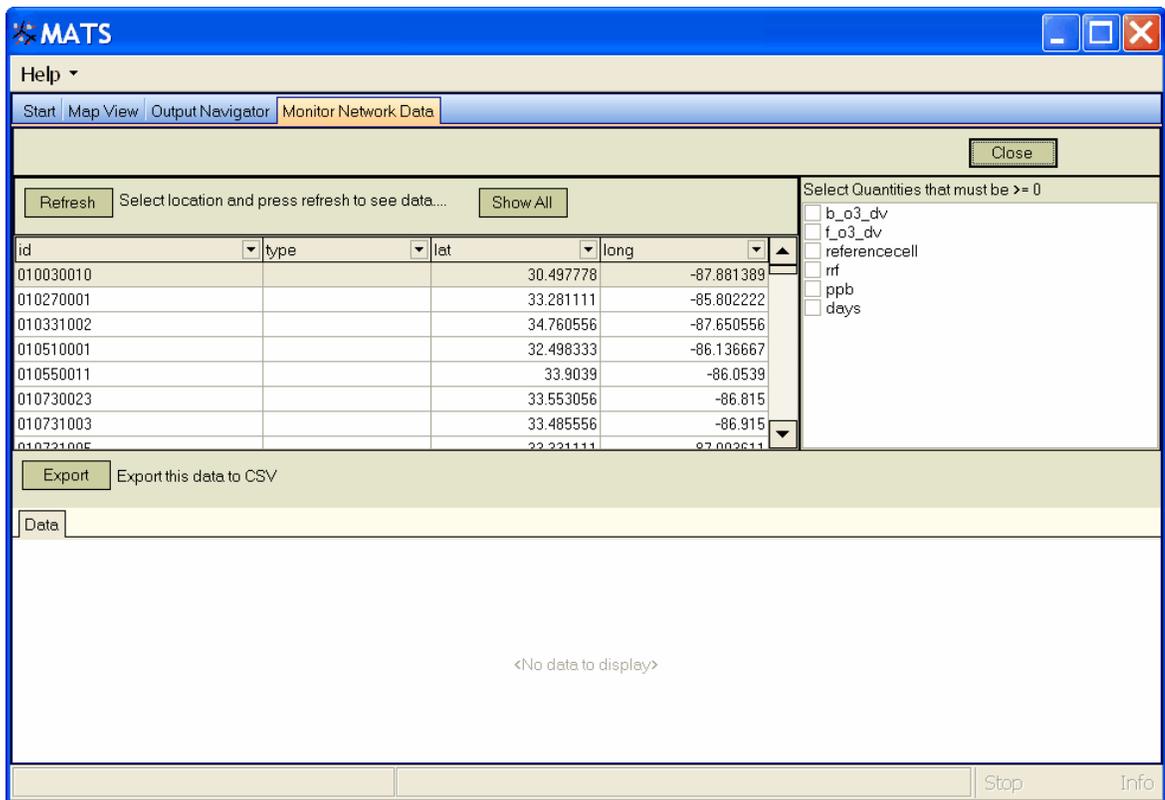
This is just a brief summary of the mapping possibilities available. For more details, there is a separate chapter on the [Map View](#). The [next step](#) is to go to the **Output Navigator** to view the data in a table format.

## 6.8 Step 8. View & Export Output

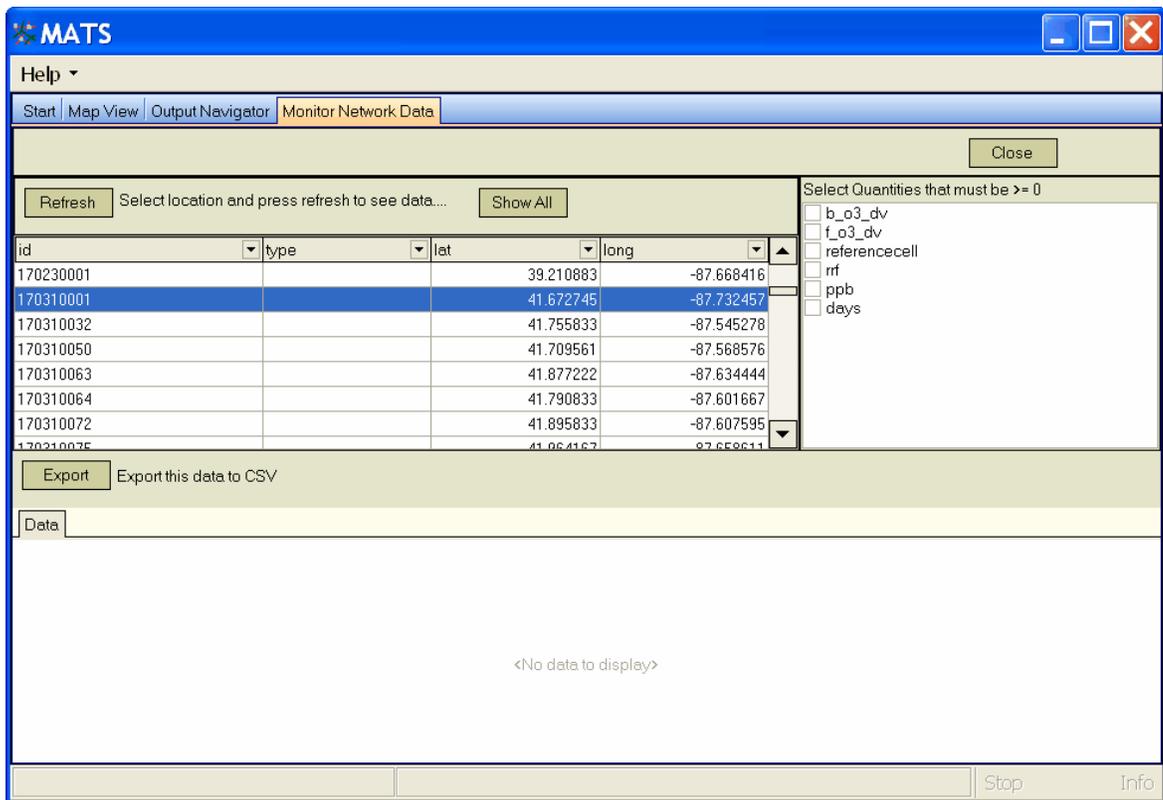
After mapping your results, click on the **Output Navigator** tab, so that you can then view the data in a table. Right-click on the file *Tutorial O3 - Ozone Monitors - monitor data temporally adjusted 2015*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *View* option.



This will bring up a **Monitor Network Data** tab. The upper left panel allows you to view the ID and latitude and longitude of the monitors in your data -- at the right of this panel there is a scrollbar with which you can locate any particular monitor of interest.



To view the data for a particular monitor -- in this example, monitor ID = "17031001" -- highlight this monitor and then click the **Refresh** button. MATS will then display the values for this monitor in the bottom panel.



To view all of the data, click on the **Show All** button.

Refresh Select location and press refresh to see data... Show All

Select Quantities that must be >= 0

- b\_o3\_dv
- f\_o3\_dv
- referencecell
- rrf
- ppb
- days

id	type	lat	long
170230001		39.210883	-87.668416
170310001		41.672745	-87.732457
170310032		41.755833	-87.545278
170310050		41.709561	-87.568576
170310063		41.877222	-87.634444
170310064		41.790833	-87.601667
170310072		41.895833	-87.607595
170310075		41.964167	-87.659611

Export Export this data to CSV

Data

id	date	b_o3_dv	f_o3_dv	referencecell	rrf	ppb	days
010030010	2005	77.7	68.6	95023	0.883	85.0	11.0
010270001	2005	77.7	61.4	108051	0.791	71.0	11.0
010331002	2005	71.0	54.2	92063	0.764	71.0	11.0
010510001	2005	75.0	61.8	106043	0.825	70.0	9.00
010550011	2005	73.0	56.5	105056	0.774	73.0	10.0
010730023	2005	75.7	59.2	100052	0.783	81.0	11.0
010731003	2005	78.0	62.4	99052	0.801	81.0	11.0
010731005	2005	79.2	60.5	99050	0.764	80.0	10.0

Stop Info

To eliminate missing values (denoted by negative numbers in the lower panel), check one or more boxes in the panel in the upper right of the window. For example, to eliminate any monitors that do not have a ozone design value forecast, check the forecasted ozone design value variable "f\_o3\_dv" and then click the **Show All** button.

The screenshot shows the MATS software interface. At the top, there is a menu bar with 'Help' and a 'Monitor Network Data' tab. Below the menu bar, there are buttons for 'Refresh' and 'Show All'. A table lists network data points with columns for 'id', 'type', 'lat', and 'long'. To the right of this table is a 'Select Quantities that must be >= 0' panel with checkboxes for 'b\_o3\_dv', 'f\_o3\_dv', 'referencecell', 'rrf', 'ppb', and 'days'. Below the table is an 'Export' button with the text 'Export this data to CSV'. At the bottom of the window, there are 'Data', 'Stop', and 'Info' buttons.

id	type	lat	long
170230001		39.210883	-87.668416
170310001		41.672745	-87.732457
170310032		41.755833	-87.545278
170310050		41.709561	-87.568576
170310063		41.877222	-87.634444
170310064		41.790833	-87.601667
170310072		41.895833	-87.607595
170310075		41.964167	-87.659611

id	date	b_o3_dv	f_o3_dv	referencecell	rrf	ppb	days
010030010	2005	77.7	68.6	95023	0.883	85.0	11.0
010270001	2005	77.7	61.4	108051	0.791	71.0	11.0
010331002	2005	71.0	54.2	92063	0.764	71.0	11.0
010510001	2005	75.0	61.8	106043	0.825	70.0	9.00
010550011	2005	73.0	56.5	105056	0.774	73.0	10.0
010730023	2005	75.7	59.2	100052	0.783	81.0	11.0
010731003	2005	78.0	62.4	99052	0.801	81.0	11.0
010731005	2005	79.2	60.5	99050	0.764	80.0	10.0

Click the **Export** button and save the file as "No Negative Forecasts." (It is unnecessary to add an extension. MATS automatically saves the file as a CSV text file and adds a ".csv" extension to your file name.) View the file in Excel.

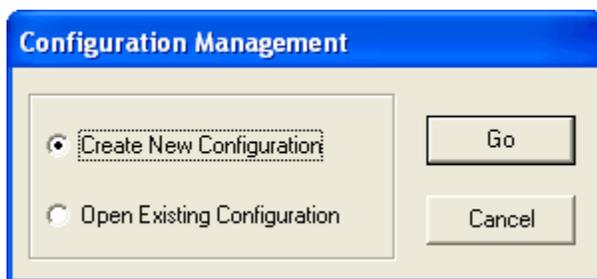
	A	B	C	D	E	F	G	H	I	J
1	id	date	b_o3_dv	f_o3_dv	referencecell	rrf	ppb	days		
2	10030010	2005	77.7	68.6	95023	0.883	85	11		
3	10270001	2005	77.7	61.4	108051	0.791	71	11		
4	10331002	2005	71	54.2	92063	0.764	71	11		
5	10510001	2005	75	61.8	106043	0.825	70	9		
6	10550011	2005	73	56.5	105056	0.774	73	10		
7	10730023	2005	75.7	59.2	100052	0.783	81	11		
8	10731003	2005	78	62.4	99052	0.801	81	11		
9	10731005	2005	79.2	60.5	99050	0.764	80	10		
10	10731009	2005	79.2	61.3	96051	0.775	75	11		
11	10731010	2005	72	55.3	102053	0.769	77	11		
12	10732006	2005	82.5	64.2	100051	0.779	81	10		
13	10735002	2005	77.2	60.9	101054	0.79	77	10		

For additional details on generating ozone results, see the chapter on [Ozone Analysis: Details](#). For additional details on viewing data, see the [View Data](#) section in chapter on the [Output Navigator](#)

## 7 Ozone Analysis: Details

MATS can forecast design values at ozone monitor locations -- these forecasts are referred to as [Point Estimates](#). MATS can also use a variety of approaches to calculate design values for a [Spatial Field](#). A *Spatial Field* refers to a set of values comprising calculations for each grid cell in a modeling domain from Eulerian grid models such as CMAQ and CAMx.

The set of choices involved in calculating either *Point Estimates* or a *Spatial Field* can be fairly involved, so MATS keeps track of these choices using a [Configuration](#). When you begin the process of generating ozone estimates, MATS provides an option to start a new Configuration or to open an existing Configuration.



Select your option and then click **Go**.

MATS will then step you through a series of windows with choices for your analysis.

- [Choose Desired Output](#). Choose whether you want Point Estimates, estimates for a Spatial Field, or both.
- [Data Input](#). Specify the air quality modeling and ambient monitoring data that you want to use. Specify which model grid cells will be used when calculating [RRFs](#) at monitor locations.
- [Filtering Interpolation](#). Choose the years of monitoring data. Identify valid monitors. Define the interpolation approach to be used (when calculating a Spatial Field).
- [RRF and Spatial Gradient](#). Specify the daily ozone values that will be used in the calculation of RRFs and [Spatial Gradients](#).
- [Final Check](#). Verify the selections that you have made

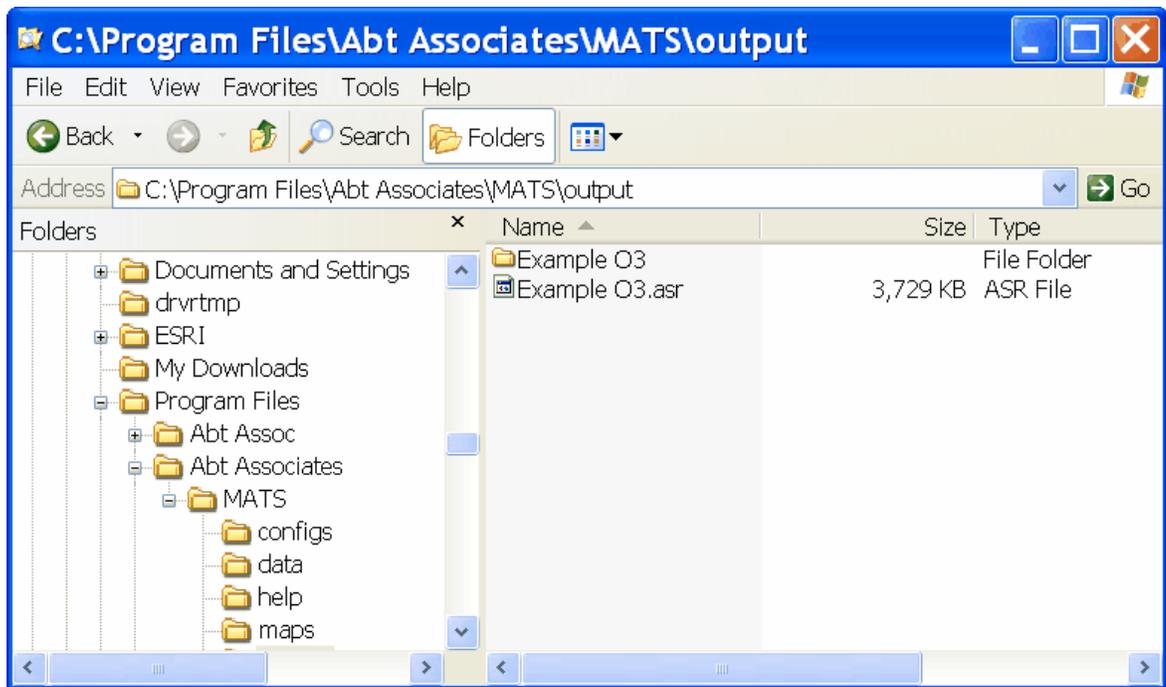
## 7.1 Choose Desired Output

MATS lets you choose to generate Point Estimates, which refer to forecasts made at fixed locations, such as monitors. MATS can also generate Spatial Fields, which refer to air pollution estimates made at the center of each grid cell in a specified model domain. (For example if the model domain has 20 columns and 30 rows, then there are 600 grid cells for which MATS can generate estimates.) The Spatial Field estimates can be baseline estimates or forecasts, generated with or without a [gradient adjustment](#).

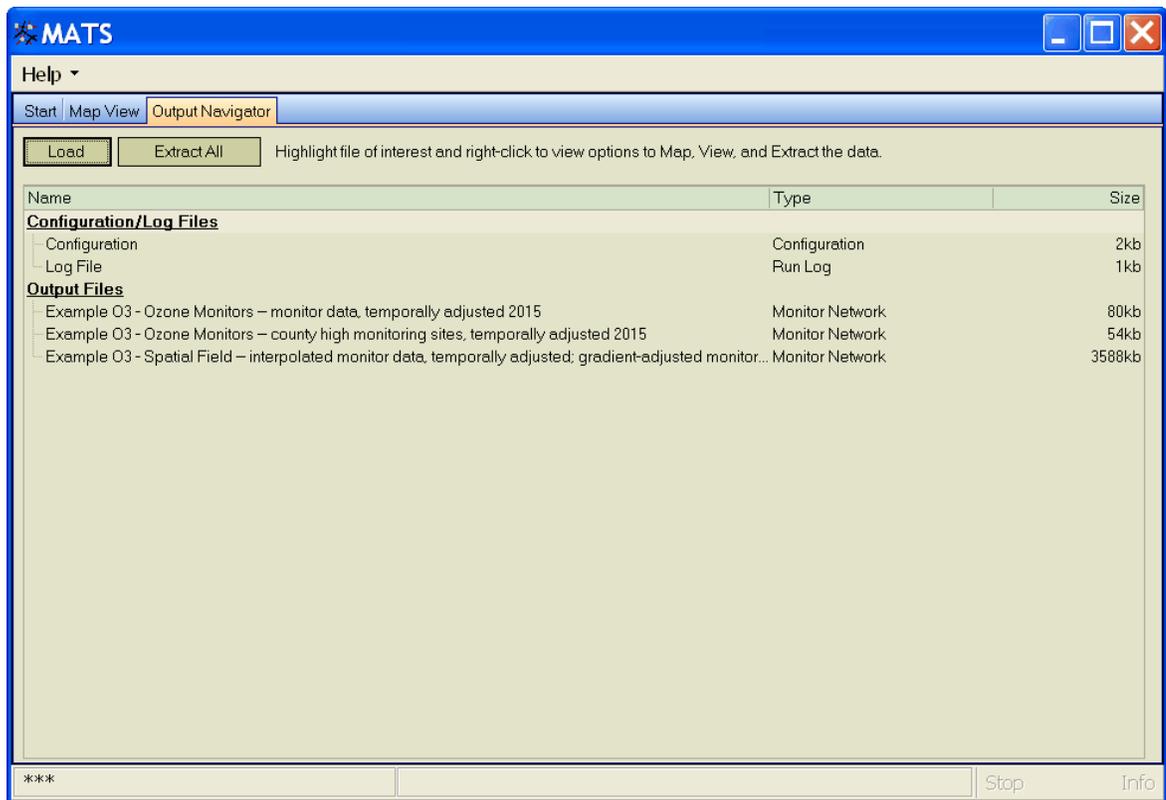
### 7.1.1 Scenario Name

The Scenario Name allows you to uniquely identify each analysis that you conduct. It is used in several ways.

- **Results file name.** The results file is given the **Scenario Name** (e.g., *Tutorial O3.asr*). Note that the extension ([.ASR](#)) is specifically designated just for MATS and can only be used by MATS.
- **Organize output.** In the Output folder, MATS will generate a folder using the [Scenario Name](#). MATS will use this folder as a default location for files generated with this Scenario Name.



- **Output file names.** The output files generated will begin with the Scenario Name.



### 7.1.2 Point Estimates

The calculation of **Point Estimates**, or future-year ozone levels at monitors, has several steps (the process is laid out in more detail in Sections 3 and 4 of the EPA modeling guidance). The first step is to calculate the baseline value as a function of up to three design values. The second step is to use model data to temporal adjust the baseline value.

Scenario Name :

**Point Estimates**

Forecast

Temporally-adjust ozone levels at monitors.

**Spatial Field**

Baseline

Interpolate monitor data to spatial field

Interpolate gradient-adjusted monitor data to spatial field.

Forecast

Interpolate monitor data to spatial field. Temporally adjust ozone levels.

Interpolate gradient-adjusted monitor data to spatial field. Temporally adjust

#### 7.1.2.1 Baseline Ozone

The baseline ozone [design value](#) is the simple average of design values, where the average carries one significant figure to the right of the decimal point. Generally, one should select design value years that match the modeling data being used. The EPA modeling guidance recommends using an average of the 3 design values periods which straddle the emissions base year. For example, if the modeled emissions base year is 2002, then design values from 2000-2002, 2001-2003, and 2002-2004 would be averaged. An average of design values is, in effect, a weighted average of annual averages -- 2002 is “weighted” three times, 2001 and 2003 are weighted twice, and 2000 and 2004 are weighted once. This creates a 5-year weighted average design value which is used to project future air quality levels.

The default design value years in MATS are the periods 2000-2004. This assumes a model base year of 2002. If the base year is not 2002, then the start and end design value period should be adjusted.

#### 7.1.2.2 Temporally-Adjust Baseline Ozone

The first step in [temporally adjusting](#) baseline ozone involves identifying the model grid cells near the monitor site. Next, MATS calculates the average of daily 8-hour average maximum model values for both the baseline and future-year model runs, and then takes the ratio of the two to calculate the [RRF](#). Finally, MATS calculates the future-year design

value by multiplying the RRF with the baseline design value measured at the monitor.

The equation for temporally adjusting baseline ozone is as follows:

$$Monitor_{i, future} = Monitor_i \cdot RRF_i$$

where:

$Monitor_{i, future}$  = future-year ozone design value at monitor site i, measured in parts per billion (ppb)

$Monitor_i$  = baseline ozone design value at monitor site i, measured in ppb

$RRF_i$  = relative response factor at monitor site i. The RRF is the ratio of the future 8-hour daily maximum concentration predicted near a monitor (averaged over multiple days) to the baseline 8-hour daily maximum concentration predicted near the monitor (averaged over the same days).

NOTE: The calculation of the RRF involves a number of assumptions that are specified in the [RRF and Spatial Gradient](#) window.

### 7.1.3 Spatial Field

A [Spatial Field](#) refers to air pollution estimates made at the center of each grid cell in a specified [model domain](#). For example, MATS might calculate ozone [design values](#) for each grid cell in a modeling domain.

MATS calculates four types of ozone-related Spatial Fields:

- [Baseline - interpolate monitor data to spatial field](#). This is an interpolation of baseline monitor values at each grid cell. MATS identifies the "neighbor" monitors for each grid cell and then calculates an inverse-distance-weighted average of the monitor values at each grid cell.
- [Baseline - interpolate gradient-adjusted monitor data to spatial field](#). This is an interpolation of [model-adjusted](#) baseline monitor values at each grid cell. MATS identifies the "neighbor" monitors for each grid cell, it adjusts the monitor values to account for the modeled spatial gradient, and then calculates an inverse-distance-weighted average of the monitor values.
- [Forecast - interpolate monitor data to spatial field. Temporally Adjust](#). This is an interpolation of baseline monitor values at each grid cell that are then temporally adjusted to a future year. MATS calculates the **Baseline - interpolate monitor data to spatial field** and multiplies it with a [RRF](#).
- [Forecast - interpolate gradient-adjusted monitor data to spatial field. Temporally adjust](#). This is an interpolation of model-adjusted baseline monitor values at each grid cell that

are then temporally adjusted to a future year. MATS calculates the **Baseline - interpolate gradient-adjusted monitor data to spatial field** and multiplies it with a RRF.

Details on the calculations are provided in the following sections.

Scenario Name :

**Point Estimates**

**Forecast**

Temporally-adjust ozone levels at monitors.

**Spatial Field**

**Baseline**

Interpolate monitor data to spatial field

Interpolate gradient-adjusted monitor data to spatial field.

**Forecast**

Interpolate monitor data to spatial field. Temporally adjust ozone levels.

Interpolate gradient-adjusted monitor data to spatial field. Temporally adjust.

#### 7.1.3.1 Baseline - interpolate monitor data to spatial field

Using modeling data for [gradient scaling](#) is fairly simple: MATS uses the model value for the grid cell of interest and the model values for the grid cells containing the monitors to be interpolated to the grid cell of interest. A general form of the equation is as follows:

$$Gridcell_{E, baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i \cdot Gradient Adjustment_{i,E}$$

where:

$Gridcell_{E, baseline}$  = baseline ozone concentration at unmonitored site E;

$Weight_i$  = inverse distance weight for monitor i;

$Monitor_i$  = baseline ozone concentration at monitor i;

$Gradient\ Adjustment_{i,E}$  = gradient adjustment from monitor i to unmonitored site E.

There are a variety of approaches that might be used to calculate the gradient adjustment. As a default, MATS averages the five highest daily 8-hour values. The equation can then be rewritten as follows:

$$Gridcell_{E,baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i \cdot \frac{Model_{E,baseline}}{Model_{i,baseline}}$$

where:

$Model_{E,baseline}$  = baseline scenario, average of five highest daily 8-hour values at site E;

$Model_{i,baseline}$  = baseline scenario, average of five highest daily 8-hour values at monitor site i.

#### 7.1.3.2 Baseline - interpolate gradient-adjusted monitor data to spatial field

Using modeling data for [gradient scaling](#) is fairly simple: MATS uses the model value for the grid cell of interest and the model values for the grid cells containing the monitors to be interpolated to the grid cell of interest. A general form of the equation is as follows:

$$Gridcell_{E,baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i \cdot Gradient\ Adjustment_{i,E}$$

where:

$Gridcell_{E,baseline}$  = baseline ozone concentration at unmonitored site E;

$Weight_i$  = inverse distance weight for monitor i;

$Monitor_i$  = baseline ozone concentration at monitor i;

$Gradient\ Adjustment_{i,E}$  = gradient adjustment from monitor i to unmonitored site E.

There are a variety of approaches that might be used to calculate the gradient adjustment. As a default, MATS averages the five highest daily 8-hour values. The equation can then be rewritten as follows:

$$Gridcell_{E, baseline} = \sum_{i=1}^n Weight_i \cdot Monitor_i \cdot \frac{Model_{E, baseline}}{Model_{i, baseline}}$$

where:

$Model_{E, baseline}$  = baseline scenario, average of five highest daily 8-hour values at site E;

$Model_{i, baseline}$  = baseline scenario, average of five highest daily 8-hour values at monitor site i.

#### 7.1.3.3 Forecast - interpolate monitor data to spatial field. Temporally-adjust ozone levels

To get the forecasted [design value](#) for each grid-cell in the [spatial field](#), MATS multiplies the [Baseline - interpolate monitor data to spatial field](#) for each grid-cell with the [RRF](#) calculated for that grid-cell. The equation is as follows:

$$Gridcell_{E, future} = Gridcell_{E, baseline} \cdot RRF_E$$

where:

$Gridcell_{E, baseline}$  = baseline ozone concentration at unmonitored site E;

$Weight_i$  = inverse distance weight for monitor i;

$Monitor_i$  = baseline ozone concentration at monitor i.

NOTE: The RRF is calculated using the same approach as for [Point Estimates](#) (except when a backstop threshold minimum is set [[see section 7.4.1.6](#)]).

#### 7.1.3.4 Forecast - interpolate gradient-adjusted monitor data to spatial field. Temporally-adjust ozone levels

To get the forecasted [design value](#) for each grid-cell in the [spatial field](#) with a [gradient adjustment](#), MATS multiplies the [Baseline - interpolate gradient-adjusted monitor data to spatial field](#) for each grid-cell with the [RRF](#) calculated for that grid cell. The equation is as follows:

$$Gridcell_{E, future} = Gridcell_{E, baseline} \cdot RRF_E$$

where:

$Gridcell_{E, baseline}$  = baseline ozone concentration at unmonitored site E;

Weight<sub>i</sub> = inverse distance weight for monitor i;

Monitor<sub>i</sub> = baseline ozone concentration at monitor i.

NOTE: The RRF is calculated using the same approach as for [Point Estimates](#) (except when a backstop threshold minimum is set [[see section 7.4.1.6](#)]).

#### 7.1.4 Ozone Output Variable Description

MATS generates up to three output files:

- [Ozone forecasts for all monitors](#). The name of this file is "Ozone Monitors -- monitor data, temporally adjusted yyyy.csv" with the [Scenario Name](#) appended at the beginning and the forecast year is inserted at the end (e.g., "Example O3 -- Ozone Monitors -- county high monitoring sites, temporally adjusted 2015.csv").
- [Ozone forecasts for the highest monitor in each county](#). The name of this file is "Ozone Monitors -- county high monitoring sites, temporally adjusted yyyy.csv" with the Scenario Name appended at the beginning and the forecast year inserted at the end.
- [Spatial field forecasts](#). The name of this file is "Spatial Field -- interpolated monitor data, temporally adjusted; gradient-adjusted monitor data, temporally adjusted yyyy.csv" with the Scenario Name appended at the beginning and the forecast year inserted at the end.

The following sub-sections describe the variables in each file.

##### 7.1.4.1 Ozone Monitors -- monitor data, temporally adjusted 2015.csv

The table below describes the variables in the output file.

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_type	Leave blank
lat	Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
long	Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
date	The date represents the last year of the chosen design value periods (e.g., if a 5 year period is chosen, 2005 represents the 2001-2005 period).
b_o3_DV	Baseline design value
f_o3_DV	Forecasted (future year) design value
referencecell	Identifier of the closest model grid cell centroid to the monitor.

rrf	Relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days).
ppb	Threshold value (measured in parts per billion) used in the rrf calculation
days	Number of days at or above the threshold value.
_state_name	State name. (This is a character variable.)
_county_name	County name. (This is a character variable.)

**7.1.4.2 Ozone Monitors -- county high monitoring sites, temporally adjusted 2015.csv**

An example of this output file is as follows (with variable definitions in the table below):

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_type	Leave blank
lat	Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
long	Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
date	The date represents the last year of the selected design value periods (e.g., if a 5 year period is selected, 2005 represents the 2001-2005 period ).
b_o3_DV	Baseline design value
f_o3_DV	Forecasted (future year) design value
referencecel	Identifier of the closest model grid cell centroid to the monitor.
l	
rrf	Relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days).
ppb	Threshold value (measured in parts per billion) used in the rrf calculation
days	Number of days at or above the threshold value.
_state_name	State name. (This is a character variable.)
e	
_county_name	County name. (This is a character variable.)
me	

**7.1.4.3 Spatial Field -- interpolated monitor data, temporally adjusted; gradient-adjusted monitor data, temporally adjusted 2015.csv**

An example of this output file is as follows (with variable definitions in the table below):

Variable	Description
_id	The ID is a unique name for each monitor in a particular location. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
_type	Leave blank

lat	Latitude in decimal degrees of the center of each grid cell. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
long	Longitude in decimal degrees of the center of each grid cell. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
date	The date represents the last year of the selected design value periods (e.g., if a 5 year period is selected, 2005 represents the 2001-2005 period ).
ga_conc	Modeled concentration (ppb) used for gradient adjustment (average of "start value" and "end value")
i_b_o3	Interpolated (to spatial field) baseline concentration (ppb).
i_f_o3	Interpolated (to spatial field) future year concentration (ppb).
i_b_ga_o3	Interpolated (to spatial field) gradient adjusted baseline concentration (ppb).
i_f_ga_o3	Interpolated (to spatial field) gradient adjusted future year concentration (ppb).
ppb	Threshold value (measured in parts per billion) used in the rrf calculation
days	Number of days at or above the threshold value.
referencecell	Identifier of the grid cell. (In the case of spatial fields, this is identical to the _ID variable.)
rrf	Relative response factor is the ratio of the future year modeled concentration predicted near a monitor (averaged over multiple days) to the base year modeled concentration predicted near the monitor (averaged over the same days).

## 7.2 Data Input

In the Data Input window, you need to specify the air quality modeling and ambient monitoring data that you want to use. In addition, you need to specify which model grid cells will be used when calculating [RRFs](#) at monitor locations.

### 7.2.1 Monitor Data

Monitor data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, day). The second row presents comma-separated variable names. The third row begins the data values. Below is an example of the monitor data file format and descriptions of the variables in the file.

#### Format of Ozone Monitor Data

```

designValue
_ID, _TYPE, LAT, LONG, POC, DVYEAR, O3, _STATE_NAME, _COUNTY_NAME
"010030010", , 30.497778, -87.881389, 1, 1999, -9, "Alabama", "Baldwin"
"010030010", , 30.497778, -87.881389, 1, 2000, -9, "Alabama", "Baldwin"
"010030010", , 30.497778, -87.881389, 1, 2001, -9, "Alabama", "Baldwin"
"010030010", , 30.497778, -87.881389, 1, 2002, 82, "Alabama", "Baldwin"
"010030010", , 30.497778, -87.881389, 1, 2003, 76, "Alabama", "Baldwin"
"010030010", , 30.497778, -87.881389, 1, 2004, 76, "Alabama", "Baldwin"
"010030010", , 30.497778, -87.881389, 1, 2005, 77, "Alabama", "Baldwin"
"010270001", , 33.281111, -85.802222, 1, 1999, 88, "Alabama", "Clay"

```

#### Ozone Monitor Data Variable Descriptions

Variable	Description
_ID	The ID is a unique name for each monitor in a particular location. The default value is the AIRS ID. (This is a character variable.)
_TYPE	Leave this blank.
LAT	Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
LONG	Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
DATE	The time period of the monitor observation. As a convention, the date represents the last year of the three-year design value period (e.g., 2001 represents the 1999-2001 design value).
O3	Observed monitor value. Note that missing values are represented by a minus nine (-9).
_STATE_NAME	State name. (This is a character variable.)
_COUNTY_NAME	County name. (This is a character variable.)

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

## 7.2.2 Model Data

The model data should be in the form of a simple text file. The first row specifies the frequency of the data (*e.g.*, day). The second row presents comma-separated variable names. The third row begins the data values. The ozone model data should be the daily 8-hour average maximum concentration in each grid cell. Below is an example of the model data file format and descriptions of the variables in the file.

### Format of Ozone Model Data

```
Day
_ID, _TYPE, LAT, LONG, DATE, O3
1001, "", 28.471949, -99.489582, 20150501, 45.2324
1001, "", 28.471949, -99.489582, 20150502, 42.6581
1001, "", 28.471949, -99.489582, 20150503, 47.4534
1001, "", 28.471949, -99.489582, 20150504, 51.9678
1001, "", 28.471949, -99.489582, 20150505, 53.6575
1001, "", 28.471949, -99.489582, 20150506, 47.1936
1001, "", 28.471949, -99.489582, 20150507, 48.3454
1001, "", 28.471949, -99.489582, 20150508, 49.5464
1001, "", 28.471949, -99.489582, 20150509, 34.3454
```

### Ozone Model Data Variable Descriptions

Variable	Description
_ID	The ID is a unique number for each model grid cell in the air quality model domain. It is generally based on the column and row identifiers from the air quality modeling domain. The default convention is to calculate the ID by multiplying the column identifier by one thousand (1000) and adding the row identifier. (This is a character variable.)
_TYPE	Leave this blank.
LAT	Latitude in decimal degrees of the center of each grid cell. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
LONG	Longitude in decimal degrees of the center of each grid cell. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
DATE	The time of the monitor observation. The day is represented in the yyyyymmdd format
O3	Modeled ozone concentration (8-hour average daily maximum).

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

#### 7.2.2.1 EPA Default Model Data

The example model output dataset in MATS comprises daily 8-hour average maximums from May-September at 12km resolution. The baseline year for the modeling is 2001 and the future year is 2015.

#### 7.2.3 Using Model Data

The RRF for a monitor is calculated from "nearby" model grid cells. For purposes of this calculation, a monitor is assumed to be at the center of the cell in which it is located, and this cell is at the center of an array of "nearby" cells.

The number of cells considered "nearby" a monitor is a function of the size of the grid cells used in the modeling. In the example case of a 12 km grid, EPA uses as a default 3x3 array of grid cells (see section 3.2 of the EPA modeling guidance for more details).

**Data Input**

Desired output  
■ **Data Input**  
□ Filtering/Interpolation  
□ RRF/Spatial Gradient  
□ Final Check

**Monitor Data**

Ozone Data: SampleData\OZONE\_ASIP\_input\_97-05.csv ...

**Model Data**

Baseline File: \SampleData\ozone\_model\_data\_2001.csv ...

Forecast File: \SampleData\ozone\_model\_data\_2015.csv ...

**Using Model Data**

Temporal adjustment at monitor: 3x3 Maximum

1x1  
3x3  
5x5  
7x7

< Back Next > Cancel

With the array size determined, MATS gives you two options for how you might use the modeling data.

- **Maximum.** For each day of modeling data, MATS will identify the highest 8-hour daily maximum among the grid cells in the chosen array. In the case of a 3x3 array, MATS will identify the highest daily 8-hour average maximum from among the nine “nearby” grid cells for each day and for each monitor site.
- **Mean.** For each day of modeling data, MATS will average the 8-hour daily values for the grid cells in the chosen array. In the case of a 3x3 array, MATS will average nine values.

The default choice for the ozone analysis in MATS is to use the **maximum** value among the array of grid cells, when calculating temporally-adjusted ozone levels at each monitor.

NOTE: For monitors on the border of a modeling domain -- where it may not be possible to have a full set of neighbors -- MATS uses the available modeling data.

#### 7.2.3.1 Nearby Monitor Calculation - Example 1

##### Given:

- (1) Four primary days have been simulated using baseline and future emissions.
- (2) The horizontal dimensions for each surface grid cell are 12 km x 12 km.
- (3) In each of the 9 grid cells “near” a monitor site I, the maximum daily predicted future concentrations are 87.2, 82.4, 77.5, and 81.1 ppb.
- (4) In each of the 9 grid cells “near” a monitor site I, the maximum daily predicted baseline 8-hour daily maximum ozone concentrations are 98.3, 100.2, 91.6, and 90.7 ppb.

##### Find:

The site-specific relative response factor for monitoring site I, (RRF)<sub>I</sub>

**Solution:**

(1) For each day and for both baseline and future emissions, identify the 8-hour daily maximum concentration predicted near the monitor. Since the grid cells are 12 km, a 3 x 3 array of cells is considered “nearby” (see Table 3.2).

(2) Compute the mean 8-hour daily maximum concentration for (a) future and (b) baseline emissions. Using the information from above, (a) (Mean 8-hr daily max.)future =  $(87.2 + 82.4 + 77.5 + 81.1)/4 = 82.1$  ppb and (b) (Mean 8-hr daily max.)baseline =  $(98.3 + 100.2 + 91.6 + 90.7)/4 = 95.2$  ppb

(3) The relative response factor for site I is

$$(RRF)I = (\text{mean 8-hr daily max.})_{\text{future}} / (\text{mean 8-hr daily max.})_{\text{baseline}} = 82.1 / 95.2 = 0.862$$

**Figure 3.1. Choosing Ozone Predictions To Estimate RRF's**

**(a) Predictions With Baseline Emissions**

Day 1	Day 2	Day 3	Day 4																																				
<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>97.2</td><td>95.5</td><td>96.2</td></tr> <tr><td>97.1</td><td>95.2</td><td>89.1</td></tr> <tr><td>97.2</td><td>98.3</td><td>97.6</td></tr> </table>	97.2	95.5	96.2	97.1	95.2	89.1	97.2	98.3	97.6	<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>100.2</td><td>98.5</td><td>98.1</td></tr> <tr><td>100.0</td><td>99.1</td><td>97.3</td></tr> <tr><td>99.5</td><td>95.4</td><td>97.9</td></tr> </table>	100.2	98.5	98.1	100.0	99.1	97.3	99.5	95.4	97.9	<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>87.8</td><td>90.1</td><td>89.9</td></tr> <tr><td>90.9</td><td>91.6</td><td>88.7</td></tr> <tr><td>88.5</td><td>89.4</td><td>90.2</td></tr> </table>	87.8	90.1	89.9	90.9	91.6	88.7	88.5	89.4	90.2	<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>85.9</td><td>87.9</td><td>88.9</td></tr> <tr><td>87.9</td><td>90.5</td><td>90.7</td></tr> <tr><td>86.9</td><td>87.3</td><td>88.4</td></tr> </table>	85.9	87.9	88.9	87.9	90.5	90.7	86.9	87.3	88.4
97.2	95.5	96.2																																					
97.1	95.2	89.1																																					
97.2	98.3	97.6																																					
100.2	98.5	98.1																																					
100.0	99.1	97.3																																					
99.5	95.4	97.9																																					
87.8	90.1	89.9																																					
90.9	91.6	88.7																																					
88.5	89.4	90.2																																					
85.9	87.9	88.9																																					
87.9	90.5	90.7																																					
86.9	87.3	88.4																																					
98.3	100.2	91.6	90.7																																				

$$\text{Mean Baseline Ozone Concentration} = (98.3 + 100.2 + 91.6 + 90.7) / 4 = 95.2 \text{ ppb}$$

**(b) Predictions With Future Emissions**

Day 1	Day 2	Day 3	Day 4																																				
<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>86.1</td><td>85.4</td><td>86.8</td></tr> <tr><td>86.2</td><td>84.5</td><td>84.3</td></tr> <tr><td>85.8</td><td>87.2</td><td>86.9</td></tr> </table>	86.1	85.4	86.8	86.2	84.5	84.3	85.8	87.2	86.9	<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>82.2</td><td>80.8</td><td>81.2</td></tr> <tr><td>82.4</td><td>79.9</td><td>80.5</td></tr> <tr><td>81.4</td><td>77.8</td><td>80.1</td></tr> </table>	82.2	80.8	81.2	82.4	79.9	80.5	81.4	77.8	80.1	<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>72.1</td><td>76.1</td><td>75.5</td></tr> <tr><td>74.6</td><td>77.5</td><td>74.3</td></tr> <tr><td>76.9</td><td>77.4</td><td>75.6</td></tr> </table>	72.1	76.1	75.5	74.6	77.5	74.3	76.9	77.4	75.6	<table border="1" style="border-collapse: collapse; width: 60px; height: 60px;"> <tr><td>75.4</td><td>78.8</td><td>79.8</td></tr> <tr><td>80.8</td><td>79.5</td><td>80.9</td></tr> <tr><td>80.4</td><td>76.9</td><td>81.1</td></tr> </table>	75.4	78.8	79.8	80.8	79.5	80.9	80.4	76.9	81.1
86.1	85.4	86.8																																					
86.2	84.5	84.3																																					
85.8	87.2	86.9																																					
82.2	80.8	81.2																																					
82.4	79.9	80.5																																					
81.4	77.8	80.1																																					
72.1	76.1	75.5																																					
74.6	77.5	74.3																																					
76.9	77.4	75.6																																					
75.4	78.8	79.8																																					
80.8	79.5	80.9																																					
80.4	76.9	81.1																																					
87.2	82.4	77.5	81.1																																				

$$\text{Mean Future Ozone Concentration} = (87.2 + 82.4 + 77.5 + 81.1) / 4 = 82.1 \text{ ppb}$$

## 7.3 Filtering and Interpolation

The **Filtering and Interpolation** window allows you to choose the years of monitoring data that you will use in your analysis. MATS allows you to specify the rules to determine the monitors that you will use. And in the case of calculating Spatial Fields, it allows you to define the interpolation method that MATS will use.

### 7.3.1 Choose Ozone Design Values

Choosing the **Start Year** and the **End Year** defines the range of the ozone design values that will be used in the calculation of the baseline ozone level. You can vary the number of design values used in this calculation.

The database that comes with MATS has design values periods from (1997-1999)-(2005-2007). The default approach in MATS is to average 3 design value periods. For example, if the modeling base year is 2002, then you would use the design values from 2000-2002, 2001-2003, and 2002-2004. The **Start Year** is set to 2000-2002 and the **End Year** is set to 2002-2004.

**Choose Ozone Design Values**

Start Year  End Year

---

**Valid Ozone Monitors**

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

**Default Interpolation Method**

check to set a maximum interpolation distance [km]

### 7.3.2 Valid Ozone Monitors

MATS provides three choices for identifying monitors that are "valid" and thus included in your analysis.

- **Minimum Number of Design Values.** Specifies the minimum number of design value periods that need to be included in the calculation of the baseline ozone design value (1, 2, or 3).
- **Max Distance from Domain [km].** Specifies how far a monitor may be from a model grid cell and still be included in calculations that use that grid cell's model values. (This is relevant for the calculation of RRFs and gradient-adjustments.)
- **Required Design Values.** Specifies whether a particular design value period needs to be valid for the calculations to be performed at that monitor.

**Choose Ozone Design Values**

Start Year  End Year

---

**Valid Ozone Monitors**

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

**Default Interpolation Method**

check to set a maximum interpolation distance [km]

### 7.3.2.1 Minimum Number Design Values

The **Minimum Number of Design Values** specifies the minimum number of design values that need to be available in the potential range of design values specified by the Start Year and End Year. Monitors that do not meet the minimum are excluded from the calculation of baseline ozone levels.

Recall that the baseline ozone level is an average of one or more design values. The number of design values available for this calculation will typically be either 1, 2, or 3 design value periods. The default option is to require that one design value be available in the specified range.

### Choose Ozone Design Values

Start Year  End Year

---

### Valid Ozone Monitors

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

### Default Interpolation Method

check to set a maximum interpolation distance [km]

#### Example 1: Point Estimates

When calculating ozone levels at monitors, if MATS finds that a monitor has an insufficient number of valid design values (e.g., one required but none available in the specified range), then MATS will set the baseline level and forecast values to missing (denoted by a negative number).

#### Example 2: Spatial Field

The calculation of the ozone level in each grid cell of a Spatial Field involves multiple monitors. MATS uses Voronoi Neighbor Averaging to identify "neighboring" monitors from the available set of valid monitors, and then calculates an inverse-distance weighted average of the baseline ozone levels from these neighbors. The **Minimum Number of Design Values** determines which monitors are "valid" -- that is, those monitors that will be included in the calculation.

#### 7.3.2.2 Max Distance from Domain

The option to specify the **Max Distance from Domain** allows you to choose how far (in kilometers) a monitor may be from the center of a model grid cell and still be included in calculations that use that grid cell's model values.

### Choose Ozone Design Values

Start Year  End Year

---

### Valid Ozone Monitors

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

### Default Interpolation Method

check to set a maximum interpolation distance [km]

#### Example 1: Point Estimates

When calculating ozone levels at monitors, if MATS finds that a monitor is further than the specified **Max Distance from Domain**, then MATS will drop the monitor from the analysis. For example, if the Max Distance from Domain is set to 25 kilometers and the model domain includes the continental U.S., then monitors in Alaska, or other locations far from the model domain are excluded from calculations involving model data. If an extremely large distance is specified, say 10,000 kilometers, then all monitors would be included, regardless of the model domain location

#### Example 2: Spatial Field

The calculation of the ozone level in each grid cell of a Spatial Field can involve multiple monitors. MATS uses Voronoi Neighbor Averaging to identify "neighboring" monitors from the available set of valid monitors, and then calculates an inverse-distance weighted average of the baseline ozone levels from these neighbors. The **Max Distance from Domain** determines which monitors are "valid" -- that is, those monitors that will be included in the calculation.

#### 7.3.2.3 Required Design Values

Using the **Required Design Value** drop-down list, you can specify that a particular design value must be available at each monitor included in the analysis. If you want to use all

monitors that have a valid design value for 2001-2003, then MATS will only include those monitors that have this valid design value. The default is to choose *None Selected*.

### Choose Ozone Design Values

Start Year  End Year

---

### Valid Ozone Monitors

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

### Default Interpolation Method

check to set a maximum interpol

1997-1999  
 1998-2000  
 1999-2001  
 2000-2002  
 2001-2003  
 2002-2004  
 2003-2005

### 7.3.3 Default Interpolation Method

The **Default Interpolation Method** panel allows you to choose how you will [interpolate](#), or combine, the values from different monitors. One approach is to use [Inverse Distance Weights](#). This means that the weight given to any particular monitor is inversely proportional to its distance from the point of interest. A second approach is Inverse Distance Squared Weights, which means that the weights are inversely proportional to the square of the distance. And the third approach is Equal Weighting of Monitors. The default approach for ozone is Inverse Distance Weights.

**Choose Ozone Design Values**

Start Year  End Year

---

**Valid Ozone Monitors**

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

**Default Interpolation Method**

- Equal Weighting of Monitors
- Inverse Distance Weights**
- Inverse Distance Squared Weights

When interpolating monitor values, MATS allows you to identify the monitors you want to use based on their distance away from the point of interest (*e.g.*, the center of a grid cell). The first step in the interpolation process is to identify the monitors that are nearby, or neighbors, for each point of interest. The next step is to determine the distance from the nearby monitors to the point of interest.

The default approach is to include all valid monitors (*i.e.*, those that satisfy the three criteria in the [Valid Ozone Monitors](#) panel), regardless of distance. If you want to limit the use of monitors based on distance, check the box next to *check to set a maximum interpolation distance*, and then specify a distance (in kilometers). A distance of one hundred (100) kilometers means that any monitors further than 100 kilometers can no longer be used in the interpolation. If a point of interest has no monitors within the specified distance, then no value is calculated. The default is to leave this box unchecked.

### Choose Ozone Design Values

Start Year  End Year

---

### Valid Ozone Monitors

Minimum Number of design values

Max Distance from Domain [km]

Required Design Values

---

### Default Interpolation Method

## 7.4 RRF and Spatial Gradient

In calculating an ozone [RRF](#) or a [Spatial Gradient](#), typically, not all of the model data are used. In the case of RRFs, daily values falling below specified thresholds can be excluded from the calculation (*e.g.*, [RRF Calculation - Example 1](#)). In the case of a spatial gradient, MATS be be setup to follow the same thresholds as used for point estimates or if a valid result is needed in all grid cells, a **Backstop minimum threshold** can be used (*e.g.*, [RRF Calculation Spatial Gradient with Backstop Threshold - Example 6](#)). You can also specify a sub-range of days included in the model data files and base and future year model days can be paired by high concentration instead of by date. MATS also averages a user-specified range of values to calculate gradient adjustments (*e.g.*, [Spatial Gradient Calculation - Example 1](#)).

### 7.4.1 RRF Setup

The [RRF](#) Setup involves four variables that specify the thresholds and the numbers of days above the thresholds -- **Initial threshold value**; **Minimum number of days in baseline at or above threshold**; **Minimum allowable threshold value**; and **Min number of days at or above minimum allowable threshold**.

The first step in calculating the RRF is to determine the number of days at or above the **Initial threshold value**. If the number of days is above the **Minimum number of days in baseline at or above threshold**, then MATS averages the 8-hour values for those grid cells with at least this number. For example, MATS performs the following steps:

- In the case of a 3x3 array, MATS identifies the highest daily 8-hour average maximum from among the nine “nearby” grid cells for each day and for each monitor site. In the case where there are 90 days of model outputs, MATS generates 90 daily values. NOTE: MATS does this calculation separately for the baseline and future-year scenarios. As a result two different grid cells in the baseline and future-year might be used to represent a given day.
- The default **Initial threshold value** is set to 85 ppb. The default **Minimum number of days in baseline at or above threshold** is set to 10. If there are fewer than 10 days at or above 85 ppb in the baseline scenario, then MATS lowers the threshold in increments of 1 ppb, until there are at least 10 days at or above this new, lower threshold. This process is continued, if needed, until the **Minimum allowable threshold value** is reached. The

default **Minimum allowable threshold value** is 70 ppb. MATS calculates the number of days at or above the **Minimum allowable threshold value**. If there are fewer than the **Min number of days at or above minimum allowable threshold**, then the monitor site will be dropped. The default **Min number of days at or above minimum allowable threshold** is 5.

- Using the threshold established with the baseline scenario, MATS checks the daily 8-hour maxima calculated for the baseline scenario, and sets to missing any daily value falling below the threshold. For any day set to missing in the baseline scenario, MATS also sets the corresponding day in the future-year scenario to missing.
- For each monitor site, MATS averages the non-missing daily values for the baseline and future-year scenarios, and then calculates the RRF as the ratio of the future-year average to the baseline average.

You can also set a **Backstop minimum threshold for spatial fields**. As noted in Example 6 ([below](#)), the backstop minimum threshold allows the minimum threshold to be lowered to a value below the **Minimum allowable threshold value** until the minimum number of days is reached. The backstop threshold is only used for grid cells which do not have enough days to meet the minimum number of days value with the minimum allowable threshold. The backstop threshold does not change the calculation for grid cells that already meet the minimum number of days.

Another option is to specify a **Subrange** of days to use in the model RRF calculation. The start day and end day of the subrange are specified based on a count of the number of days from the first day in the file. For example, if the model files contained data for June 1st-August 30th, a subrange start and end day of "31" and "61" respectively would specify the July 1st-July 31st period.

There is also an option to **pair days based on high concentration instead of date**. This may be useful for model runs where the future year meteorology is different than the base year (such as climate modeling). MATS will pair the future year highest concentrations with the highest concentrations in the base year file, regardless of date. The number of days in the RRF will continue to be based on the threshold variables. For example, if 11 days are greater than the selected threshold in the base year, then the RRF will be calculated based on the 11 highest base and future year concentration days.

#### 7.4.1.1 RRF Calculation - Example 1

Assume the following default values:

**RRF Setup:**

Initial threshold value (ppb)

Minimum number of days in baseline at or above threshold

Minimum allowable threshold value (ppb)

Min number of days at or above minimum allowable threshold

Enable Backstop minimum threshold for spatial fields

Backstop minimum threshold for spatial fields

Subrange first day of ozone season used in RRF

Subrange last day of ozone season used in RRF

Pair days based on high concentration instead of date.

**Spatial Gradient Setup:**

Start Value

End Value

Assume that there are 15 days of data:

Baseline day	Baseline value	Future day	Future value
1	103	1	95
2	112	2	97
3	98	3	94
4	97	4	95
5	95	5	94
6	95	6	93
7	94	7	89
8	92	8	86
9	90	9	80
10	85	10	78
11	89	11	80
12	88	12	81
13	85	13	76
14	78	14	75
15	78	15	74

MATS will sort the values from high to low based on the Baseline values:

Baseline day	Baseline value	Future day	Future value
2	112	2	97
1	103	1	95
3	98	3	94
4	97	4	95
5	95	5	94
6	95	6	93
7	94	7	89
8	92	8	86
9	90	9	80
11	89	11	80
12	88	12	81
10	85	10	78
13	85	13	76
14	78	14	75
15	78	15	74

Note that Day 2 has the highest Baseline value. And note that the Future values are not sorted high to low, and instead the Future days match the Baseline days.

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are thirteen (13) Baseline values at or above this threshold. Since there are more days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will use all 13 days.

MATS will take the top 13 days (highlighted in yellow) and then calculate separate averages for the Control and Baseline values:

Control average = 87.5385 ppb

Baseline average = 94.0769 ppb.

The RRF equals the ratio of the Control to the Baseline:

$RRF = 87.5385 / 94.0769 = 0.930$

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.2 RRF Calculation - Example 2

Assume the following default values:

**RRF Setup:**

Initial threshold value (ppb)

Minimum number of days in baseline at or above threshold

Minimum allowable threshold value (ppb)

Min number of days at or above minimum allowable threshold

Enable Backstop minimum threshold for spatial fields

Backstop minimum threshold for spatial fields

Subrange first day of ozone season used in RRF

Subrange last day of ozone season used in RRF

Pair days based on high concentration instead of date.

**Spatial Gradient Setup:**

Start Value

End Value

Assume that there are 15 days of data:

Baseline day	Baseline value	Future day	Future value
1	100	1	95
2	100	2	97
3	98	3	94
4	97	4	95
5	95	5	94
6	95	6	93
7	90	7	89
8	85	8	86
9	84	9	80
10	83	10	78
11	83	11	80
12	83	12	81
13	79	13	76
14	78	14	75
15	78	15	74

MATS will sort the data from high to low based on the Baseline values:

Baseline day	Baseline value	Future day	Future value
1	100	1	95
2	100	2	97
3	98	3	94
4	97	4	95
5	95	5	94
6	95	6	93
7	90	7	89
8	85	8	86
9	84	9	80
10	83	10	78
11	83	11	80
12	83	12	81
13	79	13	76
14	78	14	75
15	78	15	74

Note that the Baseline values happen to stay in the same order. And note that the Future values are not sorted high to low, and instead the Future days match the Baseline days.

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are only eight (8) Baseline values (highlighted in yellow) at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will then lower the threshold by one ppb to 84 ppb. There are nine (9) Baseline values at or above this lower threshold -- still less than the value of ten (10) that specified as the Minimum number of days in baseline at or above threshold. MATS will lower the threshold again by one ppb to 83 ppb. At this point, there are twelve (12) days at or above this threshold.

MATS will take the top 12 days:

Baseline day	Baseline value	Future day	Future value
1	100	1	95
2	100	2	97
3	98	3	94
4	97	4	95
5	95	5	94
6	95	6	93
7	90	7	89
8	85	8	86
9	84	9	80
10	83	10	78

11	83	11	80
12	83	12	81
13	79	13	76
14	78	14	75
15	78	15	74

and then calculate separate averages for the Control and Baseline values:

Control average = 88.5000 ppb

Baseline average = 91.0833 ppb.

The RRF equals the ratio of the Control to the Baseline:

$$\text{RRF} = 88.5000 / 91.0833 = 0.972$$

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.3 RRF Calculation - Example 3

Assume the following default values:

**RRF Setup:**

Initial threshold value (ppb)

Minimum number of days in baseline at or above threshold

Minimum allowable threshold value (ppb)

Min number of days at or above minimum allowable threshold

Enable Backstop minimum threshold for spatial fields

Backstop minimum threshold for spatial fields

Subrange first day of ozone season used in RRF

Subrange last day of ozone season used in RRF

Pair days based on high concentration instead of date.

**Spatial Gradient Setup:**

Start Value

End Value

Assume that there are 15 days of data:

Baseline day	Baseline value	Future day	Future value
1	84	1	83
2	85	2	84
3	85	3	84
4	82	4	82
5	78	5	78
6	76	6	75
7	70	7	72
8	70	8	62
9	70	9	70
10	67	10	62
11	64	11	63
12	63	12	60
13	62	13	62
14	62	14	59
15	59	15	57

MATS will sort the data from high to low based on the Baseline values:

Baseline day	Baseline value	Future day	Future value
2	85	2	84
3	85	3	84
1	84	1	83
4	82	4	82
5	78	5	78
6	76	6	75
7	70	7	72
8	70	8	62
9	70	9	70
10	67	10	62
11	64	11	63
12	63	12	60
13	62	13	62
14	62	14	59
15	59	15	57

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are only two (2) Baseline values at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above

threshold, MATS will then lower the threshold by one ppb to 84 ppb. There are three (3) Baseline values at or above this lower threshold -- still less than the value of ten (10) that specified as the Minimum number of days in baseline at or above threshold. MATS will lower the threshold again by one ppb, and eventually get to the Minimum allowable threshold value of 70 ppb. At this point, there are still only nine (9) days at or above this threshold.

MATS will take the nine days (highlighted in yellow) above the Minimum allowable threshold value and then calculate separate averages for the Control and Baseline values:

$$\text{Control average} = 76.6667 \text{ ppb}$$

$$\text{Baseline average} = 77.7778 \text{ ppb.}$$

The RRF equals the ratio of the Control to the Baseline:

$$\text{RRF} = 76.6667 / 77.7778 = 0.986$$

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.4 RRF Calculation - Example 4

Assume the following default values:

<b>RRF Setup:</b>	
Initial threshold value (ppb)	85
Minimum number of days in baseline at or above threshold	10
Minimum allowable threshold value (ppb)	70
Min number of days at or above minimum allowable threshold	5
<input type="checkbox"/> Enable Backstop minimum threshold for spatial fields	
Backstop minimum threshold for spatial fields	60
Subrange first day of ozone season used in RRF	1
Subrange last day of ozone season used in RRF	153
<input type="checkbox"/> Pair days based on high concentration instead of date.	
<b>Spatial Gradient Setup:</b>	
Start Value	1
End Value	5

Assume that there are 15 days of data:

Baseline day	Baseline value	Future day	Future value
1	67	1	65
2	74	2	73
3	70	3	69
4	68	4	66
5	78	5	77
6	66	6	64
7	66	7	63
8	65	8	63
9	63	9	63
10	62	10	60
11	61	11	61
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

MATS will sort the data sorted from high to low based on the Baseline values:

Baseline day	Baseline value	Future day	Future value
5	78	5	77
2	74	2	73
3	70	3	69
4	68	4	66
1	67	1	65
6	66	6	64
7	66	7	63
8	65	8	63
9	63	9	63
10	62	10	60
11	61	11	61
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are zero (0) Baseline values at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above

threshold, MATS will lower the threshold by one ppb, and eventually get to the Minimum allowable threshold value of 70 ppb.

At this point, there are still only three (3) days at or above this threshold -- still less than the Min number of days at or above minimum allowable. As a result, MATS will not calculate a RRF and will set the future year design value to missing.

**7.4.1.5 RRF Calculation - Example 5**

Rather than assume the MATS default values, assume the Minimum allowable threshold value is 60 ppb:

**RRF Setup:**

Initial threshold value (ppb)

Minimum number of days in baseline at or above threshold

Minimum allowable threshold value (ppb)

Min number of days at or above minimum allowable threshold

Enable Backstop minimum threshold for spatial fields

Backstop minimum threshold for spatial fields

Subrange first day of ozone season used in RRF

Subrange last day of ozone season used in RRF

Pair days based on high concentration instead of date.

**Spatial Gradient Setup:**

Start Value

End Value

Assume that there are 15 days of data:

Baseline day	Baseline value	Future day	Future value
1	67	1	65
2	74	2	73
3	70	3	69
4	68	4	66
5	78	5	77
6	67	6	64
7	66	7	63
8	65	8	63
9	63	9	63

10	62	10	60
11	61	11	61
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

MATS will sort the data from high to low based on the Baseline values:

Baseline day	Baseline value	Future day	Future value
5	78	5	77
2	74	2	73
3	70	3	69
4	68	4	66
1	67	1	65
6	67	6	64
7	66	7	63
8	65	8	63
9	63	9	63
10	62	10	60
11	61	11	61
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are zero (0) Baseline values at or above this threshold. Since there are fewer days than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will lower the threshold by one ppb, and eventually get to the Minimum allowable threshold value of 62 ppb. At this point, there are ten (10) days at or above this threshold.

MATS will take the ten days (highlighted in yellow) above the Minimum allowable threshold value and then calculate separate averages for the Control and Baseline values:

Control average = 66.3000 ppb

Baseline average = 68.0000 ppb.

The RRF equals the ratio of the Control to the Baseline:

$$\text{RRF} = 66.3000 / 68.0000 = 0.975$$

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

#### 7.4.1.6 RRF Calculation Spatial Gradient with Backstop Threshold - Example 6

The following is an example showing the difference between RRFs calculated for Point Estimates and RRFs calculated for Spatial Fields. The key difference is that MATS allows you to choose a **Backstop minimum threshold for spatial fields**, which applies just to Spatial Fields. This extra parameter allows you to calculate RRFs for Spatial Fields exactly as you would for Point Estimates, except in the case when the minimum number of days threshold cannot be met (MATS would return a -9 value for point estimates).

An example of such a case of where the two RRF calculations differ is when the number of days at or above the **Minimum allowable threshold value** is less than the **Minimum number of days at or above minimum allowable threshold**. In this case, MATS would not calculate an RRF for a Point Estimate. However, if the **Backstop minimum threshold for spatial fields** is set to some value lower than the **Minimum allowable threshold value**, then MATS could potentially calculate an RRF for all or most grid cells in a Spatial Field. The backstop minimum threshold allows the minimum threshold to be lowered to a value below the **Minimum allowable threshold value** until the minimum number of days is reached. The backstop threshold is only used for grid cells which do not have enough days to meet the minimum number of days value with the minimum allowable threshold. The backstop threshold does not change the calculation for grid cells that already meet the minimum number of days.

RRF Setup:	
Initial threshold value (ppb)	85
Minimum number of days in baseline at or above threshold	10
Minimum allowable threshold value (ppb)	70
Min number of days at or above minimum allowable threshold	5
<input checked="" type="checkbox"/> Enable Backstop minimum threshold for spatial fields	
Backstop minimum threshold for spatial fields	60
Subrange first day of ozone season used in RRF	1
Subrange last day of ozone season used in RRF	153
<input type="checkbox"/> Pair days based on high concentration instead of date.	
Spatial Gradient Setup:	
Start Value	1
End Value	5

Assume that there are 15 days of data for a grid cell:

Baseline day	Baseline value	Future day	Future value
1	67	1	65
2	74	2	73
3	70	3	69
4	68	4	66
5	78	5	77
6	67	6	64
7	66	7	63
8	65	8	63
9	63	9	63
10	62	11	61
11	61	10	60
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

MATS will sort the data from high to low based on the Baseline values:

Baseline day	Baseline value	Future day	Future value
5	78	5	77
2	74	2	73
3	70	3	69
4	68	4	66
1	67	1	65
6	67	6	64
7	66	7	63
8	65	8	63
9	63	9	63
10	62	11	61
11	61	10	60
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

When you compare these sorted data with the Initial threshold value of 85 ppb, note that there are zero (0) Baseline values at or above this threshold. Since there are fewer days

than the ten (10) specified as the Minimum number of days in baseline at or above threshold, MATS will lower the threshold by one ppb, and eventually get to the Minimum allowable threshold value of 70 ppb.

At this point, there are still only three (3) Baseline values (highlighted in yellow) at or above this lower threshold -- still less than the value of ten (10) that specified as the Minimum number of days in baseline at or above threshold. This fails the test for calculating an RRF for a Point Estimate. However, there is still a possibility that MATS can calculate an RRF for a Spatial Field. MATS just needs to find at least five values

MATS will lower the threshold again by one ppb. At a threshold of 68 ppb, there are four (4) days. MATS will lower the threshold again by one ppb. At a value of 67 ppb, there are six (6) days at or above the Backstop minimum threshold for spatial fields.

Baseline day	Baseline value	Future day	Future value
5	78	5	77
2	74	2	73
3	70	3	69
4	68	4	66
1	67	1	65
6	67	6	64
7	66	7	63
8	65	8	63
9	63	9	63
10	62	11	61
11	61	10	60
12	60	12	59
13	60	13	57
14	59	14	56
15	57	15	55

Since MATS is looking for at least five days, MATS will take these six days (highlighted in yellow) above the Backstop minimum threshold for spatial fields and then calculate separate averages for the Control and Baseline values:

Control average = 70.0000 ppb

Baseline average = 71.4000 ppb.

The RRF equals the ratio of the Control to the Baseline:

$$\text{RRF} = 70.0000 / 71.4000 = 0.980$$

Note that we report the RRF with three digits after the decimal point. The calculation of the Baseline and Control averages does not involve any rounding or truncation.

## 7.4.2 Spatial Gradient Setup

In using a spatial gradient to estimate ozone levels, MATS estimates ozone levels in *unmonitored* locations by using the values of a nearby monitored data scaled by a ratio of model values. The ratio, or spatial gradient, is a mean of model values at the unmonitored location over the mean of the model values at a monitor.

Note that several "nearby" monitors (and their associated model values) are used in the calculation of ozone values at an unmonitored location. MATS uses a process called Voronoi Neighbor Averaging (VNA) to identify these neighbors, and then takes an inverse distance-weighted average of these monitors.

MATS sorts the daily 8-hour maximum ozone values from high to low, averages a certain number of these values (by default the top five), and then uses these averages in the calculation of the spatial gradient. Note that the highest days for Cell A and Cell E are determined independently of each other.

If you want to use a different set of days for the gradient adjustment, you can do so with the **Start Value** and **End Value**. MATS assigns an index of value of 1 to the highest daily 8-hour maximum ozone value in each grid cell. The second-highest an index value of 2. And so on. Using the **Start Value** and the **End Value**, you can identify the values that you want to average by using this index.

### 7.4.2.1 Spatial Gradient Calculation - Example 1

Assume a Start Value of "1" and an End Value of "5":

RRF Setup:	
Initial threshold value (ppb)	85
Minimum number of days in baseline at or above threshold	10
Minimum allowable threshold value (ppb)	70
Min number of days at or above minimum allowable threshold	5
<input type="checkbox"/> Enable Backstop minimum threshold for spatial fields	
Backstop minimum threshold for spatial fields	60
Subrange first day of ozone season used in RRF	1
Subrange last day of ozone season used in RRF	153
<input type="checkbox"/> Pair days based on high concentration instead of date.	
Spatial Gradient Setup:	
Start Value	1
End Value	5

For this example calculation, assume that we have one monitor and we want to use this monitor to estimate the ozone level at the center of a nearby grid cell. Further assume that the monitor resides in grid cell "A" and the we want to estimate the ozone level in grid cell "E".

With the default Start Value equal to one (1) and the default End Value, equal to five (5), MATS will average the five highest daily 8-hour maximum ozone values. Note, however, that the highest days for Cell A and Cell E are determined independently of each other.

Assume that there are 15 days of data:

Day	Cell A	Day	Cell E
1	100	1	68
2	100	2	73
3	98	3	74
4	97	4	78
5	95	5	72
6	95	6	69
7	90	7	77
8	85	8	63
9	84	9	65
10	83	10	61
11	83	11	60
12	83	12	62
13	79	13	58
14	78	14	56
15	78	15	57

MATS will sort the data for cell A from high to low. Independently, MATS will also sort the data for Cell E from high to low. In this example, Day 1 has the highest value for cell A, while the highest value for cell E falls on Day 2.

Day	Cell A	Day	Cell E
1	100	4	78
2	100	7	77
3	98	3	74
4	97	2	73
5	95	5	72
6	95	6	69
7	90	1	68
8	85	9	65
9	84	8	63
10	83	12	62
11	83	10	61
12	83	11	60

13	79	13	58
14	78	15	57
15	78	14	56

MATS will take the top 5 days (highlighted in yellow) and then calculate separate averages for cell A and cell E:

cell E average = 74.8000 ppb

cell A average = 98.0000 ppb.

The [Spatial Gradient](#) equals the ratio of Cell E to Cell A:

Spatial Gradient =  $74.8000 / 98.0000 = 0.763$

Note that we report the Spatial Gradient with three digits after the decimal point. The calculation of the averages does not involve any rounding or truncation.

#### 7.4.2.2 Spatial Gradient Calculation - Example 2

Assume a Start Value of "2" and an End Value of "3":

**RRF Setup:**

Initial threshold value (ppb)

Minimum number of days in baseline at or above threshold

Minimum allowable threshold value (ppb)

Min number of days at or above minimum allowable threshold

Enable Backstop minimum threshold for spatial fields

Backstop minimum threshold for spatial fields

Subrange first day of ozone season used in RRF

Subrange last day of ozone season used in RRF

Pair days based on high concentration instead of date.

**Spatial Gradient Setup:**

Start Value

End Value

For this example calculation, assume that we have one monitor and we want to use this monitor to estimate the ozone level at the center of a nearby grid cell. Further assume that the monitor resides in grid cell "A" and the we want to estimate the ozone level in grid cell

"E".

With the default Start Value equal to two (2) and the default End Value, equal to three (3), MATS will average the second and third highest daily 8-hour maximum ozone values.

Assume that there are 15 days of data:

Day	Cell A	Day	Cell E
1	100	1	68
2	100	2	73
3	98	3	74
4	97	4	78
5	95	5	72
6	95	6	69
7	90	7	77
8	85	8	63
9	84	9	65
10	83	10	61
11	83	11	60
12	83	12	62
13	79	13	58
14	78	14	56
15	78	15	57

MATS will sort the data for cell A from high to low. Independently, MATS will also sort the data for Cell E from high to low.

Day	Cell A	Day	Cell E
1	100	4	78
2	100	7	77
3	98	3	74
4	97	2	73
5	95	5	72
6	95	6	69
7	90	1	68
8	85	9	65
9	84	8	63
10	83	12	62
11	83	10	61
12	83	11	60
13	79	13	58
14	78	15	57
15	78	14	56

MATS will take the second and third highest days (highlighted in yellow) and then

calculate separate averages for cell A and cell E:

cell E average = 75.5000 ppb

cell A average = 99.0000 ppb.

The [Spatial Gradient](#) equals the ratio of Cell E to Cell A:

Spatial Gradient =  $75.5000 / 99.0000 = 0.763$

Note that we report the Spatial Gradient with three digits after the decimal point. The calculation of the averages does not involve any rounding or truncation.

### 7.4.2.3 Spatial Gradient Calculation - Example 3

Assume a Start Value of "4" and an End Value of "4":

RRF Setup:	
Initial threshold value (ppb)	85
Minimum number of days in baseline at or above threshold	10
Minimum allowable threshold value (ppb)	70
Min number of days at or above minimum allowable threshold	5
<input checked="" type="checkbox"/> Enable Backstop minimum threshold for spatial fields	
Backstop minimum threshold for spatial fields	60
Subrange first day of ozone season used in RRF	1
Subrange last day of ozone season used in RRF	153
<input type="checkbox"/> Pair days based on high concentration instead of date.	
Spatial Gradient Setup:	
Start Value	4
End Value	4

For this example calculation, assume that we have one monitor and we want to use this monitor to estimate the ozone level at the center of a nearby grid cell. Further assume that the monitor resides in grid cell "A" and the we want to estimate the ozone level in grid cell "E".

With the default Start Value equal to four (4) and the default End Value, equal to four (4), MATS will only use the fourth highest daily 8-hour maximum ozone value in each grid cell.

Assume that there are 15 days of data:

Day	Cell A	Day	Cell E
1	100	1	68
2	100	2	73
3	98	3	74
4	97	4	78
5	95	5	72
6	95	6	69
7	90	7	77
8	85	8	63
9	84	9	65
10	83	10	61
11	83	11	60
12	83	12	62
13	79	13	58
14	78	14	56
15	78	15	57

MATS will sort the data for cell A from high to low. Independently, MATS will also sort the data for Cell E from high to low.

Day	Cell A	Day	Cell E
1	100	4	78
2	100	7	77
3	98	3	74
4	97	2	73
5	95	5	72
6	95	6	69
7	90	1	68
8	85	9	65
9	84	8	63
10	83	12	62
11	83	10	61
12	83	11	60
13	79	13	58
14	78	15	57
15	78	14	56

MATS will take the fourth highest day (highlighted in yellow) for cell A and cell E:

cell E = 73 ppb

cell A = 97 ppb.

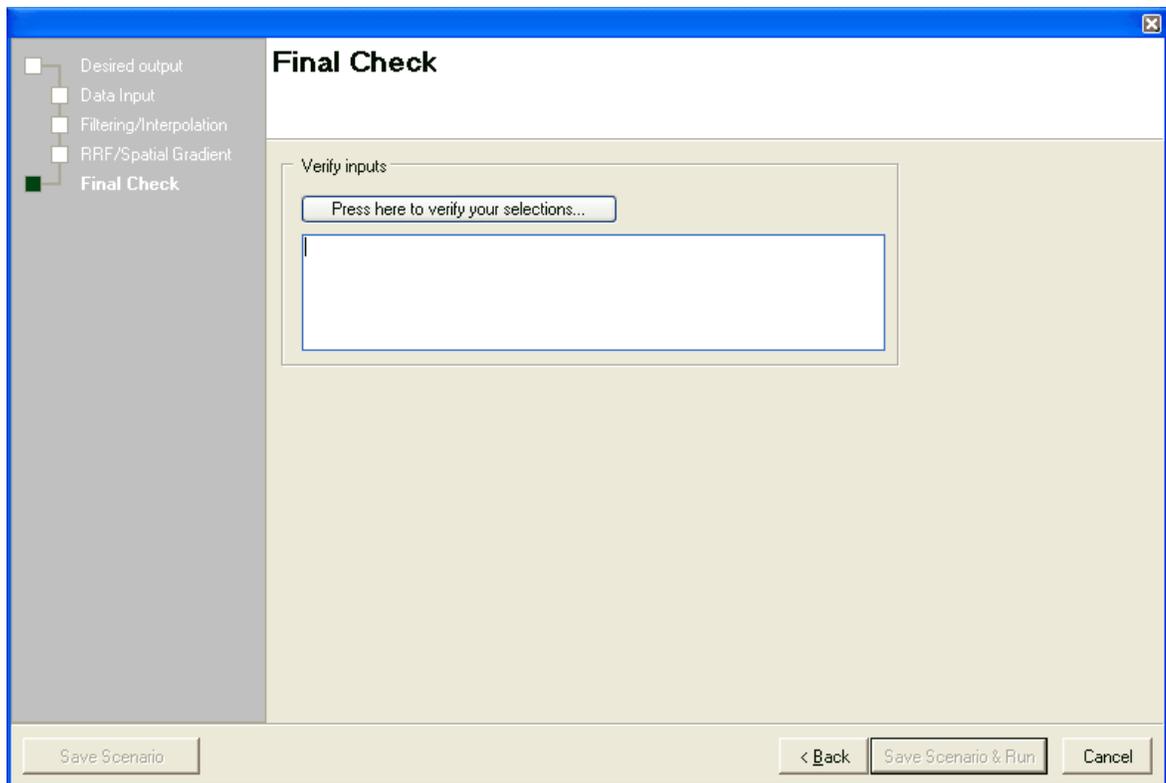
The [Spatial Gradient](#) equals the ratio of Cell E to Cell A:

$$\text{Spatial Gradient} = 73 / 97 = 0.753$$

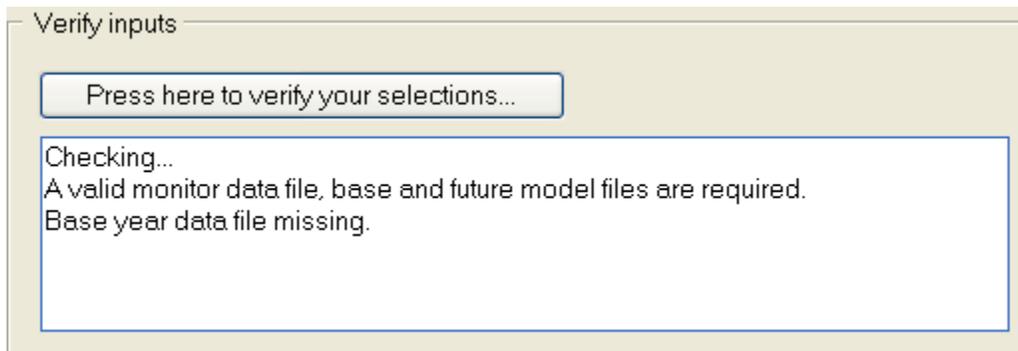
Note that we report the Spatial Gradient with three digits after the decimal point.

## 7.5 Final Check

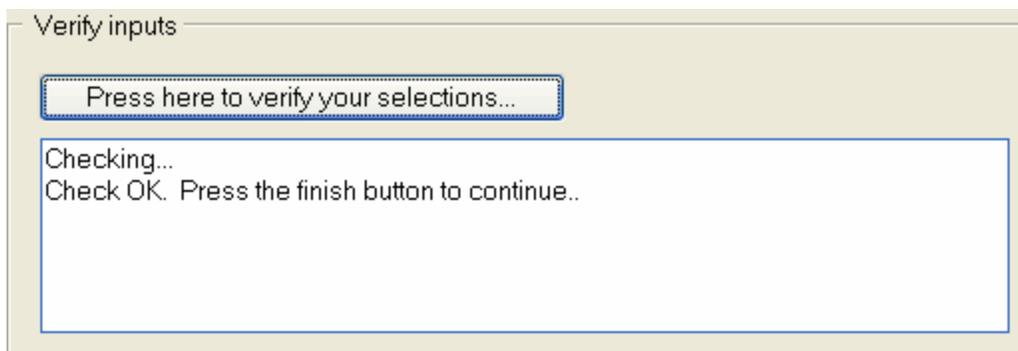
The **Final Check** window verifies the selections that you have made.



Click the button **Press here to verify your selections**. If there are any errors, MATS will present a message letting you know. For example, if the path to a model file is invalid -- perhaps you misspelled the file name -- you would get the following error:



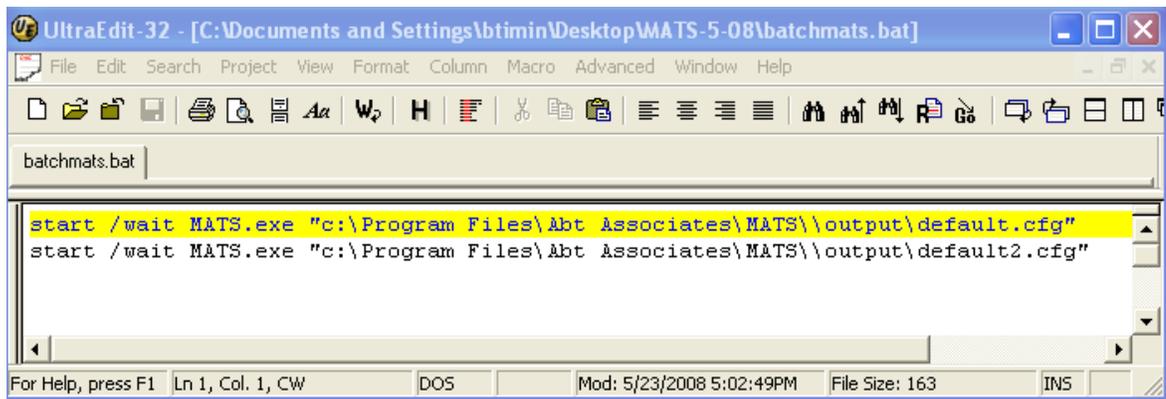
After making the necessary correction, click the button **Press here to verify your selections.** .



When your window looks like the window above, click either **Save Scenario & Run** or **Save Scenario**. Save Scenario & Run will cause MATS to immediately run the scenario.

### 7.5.1 Running MATS in Batch Mode

The **Save Scenario** button will save the scenario as a configuration file (.cfg file). The "\*.cfg" file will be saved in the .\MATS\output directory. Several .cfg files can be created with the MATS interface and run later in batch mode. To do this, edit the default batch file located in the .\MATS directory. The file "batchmats.bat" should be edited with a text editor to point to the name and location of the .cfg files that will be run in batch mode.



```
UltraEdit-32 - [C:\Documents and Settings\btimin\Desktop\MATS-5-08\batchmats.bat]
File Edit Search Project View Format Column Macro Advanced Window Help
batchmats.bat
start /wait MATS.exe "c:\Program Files\Abt Associates\MATS\output\default.cfg"
start /wait MATS.exe "c:\Program Files\Abt Associates\MATS\output\default2.cfg"
For Help, press F1 Ln 1, Col. 1, CW DOS Mod: 5/23/2008 5:02:49PM File Size: 163 INS
```

After editing the batchmats.bat file, simply run the .bat file. MATS will start and run in the background.

## 8 Visibility Analysis: Quick Start Tutorial

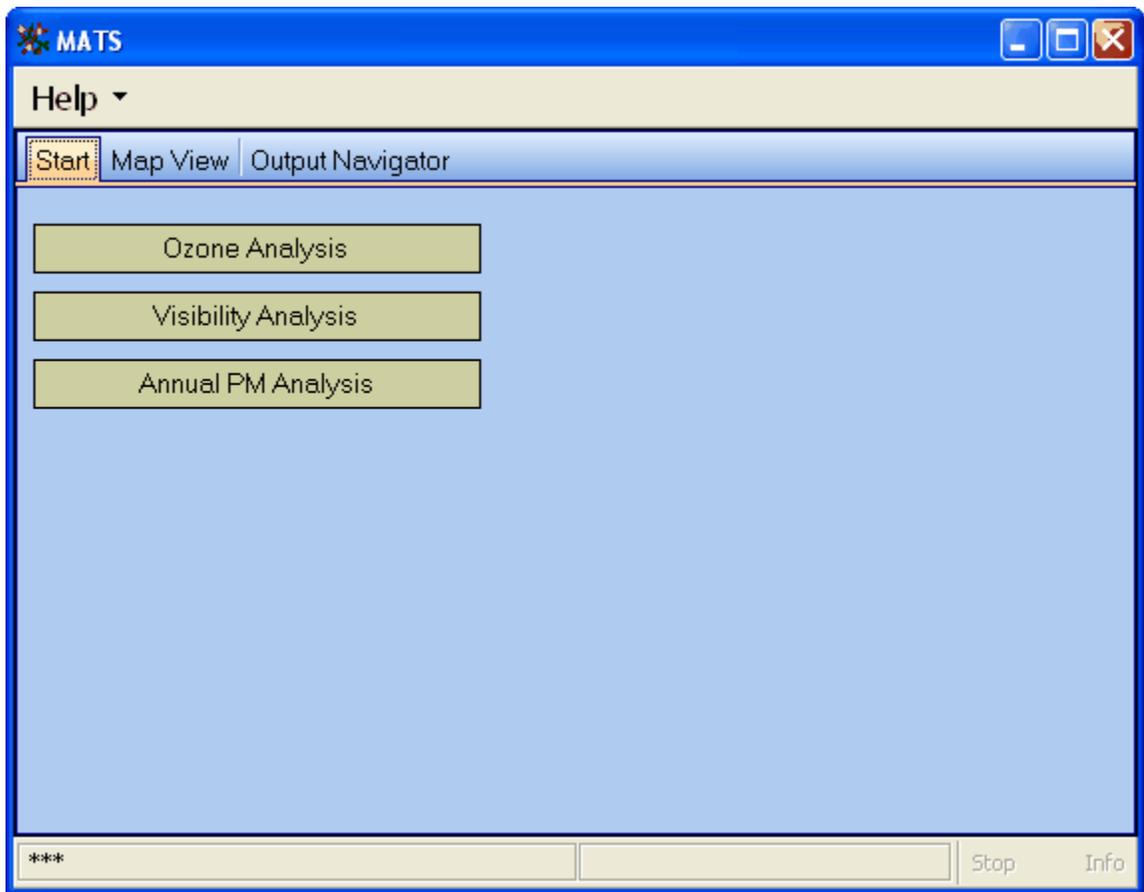
In this tutorial you will forecast visibility levels at [Class I Areas](#) in the United States. The steps in this analysis are as follows:

- [Step 1. Start MATS](#). Start the MATS program and choose to do a Visibility analysis.
- [Step 2. Output Choice](#). Choose the output to generate. In this example, you will forecast visibility levels using the new [IMPROVE algorithm](#) and model data at the IMPROVE monitors.
- [Step 3. Data Input](#). Choose the data files for input to MATS.
- [Step 4. Filtering](#). Choose the years of monitor and model data that you want to use, and then choose the particular monitors in these data that you want to include in the analysis.
- [Step 5. Final Check](#). Verify the choices you have made.
- [Step 6. Load & Map Results](#). Load your results and prepare maps of your forecasts.
- [Step 7. Working with Configuration File](#). Examine the Configuration file that stores the choices that you made underlying your analysis.

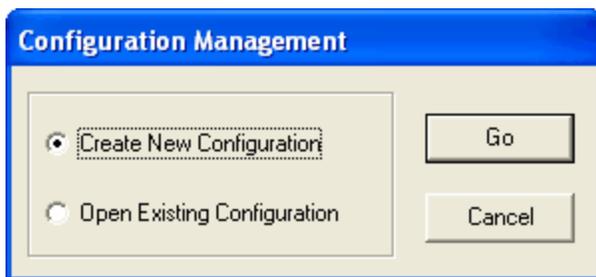
Each step is explained in detail below. Additional details are provided in the section [Visibility Analysis: Details](#).

### 8.1 Step 1. Start MATS

Double-click on the MATS icon on your desktop, and the following window will appear:



Click the **Visibility Analysis** button on the main MATS window. This will bring up the **Configuration Management** window.



A [Configuration](#) allows you to keep track of the choices that you make when using MATS. For example, after generating results in MATS, you can go back, change one of your choices, rerun your analysis, and then see the impact of this change without having to enter in all of your other choices. For this example, we will start with a new Configuration.

Choose **Create New Configuration** and click the **Go** button. This will bring up the [Choose Desired Output](#) window.

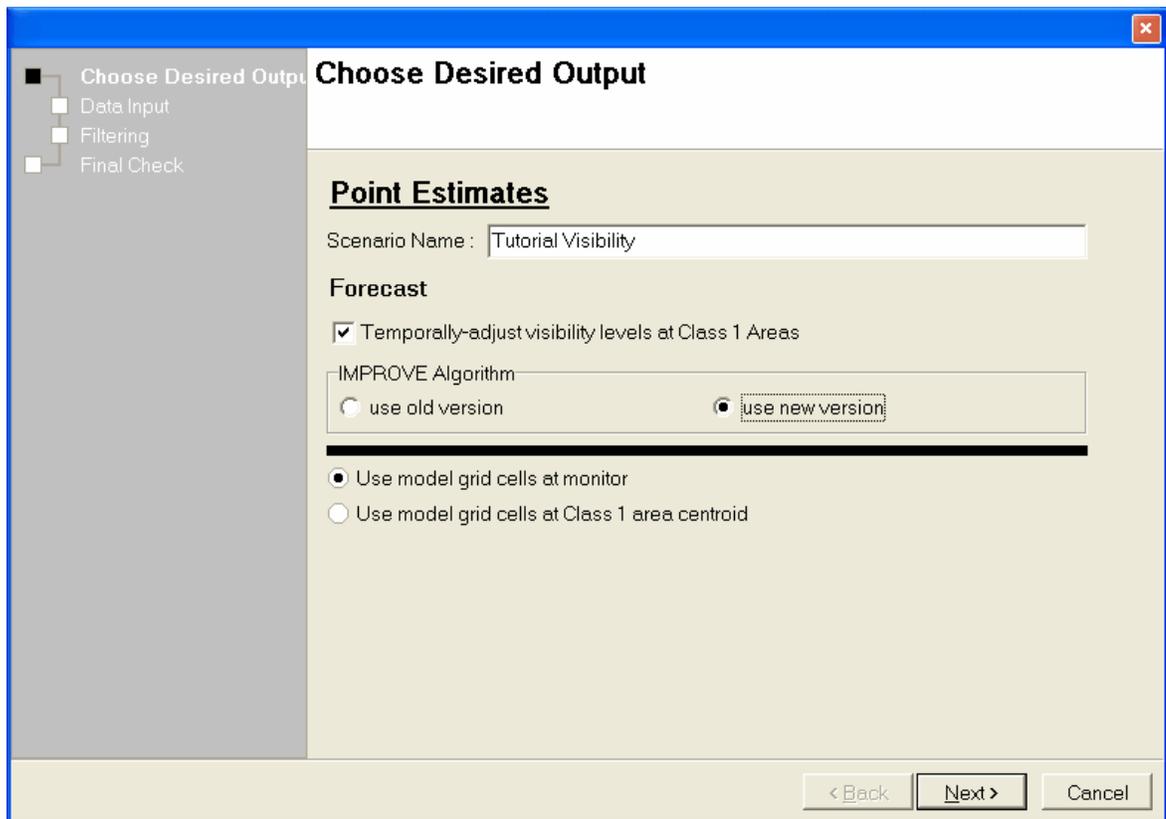
## 8.2 Step 2. Output Choice

The Choose Desired Output window allows you to choose the output that you would like to generate. MATS allows you to calculate future year (forecast) visibility levels at [Class I Areas](#).

In the **Scenario Name** box type "Tutorial Visibility" – this will be used to keep track of where your results are stored and the variable names used in your results files. Leave the box checked next to **Temporally-adjust visibility levels at Class I Areas**. MATS will create forecasts for each Class I Area in your modeling domain.

MATS provides two algorithms for calculating visibility -- an "*old version*" and a "*new version*" of the IMPROVE visibility algorithm ([see IMPROVE 2006](#)) (The old and new versions are discussed in [Desired Output](#) section of the [Visibility Analysis: Details](#) chapter.) Choose the new version.

A single IMPROVE monitor is associated with each Class I Area. MATS multiplies the monitor value with a [relative response factor \(RRF\)](#), which is the modeled future-year visibility divided the modeled current-year visibility. In calculating the RRF, MATS allows you to use either the model values in the grid cell at the IMPROVE monitor or to use the model values in the grid cell at the Class I Area centroid. Choose the default option of using model values in the grid cell at the monitor. (For additional details see the [Desired Output](#) section of the [Visibility Analysis: Details](#) chapter.)



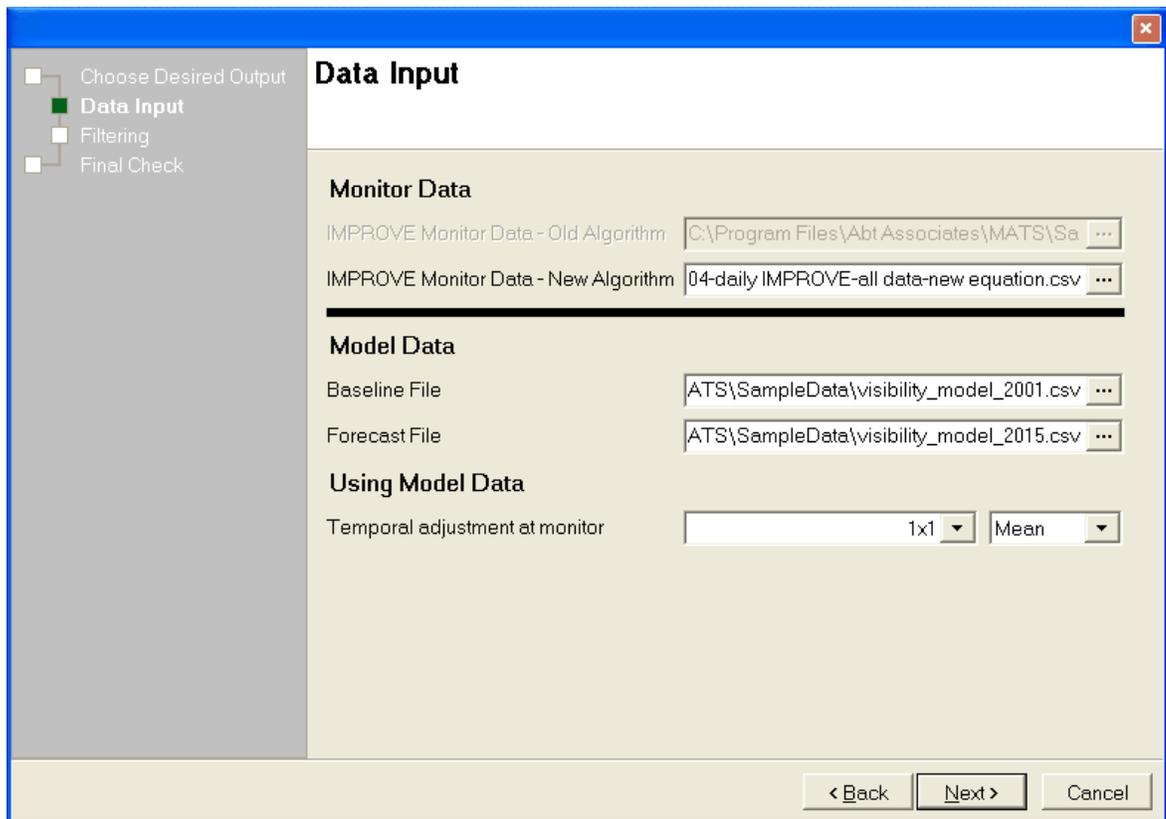
When your window looks like the window above, click **Next**. This will bring up the [Data Input](#) window.

### 8.3 Step 3. Data Input

The **Data Input** window allows you to choose the monitor data and the model data that you want to use. As discussed in more detail in the [Visibility Analysis: Details](#) chapter, MATS calculates the ratio of the model data to calculate a [relative response factor \(RRF\)](#) for the 20% best and 20% worst visibility days separately. MATS then multiplies the visibility level measured at the monitor for the best days with the RRF for the best days to calculate a future-year estimate for visibility on the best visibility days. MATS performs an analogous calculation for the worst visibility days.

MATS comes loaded with IMPROVE visibility monitor values from 2000 through 2004. It also comes loaded with an example model output dataset for visibility for 2001 and 2015. These are the key ingredients for creating your visibility forecasts.

Use the default settings in the **Data Input** window. The window should look like the following:



Note that MATS gives you the option to use model data in different ways when calculating forecasts at each monitor. The example model datasets are at 36km resolution. Therefore, the default is to use a 1x1 array of model cells around each monitor. This is described in more detail in the [Using Model Data](#) section of the [Visibility Analysis: Details](#) chapter.

When your window looks like the window above, click **Next**. This brings up the visibility [Filtering](#) window.

## 8.4 Step 4. Filtering

The **Filtering** window has two sets of functions. The first involves identifying the years of monitor and model data that you want to use. The second involves identifying the particular monitors in these data that you want to include in the analysis. Use the default settings pictured in the screenshot below.

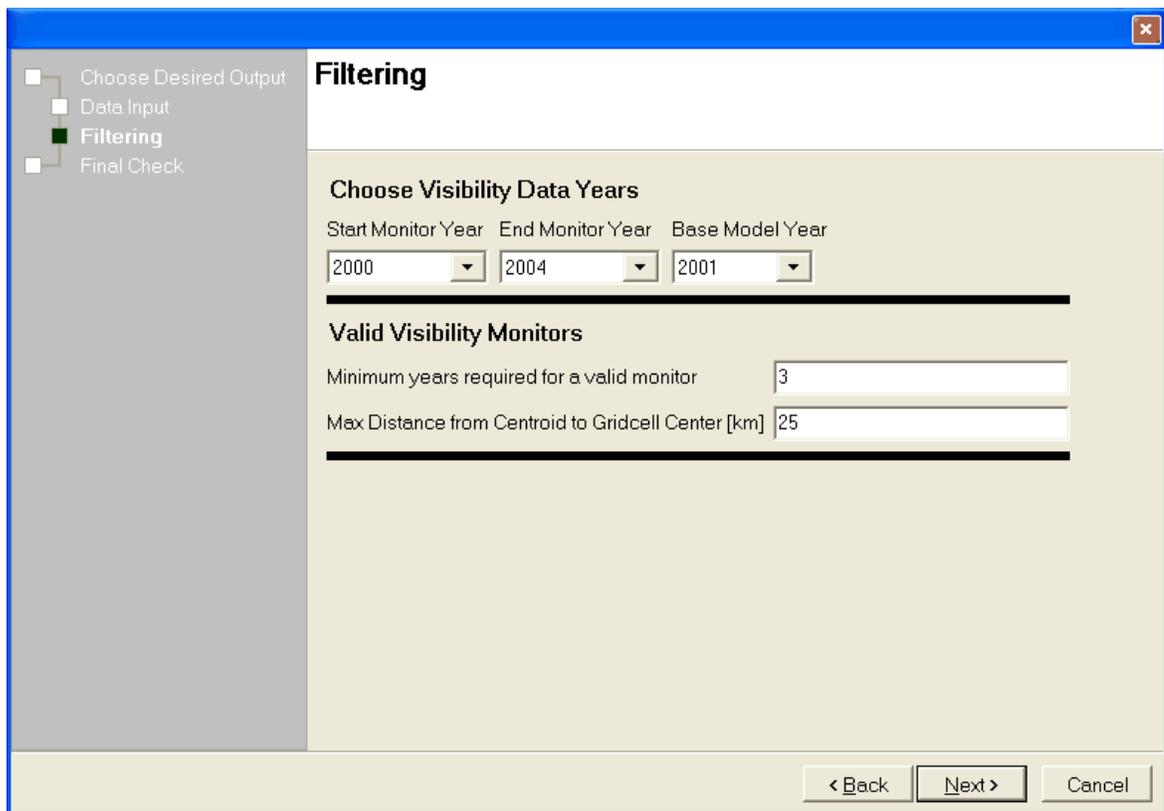
### Choose Visibility Data Years

- Specify the range of visibility monitor data that you want to use. The default is to use all of the available data: 2000 through 2004. (That is, **Start Monitor Year** set to 2000 and **End Monitor Year** set to 2004.)
- Choose the **Base Model Year**. This should match the meteorological year that is being

modeled. It should fall within the range specified by the Start Monitor Year and the End Monitor Year. The **Base Model Year** for the example dataset is *2001*.

**Valid Visibility Monitors**

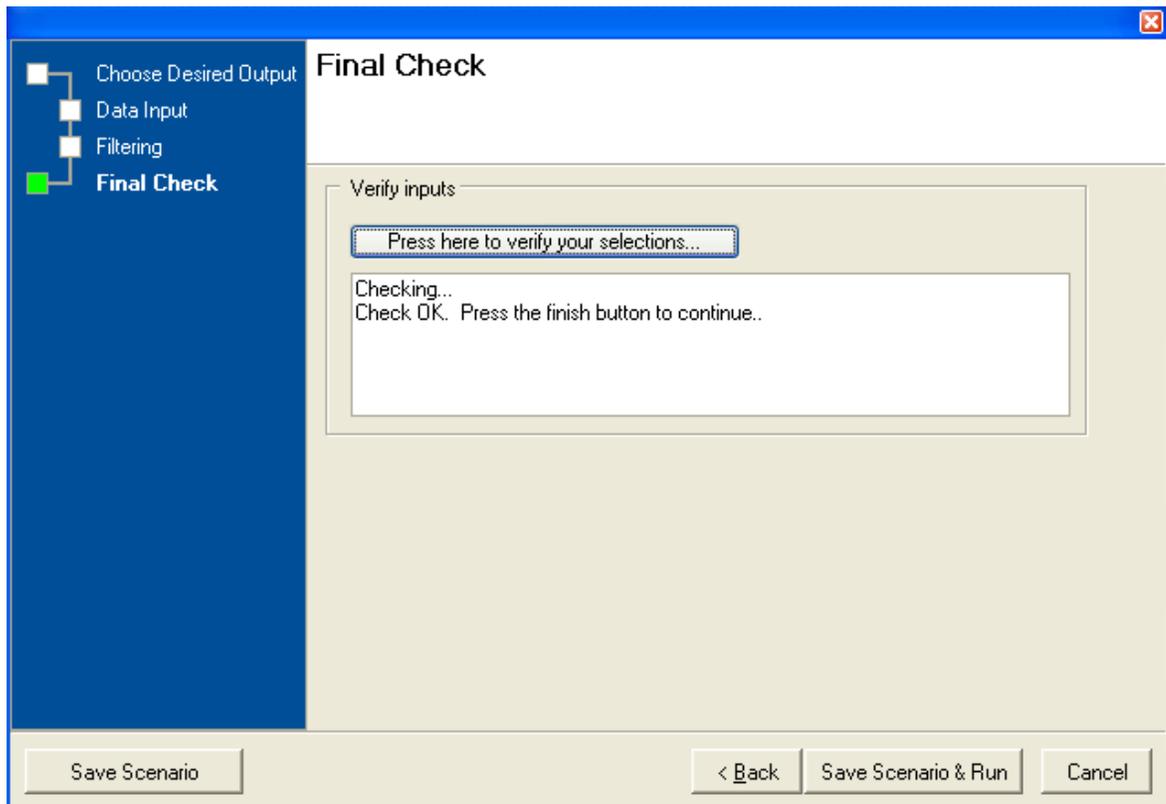
- Identify the monitors that you want to include in the analysis. First, specify the **Minimum years required for a valid monitor**. MATS excludes from the analysis any monitors with fewer than the **Minimum years required for a valid monitor**. The default value is 3 years.
- Specify the **Maximum Distance from Domain [km]**. Monitors that are further than the **Maximum Distance from Domain [km]** are excluded from the analysis. The default value is 25 kilometers (km).



**8.5 Step 5. Final\_Check**

The **Final Check** window verifies the choices that you have made. For example, it makes sure that the paths specified to each of the files used in your [Configuration](#) are valid.

Click on the **Press here to verify selections** button.

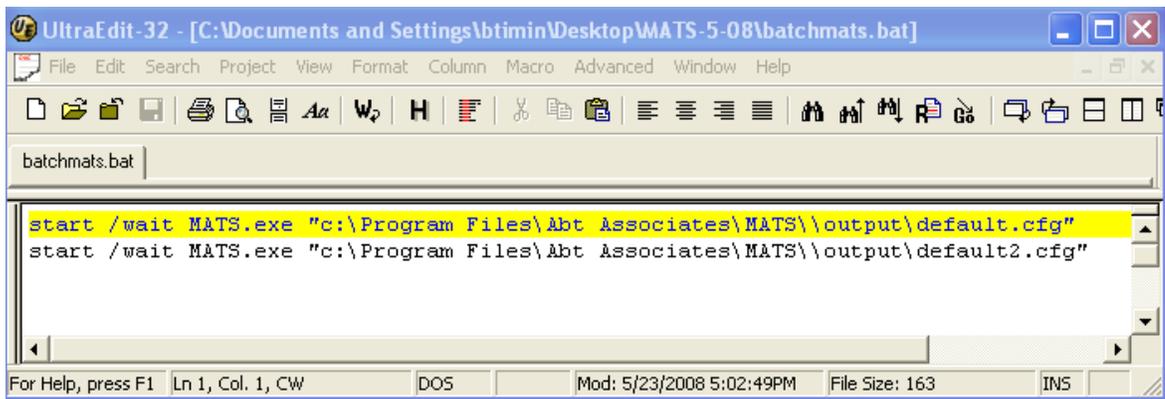


If you encounter any errors, go back to the choices you have previously made by clicking on the appropriate part (e.g., [Data Input](#)) of the tree in the left panel, and then make any changes required.

When your window looks like the window above, click either **Save Scenario & Run** or **Save Scenario**. Save Scenario & Run will cause MATS to immediately run the scenario.

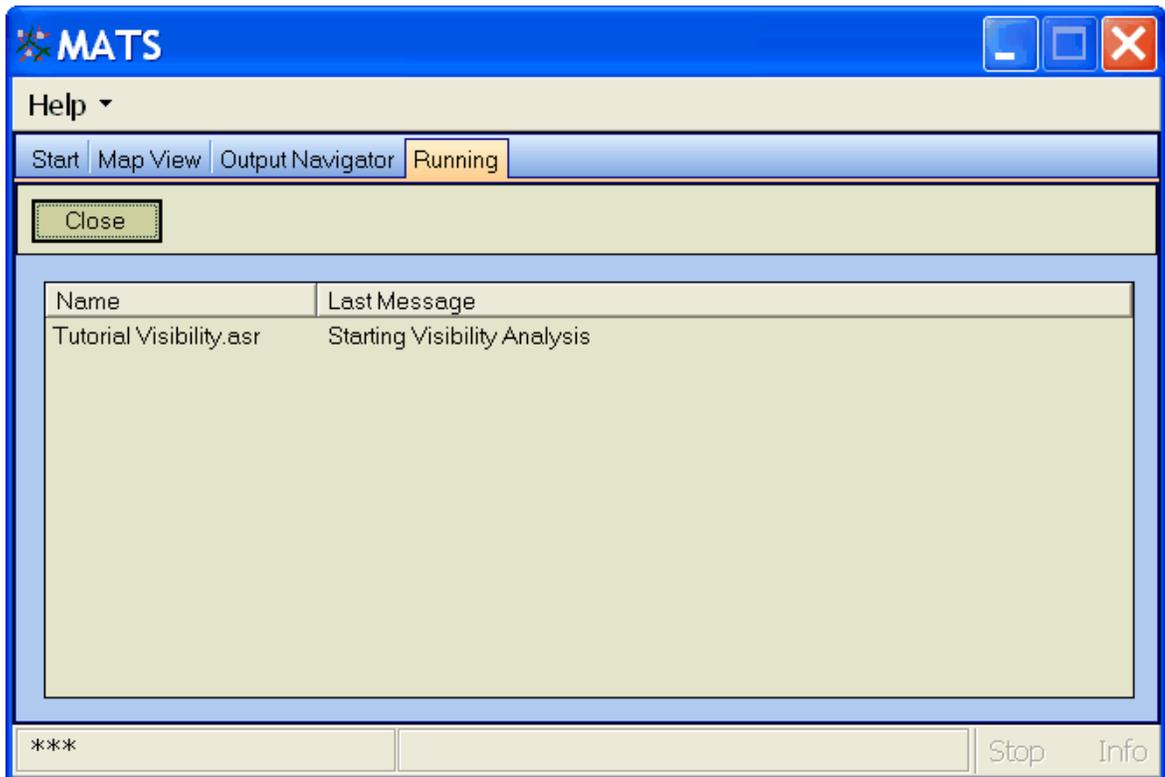
### Running MATS in Batch Mode

The **Save Scenario** button will save the scenario as a configuration file (.cfg file). The "\*.cfg" file will be saved in the .\MATS\output directory. Several .cfg files can be created with the MATS interface and run later in batch mode. To do this, edit the default batch file located in the .\MATS directory. The file "batchmats.bat" should be edited with a text editor to point to the name and location of the .cfg files that will be run in batch mode.



After editing the batchmats.bat file, simply run the .bat file. MATS will start and run in the background.

A temporary, new **Running** tab will appear (in addition to the **Start**, [Map View](#) and [Output Navigator](#) tabs).

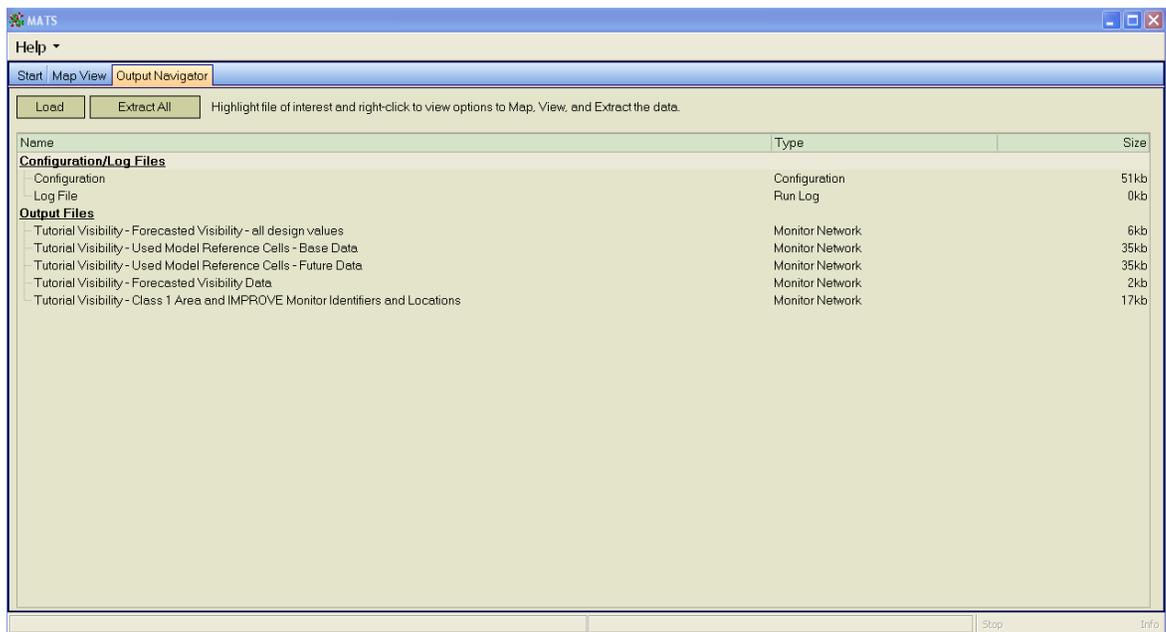


Note that MATS is very computation-intensive, so if you try to work with other programs in addition they may run very slowly. When the calculations are complete, a small window

indicating the results are **Done** will appear. Click **OK**.



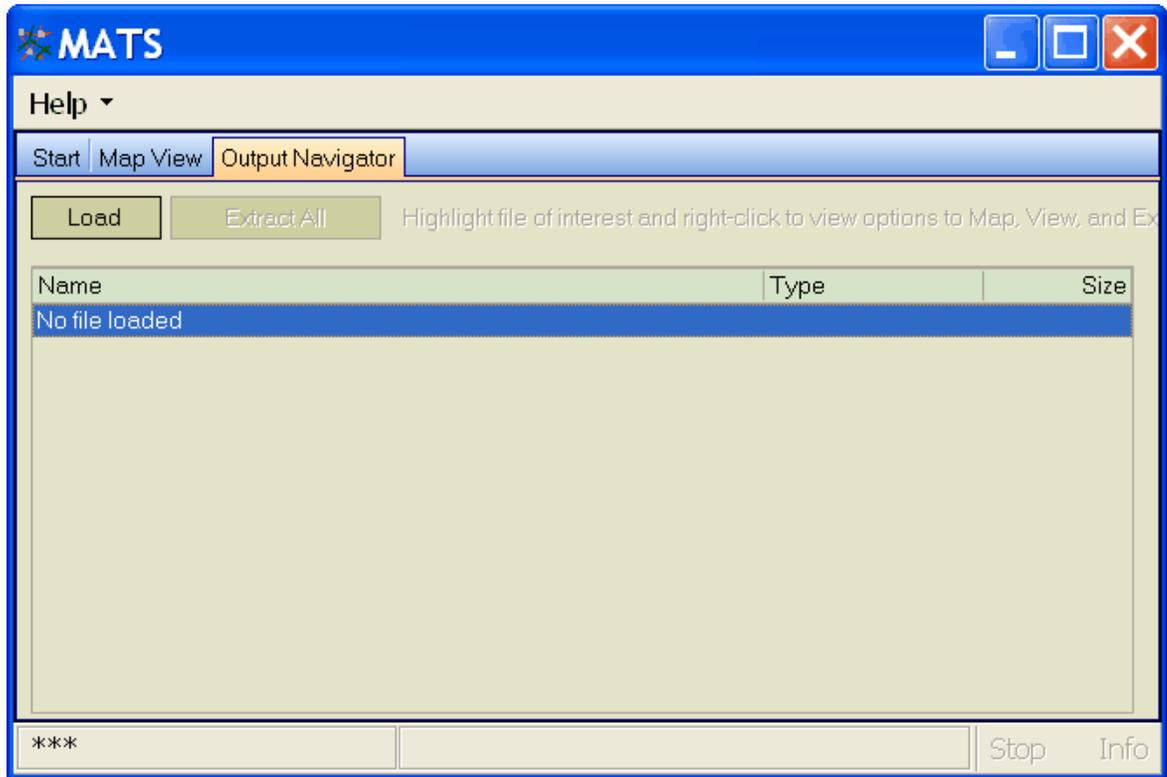
After clicking **OK**, the **Output Navigator** tab will be active. (The **Running** tab will no longer be seen.). MATS will automatically load the output files associated with the .asr configuration that just finished running.



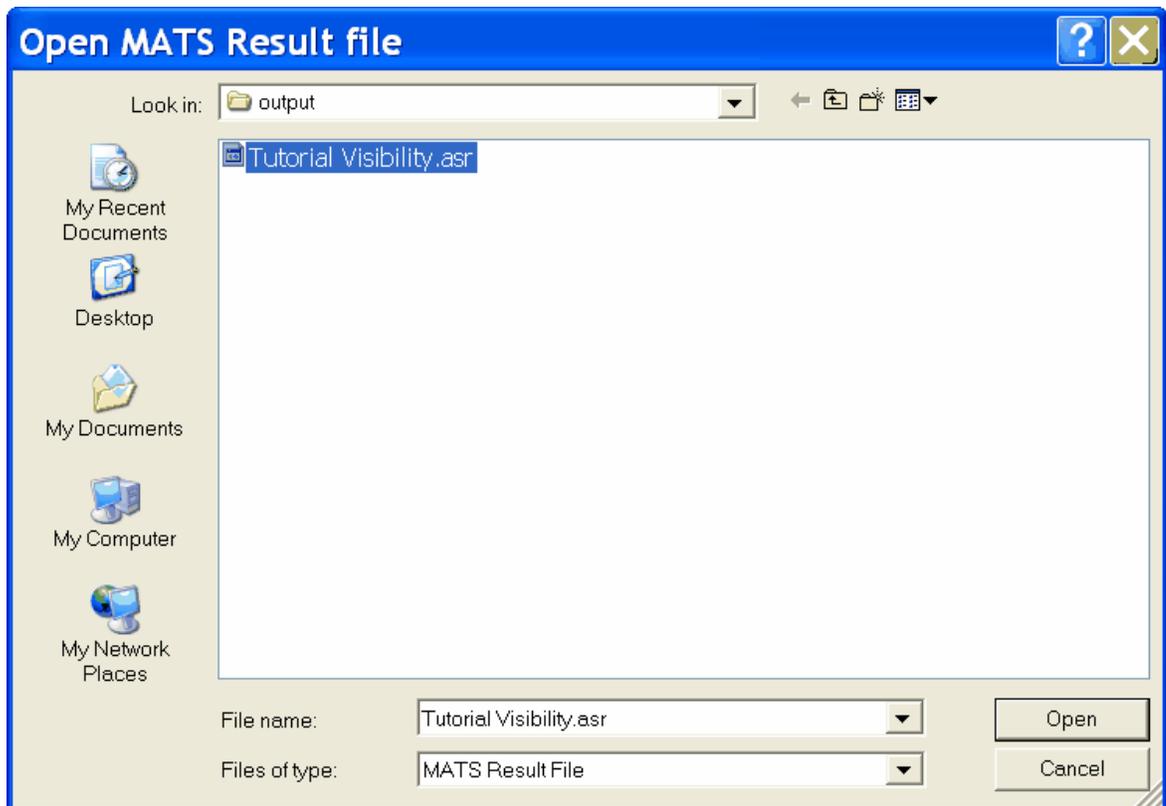
The next step ([click here](#)) shows you how to map your results with the **Output Navigator**. For more details on mapping and other aspects of the **Output Navigator**, there is a separate chapter on the [Output Navigator](#).

## 8.6 Step 6. Load and Map Results

The **Output Navigator** tab allows you to look at and export your results in table form or as a map. To start, make sure that the **Output Navigator** tab is active by simply clicking on the tab.



Click on the **Load** button and choose the *Tutorial Visibility.asr* file.



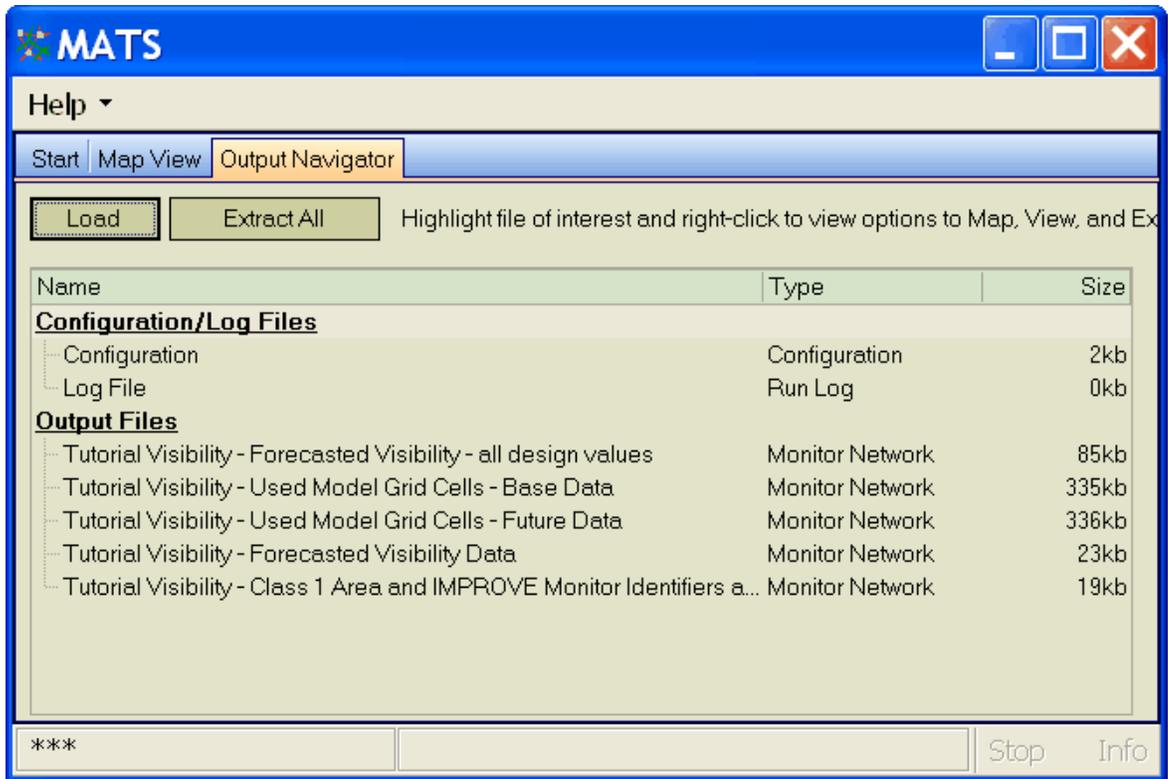
Under **Configuration/Log Files**, you will see two files:

- [Configuration](#): keeps track of the assumptions that you have made in your analysis.
- [Log File](#): provides information on a variety of technical aspects regarding how a results file (\*.ASR) was created.

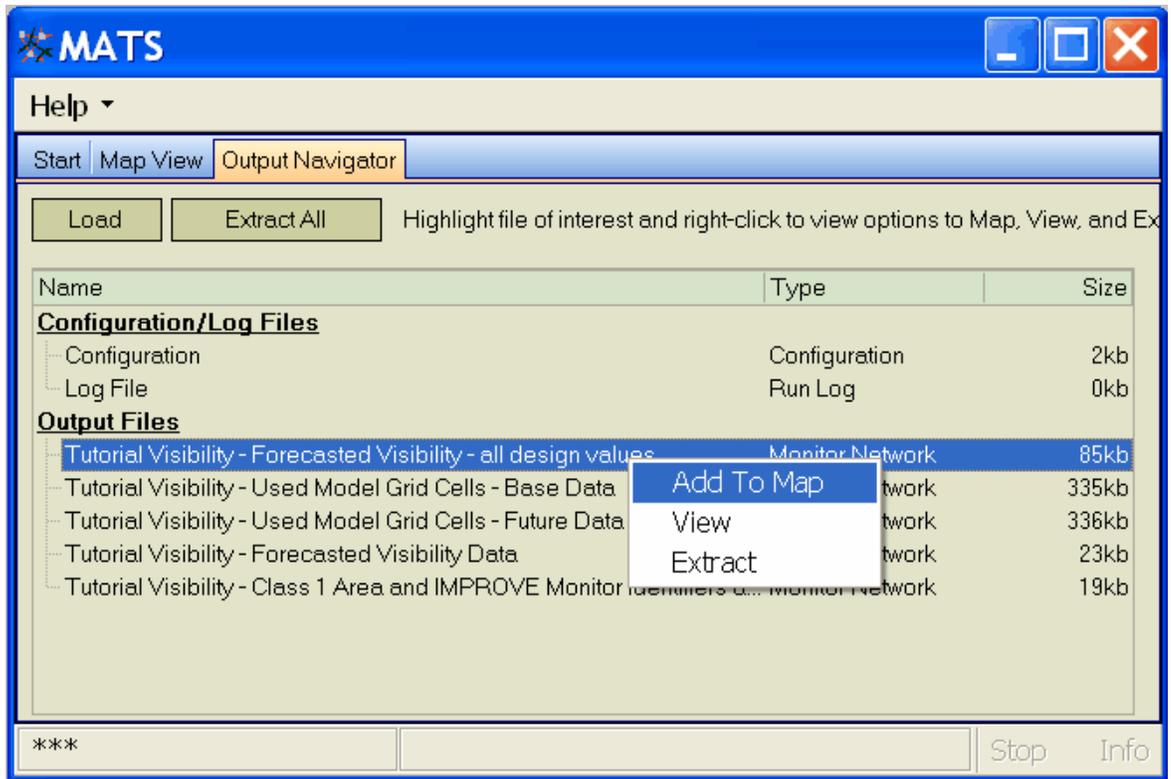
Under **Output Files** you will see:

- *Tutorial Visibility - Forecasted Visibility - all design values*: baseline and forecasted visibility levels for the best and worst days for each year of the five year base period.
- *Tutorial Visibility - Used Model Grid Cells - Base Data*: baseline model values for PM species for the grid cells and days used in the RRF calculations.
- *Tutorial Visibility - Used Model Grid Cells - Future Data*: future-year model values for PM species for the grid cells and days used in the RRF calculations.
- *Tutorial Visibility - Forecasted Visibility Data*: baseline and forecasted deciview values for the best and worst days (averaged across up to five years). Also includes species-specific [relative response factors](#) for the best and worst days.
- *Tutorial Visibility - Class 1 Area and IMPROVE Monitor Identifiers and Locations*:

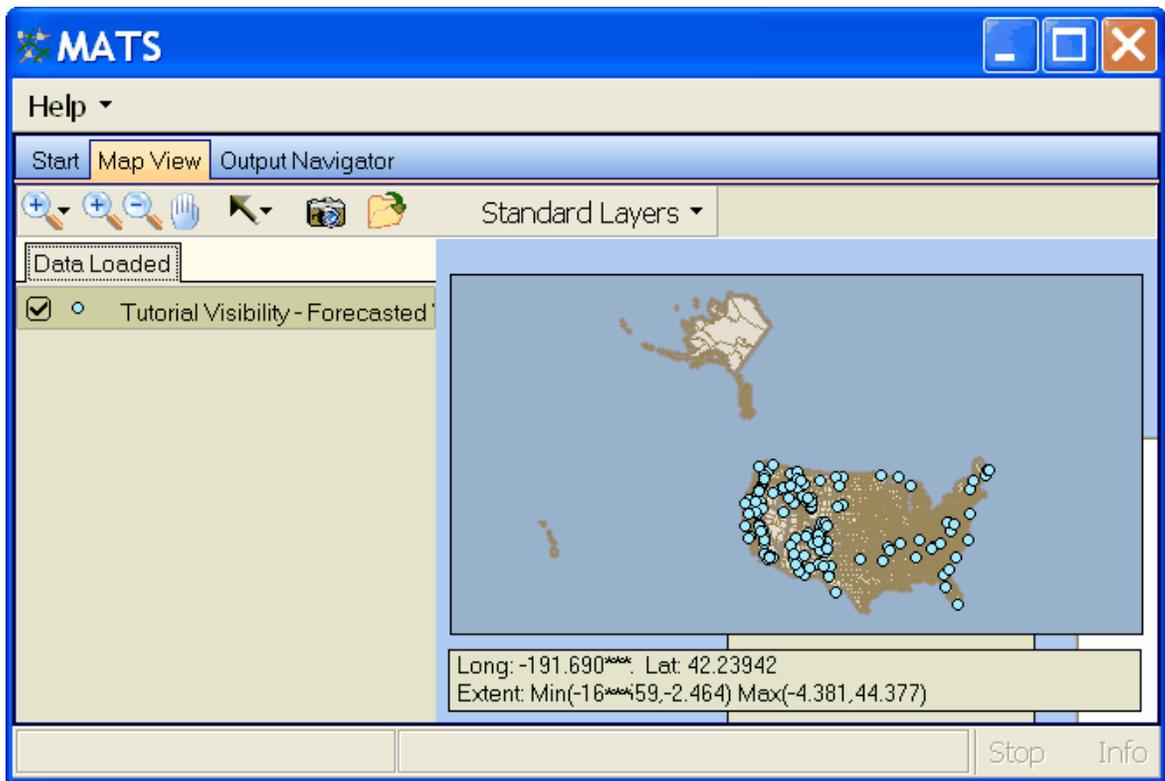
monitor latitude and longitude.



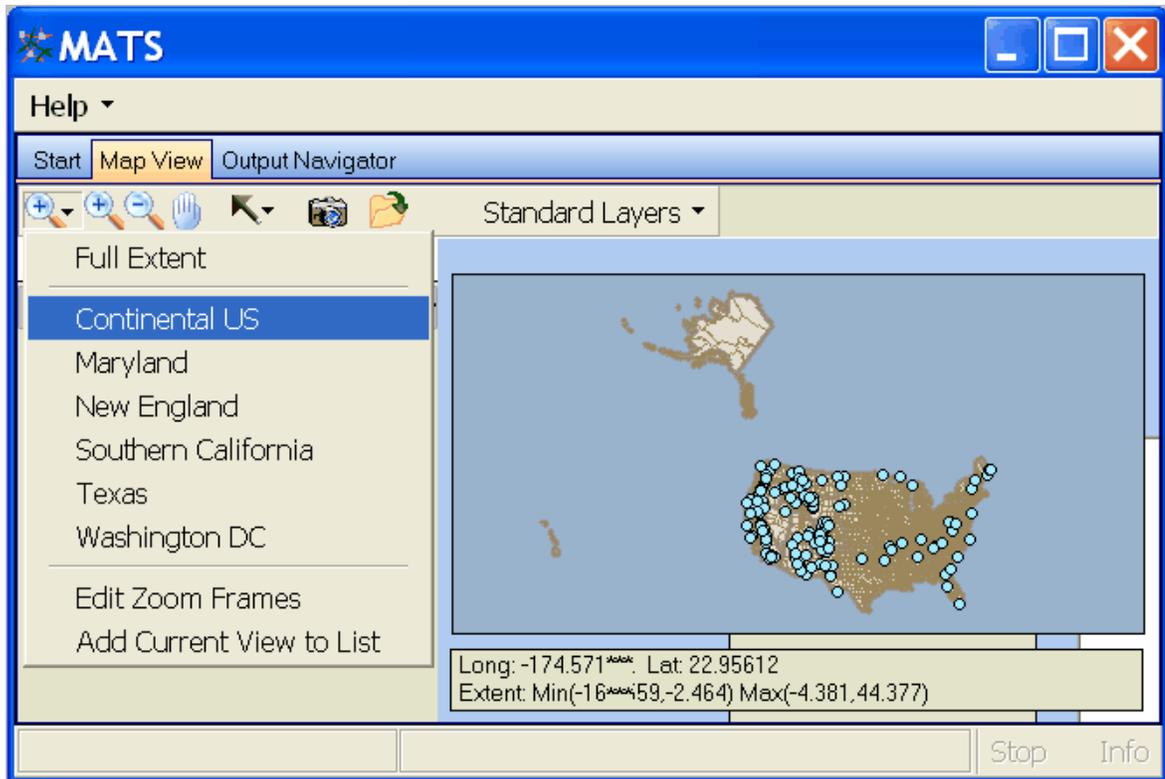
Right-click on the file *Tutorial Visibility - Forecasted Visibility Data*. This gives you three options: *Add to Map*, *View*, and *Extract*. Choose the *Add to Map* option.



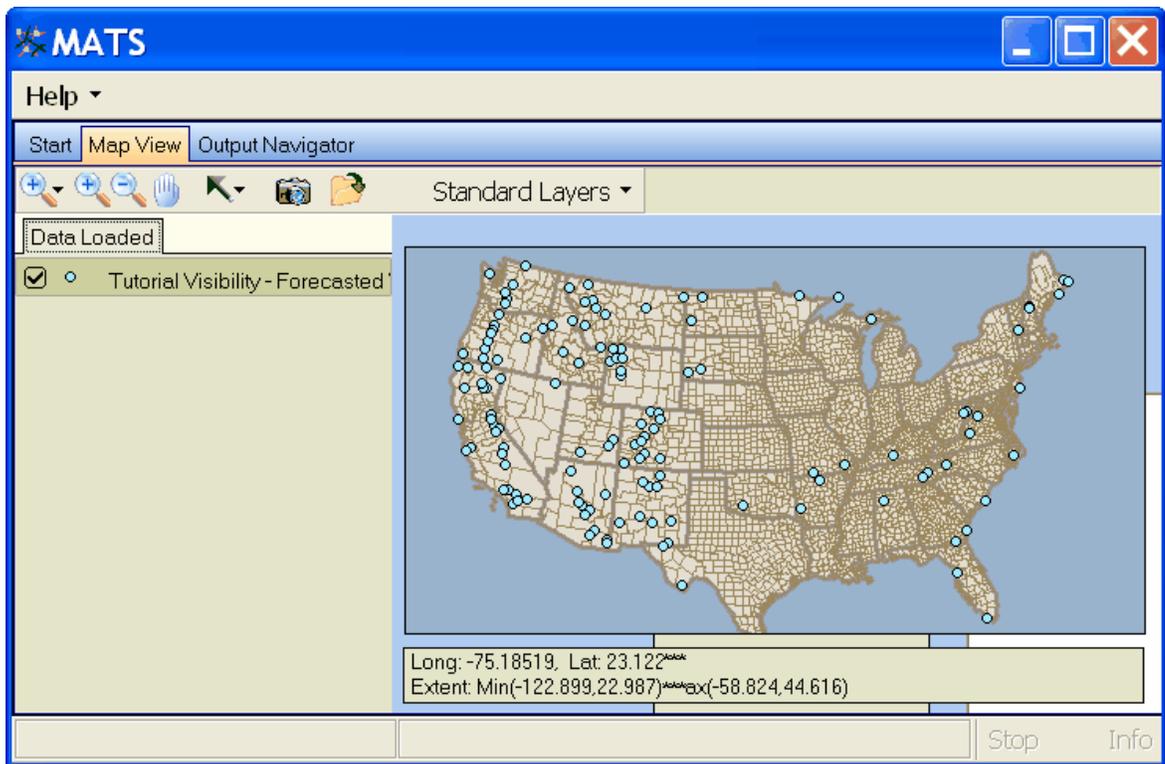
This will bring up the **Map View**.



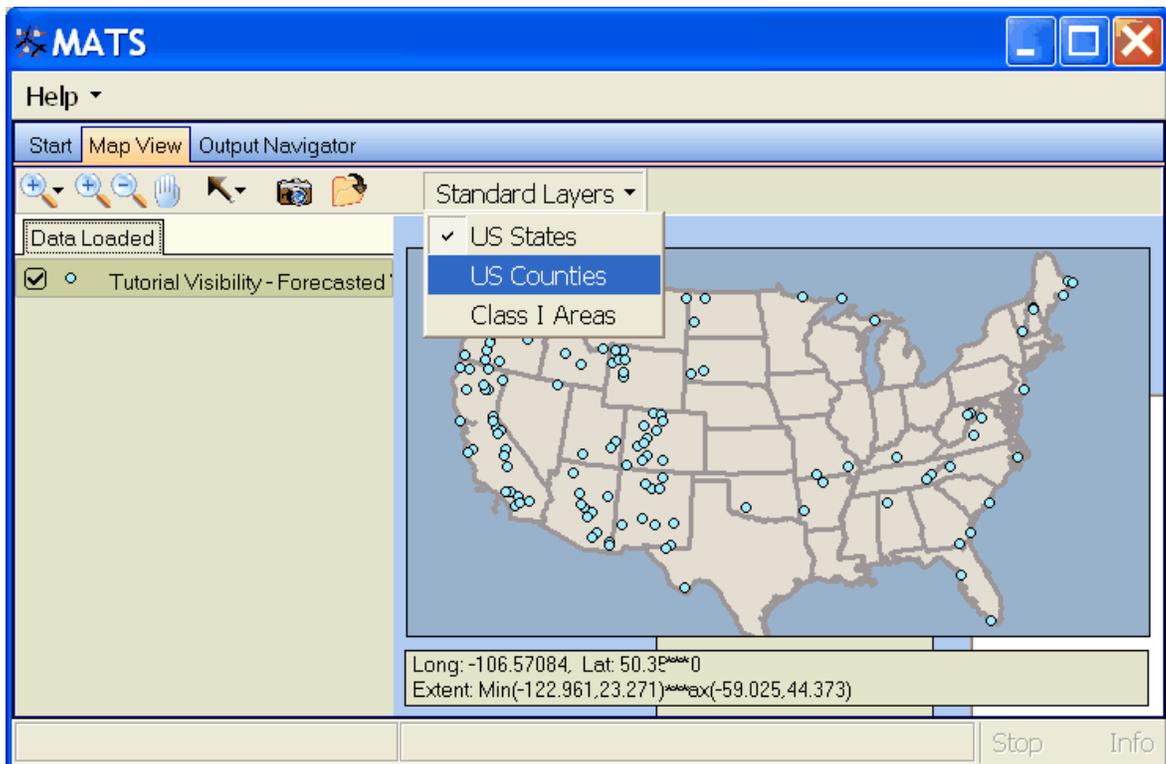
To view an enlarged map, use the **Zoom to an area** Task Bar button on the far left. Choose the *Continental US*.



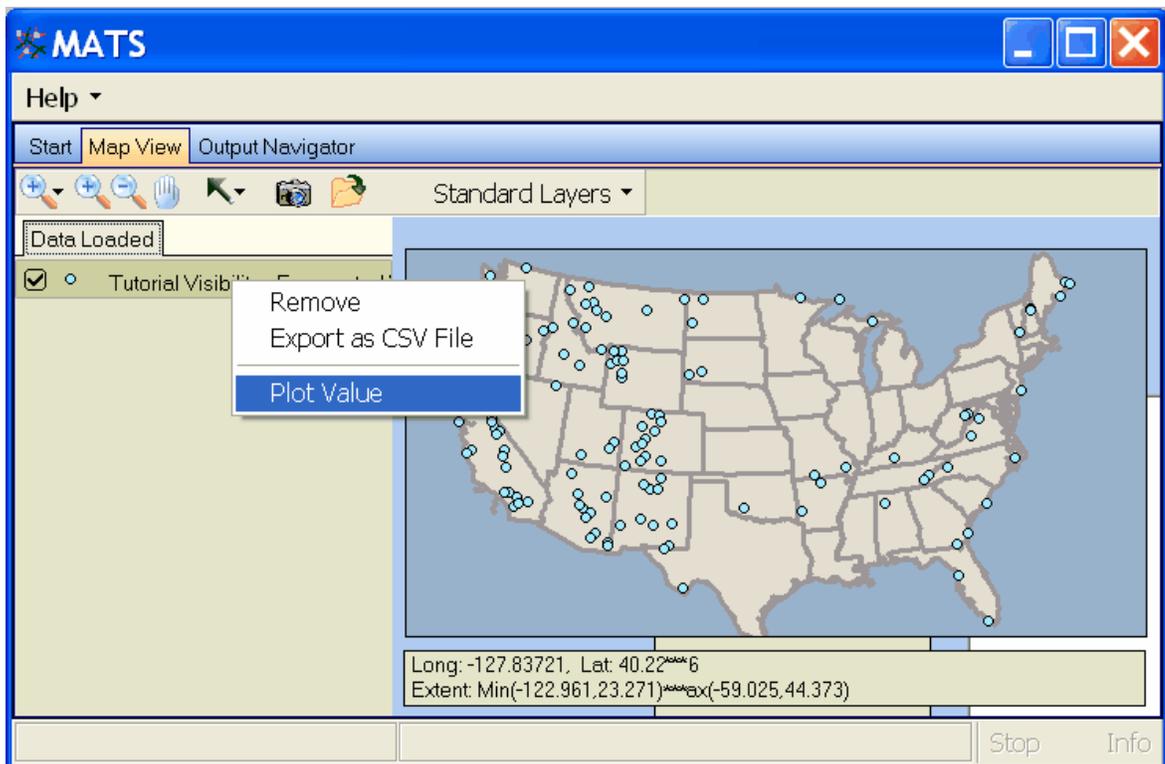
The map will then zoom to the Continental US.



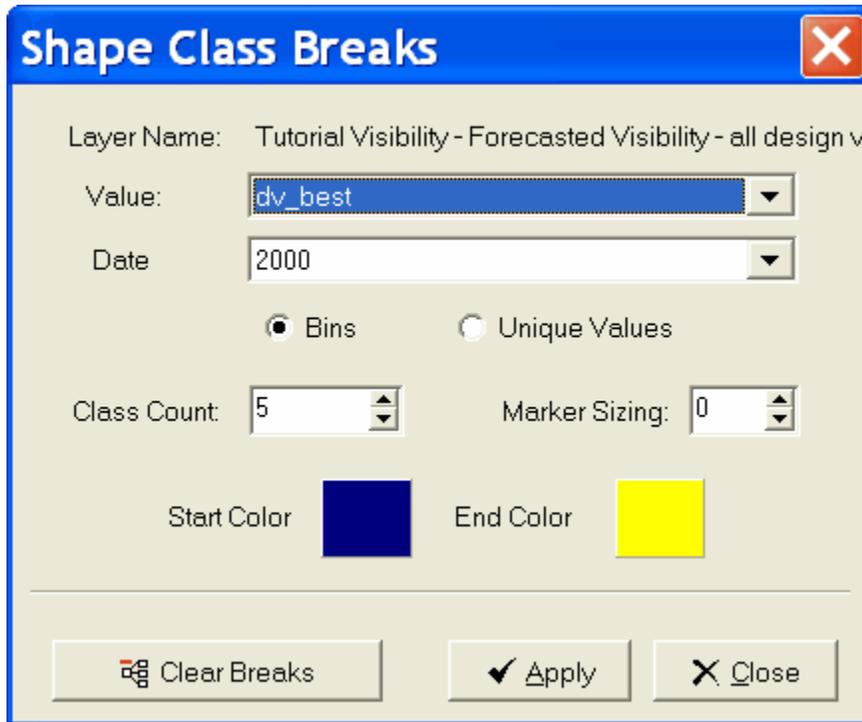
To more easily view the location of monitors in particular states, uncheck *US Counties* using the **Standard Layers** drop down menu on the far right of the Task Bar. Your window should look like the following:



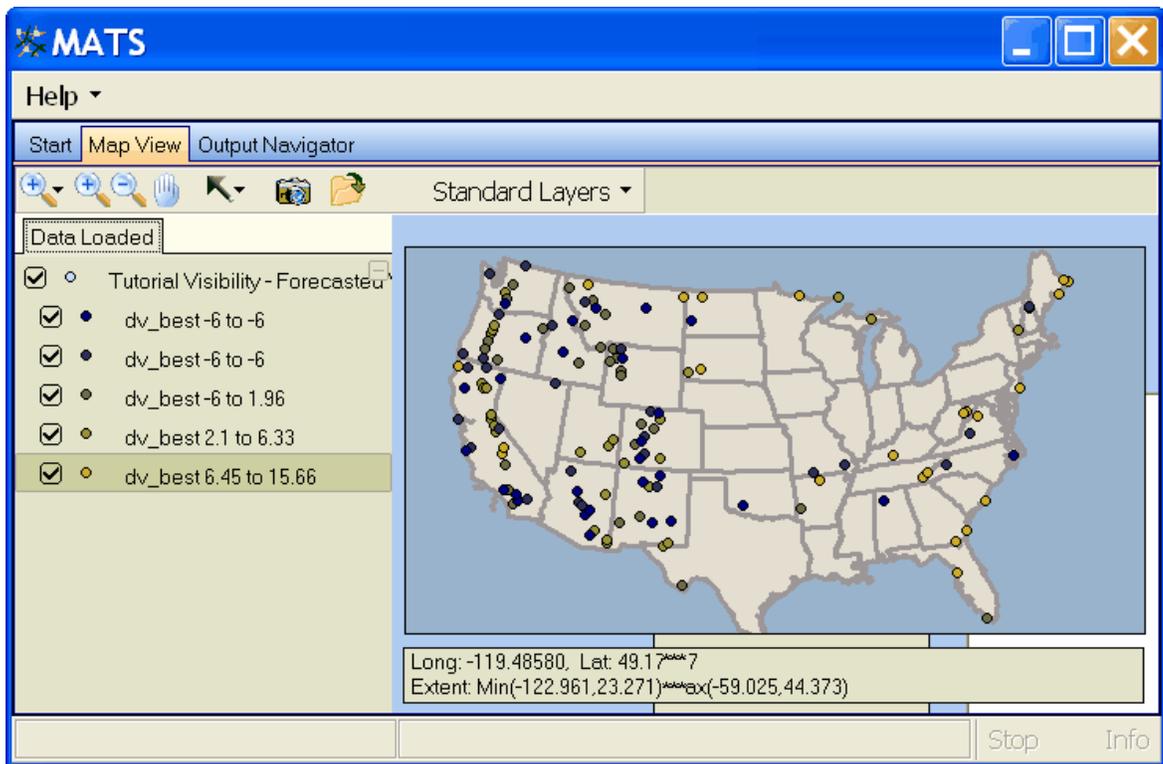
Right click on the "Tutorial Visibility - Forecasted Visibility Data" layer in the panel on the left side of the window. Choose the **Plot Value** option.



This will bring up **Shape Class Breaks** window. In the **Value** drop-down list, choose the variable "*dv\_best*" -- this is forecasted visibility design value for the best visibility days in 2015. (Note that the **Date** box defaults to the baseline year; in this case 2001.)



Click **Apply** and then click **Close**. This will bring you back to the **Map View** window.



Examine the other variables:

*dv\_worst*: forecasted deciview values for 20% worst days;

*dv\_best*: forecasted deciview values for 20% best days

*base\_best*: baseline design values for best days;

*base\_worst*: baseline design values for worst days;

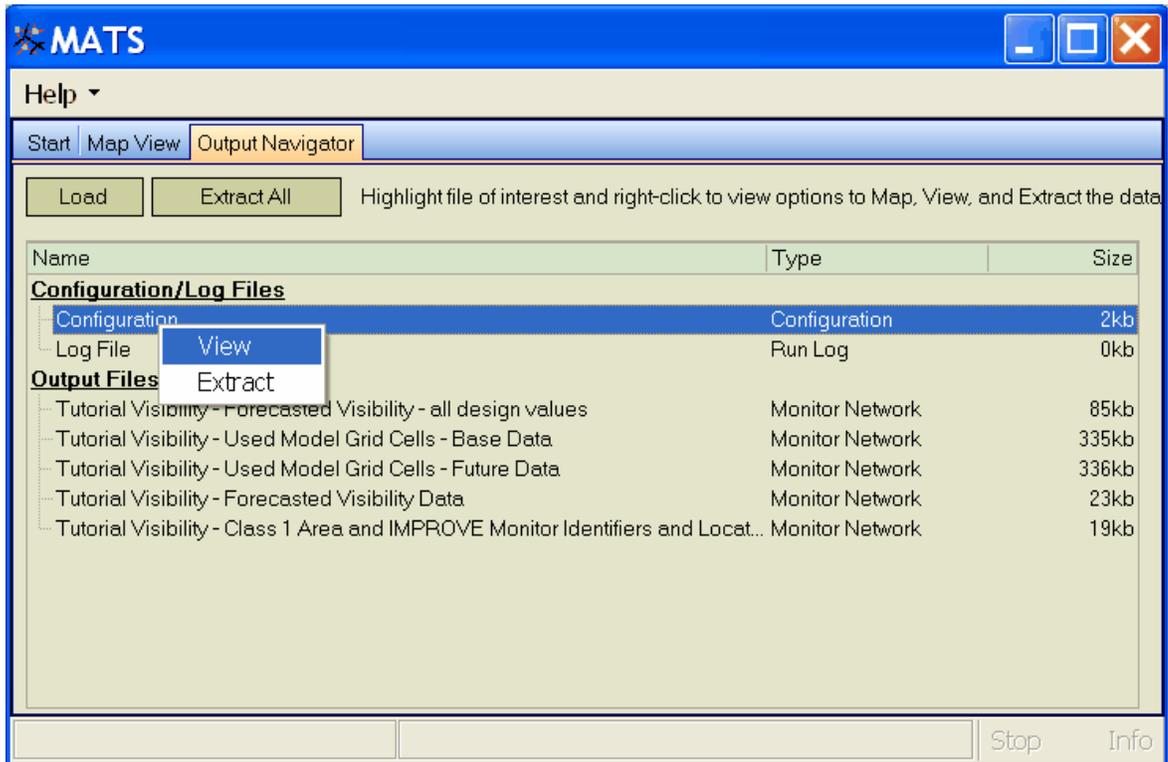
*rrf\_b\_crystal*, *rrf\_b\_no3*, *rrf\_b\_oc*, *rrf\_b\_ec*, *rrf\_b\_cm*, and *rrf\_b\_so4*: relative response factor used to forecast the best visibility days;

*rrf\_w\_crystal*, *rrf\_w\_no3*, *rrf\_w\_oc*, *rrf\_w\_ec*, *rrf\_w\_cm*, and *rrf\_w\_so4*: relative response factor used to forecast the worst visibility days;

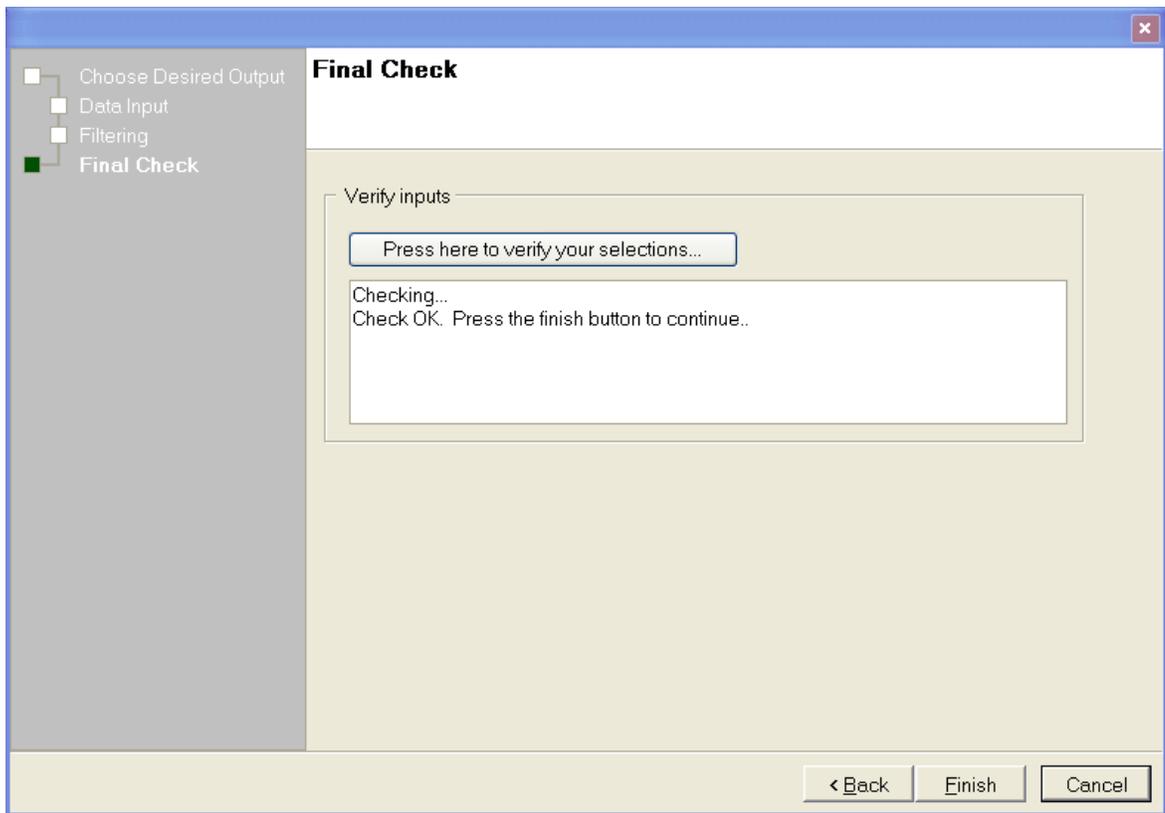
This is just a brief summary of the mapping possibilities available. For more details, there is a separate chapter on the [Map View](#).

## 8.7 Step 7. Working with Configuration File

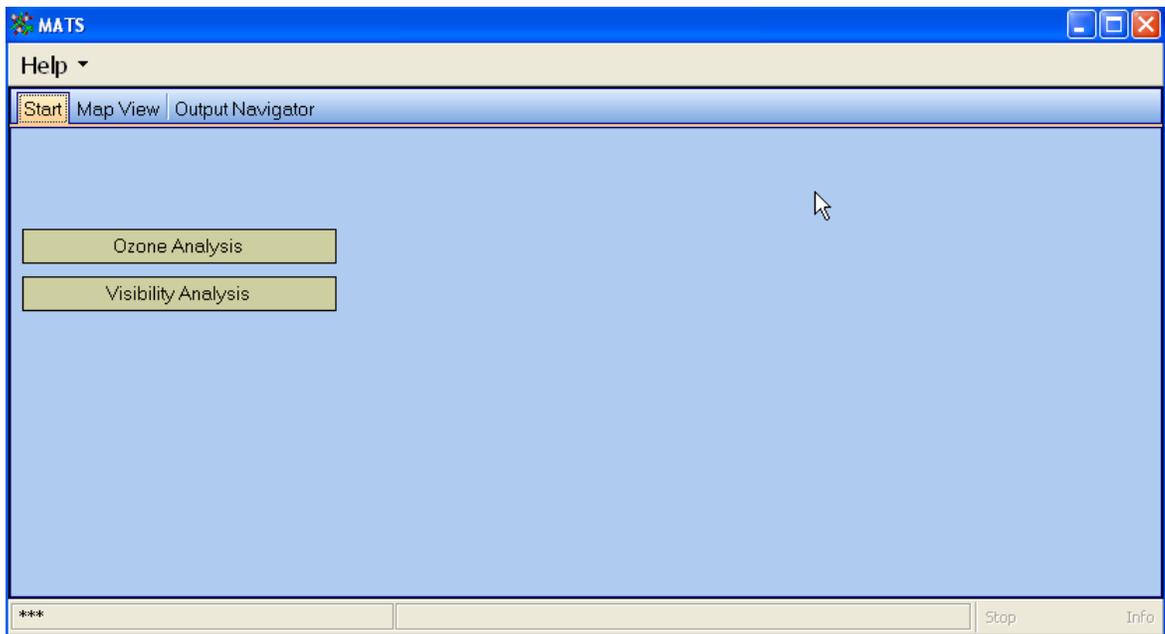
Configurations keep track of the choices that you have made in your analysis. There are two ways that you can access your configuration. First, you can view your configuration using the Output Navigator. Right-click on **Configuration** and choose *View*.



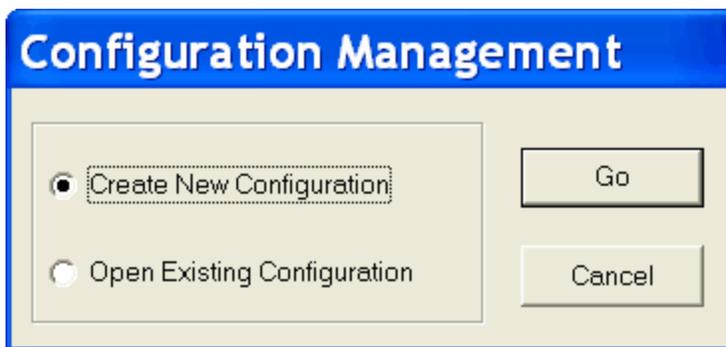
This will take you to the *Tutorial Visibility* configuration that you used to generate your visibility results.



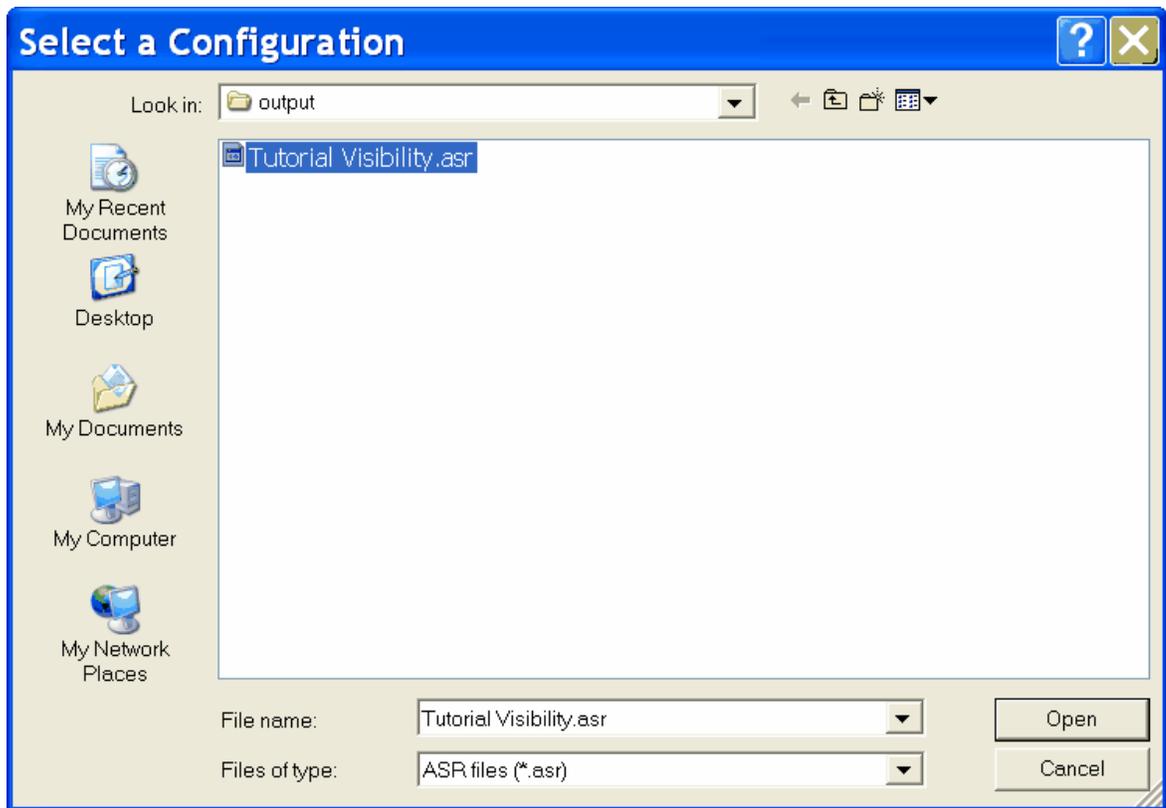
A second way to access your Tutorial Visibility configuration is to go back to the **Start** window.



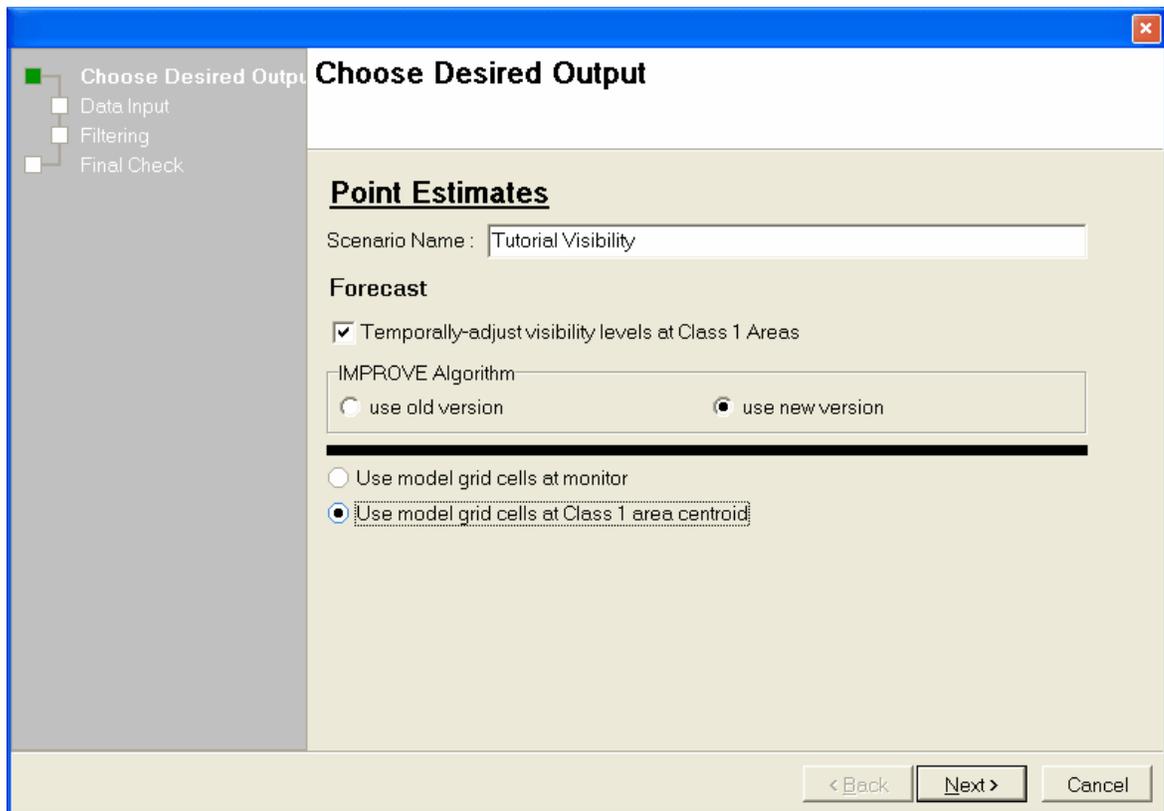
Click on the **Visibility Analysis** button. This will bring up the **Configuration Management** window.



Choose **Open Existing Configuration** and then click the **Go** button. This will bring up the **Select a Configuration** window. Find the *Tutorial Visibility.asr* file that you generated.

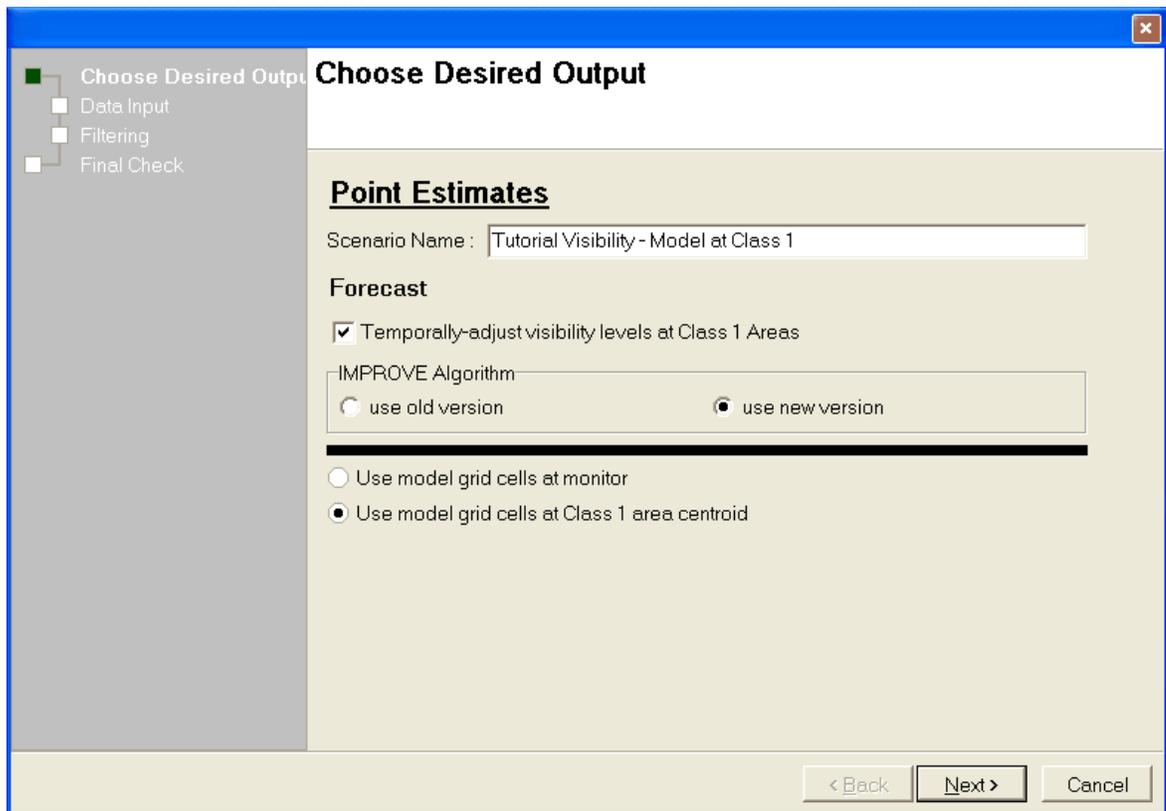


Click **Open** and this will bring you your *Tutorial Visibility* configuration. Choose the **Use model grid cells at Class 1 area centroid** option.



MATS will now calculate RRFs using model data located over the center of each Class 1 area, instead of using model data located over the monitor linked to each Class 1 area.

To reflect this change in your analysis, change the **Scenario Name** box to *Tutorial Visibility - Model at Class 1*.

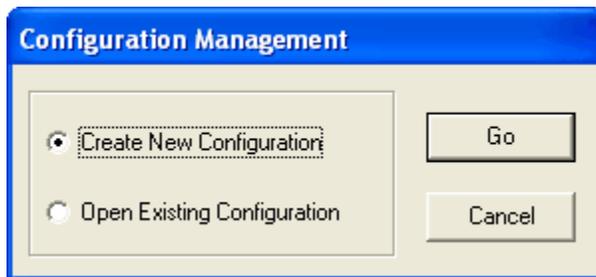


Keep all of the other assumptions the same. At the **Filtering** window, click the **Finish** button. MATS will generate a new set of results and save them in a file called: *Tutorial Visibility - Model at Class 1.asr*. You can then view and map your results in the same way as with other results files.

## 9 Visibility Analysis: Details

MATS can calculate baseline and future-year visibility levels for the best and worst days for [Class I Areas](#) -- these estimates are referred to as [Point Estimates](#), as they refer to particular locations. MATS gives you several options for how to generate these estimates, and keeps track of the choices you make with a [Configuration](#).

When you begin the process of generating visibility estimates, MATS provides an option to start a new Configuration or to open an existing Configuration.



Select your option and then click **Go**.

MATS will then step you through a series of windows with choices for your analysis.

- [Choose Desired Output](#). Choose whether you want to calculate *Point Estimates* at IMPROVE monitors or at Class I Area centroids and whether to use the old or new version of the IMPROVE visibility equation.
- [Data Input](#). Specify the air modeling and monitoring data that you want to use. Specify which model grid cells will be used when calculating [RRFs](#) at monitor locations.
- [Filtering](#). Choose the years of monitoring data. Identify valid monitors.

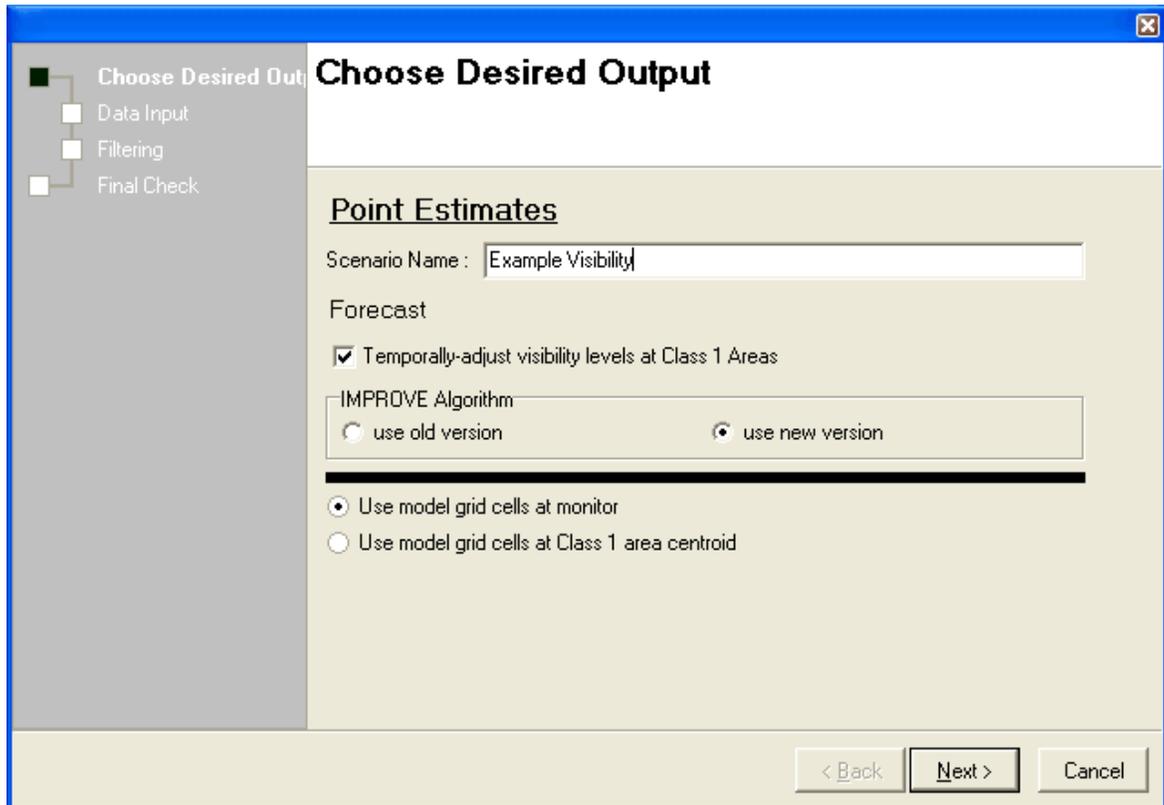
MATS comes with a set of default choices and an example set of input files. If desired you can use these defaults and skip to the [Final Check](#) window and click the **Finish** button to generate your calculations.

### 9.1 Choose Desired Output

In the **Choose Desired Output** window, you specify the [Scenario Name](#) that you would like to use, as well as choices regarding how you would like to calculate future year (forecast) visibility levels for Class I Areas. As discussed in the section on [Forecasting Visibility](#), the forecast calculations have a number of steps. At the end of this section, there is an [example](#) of these calculations.

You may use the "old version" or "new version" of the [IMPROVE Equation](#) ([IMPROVE](#),

2006), which MATS uses to translate PM levels (measured in ug/m3) to visibility levels (measured in extinction or deciviews). You may also choose between [using model data](#) at the monitor or model data at the center of the Class I Area.\*



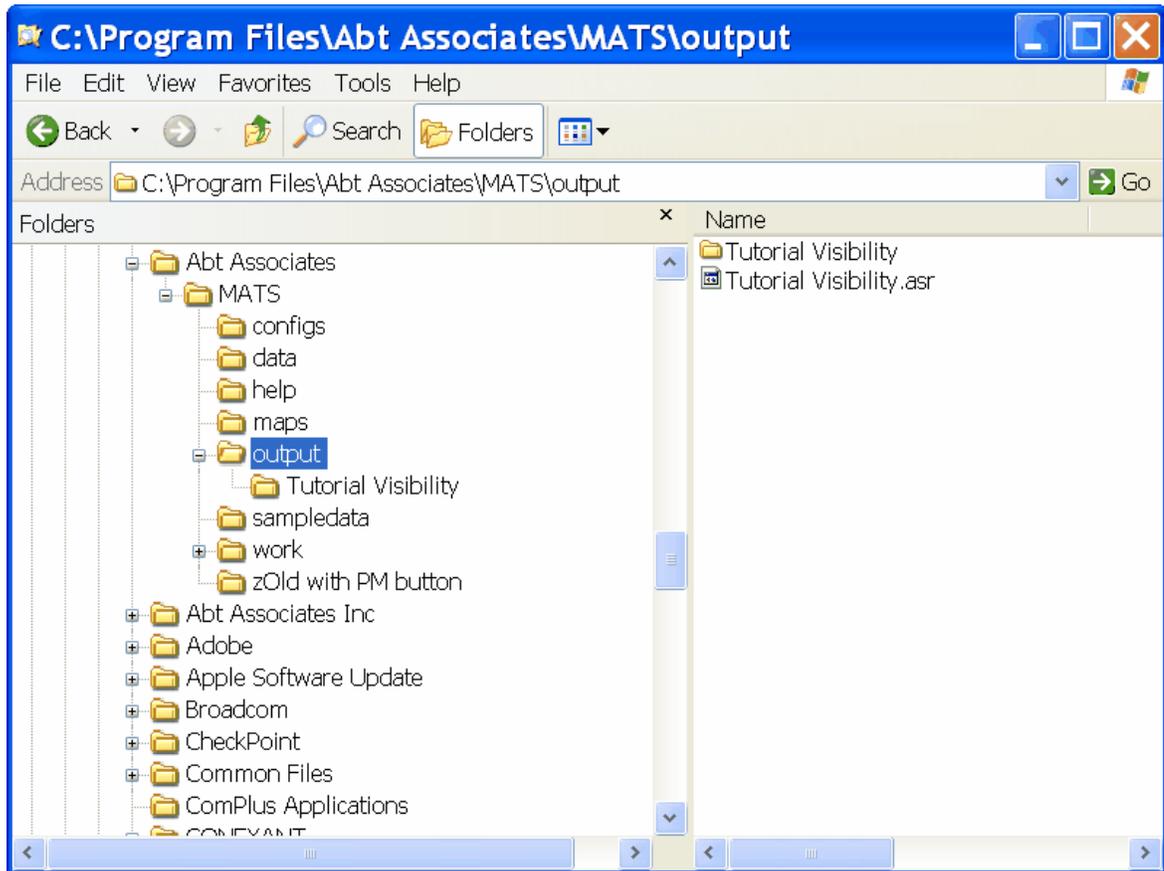
\* Monitors assigned to represent a Class I Area are generally close to the Class I Area. However, in some cases, the distance can be substantial. For example, the YELL2 monitor in Wyoming (44.5653 latitude, -110.4002 longitude) is located more than a degree longitude away from the Red Rocks Lake Class I Area (44.64 latitude, -111.78 longitude). By default, MATS uses model data at the monitor.

### 9.1.1 Scenario Name

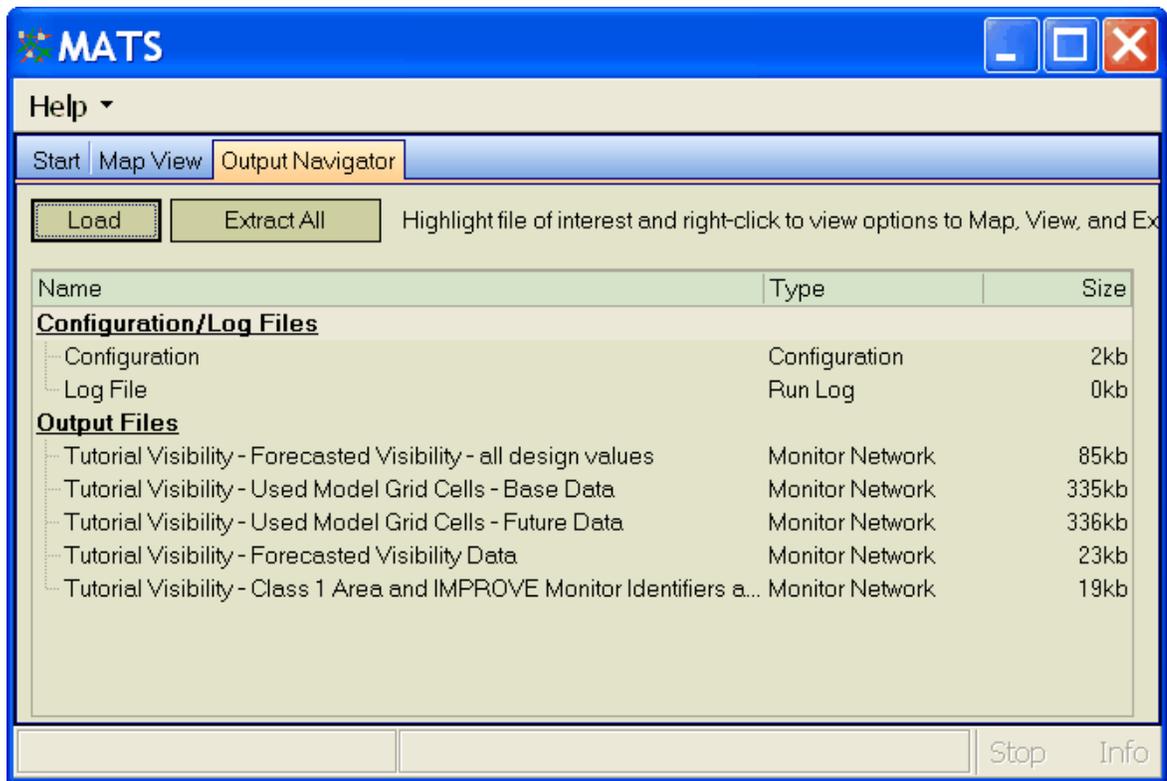
The **Scenario Name** allows you to uniquely identify each analysis that you conduct. It is used in three ways.

**(1) Results file name.** The results file is given the **Scenario Name** (e.g., *Tutorial Visibility.asr*). Note that the extension ([.ASR](#)) is specifically designated just for MATS and can only be used by MATS.

**(2) Organize output.** In the **Output** folder, MATS will generate a folder using the **Scenario Name**. MATS will use this folder as a default location for files generated with this **Scenario Name**.



**(3) Output file names.** The output files generated will begin with the **Scenario Name**.



### 9.1.2 Forecast Visibility at Class I Areas

MATS provides a forecast of visibility in [Class I Areas](#). The approach used has the following steps:

- **Identify best & worst visibility monitor days in Base Model Year.** Use monitored [total extinction](#) data from a user-specified year to identify the 20 percent best and 20 percent worst visibility days at each Class I area. At this stage MATS is using extinction values (measured in inverse megameters). By the end of this series of calculations, MATS will convert these extinction visibility measures to [deciviews](#).

Note that you specify the particular year, the **Base Model Year**, from the available monitoring data in the [Filtering](#) window. MATS labels the year of monitoring data as the **Base Model Year**, because this particular year of monitor data matches the baseline model data, specified in the [Data Input](#) window.

- **Average best & worst baseline model days.** Using baseline speciated model data (specified in the **Data Input** window), average the 20 percent best visibility days and then average the 20 percent worst visibility days at each Class I areas (matched with the ambient data). The model data comes into MATS as speciated values measured in  $\mu\text{g}/\text{m}^3$ . Average these speciated values. When done there will be two averages (one “best” the other “worst”) for each species and these averages will be  $\mu\text{g}/\text{m}^3$ .
- **Average best & worst forecast model days.** Calculate these same averages for the

forecast model data (specified in the **Data Input** window). That is, identify the same 20 percent best and 20 percent worst visibility days and then average the specified model data (measured in  $\mu\text{g}/\text{m}^3$ ).<sup>\*</sup> When done there will be two averages (one “best” the other “worst”) for each species and these averages will be in  $\mu\text{g}/\text{m}^3$ .

- **Calculate RRFs.** Use the specified (best & worst) averages from the baseline and forecast model data to calculate two RRFs for each species. That is, there will be one RRF for the 20 percent best visibility days and another for the 20 percent worst visibility days at each Class I area. The “best” RRF is simply the ratio of the baseline “best” average (measured in  $\mu\text{g}/\text{m}^3$ ) to the control scenario “best” average (measured in  $\mu\text{g}/\text{m}^3$ ). The “worst” RRF is calculated in an analogous way. An RRF is unitless and there are two for each species.
- **Identify best & worst visibility days in other monitored years.** Using monitored total extinction, identify the 20 percent best visibility days and the 20 percent worst visibility days from the other available years of monitoring data. The default in MATS is that there should be at least three valid years and one of those years should be the base modeling year (the base meteorological year). (Monitor validity is discussed further in the [Valid Visibility Monitors](#) section.)

Note that the 20 percent best days will occur on a different set of days for each year; similarly, the 20 percent worst days will occur on a different set of days for each year.

- **Multiply RRF with specified monitor data from each year.** Multiply the species-specific “best” RRF (unitless) with the “best” daily specified monitor values (measured in  $\mu\text{g}/\text{m}^3$ ) from each of the available years. Do analogous calculations for the worst days. When done, there will be the original (baseline) monitor values and an analogous set of forecast values (equal to the baseline times the RRF).

Note that the RRF is based on best/worst days identified from the **Base Model Year**. This same "**Base Model Year**" RRF is used with all of the valid monitor years. For example, if the Base Model Year were 2001, then the RRF developed from 2001 modeling data will be applied to all valid data in the five year ambient base period.

- **Convert  $\mu\text{g}/\text{m}^3$  values to daily extinction values and sum to get total extinction.** For each day in each [valid monitor](#) year (for both the baseline and forecast), use either the [New IMPROVE equation](#) or the [Old IMPROVE equation](#) to convert  $\mu\text{g}/\text{m}^3$  values to get daily total extinction (measured in inverse megameters). After this calculation there will be a set of total extinction values for the best and worst visibility days in each valid year for both the baseline and the forecast.
- **Convert extinction to deciviews.** For each valid year in both the baseline and forecast, convert the best & worst daily averages from extinction (inverse megameters) to [deciviews](#) (unitless). The formula for this conversion is as follows:  $\text{Deciviews} = 10 \cdot \ln(\text{extinction}/10)$
- **Average daily best and worst days.** For each valid year, average the daily deciview values from the 20 percent best visibility days and calculate the same average for the 20

percent worst visibility days. There will be up to five “best” averages and “worst” total visibility measures (measured in deciviews) for both the baseline and the forecast.

- **Calculate final average.** Average the valid best/worst yearly visibility measures. When done there will be one “best” value and one “worst” value, measured in deciviews (unitless), for both the baseline and forecast.

---

\* The future days are the same as the base year days. The identification of the 20 percent best and worst is solely based on the base year ambient data.

#### 9.1.2.1 Old IMPROVE Equation

The Old IMPROVE equation is as follows:

$$\begin{aligned} \text{bext} = & 3 * f(\text{RH}) * \text{AMM\_SO4} \\ & + 3 * f(\text{RH}) * \text{AMM\_NO3} \\ & + 4 * \text{OMC} \\ & + 10 * \text{EC} \\ & + \text{CRUSTAL} \\ & + 0.6 * \text{CM} \\ & + \text{RAYLEIGH}. \end{aligned}$$

where:

bext = total extinction (measured in inverse megameters)

FRH = term to account for enhancement of light scattering due to hyroscopic growth of sulfate and nitrate (unitless)

AMM\_SO4 = ammonium sulfate (ug/m<sup>3</sup>)

AMM\_NO3 = ammonium nitrate (ug/m<sup>3</sup>)

OMC = organic carbon mass (ug/m<sup>3</sup>) (OC\*1.4)

EC = elemental carbon (ug/m<sup>3</sup>)

CRUSTAL = fine soil (ug/m<sup>3</sup>)

CM = coarse particulate matter (ug/m<sup>3</sup>)

RAYLEIGH = Rayleigh scattering. Accounts for natural scattering of light by gases in the atmosphere. Assumed to equal 10 inverse megameters at all locations.

### Example Calculation Old IMPROVE Equation

The first column "bext" presents the calculated value given the following data.

bext	_ID	LAT	LONG	DATE	FRH	CRUSTAL	AMM_NO3	OMC	EC	CM	AMM_SO4
71.04	ACAD1	44.3771	-68.261	20000101	3.22	0.22	1.02	2.05	1.12	2.99	3.09
23.70	ACAD1	44.3771	-68.261	20000105	3.22	0.12	0.11	0.38	0.07	0.89	1.01
34.08	ACAD1	44.3771	-68.261	20000108	3.22	0.13	0.24	0.95	0.15	1.69	1.58
37.86	ACAD1	44.3771	-68.261	20000112	3.22	0.14	0.22	0.69	0.19	4.48	1.89
31.26	ACAD1	44.3771	-68.261	20000115	3.22	0.16	0.19	0.72	0.19	2.65	1.33
39.77	ACAD1	44.3771	-68.261	20000119	3.22	0.18	0.60	1.44	0.30	0.95	1.49
42.24	ACAD1	44.3771	-68.261	20000122	3.22	0.46	0.37	0.80	0.16	15.77	1.44

#### 9.1.2.2 New IMPROVE Equation

The New IMPROVE Equation has a number of additional terms, in relation to the [Old IMPROVE](#) equation. In particular, it takes into account the different effects of small and large sulfate, nitrate, and organic carbon particles. A separate equation defining small and large is given below.

$$\begin{aligned}
 \text{bext} = & 2.2 * f_s(\text{RH}) * [\text{SMALL\_AMM\_SO4}] + 4.8 * f_l(\text{RH}) * [\text{LARGE\_AMM\_SO4}] \\
 & + 2.4 * f_s(\text{RH}) * [\text{SMALL\_AMM\_NO3}] + 5.1 * f_l(\text{RH}) * [\text{LARGE\_AMM\_NO3}] \\
 & + 2.8 * [\text{SMALL\_OMC}] + 6.1 * [\text{LARGE\_OMC}] \\
 & + 10 * \text{EC} \\
 & + \text{CRUSTAL} \\
 & + 0.6 * \text{CM} \\
 & + \text{SS\_RAYLEIGH} \\
 & + 1.7 * f_{ss}(\text{RH}) * \text{SEA\_SALT} \\
 & + 0.33 * \text{NO2}.
 \end{aligned}$$

where:

bext = total extinction (measured in inverse megameters)

$f_s(\text{RH})$  = term to account for enhancement of light scattering due to hygroscopic growth of small ammonium nitrate and ammonium sulfate (unitless)

$f_l(\text{RH})$  = term to account for enhancement of light scattering due to hygroscopic growth of large ammonium nitrate and ammonium sulfate (unitless)

SMALL\_AMM\_SO4 = small ammonium sulfate (ug/m<sup>3</sup>)

LARGE\_AMM\_SO4 = large ammonium sulfate (ug/m<sup>3</sup>)

SMALL\_AMM\_NO3 = small ammonium nitrate (ug/m<sup>3</sup>)

LARGE\_AMM\_NO3 = large ammonium nitrate (ug/m<sup>3</sup>)

SMALL\_OMC = small organic carbon mass (ug/m<sup>3</sup>) (OC\*1.8)

LARGE\_OMC = large organic carbon mass (ug/m<sup>3</sup>) (OC\*1.8)

EC = elemental carbon (ug/m<sup>3</sup>)

CRUSTAL = fine soil (ug/m<sup>3</sup>)

CM = coarse particulate matter (ug/m<sup>3</sup>)

SS\_RAYLEIGH = Site-specific Rayleigh scattering (inverse megameters)

$f_{ss}(RH)$  = term to account for enhancement of light scattering due to hygroscopic growth of sea salt (unitless)

SEA\_SALT = Sea salt (ug/m<sup>3</sup>)

NO2 = Nitrogen dioxide levels (parts per billion). This term is assumed to be zero.

The apportionment of the total concentration of sulfate compounds into the concentrations of the small and large size fractions is accomplished using the following equations:

$$[\text{Large Sulfate}] = [\text{Total Sulfate}] / 20 \text{ ug/m}^3 \times [\text{Total Sulfate}], \text{ for } [\text{Total Sulfate}] < 20 \text{ ug/m}^3$$

$$[\text{Large Sulfate}] = [\text{Total Sulfate}], \text{ for } [\text{Total Sulfate}] \geq 20 \text{ ug/m}^3$$

$$[\text{Small Sulfate}] = [\text{Total Sulfate}] - [\text{Large Sulfate}]$$

The same equations are used to apportion total nitrate and total organic mass concentrations into the small and large size fractions.

### Example Calculation New IMPROVE Equation

The first column "bext" presents the calculated value given the following data.

bext	_ID	LAT	LONG	DATE	FRH	FSRH	FLRH	FSSRH	SS_RAYLEIGH
71.52	ACAD1	44.3771	-68.261	20000101	3.22	3.82	2.75	3.91	12
24.51	ACAD1	44.3771	-68.261	20000105	3.22	3.82	2.75	3.91	12
34.45	ACAD1	44.3771	-68.261	20000108	3.22	3.82	2.75	3.91	12
38.10	ACAD1	44.3771	-68.261	20000112	3.22	3.82	2.75	3.91	12
35.45	ACAD1	44.3771	-68.261	20000115	3.22	3.82	2.75	3.91	12
40.22	ACAD1	44.3771	-68.261	20000119	3.22	3.82	2.75	3.91	12
43.92	ACAD1	44.3771	-68.261	20000122	3.22	3.82	2.75	3.91	12

SEA_SALT	CRUSTAL	AMM_NO3	OMC	EC	PM10	CM	AMM_SO4	LARGE_OMC	SMALL_OMC
0	0.22	1.02	2.63	1.12	11.05	2.99	3.09	0.35	2.29
0	0.12	0.11	0.49	0.07	2.72	0.89	1.01	0.01	0.48
0	0.13	0.24	1.22	0.15	4.94	1.69	1.58	0.07	1.15
0	0.14	0.22	0.89	0.19	7.82	4.48	1.89	0.04	0.85
0.55116	0.16	0.19	0.93	0.19	5.53	2.65	1.33	0.04	0.89
0	0.18	0.60	1.85	0.30	5.03	0.95	1.49	0.17	1.68
0.192906	0.46	0.37	1.02	0.16	19.56	15.77	1.44	0.05	0.97

LARGE_AMM_SO4	SMALL_AMM_SO4	LARGE_AMM_NO3	SMALL_AMM_NO3
0.48	2.61	0.05	0.97
0.05	0.96	0.00	0.11
0.13	1.46	0.00	0.24
0.18	1.71	0.00	0.22
0.09	1.24	0.00	0.19
0.11	1.38	0.02	0.59
0.10	1.34	0.01	0.37

**9.1.2.3 Choose Model Grid Cell**

The model data are used to calculate an RRF for each species for both the best and worst visibility days. The RRF is the ratio of future-year modeled visibility levels over baseline modeled visibility levels. When forecasting visibility, MATS allows you to choose whether the RRF will be calculated with model data from the grid cell containing the monitor or the centroid of the Class I Area.

The representative IMPROVE monitor assignments are taken from Appendix A, Table A-2 of "Guidance for Tracking Progress Under the Regional Haze Rule" [http://www.epa.gov/ttn/oarpg/t1/memoranda/rh\\_tpurhr\\_gd.pdf](http://www.epa.gov/ttn/oarpg/t1/memoranda/rh_tpurhr_gd.pdf). Monitors assigned to represent a Class I Area are generally close to the Class I Area. However, in some cases, this distance can be substantial. For example, the YELL2 monitor in Wyoming (44.5653 latitude, -110.4002 longitude) is located more than a degree longitude away from the Red Rocks Lake Class I Area (44.64 latitude, -111.78 longitude). By default, MATS uses model data at the monitor.

**9.1.3 Visibility Output Variable Description**

MATS generates five output files:

- [Visibility forecast \(average of design values\)](#). (Up to) five year average of forecasted and base-year average visibility. When you have specified the option **Use model grid cells at monitor**, name of this file is "Forecasted Visibility Data.csv" with the [Scenario Name](#) appended at the beginning (e.g., "Tutorial Visibility - Forecasted Visibility Data.csv"). When you have specified the option **Use model grid cells at Class 1 area centroid**, name of this file changes to "Forecasted Visibility Data for Class 1 Areas.csv" plus the Scenario Name (e.g., "Example Visibility - Forecasted Visibility Data for Class 1 Areas.csv").
- [Visibility forecast \(all design values\)](#). Forecasted and base-year values for individual years. (The forecast is based on The name of this file is "Forecasted Visibility - all design values.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Forecasted Visibility - all design values.csv").
- [Class I areas and the monitors](#). Contains a list of all of the Class I areas and the monitors assigned to each. The name of this file is "Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv").
- [Base-year model data used](#). The name of this file is: "Used Model Grid Cells - Base Data.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Used Model Grid Cells - Base Data.csv"). This file contains the base year model values for PM species for the grid cells and days used in the RRF calculations.
- [Future-year model data used](#). The format for this file is the same as for the base-year. The name of this file is: "Used Model Grid Cells - Future Data.csv" plus the Scenario Name (e.g., "Tutorial Visibility - Used Model Grid Cells - Future Data.csv"). This file contains the future year model values for PM species for the grid cells and days used in the RRF calculations.

The following sub-sections describe the variables in each file.

#### 9.1.3.1 Forecasted Visibility Data.csv

The table below describes the variables in the output file. Note that the output data includes a large number of variables, so in the sample output below we have divided the variables into two blocks. In a file actually generated by MATS, these two blocks would be combined.

Note also that the variables output by MATS depend on whether you have specified [using model data](#) at the monitor or model data at the center of the Class I Area. This is detailed in the description table below.

Variable	Description
_id	Site ID
_type	Leave blank
date	Meteorological modeling year (used to identify the 20% best and worst days from the ambient data)

dv_best	Forecasted (future year) best visibility [up to five year average] (in deciviews)
dv_worst	Forecasted (future year) worst visibility [up to five year average]
base_best	Base-year best visibility [up to five year average]
base_worst	Base-year worst visibility [up to five year average]
rrf_b_crustal	Relative response factor (RRF) for crustal matter on the best visibility days
rrf_b_no3	RRF for nitrate on the best visibility days
rrf_b_oc	RRF for organic mass on the best visibility days
rrf_b_ec	RRF for elemental carbon on the best visibility days
rrf_b_cm	RRF for coarse matter (PM10 minus PM2.5) on the best visibility days
rrf_b_so4	RRF for sulfate on the best visibility days
rrf_w_crustal	RRF for crustal matter on the worst visibility days
rrf_w_no3	RRF for nitrate on the worst visibility days
rrf_w_oc	RRF for organic mass on the worst visibility days
rrf_w_ec	RRF for elemental carbon on the worst visibility days
rrf_w_cm	RRF for coarse matter (PM10 minus PM2.5) on the worst visibility days
rrf_w_so4	RRF for sulfate on the worst visibility days
monitor_gridcell	Identifier for grid cell closest to monitor. (This variable only appears if you specified the <b>Use model grid cell at monitor</b> option.)
class_i_gridcell	Identifier for grid cell closest to Class 1 area. (This variable only appears if you specified the <b>Use model grid cell at Class 1 area centroid</b> option.)
gridcell_lat	Centroid latitude in decimal degrees of grid cell used in calculation. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Centroid longitude in decimal degrees of grid cell used in calculation. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_lat	Monitor latitude. (This variable only appears if you specified the <b>Use model grid cell at monitor</b> option.)
class_i_lat	Class 1 area centroid latitude. (This variable only appears if you specified the <b>Use model grid cell at Class 1 area centroid</b> option.)
monitor_long	Monitor longitude. (This variable only appears if you specified the <b>Use model grid cell at monitor</b> option.)
class_i_long	Class 1 area centroid longitude. (This variable only appears if you specified the <b>Use model grid cell at Class 1 area centroid</b> option.)

### 9.1.3.2 Forecasted Visibility - all design values.csv

The table below describes the variables in the output file. Note that the variables output by MATS depend on whether you have specified [using model data](#) at the monitor or model data at the center of the Class I Area. This is detailed in the description table below.

Variable	Description
_id	Site ID
_type	Leave blank

date	Base year of monitoring data
dv_best	Forecasted (future year) best visibility (in deciviews)
dv_worst	Forecasted (future year) worst visibility
base_best	Base-year best visibility
base_worst	Base-year worst visibility
monitor_gridcell ll	Identifier for grid cell closest to monitor. (This variable only appears if you specified the <b>Use model grid cell at monitor</b> option.)
class_i_gridcell l	Identifier for grid cell closest to Class 1 area. (This variable only appears if you specified the <b>Use model grid cell at Class 1 area centroid</b> option.)
gridcell_lat	Centroid latitude in decimal degrees of grid cell used in calculation. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Centroid longitude in decimal degrees of grid cell used in calculation. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
monitor_lat	Monitor latitude. (This variable only appears if you specified the <b>Use model grid cell at monitor</b> option.)
class_i_lat	Class 1 area centroid latitude. (This variable only appears if you specified the <b>Use model grid cell at Class 1 area centroid</b> option.)
monitor_long	Monitor longitude. (This variable only appears if you specified the <b>Use model grid cell at monitor</b> option.)
class_i_long	Class 1 area centroid longitude. (This variable only appears if you specified the <b>Use model grid cell at Class 1 area centroid</b> option.)

**9.1.3.3 Class 1 Area and IMPROVE Monitor Identifiers and Locations.csv**

The table below describes the variables in the output file. Note that the output data includes a number of variables, so in the sample output below we have divided the variables into two blocks. In a file actually generated by MATS, these two blocks would be combined.

<b>Variable</b>	<b>Description</b>
_id	Class I area site ID
_type	Leave blank.
_class_i_name	Class 1 area name
class_i_state	State of Class 1 area
class_i_lat	Latitude in decimal degrees of Class 1 area centroid
class_i_long	Longitude in decimal degrees of Class 1 area centroid
class_i_gridcell	Identifier of grid cell closest to the Class 1 area centroid
date	Meteorological modeling year
_monitor_id	IMPROVE site code (either at Class I area or a representative site)
monitor_lat	IMPROVE Monitor latitude
monitor_long	IMPROVE Monitor longitude
monitor_gridcell	Identifier of grid cell closest to the monitor

**9.1.3.4 Used Model Grid Cells - Base/Future Data.csv**

The table below describes the variables in the output file.

<b>Variable</b>	<b>Description</b>
_id	The ID is a unique name for each monitor in a particular location. The default value is the column identifier multiplied by 1000 plus the row. (This is a character variable.)
_type	Leave blank
gridcell_lat	Latitude at the grid cell centroid in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
gridcell_long	Longitude at the grid cell centroid in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
date	Date of daily average model value with YYYYMMDD format (This is a numeric variable)
cm	Coarse PM (ug/m3)
crustal	Crustal PM
so4	Sulfate PM
ec	Elemental Carbon
no3	Nitrate PM
oc	Organic carbon PM
_visibility_rank	worst = 20% worst days used in rrf calculation; best = 20% best days used in rrf calculation

**9.2 Data Input**

In the **Data Input** window, you need to specify the monitor data and model data that you want to use. MATS comes with monitor and model data. Alternatively, you can add your own, following the monitor and model format described below. In addition, you need to specify how MATS will evaluate the model data when calculating [RRFs](#).

### 9.2.1 Monitor Data Input

Daily monitor data, with concentration (ug/m3) and visibility (inverse megameters) measures for each species, are available from the VIEWS website <http://vista.cira.colostate.edu/views/>.<sup>\*</sup> As described in the [Forecasting Visibility](#) section, these monitor data are used to: (1) identify the 20 percent best and worst visibility days for a given year, and (2) calculate the 5-year baseline conditions.

Note that one IMPROVE monitor is associated with each Class I site, and the calculated visibility for the IMPROVE site is assumed to be representative of the Class I site. MATS comes with a default ["linkage" database](#) that provides the cross-walk that MATS uses for IMPROVE monitors and Class I Areas.

The tables in the next sub-sections present the [old equation](#) and [new equation](#) variable names and descriptions downloaded from the VIEWS website and the variable names used in MATS. The format the data read into MATS is also included.

By default, MATS includes species concentrations (measured in ug/m3) as well as extinction estimates (measured in inverse megameters) and deciview values. MATS uses the concentration estimates. In particular, it uses the variables: AMM\_SO4, AMM\_NO3, OMC, EC, CRUSTAL, and CM. The variable GOOD\_YEAR indicates whether a particular monitor should be used for a given year. A value of "1" means the monitor can be used, and a value of "0" means that the monitor should be dropped for the year.

The variable GROUP identifies the percentile for the overall visibility level for a particular day. A value of “90” means that the particular day is among the 20 percent worst days for the year. A value of “10” means that the particular day is among the 20 percent best days for that year. (Days with other GROUP values are not needed)

There are a number of extra variables in the ambient data input file that are not directly used by MATS (such as extinction values). The additional data can be used to QA MATS output or for additional data analysis.

\* The Visibility Information Exchange Web System (VIEWS) is an online exchange of air quality data, research, and ideas designed to understand the effects of air pollution on visibility and to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze and improve visibility in national parks and wilderness areas. <http://vista.cira.colostate.edu/views/>

**9.2.1.1 Monitor Data Description (Old Equation)**

The monitor data for the old IMPROVE algorithm includes a large number of variables, so in the sample format below we have only a portion of the variables listed. The table below has a complete listing of the variables. The variables in **bold** are required variables on the input file. The additional variables are provided for QA purposes and are optional.

**Visibility Monitor Data Format (Old Algorithm)**

```

Day
_ID, _TYPE, LAT, LONG, DATE, FRH, PM25, CRUSTAL, AMM_NO3, OMC, EC, PM10, CM, AM
"ACAD1", "", 44.3771, -68.261, 20000101, 3.22, 8.0645, 0.2171958, 1.017423, 2.04764, 1.11
"ACAD1", "", 44.3771, -68.261, 20000105, 3.22, 1.8308, 0.1202492, 0.111198, 0.3829, 0.067
"ACAD1", "", 44.3771, -68.261, 20000108, 3.22, 3.2492, 0.1289628, 0.240972, 0.95102, 0.14
"ACAD1", "", 44.3771, -68.261, 20000112, 3.22, 3.3448, 0.144354, 0.2193, 0.69384, 0.1866,
"ACAD1", "", 44.3771, -68.261, 20000115, 3.22, 2.8856, 0.1553525, 0.187308, 0.72184, 0.19
"ACAD1", "", 44.3771, -68.261, 20000119, 3.22, 4.0888, 0.1827762, 0.604623, 1.44088, 0.30
"ACAD1", "", 44.3771, -68.261, 20000122, 3.22, 3.7937, 0.4609729, 0.372681, 0.79506, 0.16
"ACAD1", "", 44.3771, -68.261, 20000126, 3.22, 7.9274, 0.1164544, 0.807927, 1.19252, 0.14

```

**Visibility Monitor Data Variables and Descriptions (Old Algorithm) [Variables in bold are required]**

Variable	Description
<b>_ID</b>	IMPROVE site code
<b>_TYPE</b>	Leave blank
<b>LAT</b>	Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.

<b>LONG</b>	Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
<b>DATE</b>	Date of daily average ambient data with YYYYMMDD format (This is a numeric variable)
<b>FRH</b>	Monthly climatological relative humidity adjustment factor
PM25	Measured PM2.5 mass (ug/m3)
<b>CRUSTAL</b>	Crustal mass ( $2.2 \times [Al] + 2.49 \times [Si] + 1.63 \times [Ca] + 2.42 \times [Fe] + 1.94 \times [Ti]$ )
<b>AMM_NO3</b>	Ammonium nitrate mass (NO3*1.29)
<b>OMC</b>	Organic carbon mass (OC*1.4)
<b>EC</b>	Elemental carbon
PM10	PM10 mass
<b>CM</b>	Coarse mass (PM10 minus PM2.5)
<b>AMM_SO4</b>	Ammonium sulfate (S*4.125)
E_AMM_SO4	Ammonium sulfate extinction (Mm-1)
E_AMM_NO3	Ammonium nitrate extinction
E_OMC	Organic mass extinction
E_EC	Elemental carbon extinction
E_CRUSTAL	Crustal extinction
E_CM	Coarse mass (PM10 minus PM2.5) extinction
TBEXT	Total bext (includes 10 Mm-1 for Rayleigh scattering)
DV	Deciviews (calculated from Total bext)
<b>GOOD_YEAR</b>	Denotes complete data for the year (1= all quarters >75% completeness, 0= incomplete)
<b>GROUP</b>	90= 20% worst days and 10= 20% best days for each year (if good_year= 1)
POSSIBLE_NDAYS	Possible samples in quarter
NDAYS	Actual complete samples per quarter
COMPLETE_QUAR	Quarter completeness (1= complete, 0= incomplete)
TER	
SF	Sulfur concentration (used to calculate ammonium sulfate)
SO4F	Sulfate concentration (may be used as a backup in case S is missing)

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

### 9.2.1.2 Monitor Data Description (New Equation)

The monitor data for the new IMPROVE algorithm includes a large number of variables, so in the sample format below we have only a portion of the variables listed. The table below has a complete listing of the variables. The variables in **bold** are required variables on the input file. The additional variables are provided for QA purposes and are optional. Note that sea salt mass is optional, but is used in the visibility calculations if provided.

**Visibility Monitor Data Format (New Algorithm)**

```

Day
_ID, _TYPE, LAT, LONG, DATE, FRH, FSRH, FLRH, FSSRH, SS_RAYLEIGH, SEA_SALT, PM25, CRUSTAL, AMM_NO3, OMC, EC, PM10, CM, AMM_SO4, LARGE_OMC, SMALL_OMC, LARGE_AMM_SO4, SMALL_AMM_SO4, LARGE_AMM_NO3
ACAD1, , 44.3771, -68.261, 20000101, 3.22, 3.82, 2.75, 3.91, 12, 0, 8.0645, 0.2171958, 1.017
ACAD1, , 44.3771, -68.261, 20000105, 3.22, 3.82, 2.75, 3.91, 12, 0, 1.8308, 0.1202492, 0.111
ACAD1, , 44.3771, -68.261, 20000108, 3.22, 3.82, 2.75, 3.91, 12, 0, 3.2492, 0.1289628, 0.240
ACAD1, , 44.3771, -68.261, 20000112, 3.22, 3.82, 2.75, 3.91, 12, 0, 3.3448, 0.144354, 0.2193
ACAD1, , 44.3771, -68.261, 20000115, 3.22, 3.82, 2.75, 3.91, 12, 0, 0.55116, 2.8856, 0.1553525
ACAD1, , 44.3771, -68.261, 20000119, 3.22, 3.82, 2.75, 3.91, 12, 0, 4.0888, 0.1827762, 0.604
ACAD1, , 44.3771, -68.261, 20000122, 3.22, 3.82, 2.75, 3.91, 12, 0, 0.192906, 3.7937, 0.460972
ACAD1, , 44.3771, -68.261, 20000126, 3.22, 3.82, 2.75, 3.91, 12, 2.29752, 7.9274, 0.1164544
    
```

**Visibility Monitor Data Variables and Descriptions (New Algorithm) [Variables in bold are required]**

<b>Variable</b>	<b>Description</b>
<b>_ID</b>	IMPROVE site code
<b>_TYPE</b>	Leave blank
<b>LAT</b>	Latitude in decimal degrees. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
<b>LONG</b>	Longitude in decimal degrees. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
<b>DATE</b>	Date of daily average ambient data with YYYYMMDD format (This is a numeric variable)
<b>FRH</b>	Monthly climatological relative humidity adjustment factor
<b>FSRH</b>	Monthly climatological relative humidity adjustment factor - small sulfate and nitrate particles
<b>FLRH</b>	Monthly climatological relative humidity adjustment factor - large sulfate and nitrate particles
<b>FSSRH</b>	Monthly climatological relative humidity adjustment factor - sea salt
<b>SS_RAYLEIGH</b>	Site-specific Rayleigh scattering (Mm-1)
<b>PM25</b>	Measured PM2.5 mass (ug/m3)
<b>SEA_SALT</b>	Sea salt mass
<b>CRUSTAL</b>	Crustal mass ( 2.2 × [Al] + 2.49 × [Si] + 1.63 × [Ca] + 2.42 × [Fe] + 1.94 × [Ti])
<b>AMM_NO3</b>	Ammonium nitrate mass (NO3*1.29)
<b>OMC</b>	Organic carbon mass (OC*1.8)
<b>EC</b>	Elemental carbon
<b>PM10</b>	PM10 mass
<b>CM</b>	Coarse mass (PM10 minus PM2.5)
<b>AMM_SO4</b>	Ammonium sulfate (S*4.125)
<b>LARGE_OMC</b>	Large organic mass
<b>SMALL_OMC</b>	Small organic mass
<b>LARGE_AMM_SO4</b>	Large ammonium sulfate
<b>SMALL_AMM_SO4</b>	Small ammonium sulfate
<b>LARGE_AMM_NO3</b>	Large ammonium nitrate

SMALL_AMM_NO3	Small ammonium nitrate
E_AMM_SO4	Ammonium sulfate extinction (Mm-1)
E_AMM_NO3	Ammonium nitrate extinction
E_OMC	Organic mass extinction
E_EC	Elemental carbon extinction
E_CRUSTAL	Crustal extinction
E_CM	Coarse mass (PM10 minus PM2.5) extinction
E_SEA_SALT	Sea salt extinction
TBEXT	Total bext (includes site specific Rayleigh scattering)
DV	Deciviews (calculated from Total bext)
<b>GOOD_YEAR</b>	Denotes complete data for the year (1= all quarters >75% completeness, 0= incomplete)
<b>GROUP</b>	90= 20% worst days and 10= 20% best days for each year (if good_year= 1)
POSSIBLE_NDAYS	Possible samples in quarter
NDAYS	Actual complete samples per quarter
COMPLETE_QUAR	Quarter completeness (1= complete, 0= incomplete)
TER	
SF	Sulfur concentration (used to calculate ammonium sulfate)
SO4F	Sulfate concentration (may be used as a backup in case S is missing)

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

### 9.2.1.3 Linkage between Monitors & Class I Areas

MATS comes with a default database that provides the linkage between IMPROVE monitors and Class I Areas. The file is called "156-Class I-coordinates-all site names.csv". The format of the file and the variable descriptions are as follows:

#### Format for File Linking IMPROVE Monitors and Class I Areas

```

MONITOR_ID,MonLAT,MonLONG, CLASS_I_NAME, ID, STATE_ID,LAT, LONG
ACAD1,44.3771,-68.2610,"Acadia NP",ACAD,ME,44.35,-68.24
AGTI1,33.4636,-116.9706,"Agua Tibia Wilderness",AGTI,CA,33.42,-116.99
BADL1,43.7435,-101.9412,"Badlands NP",BADL,SD,43.81,-102.36
BALD1,34.0584,-109.4406,"Mount Baldy Wilderness",BALD,AZ,33.95,-109.54
BAND1,35.7797,-106.2664,"Bandelier NM",BAND,NM,35.79,-106.34
BIBE1,29.3027,-103.1780,"Big Bend NP",BIBE,TX,29.33,-103.31
BLIS1,38.9761,-120.1025,"Desolation Wilderness",DESO,CA,38.90,-120.17
BLIS1,38.9761,-120.1025,"Mokelumne Wilderness",MOKE,CA,38.57,-120.06
BOAP1,33.8695,-106.8520,"Bosque del Apache",BOAP,NM,33.79,-106.85

```

**Variables and Descriptions for File Linking IMPROVE Monitors and Class I Areas**

Var Name	Description (variable type)
_MONITOR_ID	IMPROVE monitor identification code (text)
MonLAT	IMPROVE monitor latitude (numeric)
MonLONG	IMPROVE monitor longitude (numeric)
_CLASS_I_NAME	Name of Class I Area (text)
_ID	Class I Area identification code (text)
_STATE_ID	State in which Class I Area is located (text)
LAT	Class I Area centroid latitude (numeric)
LONG	Class I Area centroid longitude (numeric)

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

**9.2.2 Model Data Input**

The model data for the 20 percent best and worst visibility days are used to calculate relative response factors (RRFs), which provide an estimate of the relative change in visibility from the baseline conditions to a future year. Recall from [forecast steps](#) that the monitor data are used to identify the best and worst days. Not the model data. MATS will match the best and worst measured days to the correct modeled days, by date. The model data input to MATS is in terms of PM species concentrations (measured in ug/m<sup>3</sup>).

The following exhibits provide an example of the model data format and a description of the variables. Note that the first line of the data file gives the frequency of the data. In this case, daily data. The second line gives the variables names. The data begins on the third line. Each data line represents a daily observation.

**Format for Daily PM Model Data**

```

Day
_ID, _TYPE, LAT, LONG, DATE, CM, CRUSTAL, SO4, EC, NO3, OC
1001,"",18.362337,-121.659843,20150101,0.0001,0.0003,0.0448,0.0037,0,0.0168
1001,"",18.362337,-121.659843,20150102,0.0058,0.0166,0.1202,0.0072,0,0.0325
1001,"",18.362337,-121.659843,20150103,0.0001,0.0001,0.0838,0.0093,0,0.0412
1001,"",18.362337,-121.659843,20150104,0,0,0.2813,0.0118,0,0.0481
1001,"",18.362337,-121.659843,20150105,0,0,0.6533,0.0354,0.0008,0.1588
1001,"",18.362337,-121.659843,20150106,0,0,0.5854,0.0249,0.0005,0.1146
1001,"",18.362337,-121.659843,20150107,0,0.0001,0.8663,0.0228,0.0003,0.1017
1001,"",18.362337,-121.659843,20150108,0.0011,0.0056,0.4761,0.0147,0,0.0658
1001,"",18.362337,-121.659843,20150109,0.0153,0.057,0.3192,0.0157,0,0.0751
1001,"",18.362337,-121.659843,20150110,0.005,0.0217,0.1882,0.0123,0,0.048
1001,"",18.362337,-121.659843,20150111,0,0,0.0995,0.007,0,0.0219
1001,"",18.362337,-121.659843,20150112,0.0018,0.0022,0.1087,0.0072,0,0.0235
1001,"",18.362337,-121.659843,20150113,0.0015,0.0022,0.1335,0.008,0,0.027
1001,"",18.362337,-121.659843,20150114,0.0002,0.0006,0.1797,0.008,0,0.0256
1001,"",18.362337,-121.659843,20150115,0.0025,0.0061,0.1131,0.0069,0,0.0267
1001,"",18.362337,-121.659843,20150116,0.0189,0.0407,0.2609,0.016,0,0.0658
1001,"",18.362337,-121.659843,20150117,0.0011,0.0021,0.2342,0.0157,0,0.0532
    
```

### Visibility Model Data Variable Descriptions

Variable	Description
_ID	The ID is a unique number for each model grid cell in the air quality model domain. It is generally based on the column and row identifiers from the air quality modeling domain. The default convention is to calculate the ID by multiplying the column identifier by one thousand (1000) and adding the row identifier. (This is a character variable.)
_TYPE	Leave blank
LAT	Latitude in decimal degrees of the center of each grid cell. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
LONG	Longitude in decimal degrees of the center of each grid cell. Values in the eastern hemisphere are positive, and those in the western hemisphere (e.g., United States) are negative.
DATE	Date of daily average model value with YYYYMMDD format (This is a numeric variable)
CM	Coarse PM (ug/m3)
CRUSTAL	Crustal PM
SO4	Sulfate PM
EC	Elemental carbon
NO3	Nitrate PM
OC	Organic mass PM

NOTE: Character variables have names that begin with an underscore (*i.e.*, "\_"), and the character values used can be kept with or without quotes. (If a character variable has an embedded space, such as might occur with the name of a location, then use quotes.)

Finally, note that the species variables used by MATS do not exactly correspond to the speciated [monitor data input](#) available from the VIEWS website. The following exhibit presents the correspondence used by MATS.

Monitor Data	
Variable Name (from Views)	New Variable Name (used within MATS)
Soil	CRUSTAL
Amm_NO3	AMM_NO3
OMC	OMC
LAC	EC
CM	CM
Amm_SO4	AMM_SO4

Regardless of the species names used by the air quality model, the model output variables should be changed to the MATS variable names when creating MATS input files.

**9.2.2.1 Using Model Data for Temporal Adjustment**

Relative response factors (RRFs) are calculated for each species: sulfate, nitrate, EC, OMC, Crustal, and Coarse Matter (CM), by taking the ratio of the average of the 20 percent best (or worst) days in the future to the average of the 20 percent best (or worst) days in the baseline. For example, when calculating the sulfate RRF for the 20 percent best days, MATS does the following calculation:

$$RRF_{Sulfate,j} = \frac{\frac{1}{n} \cdot \sum_{i=1}^n Sulfate_{future,j,i}}{\frac{1}{n} \cdot \sum_{i=1}^n Sulfate_{baseline,j,i}}$$

where:

j = Class I area

i = day identifier

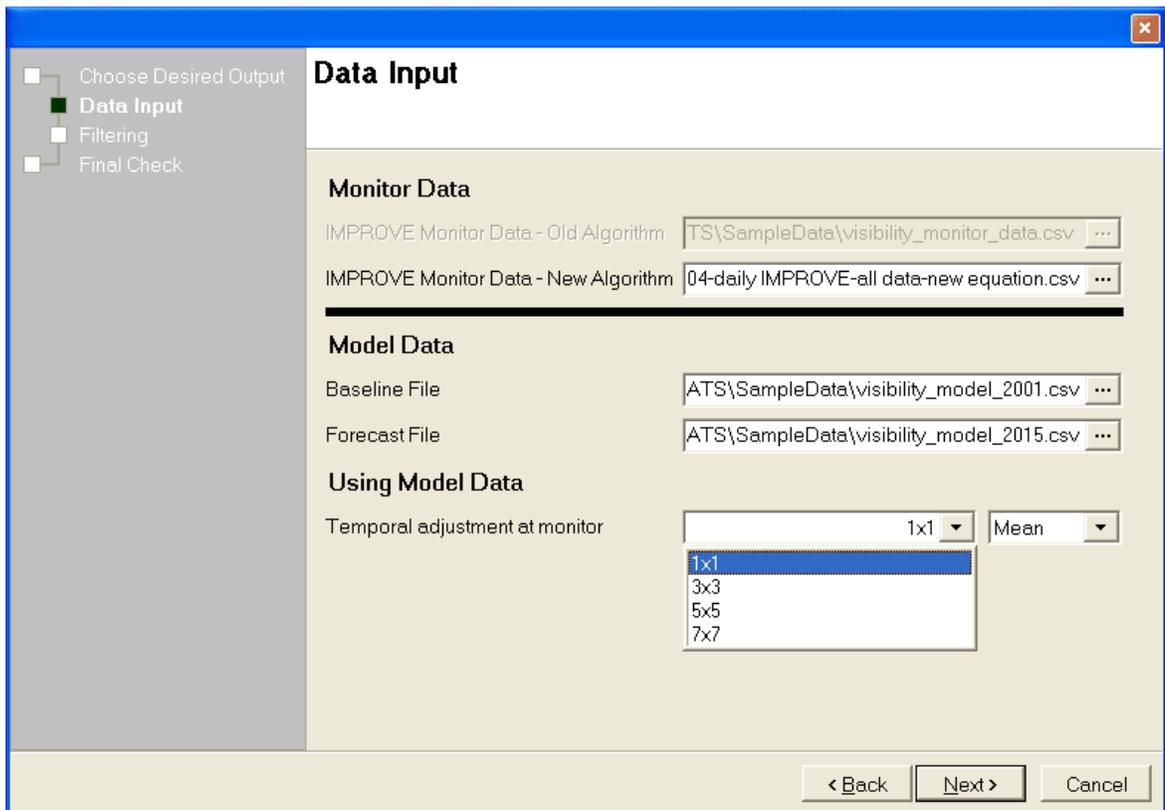
n = number of 20 percent best visibility days

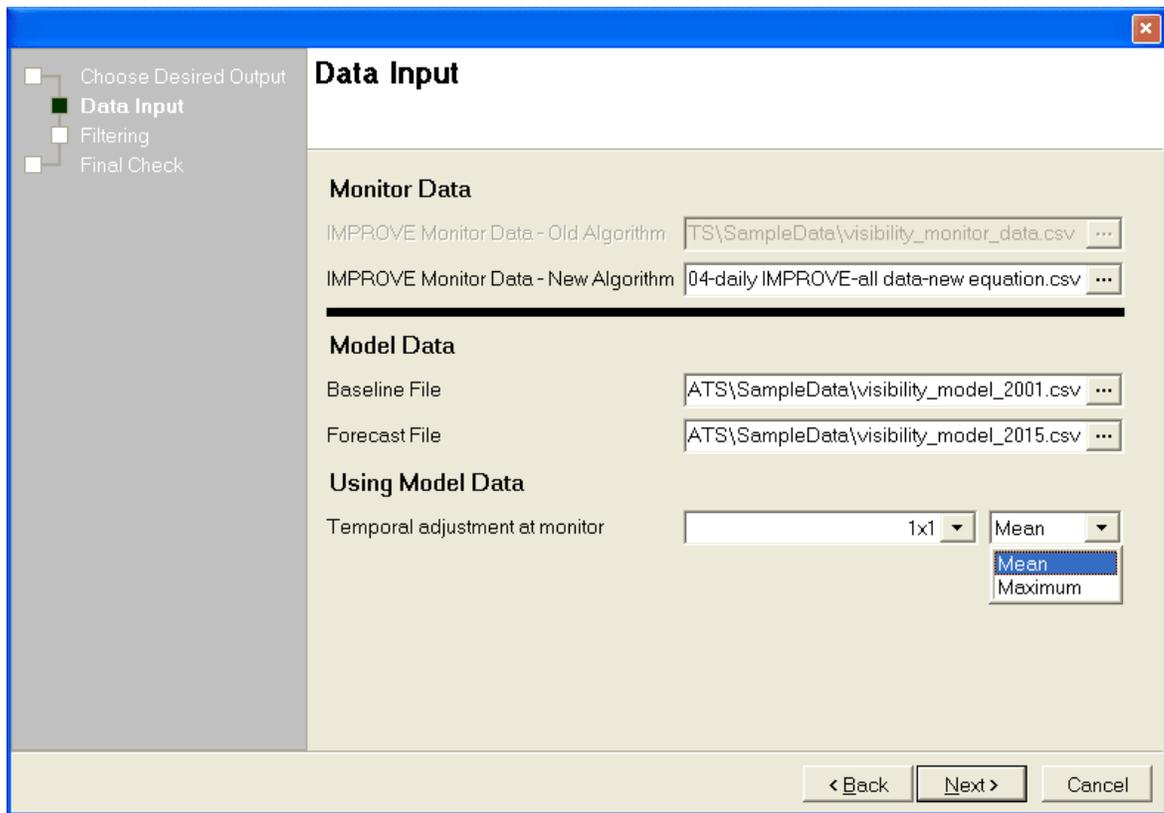
Sulfate = modeled sulfate concentration (in ug/m<sup>3</sup>) on best visibility days.

When identifying the model data for this calculation, MATS first determines whether you want to use model values located at the monitor or at the centroid of the Class I Area. You

choose the desired location (monitor or cell centroid) in the [Choose Desired Output](#) window. In addition, you need to specify how many cells around the desired location you want to use in the calculation ( $1 \times 1$  matrix,  $3 \times 3$  matrix, etc), and whether you want to use the maximum or the mean of the model cells.

In the case of a  $3 \times 3$  matrix with *Mean* specified, MATS identifies the speciated model values (measured in  $\mu\text{g}/\text{m}^3$ ) from among the nine “nearby” grid cells for each day for each Class I Area. In the typical case, where there are 365 days of model outputs, MATS will generate 365 daily values. MATS will do this calculation separately for each species for both the baseline and future-year scenarios. The Guidance Document recommends using the *Mean* of model values when calculating the RRF. Next there is a [recommended example](#) of how MATS calculates the RRF using the *Mean* for a  $3 \times 3$  matrix. (An [example](#) with the Maximum is also provided, however this is not the recommended approach for visibility calculations.)





9.2.2.1.1 RRF Calculation - Example with Mean

The Guidance Document recommends using the *Mean* of the model values. In the case of a 3x3 matrix with *Mean* specified, MATS averages the speciated model values (measured in ug/m<sup>3</sup>) from the nine “nearby” grid cells for each day for each Class I Area.

Assume there are eight best visibility days with the following modeled sulfate values in the baseline. MATS would average the values for each day.

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Mean
1	1.795	1.812	1.299	1.609	1.612	1.250	1.692	0.570	1.347	1.443
2	0.164	1.556	1.205	0.270	1.940	1.065	1.156	1.620	1.786	1.196
3	1.709	0.273	1.304	1.213	1.177	1.104	0.368	1.817	1.377	1.149
4	1.119	1.322	1.778	1.154	1.503	1.511	1.251	1.939	0.474	1.339
5	1.910	1.648	1.012	1.635	1.912	1.587	1.508	1.723	1.611	1.616
6	1.490	1.204	1.997	0.989	1.832	0.064	1.469	1.634	1.470	1.350
7	1.136	1.886	1.131	1.282	1.957	1.047	1.335	0.045	1.279	1.233
8	1.304	1.217	1.738	1.243	1.370	1.802	1.374	1.736	1.196	1.442

Assume there are eight best visibility days with the following modeled sulfate values in the forecast. Again, MATS would average the values for each day.

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Max
1	1.789	1.715	1.209	1.560	1.562	1.224	1.492	0.489	1.148	1.354
2	0.137	1.512	1.162	0.181	1.939	1.022	1.113	1.541	1.593	1.133
3	1.695	0.208	1.254	1.198	1.133	1.102	0.200	1.244	1.235	1.030
4	1.090	1.251	1.627	1.126	1.470	1.468	1.120	1.877	0.325	1.262
5	1.815	1.552	0.974	1.549	1.594	1.546	1.407	1.707	1.591	1.526
6	1.327	1.167	1.880	0.957	1.756	0.000	1.318	1.590	1.392	1.265
7	0.989	1.805	1.028	1.212	1.820	1.010	1.183	0.042	1.236	1.147
8	1.127	1.183	1.673	1.238	1.291	1.753	1.220	1.717	1.004	1.356

The average across the daily means for the baseline is 1.346 ug/m<sup>3</sup>. The average of the forecast cells is 1.259. The sulfate RRF would then be calculated as:  $RRF = 1.259 / 1.346 = 0.935$ .

A similar process occurs for the other species. The end result is 12 RRFs -- two for each of the six species (*i.e.*, sulfate, nitrate, elemental carbon, organic carbon, crustal, and ammonium).

9.2.2.1.2 RRF Calculation - Example with Maximum

The Modeling Guidance Document recommends using the *Mean* of the model values for visibility calculations. The example below, shows the calculations that would be involved if the *Maximum* were chosen. In the case of a 3x3 matrix with *Maximum* specified, MATS identifies the highest speciated model values (measured in ug/m<sup>3</sup>) from among the nine “nearby” grid cells for each day for each Class I Area.

Assume there are eight best visibility days with the following modeled sulfate values in the baseline:

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
1	1.795	1.812	1.299	1.609	1.612	1.250	1.692	0.570	1.347
2	0.164	1.556	1.205	0.270	1.940	1.065	1.156	1.620	1.786
3	1.709	0.273	1.304	1.213	1.177	1.104	0.368	1.817	1.377
4	1.119	1.322	1.778	1.154	1.503	1.511	1.251	1.939	0.474
5	1.910	1.648	1.012	1.635	1.912	1.587	1.508	1.723	1.611
6	1.490	1.204	1.997	0.989	1.832	0.064	1.469	1.634	1.470
7	1.136	1.886	1.131	1.282	1.957	1.047	1.335	0.045	1.279
8	1.304	1.217	1.738	1.243	1.370	1.802	1.374	1.736	1.196

MATS would choose the cells highlighted in orange:

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
1	1.795	1.812	1.299	1.609	1.612	1.250	1.692	0.570	1.347
2	0.164	1.556	1.205	0.270	1.940	1.065	1.156	1.620	1.786
3	1.709	0.273	1.304	1.213	1.177	1.104	0.368	1.817	1.377
4	1.119	1.322	1.778	1.154	1.503	1.511	1.251	1.939	0.474
5	1.910	1.648	1.012	1.635	1.912	1.587	1.508	1.723	1.611
6	1.490	1.204	1.997	0.989	1.832	0.064	1.469	1.634	1.470
7	1.136	1.886	1.131	1.282	1.957	1.047	1.335	0.045	1.279
8	1.304	1.217	1.738	1.243	1.370	1.802	1.374	1.736	1.196

Assume there are eight best visibility days with the following modeled sulfate values in the forecast:

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
1	1.789	1.715	1.209	1.560	1.562	1.224	1.492	0.489	1.148
2	0.137	1.512	1.162	0.181	1.939	1.022	1.113	1.541	1.593
3	1.695	0.208	1.254	1.198	1.133	1.102	0.200	1.744	1.235
4	1.090	1.251	1.627	1.126	1.470	1.468	1.120	1.877	0.325
5	1.815	1.552	0.974	1.549	1.894	1.546	1.407	1.707	1.591
6	1.327	1.167	1.880	0.957	1.756	0.000	1.318	1.590	1.392
7	0.989	1.805	1.028	1.212	1.820	1.010	1.183	0.042	1.236
8	1.127	1.183	1.673	1.238	1.291	1.753	1.220	1.717	1.004

MATS would choose the cells highlighted in orange. Note that the cells chosen for the forecast can differ from the cells chosen for the baseline.

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
1	1.789	1.715	1.209	1.560	1.562	1.224	1.492	0.489	1.148
2	0.137	1.512	1.162	0.181	1.939	1.022	1.113	1.541	1.593
3	1.695	0.208	1.254	1.198	1.133	1.102	0.200	1.244	1.235
4	1.090	1.251	1.627	1.126	1.470	1.468	1.120	1.877	0.325
5	1.815	1.552	0.974	1.549	1.594	1.546	1.407	1.707	1.591
6	1.327	1.167	1.880	0.957	1.756	0.000	1.318	1.590	1.392
7	0.989	1.805	1.028	1.212	1.820	1.010	1.183	0.042	1.236
8	1.127	1.183	1.673	1.238	1.291	1.753	1.220	1.717	1.004

The average of the best sulfate days chosen from the baseline cells is 1.897 ug/m3. The average of the forecast cells is 1.821. The sulfate RRF would then be calculated as:  $RRF = 1.821 / 1.897 = 0.960$ .

A similar (independent) process occurs for the other species. The particular cells chosen for sulfate may be quite different from the cells chosen for, say, nitrate. Continuing with the example you might have the following pattern for baseline:

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
1	0.071	0.133	0.620	0.788	0.808	0.964	0.763	0.938	0.158
2	0.561	0.891	0.105	0.689	0.695	0.302	0.523	0.209	0.485
3	0.005	0.384	0.604	0.077	0.545	0.046	0.177	0.664	0.821
4	0.926	0.651	0.111	0.334	0.887	0.548	0.447	0.547	0.730
5	0.630	0.995	0.769	0.888	0.379	0.121	0.779	0.130	0.558
6	0.700	0.761	0.993	0.556	0.659	0.877	0.761	0.474	0.821
7	0.074	0.189	0.619	0.987	0.279	0.757	0.470	0.189	0.701
8	0.848	0.100	0.964	0.535	0.566	0.315	0.440	0.011	0.852

And the following pattern for the forecast:

Best Days	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
1	0.068	0.122	0.556	0.711	0.766	0.594	0.653	0.877	0.152
2	0.514	0.515	0.092	0.615	0.687	0.283	0.460	0.198	0.479
3	0.004	0.380	0.513	0.076	0.504	0.044	0.175	0.591	0.801
4	0.769	0.581	0.099	0.327	0.852	0.537	0.416	0.482	0.719
5	0.563	0.940	0.673	0.859	0.374	0.113	0.685	0.123	0.505
6	0.610	0.694	0.910	0.514	0.621	0.828	0.649	0.438	0.794
7	0.072	0.179	0.597	0.954	0.244	0.701	0.428	0.176	0.695
8	0.837	0.090	0.940	0.522	0.500	0.295	0.434	0.011	0.809

The end result is 12 RRFs -- two for each of the six species (*i.e.*, sulfate, nitrate, elemental carbon, organic carbon, crustal, and ammonium).

### 9.3 Filtering

MATS loads in the monitor data that you have specified in [Data Input](#) window, and then in the **Filtering** window MATS presents the available years of monitor data for your analysis. You specify a range of years with the **Start Monitor Year** and **End Monitor Year** drop-down menus.

Using the **Base Model Year** drop-down menu, you can also specify the year that you want to use to determine the "best" and "worst" monitor days. The **Base Model Year** needs to fall within the range specified by the **Start Monitor Year** and **End Monitor Year**. Once you have specified the **Base Model Year**, MATS will then identify and save for each monitor the particular dates during this year that registered the best and worst visibility days. These dates are then used to identify the model values used in the calculation of RRFs for the temporal adjustment, as seen in the [Example](#) in the [Model Data Input](#) section.

Given a particular range of years that you have chosen, you can also specify the criteria for a monitor to be included in the analysis. With the **Minimum years required for a valid monitor** box, you specify the minimum number of years of data that a monitor must have (e.g., three years).

You can also specify the **Maximum Distance from Domain**. That is, you can choose the maximum distance that a monitor (or Class I Area centroid) can be from the nearest model grid cell centroid. For example, if the **Maximum Distance from Domain** is 25, and a monitor is more than 25 kilometers from the nearest model grid cell centroid, then a forecast is not generated for this particular monitor. (More detailed examples regarding distance and monitor validity are available [here](#).)

### 9.3.1 Example Valid Visibility Monitors

Using the **Maximum Distance from Domain**, you can choose the maximum distance that a monitor (or Class I Area centroid) can be from the nearest model grid cell centroid. Whether you calculate the distance from a monitor or a Class I Area centroid depends on whether you have specified **Use model grid cells at monitor** or **Use model grid cells at Class I area centroid**.

### Point Estimates

Scenario Name :

#### Forecast

Temporally-adjust visibility levels at Class 1 Areas

IMPROVE Algorithm

use old version       use new version

---

Use model grid cells at monitor

Use model grid cells at Class 1 area centroid

### Example 1

Assume you have chosen **Use model grid cells at monitor**. If you have set the **Maximum Distance from Domain** to 25, and a monitor is more than 25 kilometers from the nearest model grid cell centroid, then a forecast is not generated for this particular monitor. And by extension, a forecast is not generated for the Class I Areas that are associated with this particular monitor.

Recall from the section on the [Linkage between Monitors and Class I Areas](#) that more than one Class I Area may be linked to a monitor. Highlighted in yellow below are some examples of monitors associated with more than Class I Area. For example, if the CHIR1 monitor is more than 25 kilometers from the nearest model grid cell centroid, then no forecasts would be generated for the three Class I Areas associated with this monitor (*i.e.*, Chiricahua NM, Chiricahua Wilderness, and Galiuro Wilderness).

<u>_MONITOR</u> <u>_ID</u>	<u>MonLAT</u>	<u>MonLONG</u>	<u>_CLASS_I_NAME</u>	<u>_ID</u>	<u>_STATE_</u> <u>ID</u>	<u>LAT</u>	<u>LONG</u>
ACAD1	44.377	-68.261	Acadia NP	ACAD	ME	44.35	-68.24
AGTI1	33.464	-116.971	Agua Tibia Wilderness	AGTI	CA	33.42	-116.99
BADL1	43.744	-101.941	Badlands NP	BADL	SD	43.81	-102.36
BALD1	34.058	-109.441	Mount Baldy Wilderness	BALD	AZ	33.95	-109.54
BAND1	35.780	-106.266	Bandelier NM	BAND	NM	35.79	-106.34

BIBE1	29.303	-103.178	Big Bend NP	BIBE	TX	29.33	-103.31
BLIS1	38.976	-120.103	Desolation Wilderness	DESO	CA	38.9	-120.17
BLIS1	38.976	-120.103	Mokelumne Wilderness	MOKE	CA	38.57	-120.06
BOAP1	33.870	-106.852	Bosque del Apache	BOAP	NM	33.79	-106.85
BOWA1	47.947	-91.496	Boundary Waters Canoe Area	BOWA	MN	48.06	-91.43
BRCA1	37.618	-112.174	Bryce Canyon NP	BRCA	UT	37.57	-112.17
BRET1	29.119	-89.207	Breton	BRET	LA	29.87	-88.82
BRID1	42.975	-109.758	Bridger Wilderness	BRID	WY	42.99	-109.49
BRID1	42.975	-109.758	Fitzpatrick Wilderness	FITZ	WY	43.24	-109.6
BRIG1	39.465	-74.449	Brigantine	BRIG	NJ	39.49	-74.39
CABI1	47.955	-115.671	Cabinet Mountains Wilderness	CABI	MT	48.18	-115.68
CACR1	34.454	-94.143	Caney Creek Wilderness	CACR	AR	34.41	-94.08
CANY1	38.459	-109.821	Arches NP	ARCH	UT	38.73	-109.58
CANY1	38.459	-109.821	Canyonlands NP	CANY	UT	38.23	-109.91
CAPI1	38.302	-111.293	Capitol Reef NP	CAPI	UT	38.06	-111.15
CHAS1	28.748	-82.555	Chassahowitzka	CHAS	FL	28.69	-82.66
CHIR1	32.009	-109.389	Chiricahua NM	CHIR	AZ	32.01	-109.34
CHIR1	32.009	-109.389	Chiricahua Wilderness	CHIW	AZ	31.86	-109.28
CHIR1	32.009	-109.389	Galiuro Wilderness	GALI	AZ	32.6	-110.39
COHU1	34.785	-84.627	Cohutta Wilderness	COHU	GA	34.93	-84.57
CRLA1	42.896	-122.136	Crater Lake NP	CRLA	OR	42.92	-122.13
CRLA1	42.896	-122.136	Diamond Peak Wilderness	DIPE	OR	43.53	-122.1
CRLA1	42.896	-122.136	Gearhart Mountain Wilderness	GEMO	OR	42.51	-120.86
CRLA1	42.896	-122.136	Mountain Lakes Wilderness	MOLA	OR	42.33	-122.11
CRMO1	43.461	-113.555	Craters of the Moon NM	CRMO	ID	43.39	-113.54

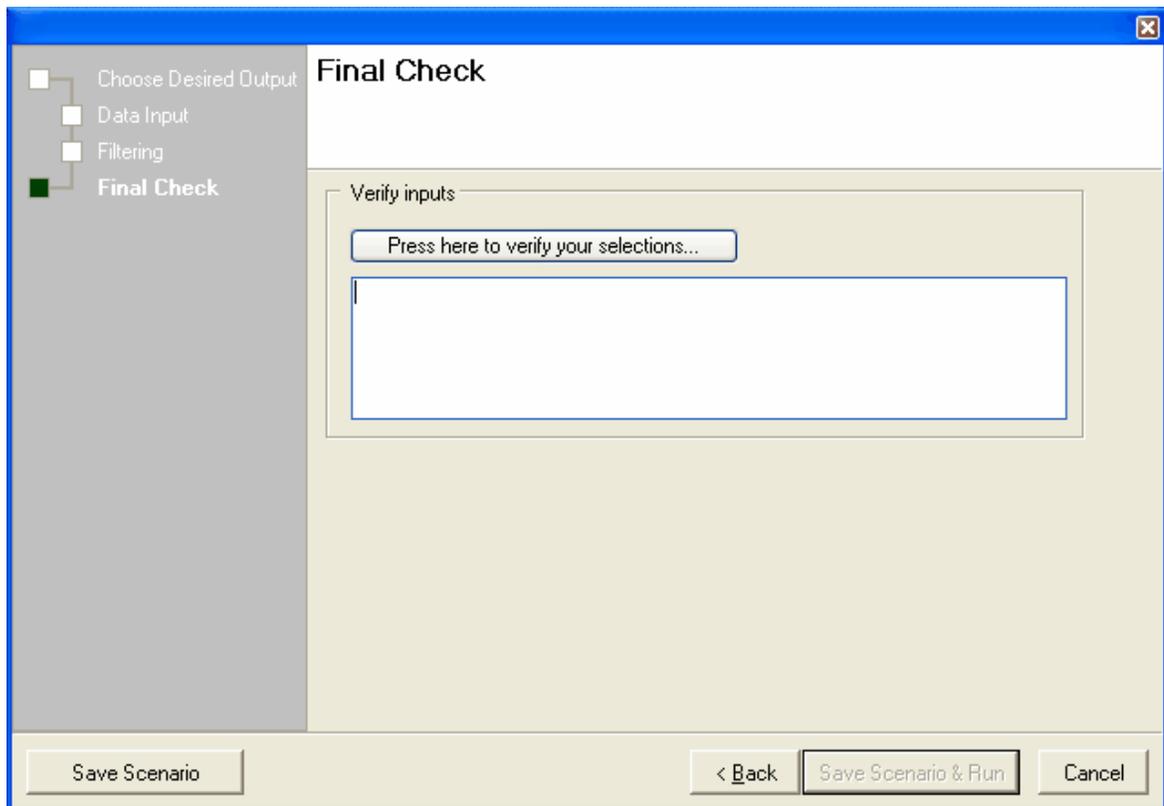
## Example 2

Assume you have chosen **Use model grid cells at Class I area centroid**. If you have set the **Maximum Distance from Domain** to 25, and a Class I Area is more than 25 kilometers from the nearest model grid cell centroid, then a forecast is not generated for this particular Class I Area (*e.g.*, Chiricahua, NM).

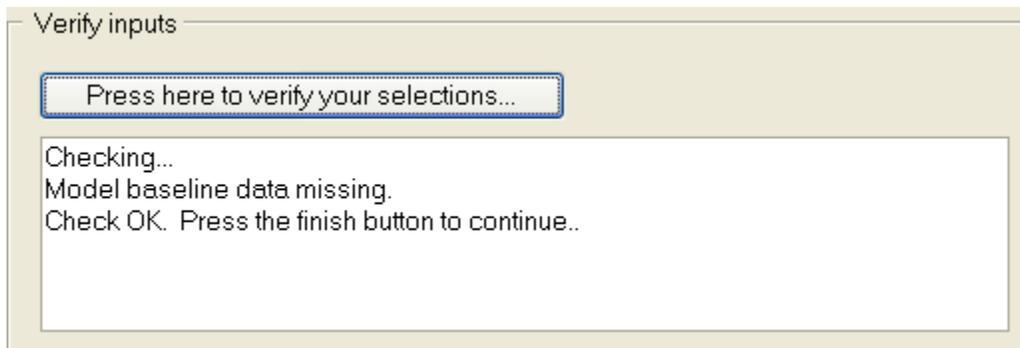
As noted above, the CHIR1 monitor is linked to two other Class I Areas. If these two other areas are within 25 kilometers of a model grid cell centroid, then the monitor values from CHIR1 would be used in the forecast for these two areas (along with the model values associated with the centroid of each area).

## 9.4 Final Check

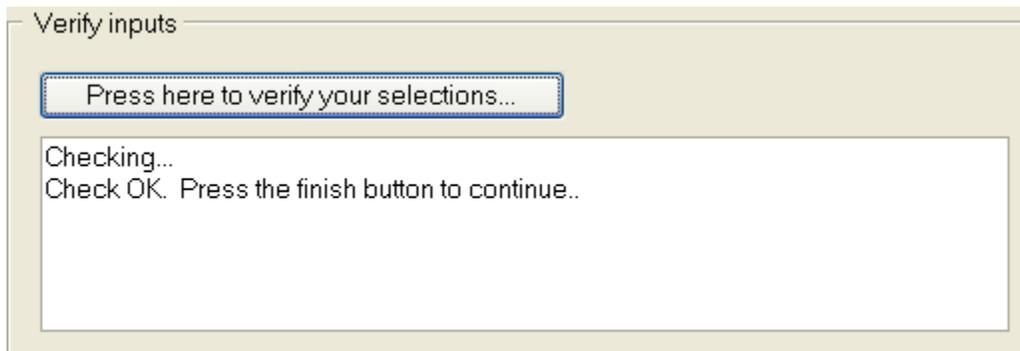
The Final Check window verifies the selections that you have made.



Click the button **Press here to verify your selections**. If there are any errors, MATS will present a message letting you know. For example, if the path to a model file is invalid -- perhaps you misspelled the file name -- you would get the following error:



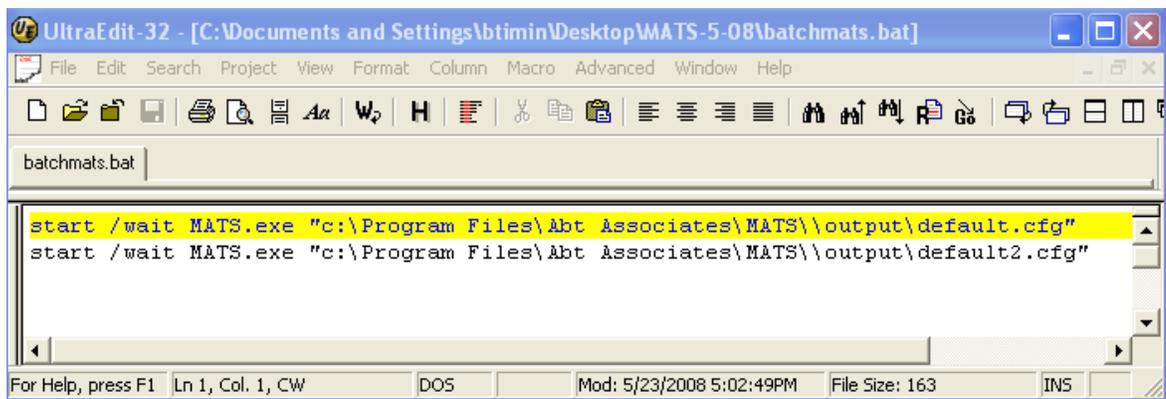
After making the necessary correction, click the button **Press here to verify your selections**.



When your window looks like the window above, click either **Save Scenario & Run** or **Save Scenario**. Save Scenario & Run will cause MATS to immediately run the scenario.

### 9.4.1 Running MATS in Batch Mode

The Save Scenario button will save the scenario as a configuration file (.cfg file). The "\*.cfg" file will be saved in the .\MATS\output directory. Several .cfg files can be created with the MATS interface and run later in batch mode. To do this, edit the default batch file located in the .\MATS directory. The file "batchmats.bat" should be edited with a text editor to point to the name and location of the .cfg files that will be run in batch mode.

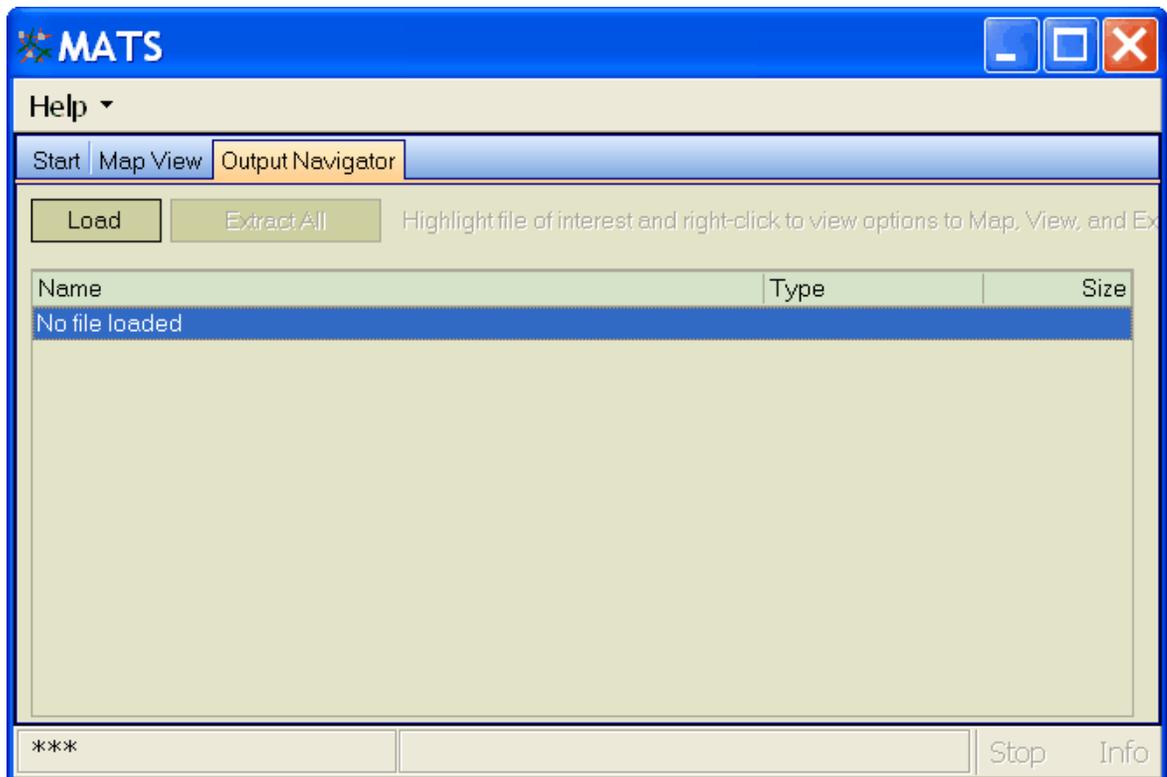


After editing the batchmats.bat file, simply run the .bat file. MATS will start and run in the background.

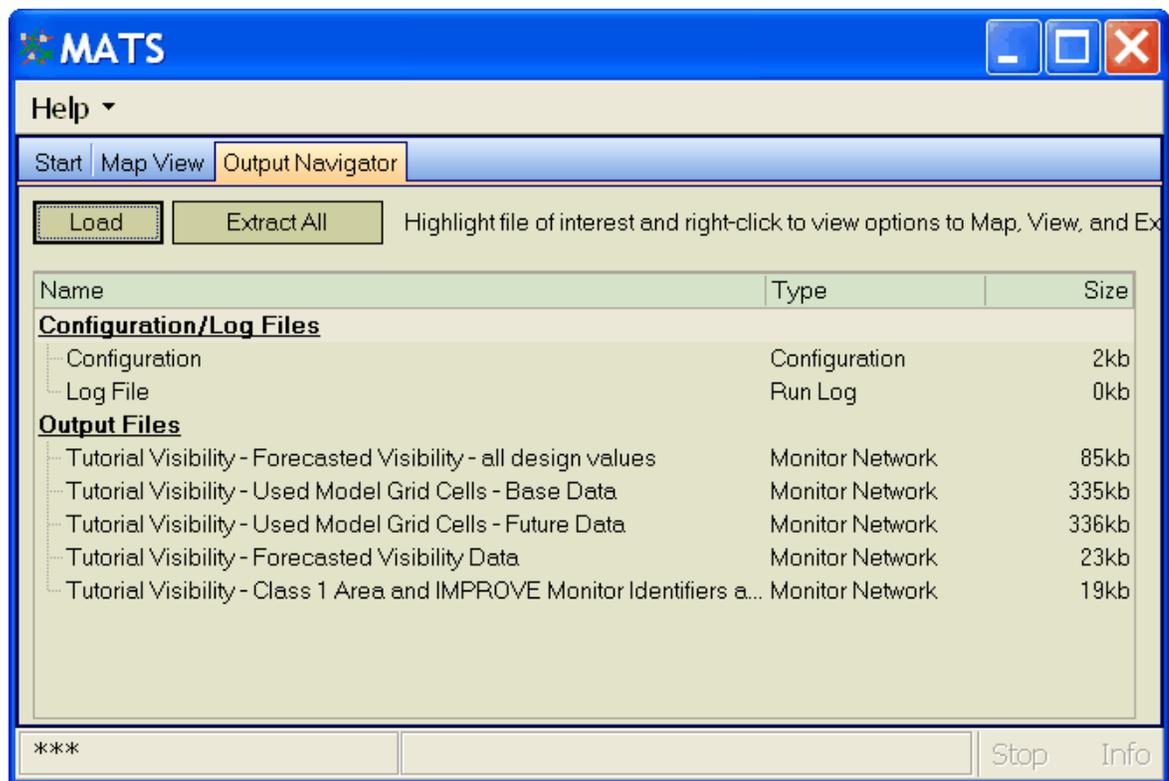
## 10 Output Navigator

The **Output Navigator** allows you to load results files (*i.e.*, [\\*.ASR files](#)) that you have previously created in MATS. You can view these data in maps and in tables, or export the data to text files that you can then work with in a program such as Excel.

To start, just click on the **Output Navigator** tab.

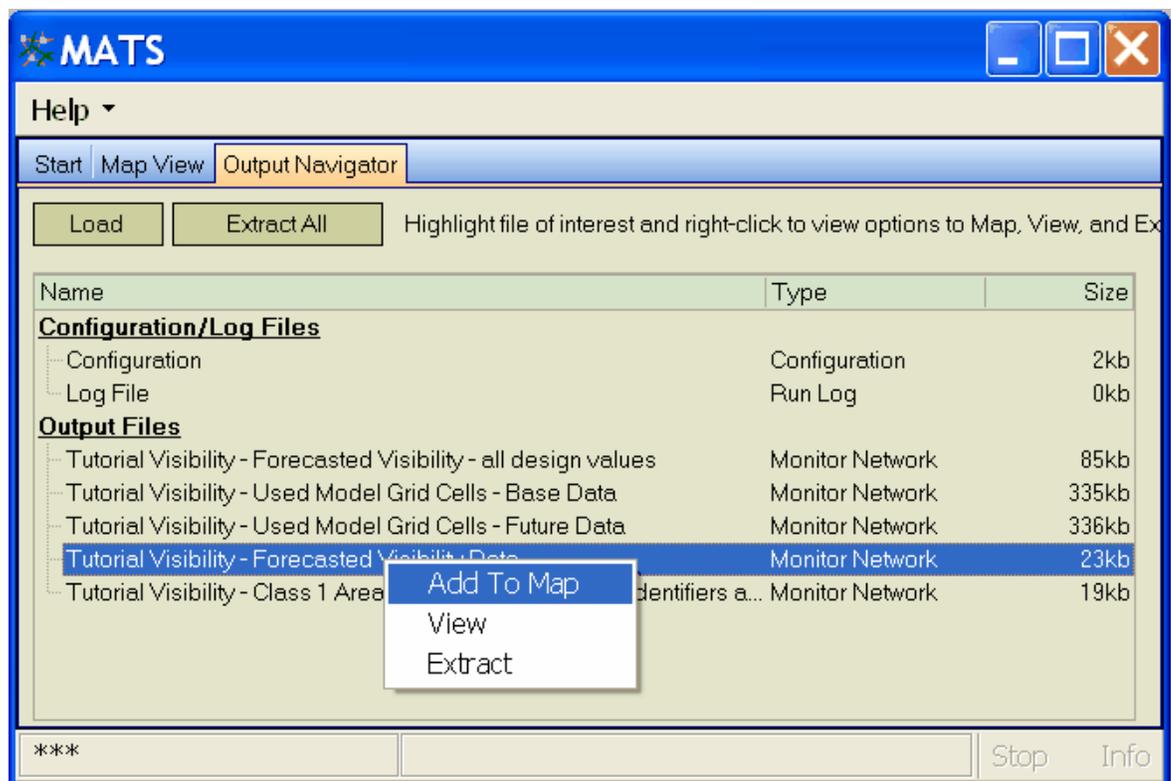


Click on the **Load** button to view your file of interest. This will bring up the **Open MATS Results file** window. Choose a results file (with the .ASR extension) This will bring you back to the Output Navigator and display the available files.

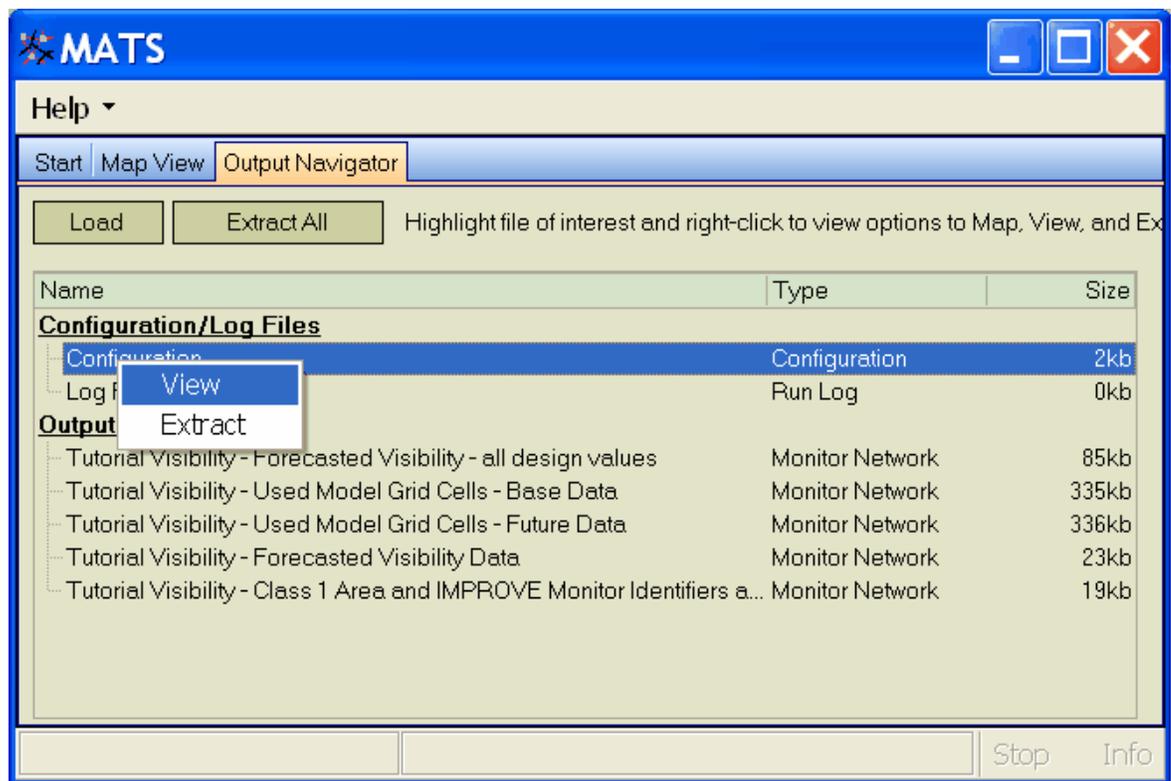


The files listed fall into two categories: **Configuration/Log Files** and **Output Files**. The [Configuration File](#) stores the assumptions used in generating your results file. The [Log File](#) stores information regarding the version of MATS used to create the results file and the date and time of its creation.

To examine a file, right-click on the file that you want to view. For **Output Files**, this will give you three choices, [Add to Map](#), [View](#), and [Extract](#).

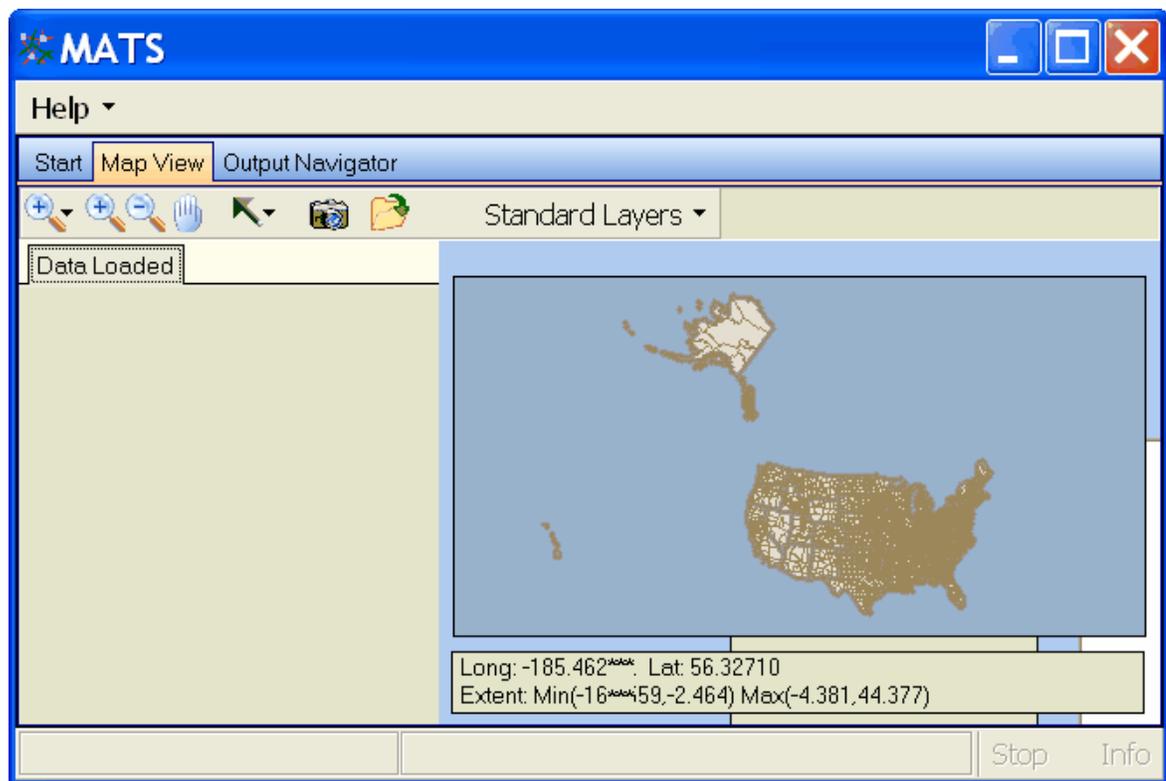


For the Configuration File and Log File you will see two options: *View* and *Extract*.

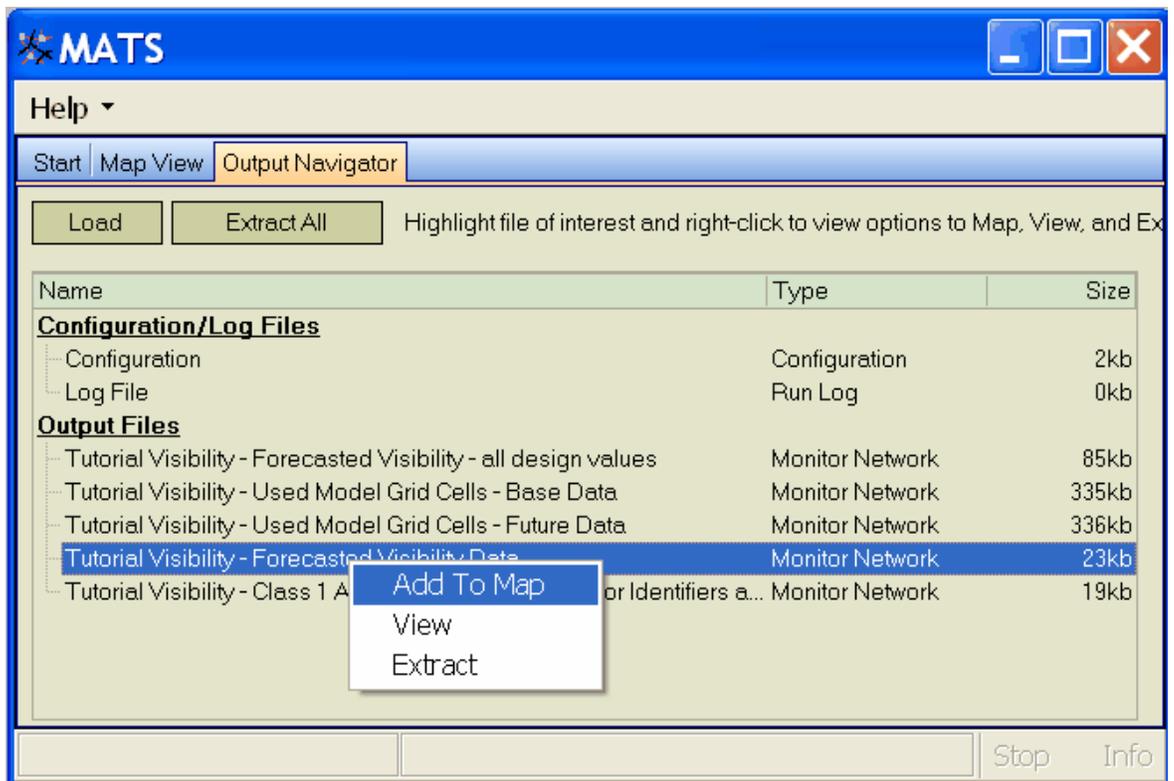


## 10.1 Add Output Files to Map

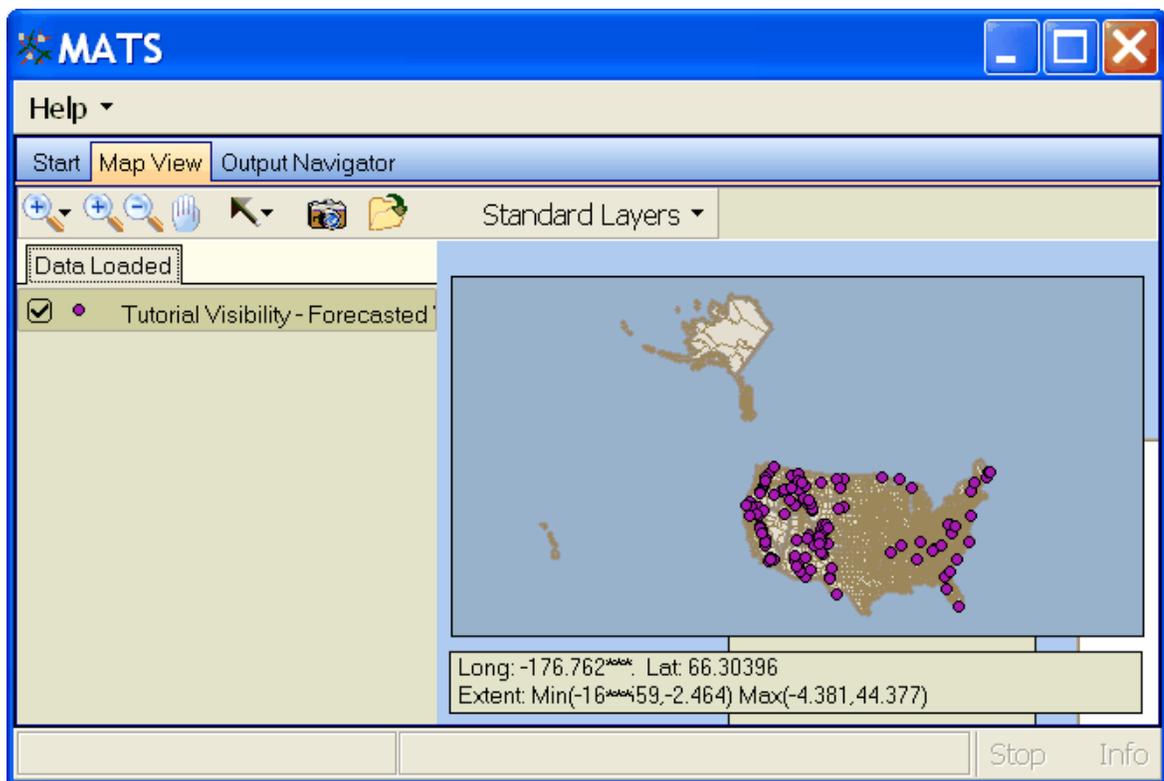
The **Map View** tab is initially empty, starting with just a blank map of the United States.



To map your results, click on the **Output Navigator** tab. Load the [ASR](#) file that you want to view and then right-click on the particular [Output File](#) that you want to map. This will give you three choices, *Add to Map*, [View](#), and [Extract](#).<sup>\*</sup> Choose the *Add To Map* option.



This will bring you back to the **Map View** tab.

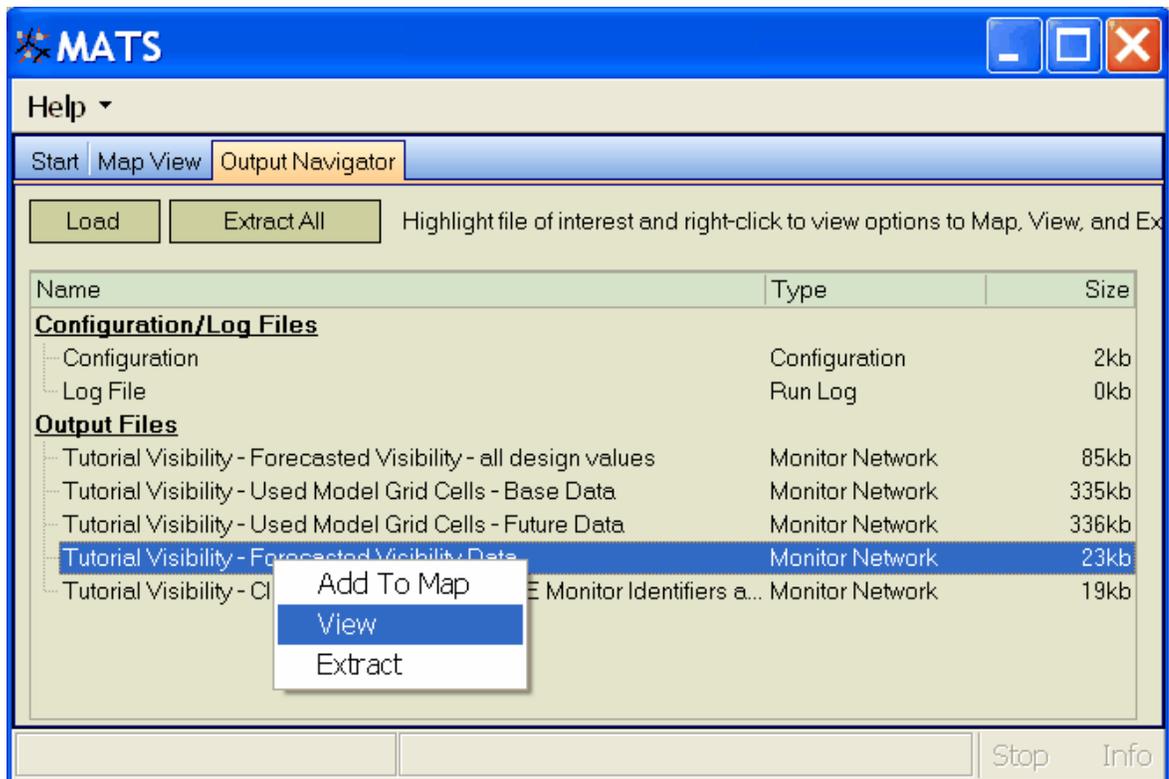


Details on how to generate a variety of maps are in the [Map View](#) chapter.

\* Note that if you right-click on the [Configuration File](#) or [Log File](#) you will only see two options: *View* and *Extract*. The Add To Map option is only relevant to the **Output Files**, as the **Configuration** and **Log** files do not have a geographic component.

## 10.2 View Files

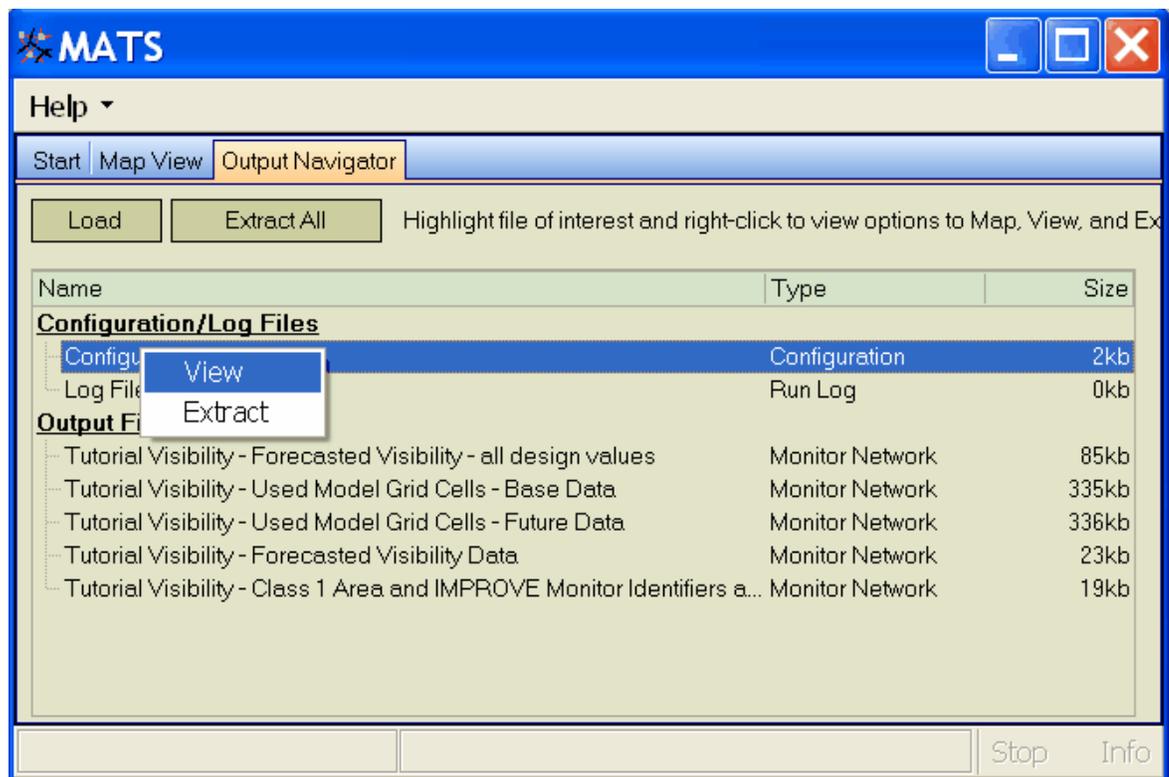
To view a file of interest, right-click on it, and then choose *View*. There are three basic types of files available: [Configuration](#), [Log](#), and [Output](#) files.



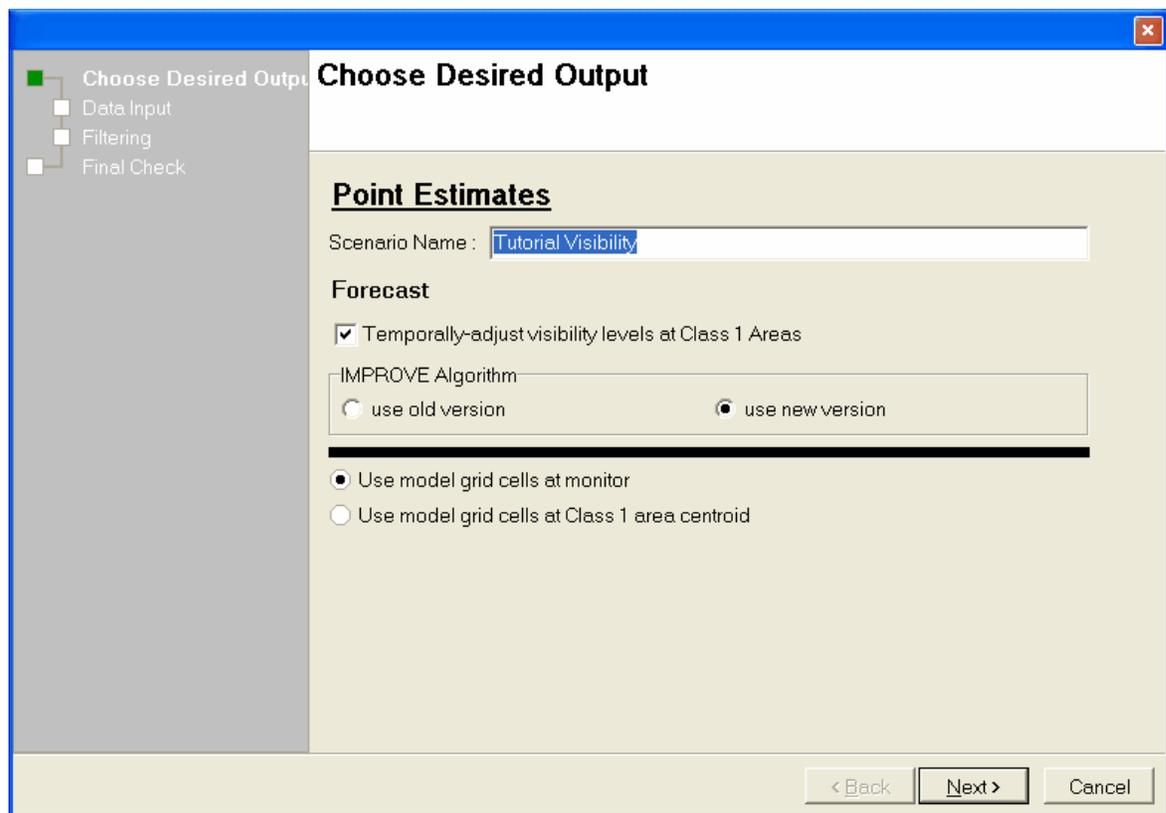
### 10.2.1 Configuration File

A Configuration File stores the choices that you have made when using MATS. A useful feature of a Configuration File is that it is reusable. You can use an existing Configuration File, make some minor changes to generate a new set of results, without having to explicitly set each of the choices you made in the previous Configuration.

To view a Configuration file from the **Output Navigator**, right-click on the file.



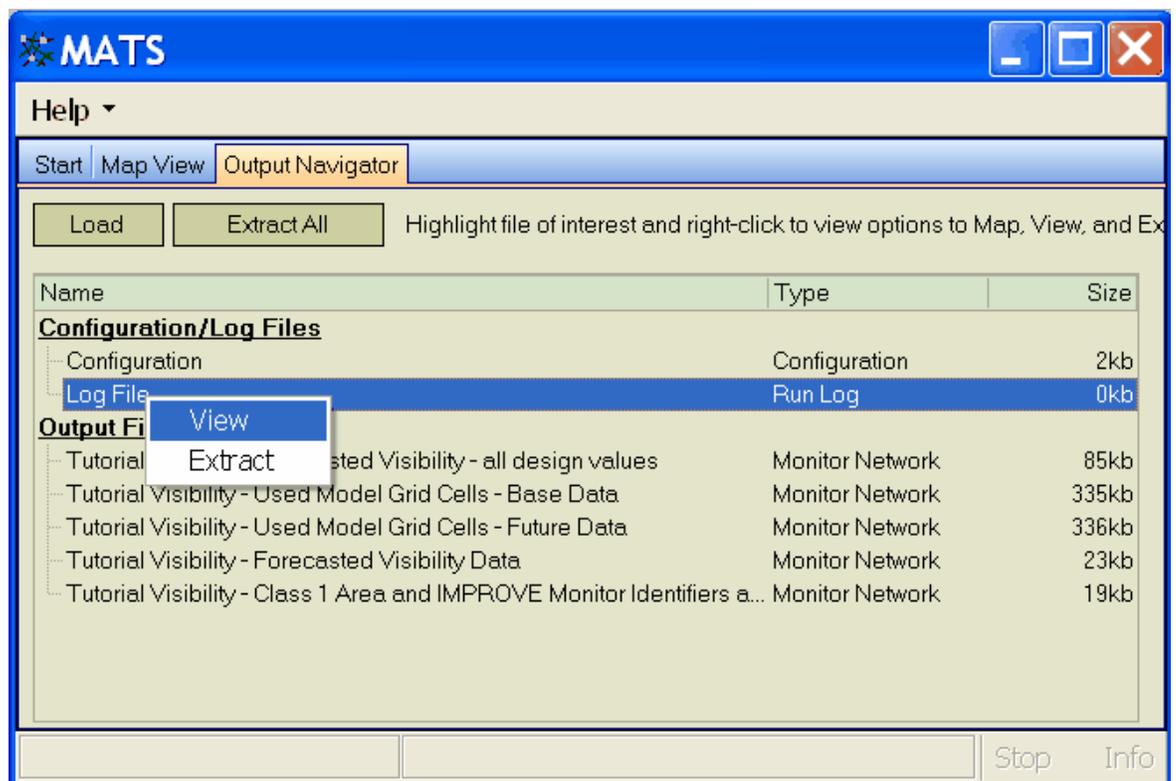
This will bring up the options that you chose when generating your results.



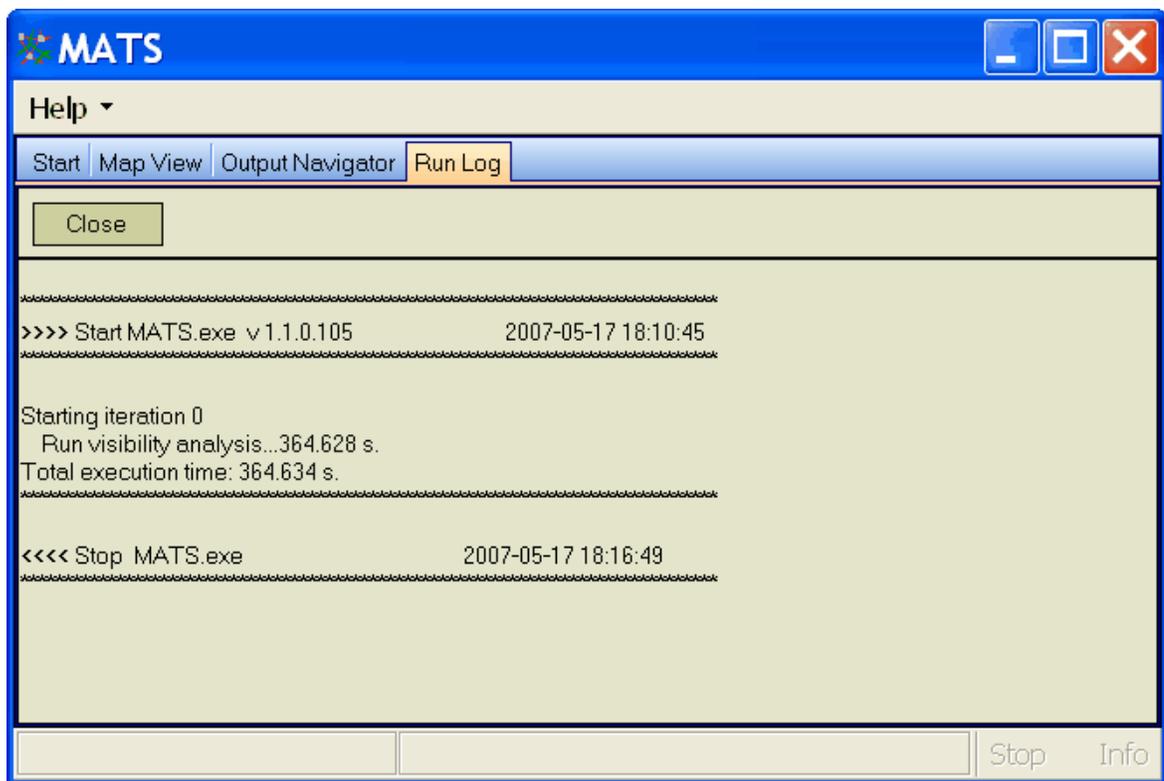
### 10.2.2 Log File

A Log File provides information on a variety of technical aspects regarding how a results file (\*.ASR) was created. This includes the version of MATS, the date and time the [\\*.ASR file](#) was created.

To view a Log file from the **Output Navigator**, right-click on the file.



A separate **Run Log** tab will appear.

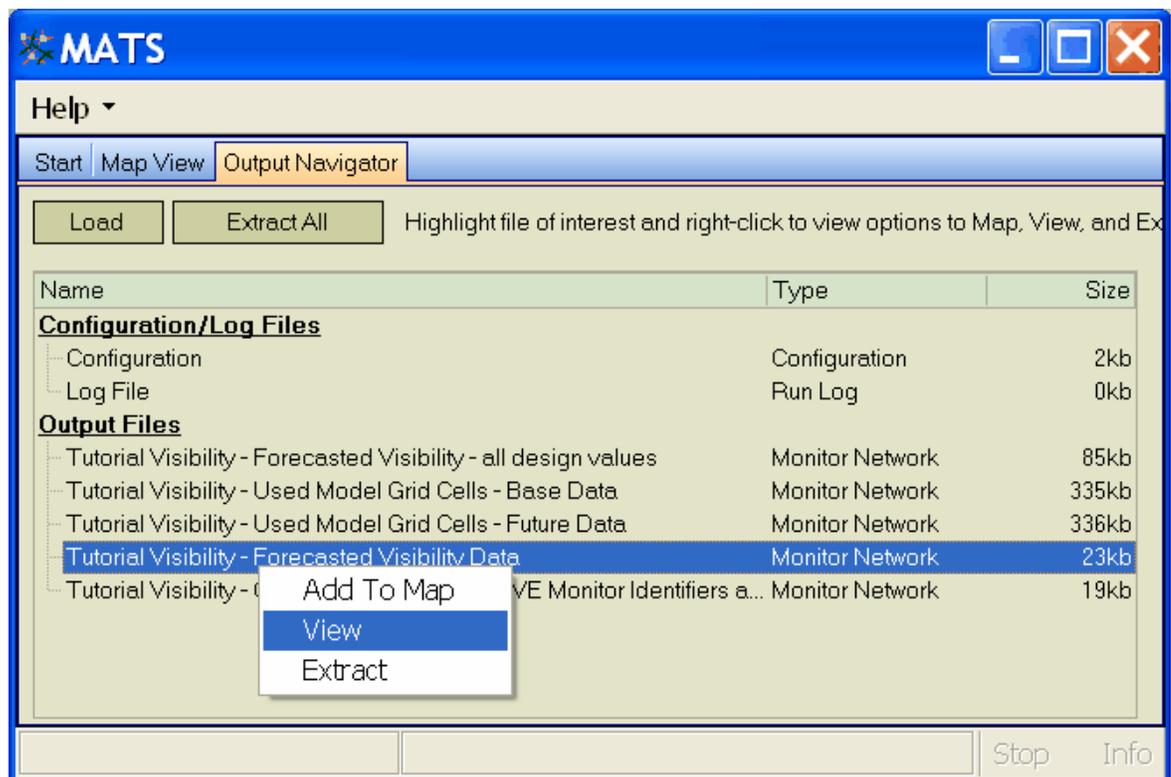


Click the **Close** button when you have finished viewing it. (The Run Log tab will disappear.)

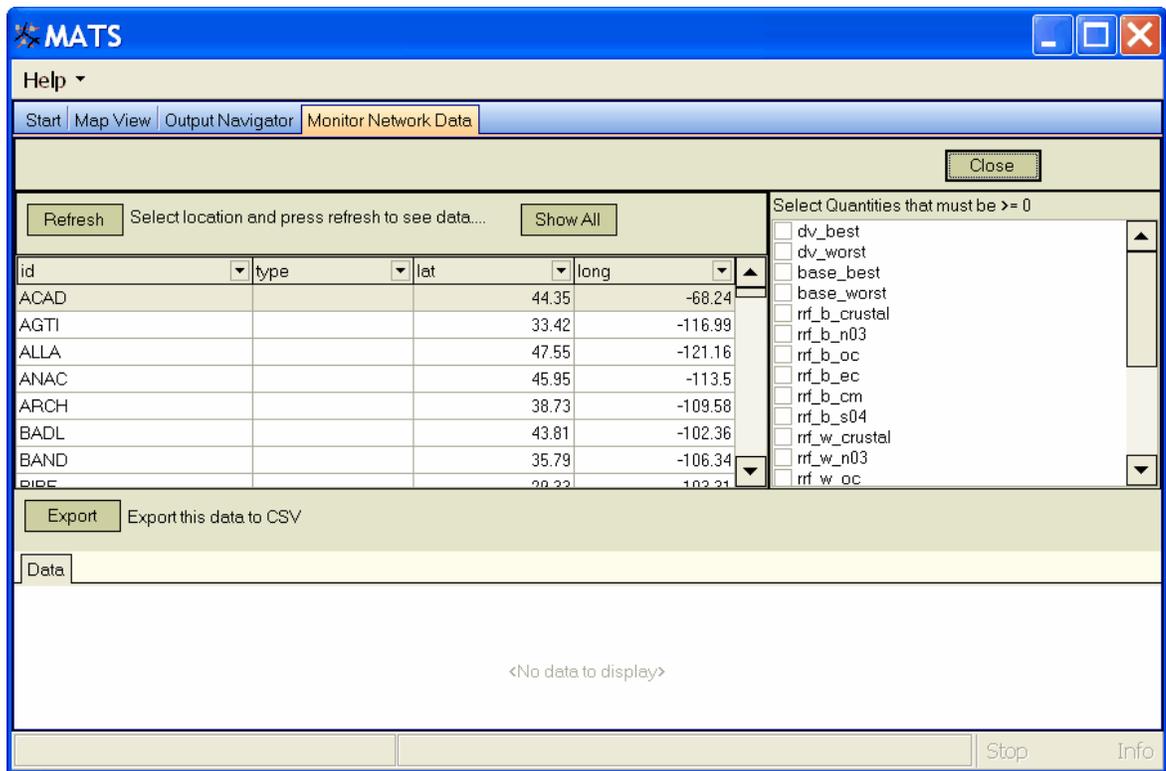
### 10.2.3 Output Files

An Output file is one of the file types within a [\\*.ASR results file](#). The types of Output Files available depend on the type of analysis ([PM](#), [Ozone](#), or [Visibility](#)) and the output choices that you have specified in the [Configuration File](#).

To view an Output file **Output Navigator**, right-click on a file.



This will bring up a separate tab with the data available for viewing.



The upper left panel has the ID and latitude and longitude for each point in the dataset.

id	type	lat	long
010030010		30.497778	-87.881389
010270001		33.281111	-85.802222
010331002		34.760556	-87.650556
010510001		32.498333	-86.136667
010550011		33.9039	-86.0539
010732006		33.386389	-86.816667
010790002		34.342778	-87.339722
010990014		34.600000	86.600000

Clicking the **Show All** button will cause the data to appear in the lower panel.

id	date	b_o3_dv	f_o3_dv	reference	rfr	ppb	days
121171002	2005	77.5	64.1	150014	0.828	70.0	9.00
121275002	2005	69.7	57.8	151019	0.830	71.0	10.0
121290001	2005	74.6	-9.00	125023	-9.00	70.0	4.00
130210012	2005	86.7	72.1	126049	0.832	80.0	11.0
130510021	2005	68.5	58.4	146045	0.853	78.0	10.0
130570001	2005	78.0	60.5	116062	0.776	77.0	10.0

The upper right panel allows you to select choose output with values greater than zero. After choosing one or more variables, click the **Show All** button.

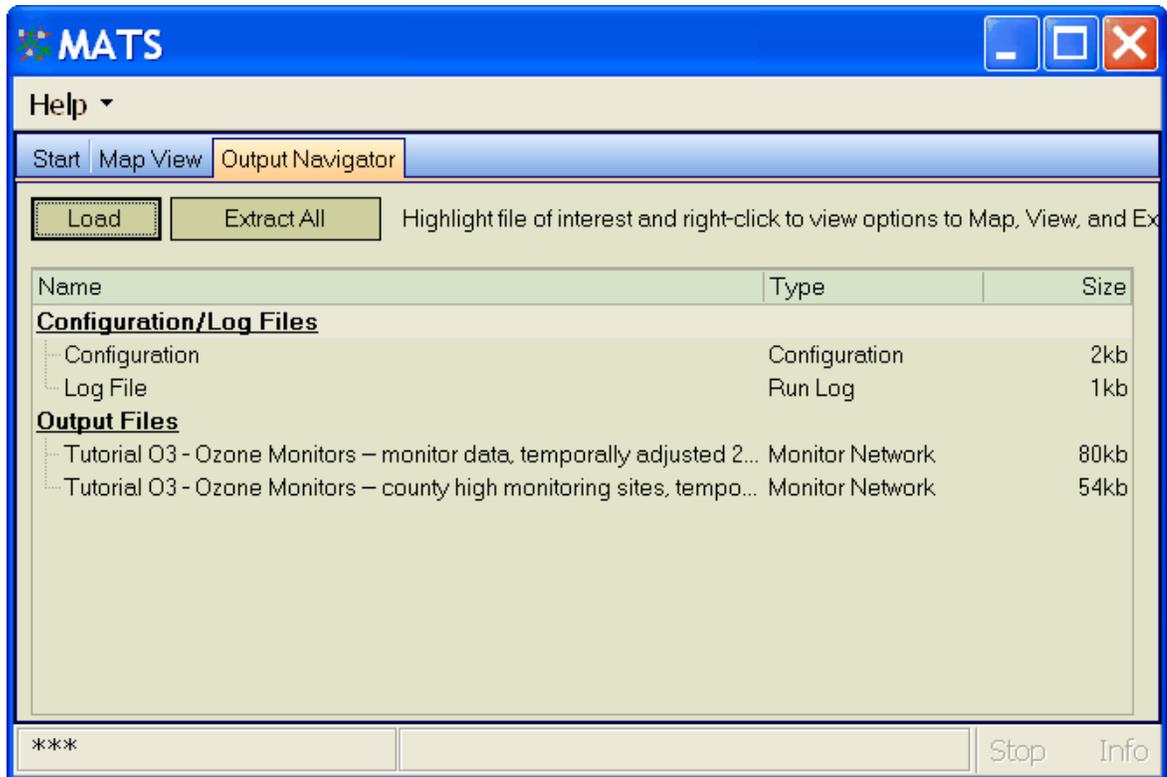
Note that missing values have a value of "-9", so this allows you to eliminate missing data. In the example below, the values for ID "121290001" are removed because the value for "f\_o3\_dv" is missing.

The screenshot shows the MATS software interface. The 'Output Navigator' panel is active, displaying a table of data. The table has columns: id, date, b\_o3\_dv, f\_o3\_dv, reference, rfr, ppb, and days. The row for ID 121290001 is highlighted in blue. To the right of the table is a 'Select Quantities that must be >= 0' panel with checkboxes for b\_o3\_dv, f\_o3\_dv, referencecell, rfr, ppb, and days. The 'f\_o3\_dv' checkbox is checked. Below the table is an 'Export' button and an 'Export this data to CSV' label. At the bottom right of the panel are 'Stop' and 'Info' buttons.

### 10.3 Extract Files

Extracting files allows you to export files from MATS and view them in another program. This is most relevant to the Output files, which you may want to view and manipulate in a database program such as Excel. MATS will generate [.CSV](#) files. These are easily viewable in a number of programs.

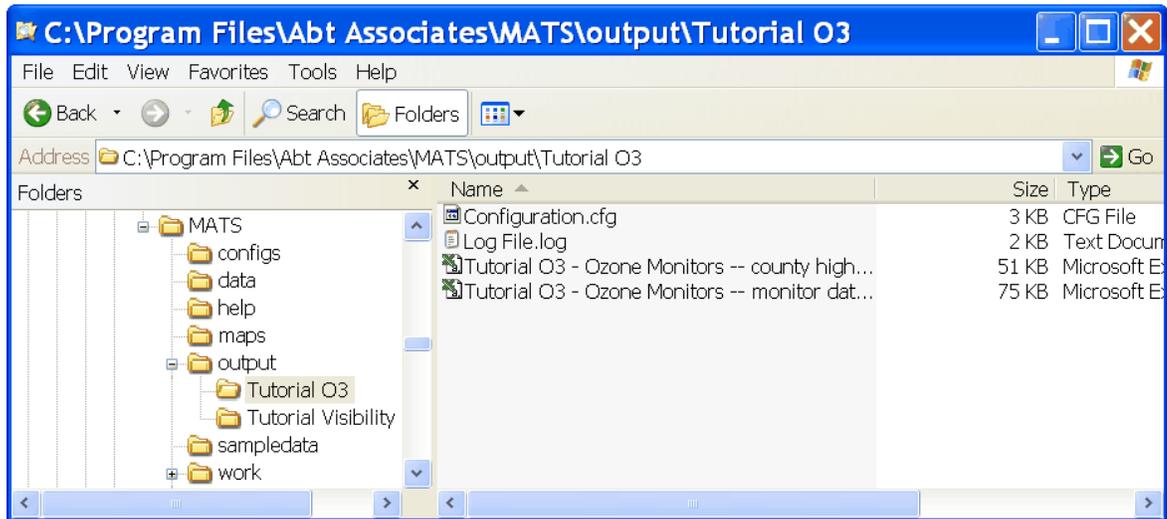
From Output Navigator load the results ([.ASR](#)) file of interest.



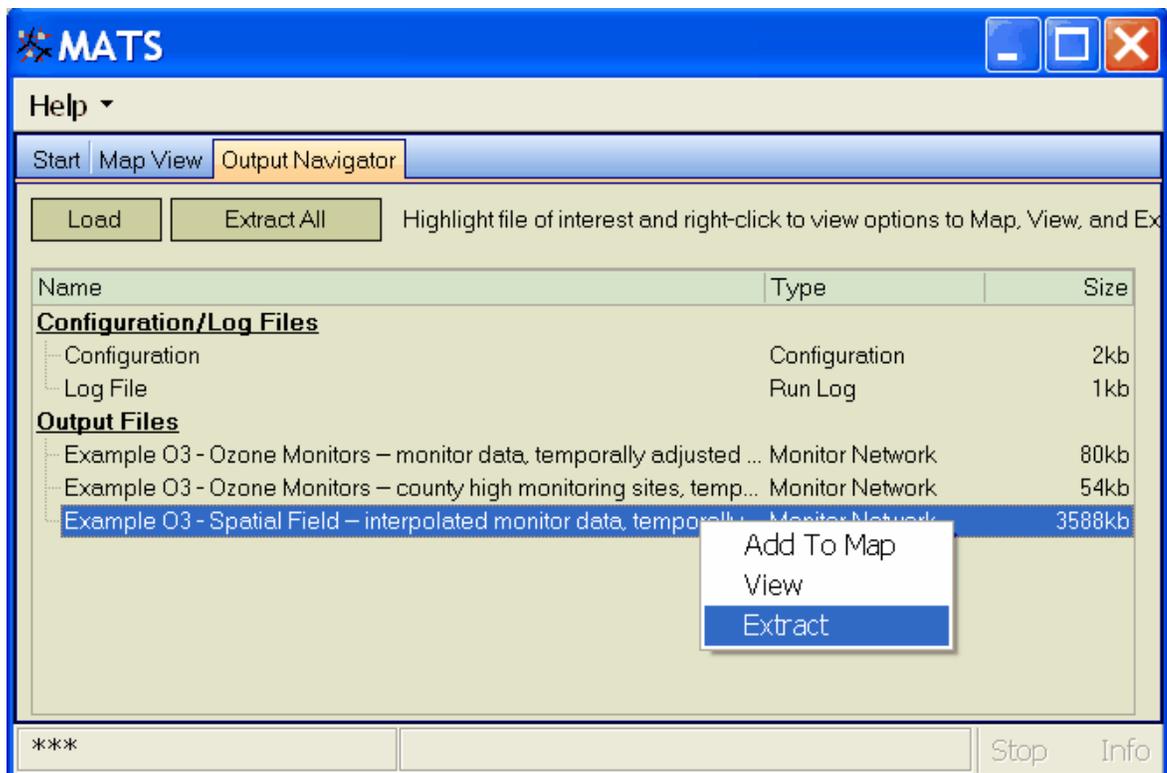
One quick method to extract all of the data in the results file is to click the **Extract All** button. An **Extracting All** screen will appear with a suggested name for the folder storing the results. MATS will use the [Scenario Name](#) as the default folder name. If desired you can rename the folder to whatever you desire.



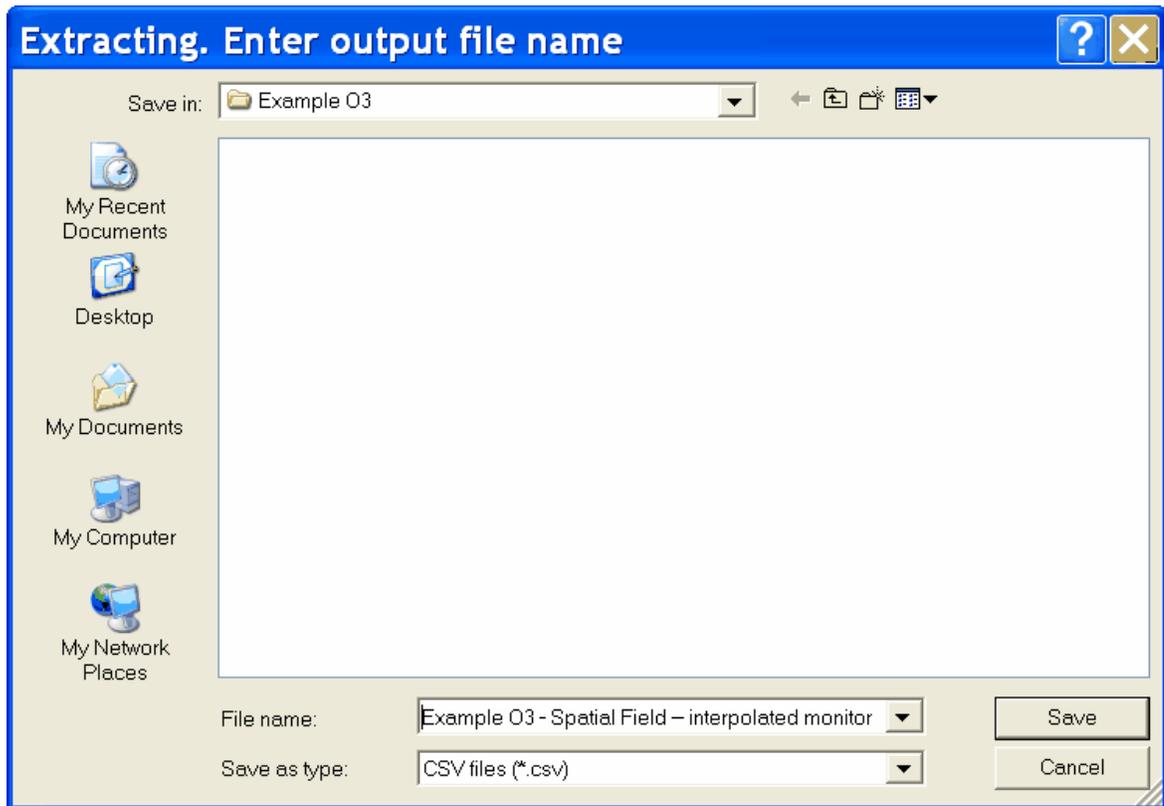
Click OK, and then MATS will export all of the files to this folder.



An alternative is to extract individual files. Right click on the file of interest, and choose the *Extract* option.

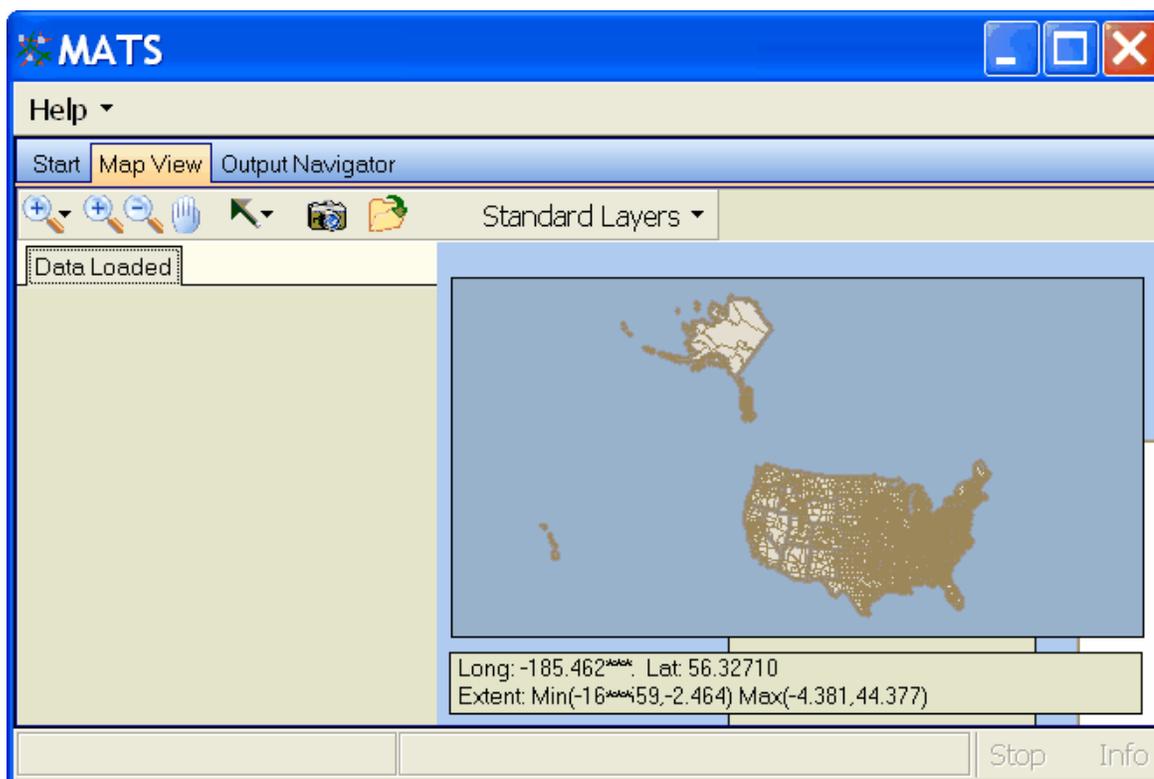


This will bring up the **Extracting. Enter output file name** window. By default, MATS will generate a folder with the [Scenario Name](#) (e.g., Example O3) and export a file with the same name used internally by MATS. You can change both the folder and the exported file name if desired.



## 11 Map View

The **Map View** tab allows you to further explore your results. Initially, it is empty, with just a blank map of the United States.



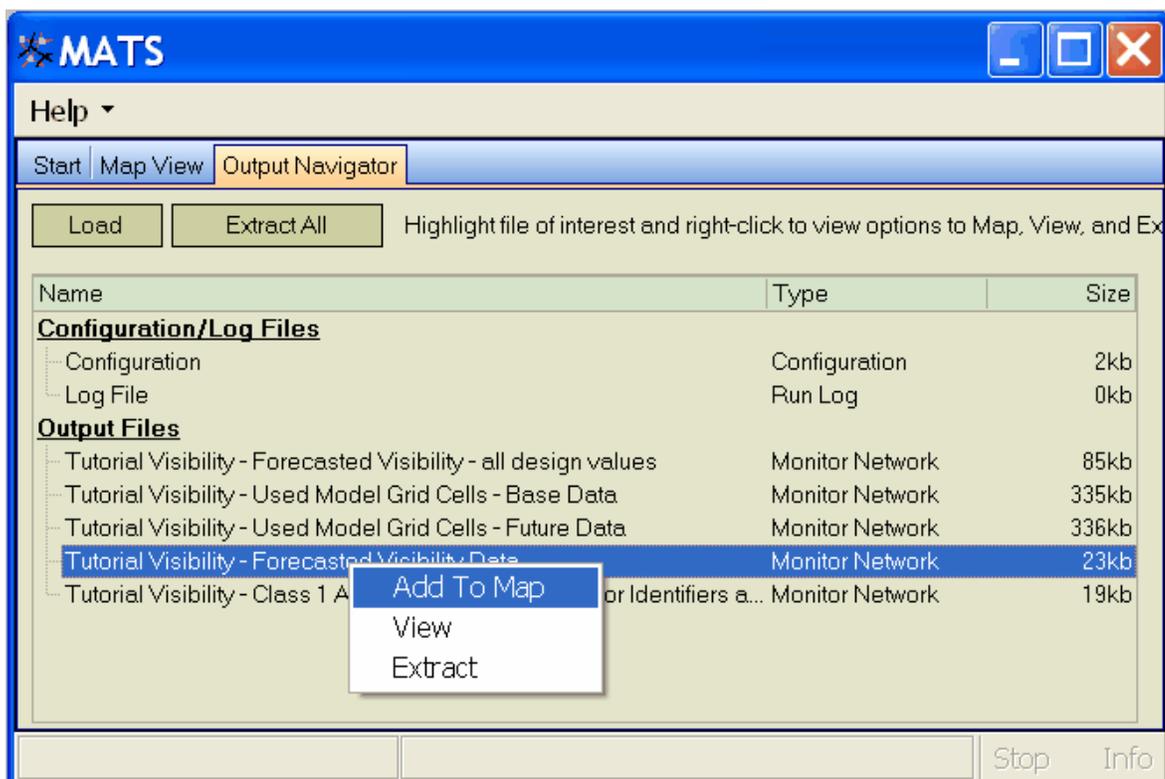
This section discusses how to:

- [Load](#) data onto the map;
- Choosing colors to represent the data (referred to as "[plotting](#)" in MATS);
- [Zoom](#) in and out on your map;
- Add and remove outlines for states, counties and Class 1 areas (these outlines are referred to as "[Standard Layers](#)");
- [Exporting](#) maps and CSV files;
- [Removing](#) data from a map.

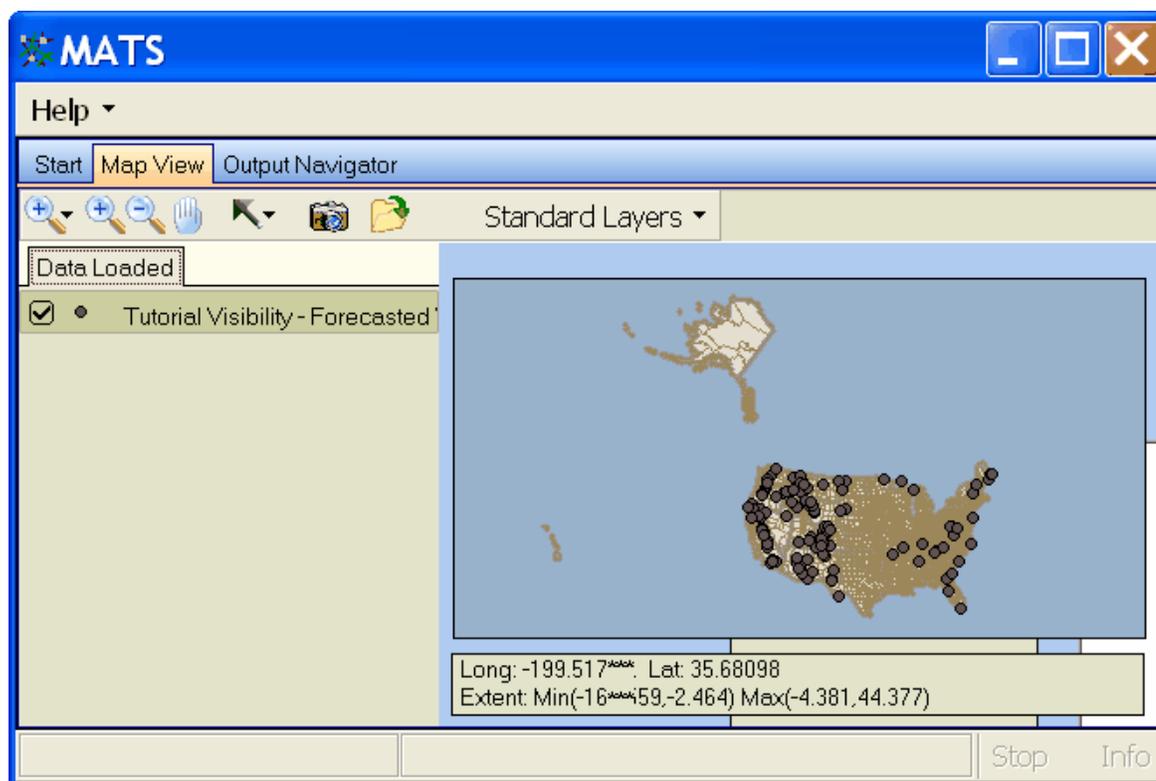
## 11.1 Loading Variables

There are two ways to bring data into a map. First, you may load data into a map with the [Output Navigator](#). Alternatively, you can load data directly from the map view taskbar (see [next sub-section](#)).

To map your results, click on the **Output Navigator** tab. Load the [ASR](#) file that you want to view and then right-click on the particular [Output File](#) that you want to map. Choose the *Add to Map* option.



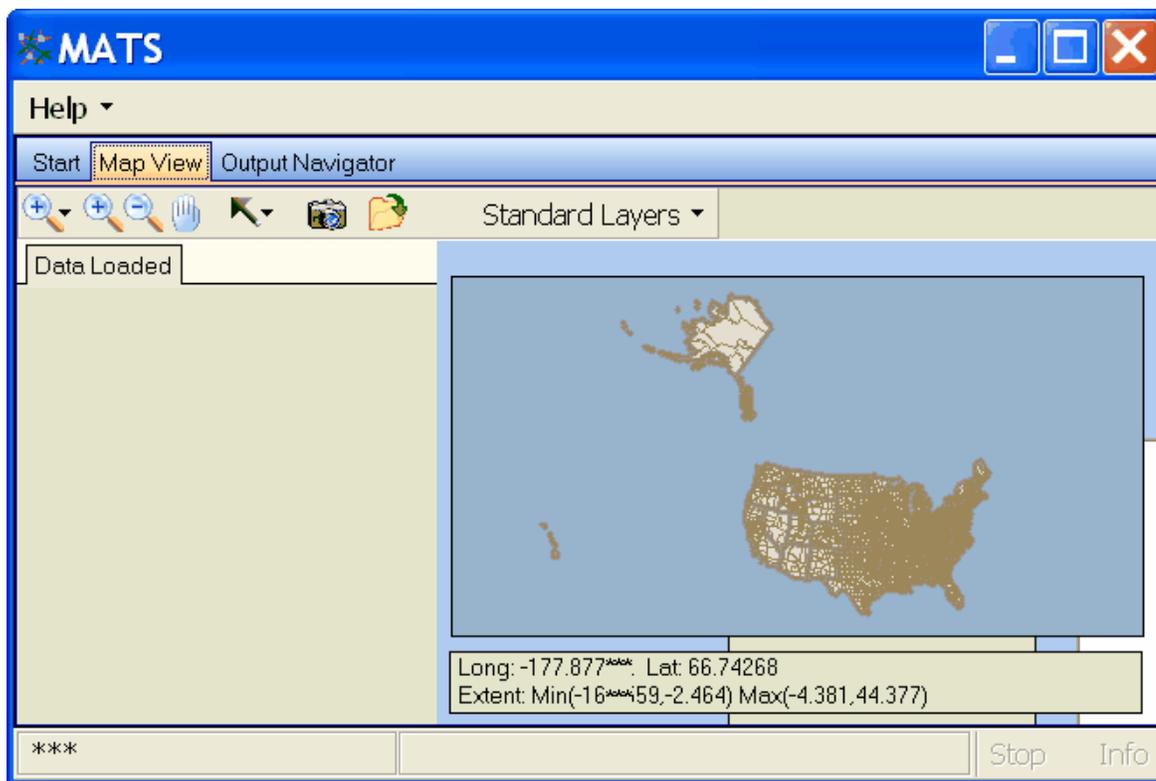
This will bring you back to the **Map View** tab.



Usually the next step is to plot your data. This is discussed [next](#).

### 11.1.1 Loading with Taskbar

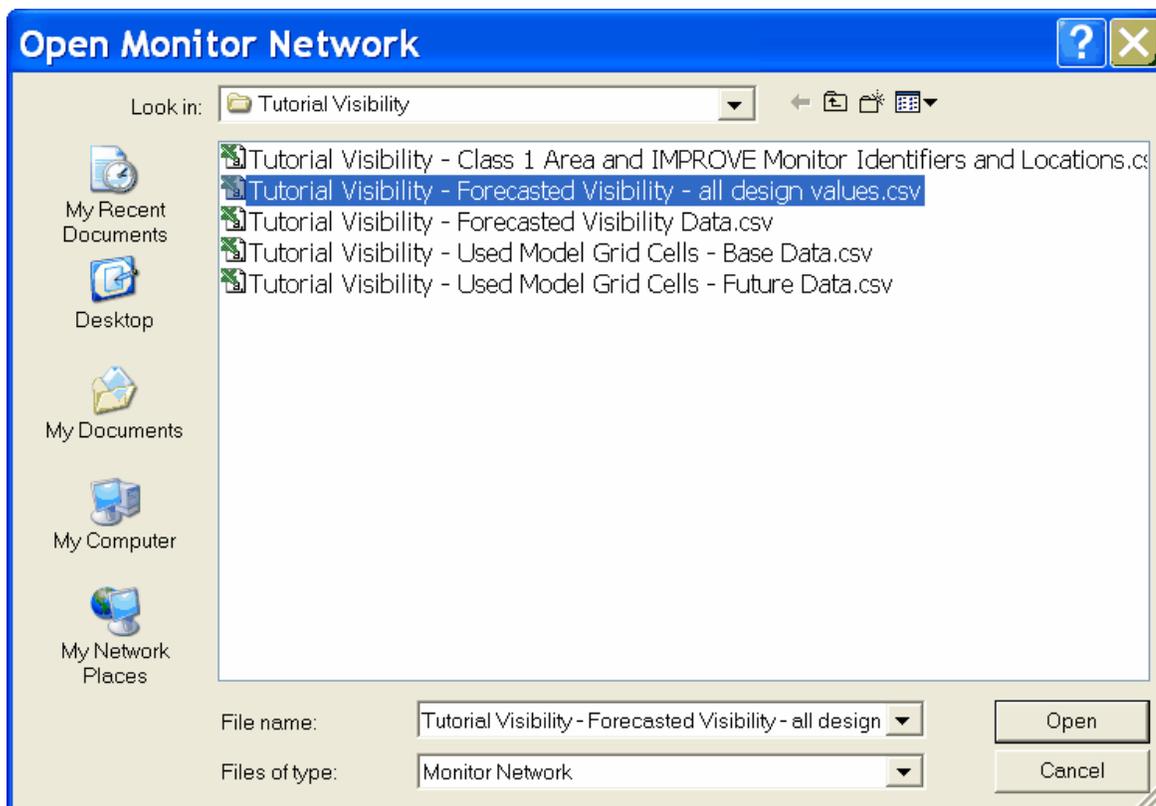
You can load data for mapping directly from the **MapView** tab, once you have exported your results file (as discussed in the [Extract Files](#) sub-section of the [Output Navigator](#) section). To start, click on the **MapView** tab.



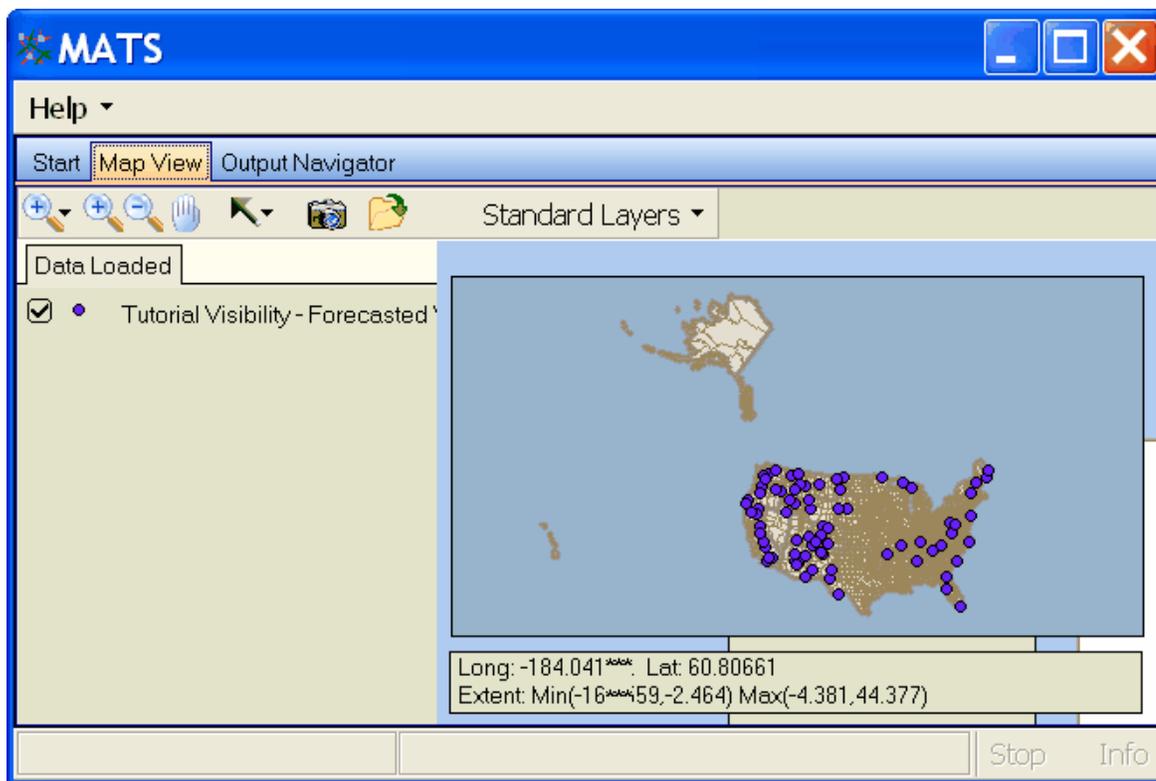
Click on the **Open a monitor network file** button:



This will bring you to the **Open Monitor Network** window. Browse to the folder with the data file that you want to load.

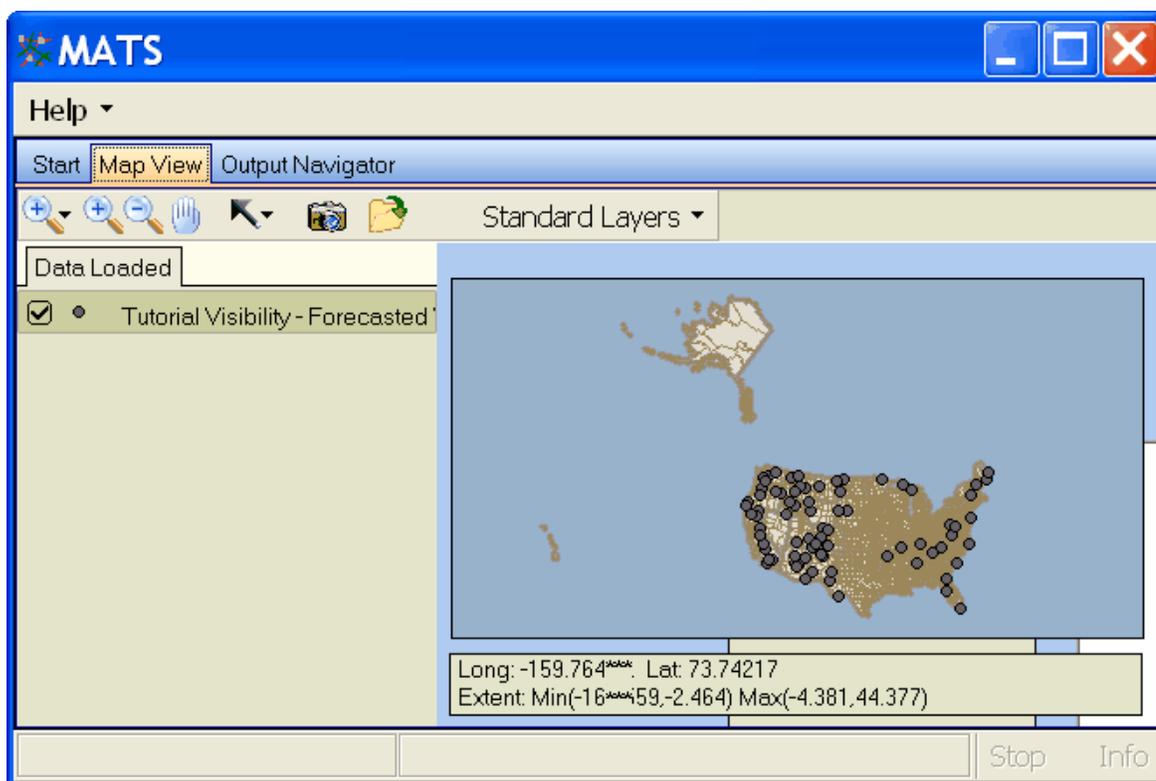


Click the **Open** button after selecting your file (or just double-click on the file you want to load) and this will take you back to the **Map View** tab.

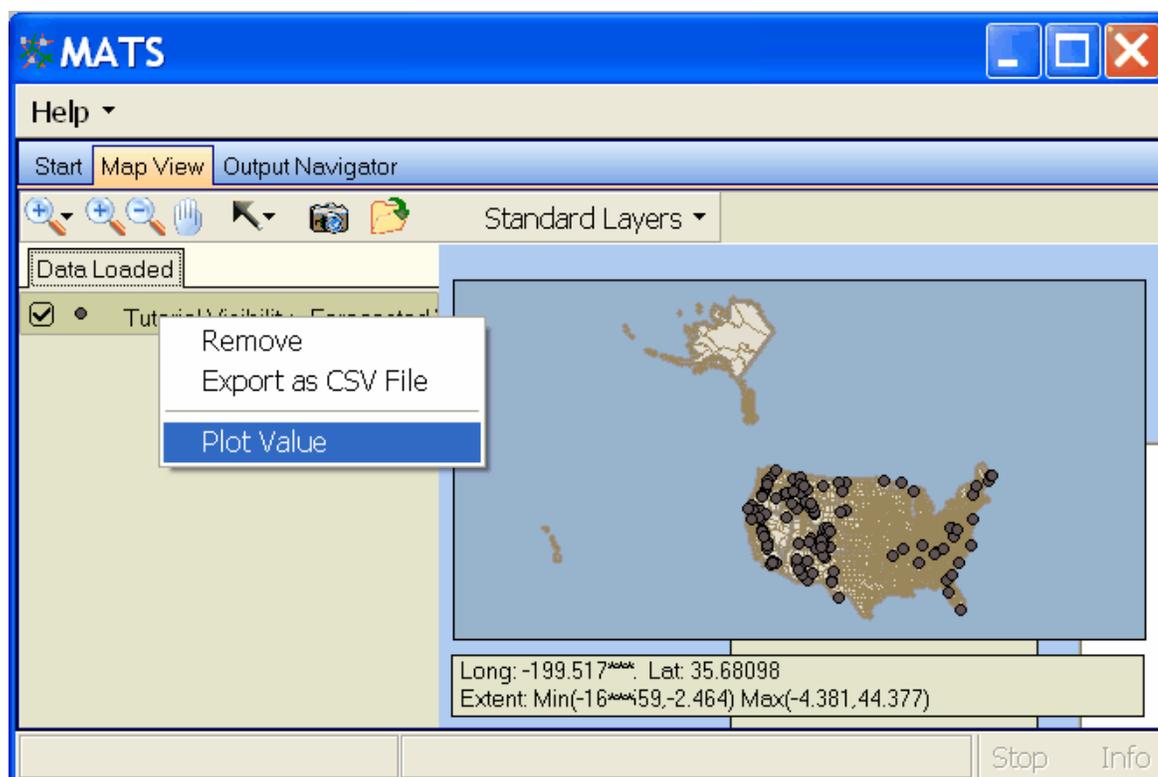


## 11.2 Plotting a Value

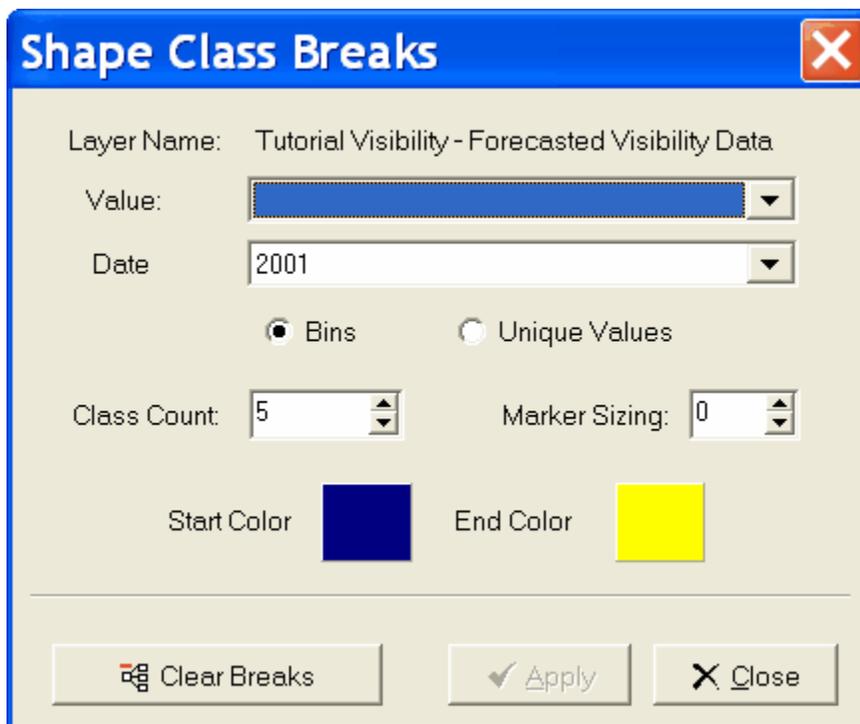
To plot a value you must first load one or more variables into the MapView.



Right click on the text in the left panel and choose *Plot Value*.

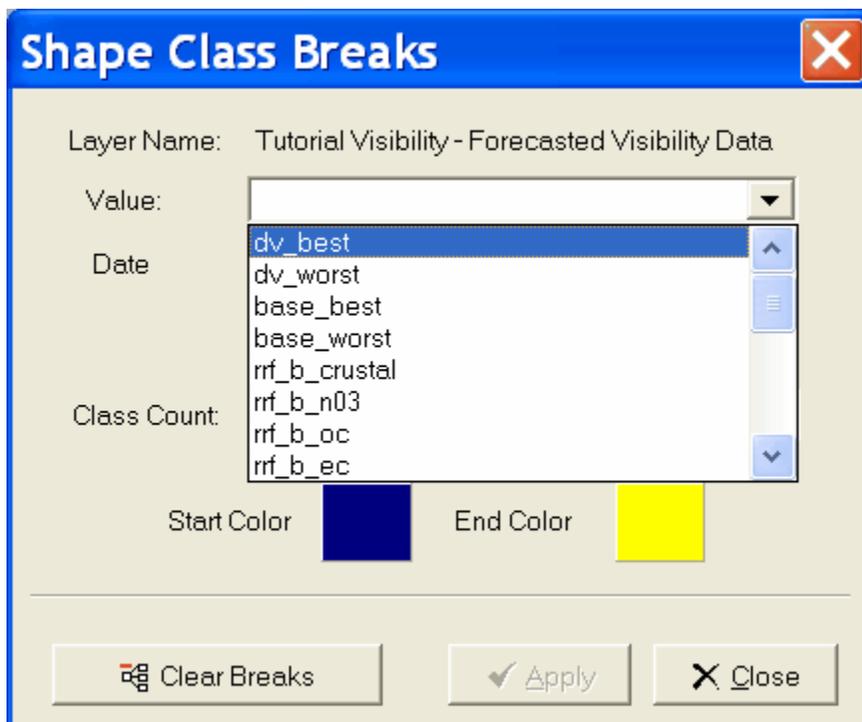


This will bring up the **Shape Class Breaks** window.



The image shows a dialog box titled "Shape Class Breaks" with a blue header and a red close button. The dialog is set for the layer "Tutorial Visibility - Forecasted Visibility Data". It features a "Value" dropdown menu, a "Date" dropdown menu set to "2001", and two radio buttons for "Bins" (selected) and "Unique Values". Below these are "Class Count" and "Marker Sizing" spinners, both set to "5" and "0" respectively. At the bottom, there are "Start Color" and "End Color" swatches, with the start color being dark blue and the end color being yellow. Three buttons are at the bottom: "Clear Breaks", "Apply", and "Close".

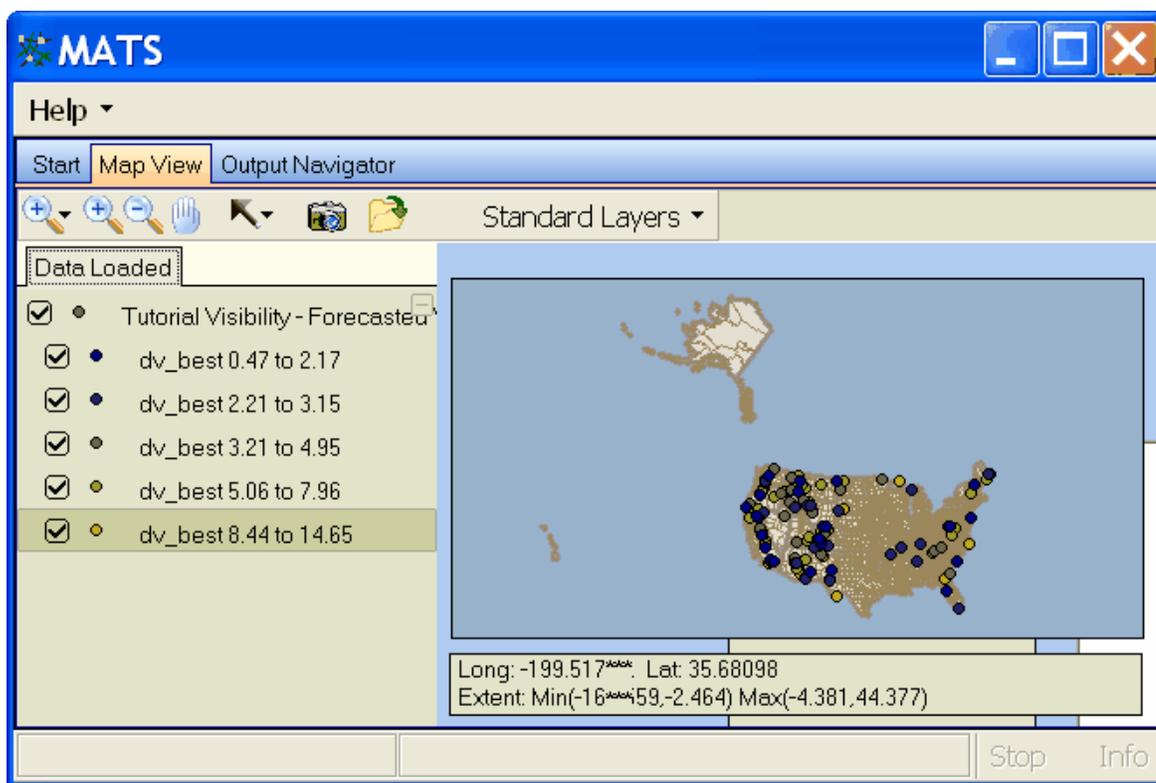
Here you can choose the variable (or "Value") that you want to display and how it will be seen. Scroll through the drop-down **Value** menu and choose *dv\_best*. This is forecasted visibility (measured in deciviews) on the days with the best visibility. (Note that a description of all results variables generated by MATS are described in the details sections for [Annual PM](#), [Ozone](#), and [Visibility](#).)



There are a variety of display options that you can choose. These options are discussed in detail in the [Plotting Options](#) section. After choosing your display options, then click the **Apply** button. View the map in the **Map View** tab. (You can move the **Shape Class Breaks** window, if it is obscuring the map.)

If you want to change your display options, go back to the **Shape Class Breaks** window, make the changes, and click **Apply** again. You may do this as many times as needed.

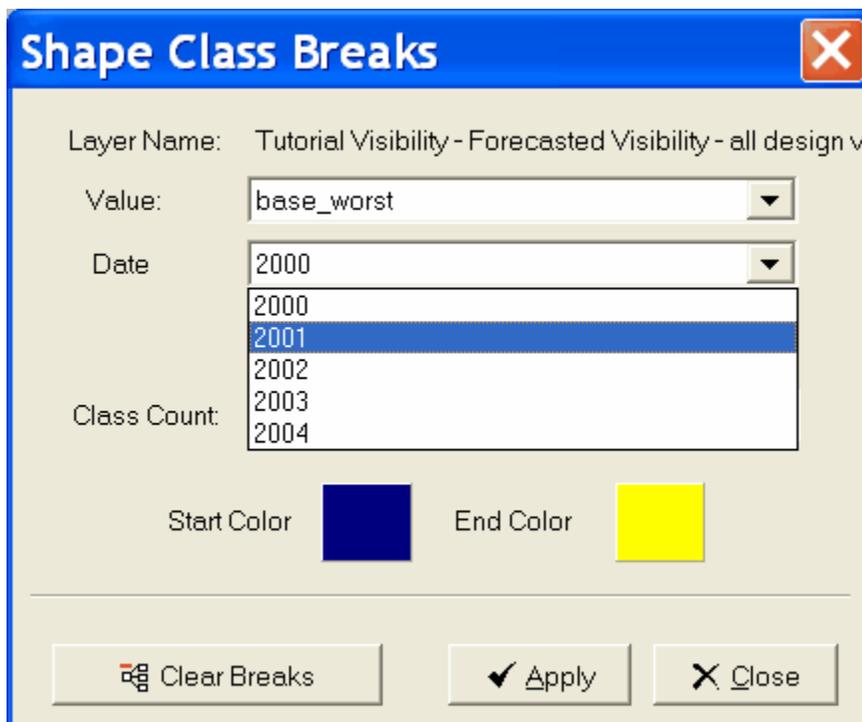
When you are satisfied with the map, click the **Close** button in the **Shape Class Breaks** window. This will bring you back to the **Map View** tab.



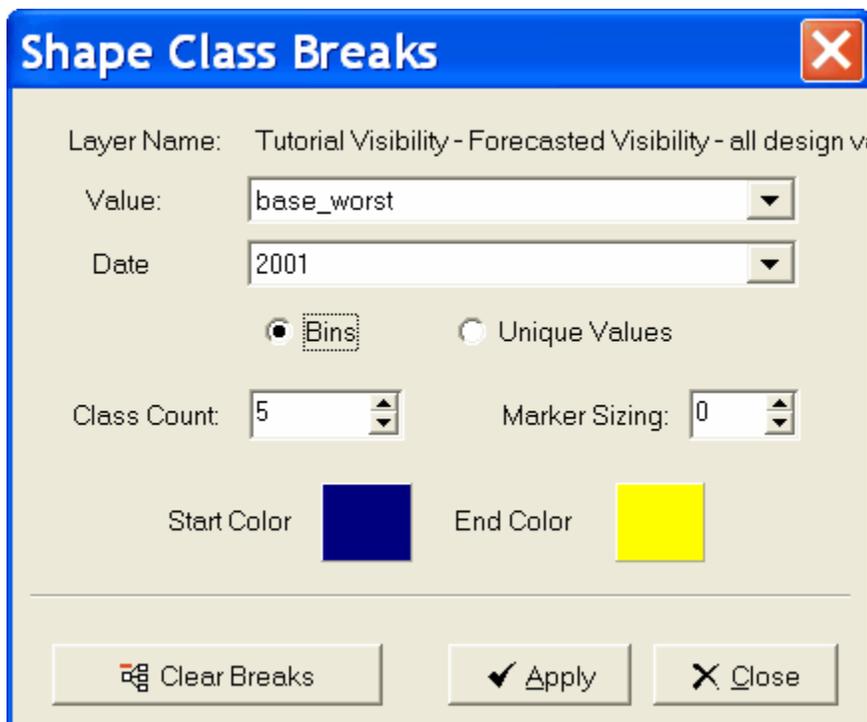
### 11.2.1 Plotting Options

MATS gives you a number of plotting options with the Shape Class Breaks window. These are demonstrated with the results file "Tutorial Visibility - Forecasted Visibility - all design values.csv" generated after completing the [visibility tutorial](#). The same concepts hold for other results files.

With the Date drop-down menu you can specify a particular year (assuming the data have multiple years).

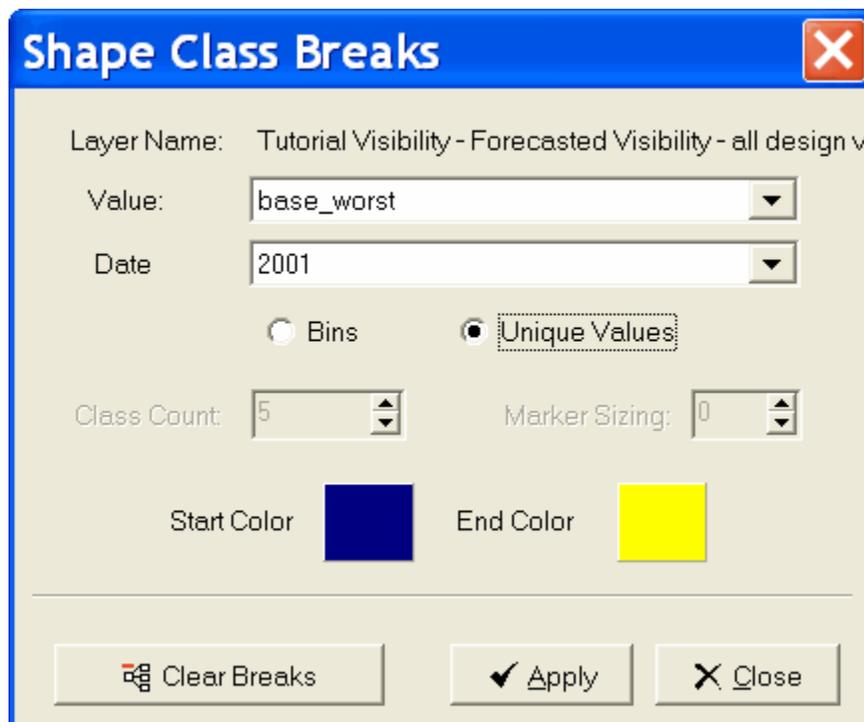


With the **Class Count** option, you can specify into how many groups you want to divide your data. The default is to use 5 bins. For most purposes this is a reasonable number.



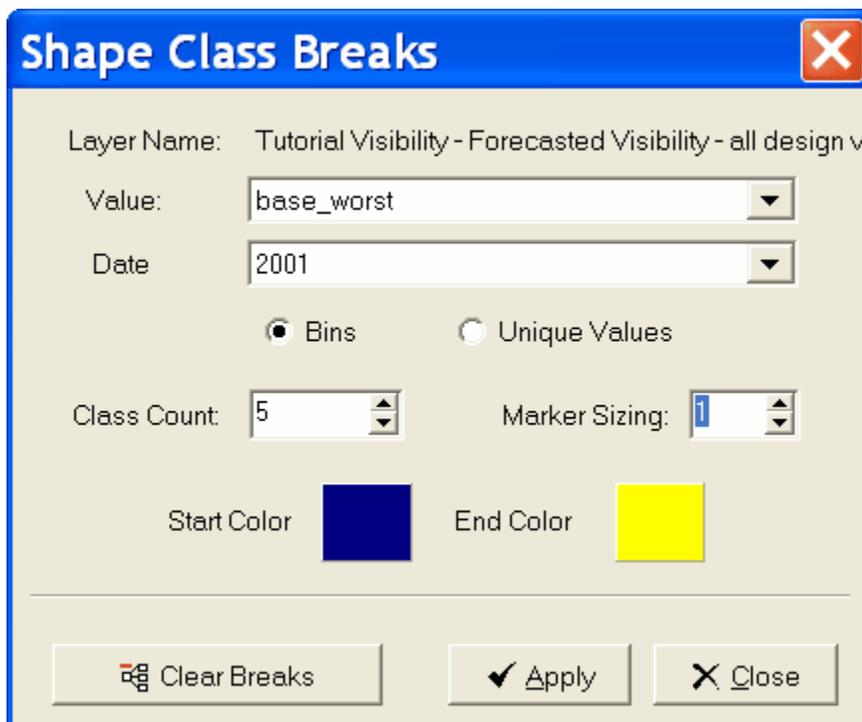
The image shows a dialog box titled "Shape Class Breaks" with a blue header and a red close button. The dialog is set for a layer named "Tutorial Visibility - Forecasted Visibility - all design v". The "Value" dropdown is set to "base\_worst" and the "Date" dropdown is set to "2001". The "Bins" radio button is selected, while "Unique Values" is unselected. The "Class Count" is set to 5 and "Marker Sizing" is set to 0. The "Start Color" is a dark blue square and the "End Color" is a yellow square. At the bottom, there are three buttons: "Clear Breaks" (with a trash icon), "Apply" (with a checkmark icon), and "Close" (with an X icon).

If you choose **Unique Values** option, you will have a separate bin or group for each unique value in your data. This can lead to hundreds of bins. Generally, this is not an option that you would want to choose. Note that if you choose this option, the **Class Count** and **Marker Sizing** (discussed next) will be inoperative.



The image shows a dialog box titled "Shape Class Breaks" with a blue header and a red close button. The dialog is set for the layer "Tutorial Visibility - Forecasted Visibility - all design v". The "Value" dropdown is set to "base\_worst" and the "Date" dropdown is set to "2001". The "Unique Values" radio button is selected, while "Bins" is unselected. The "Class Count" is set to 5 and "Marker Sizing" is set to 0. The "Start Color" is a dark blue square and the "End Color" is a yellow square. At the bottom, there are three buttons: "Clear Breaks" (with a trash icon), "Apply" (with a checkmark icon), and "Close" (with an X icon).

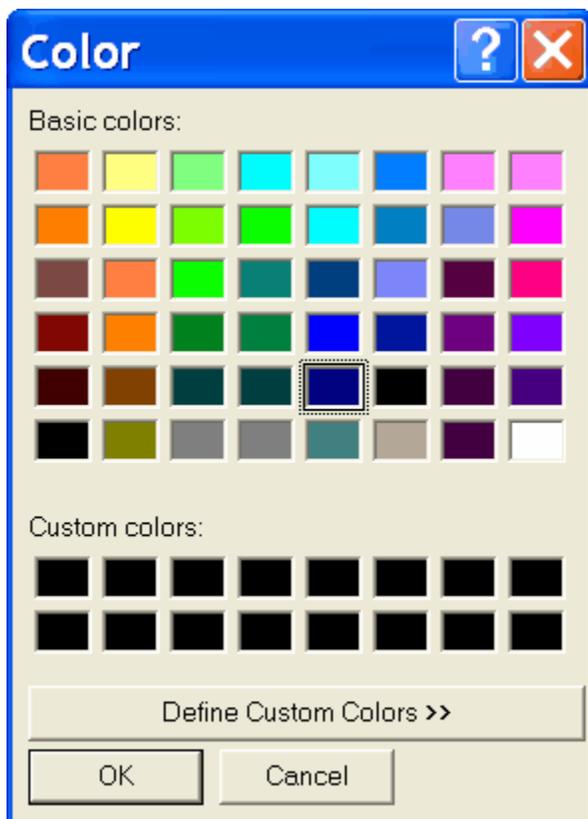
The **Marker Sizing** allows you to vary the size of the marker on your map based on the data values. The default is a **Marker Sizing** value of "0", which keeps the marker on your map all the same size. A value of "1" and higher gives the larger values progressively larger markers on the map.



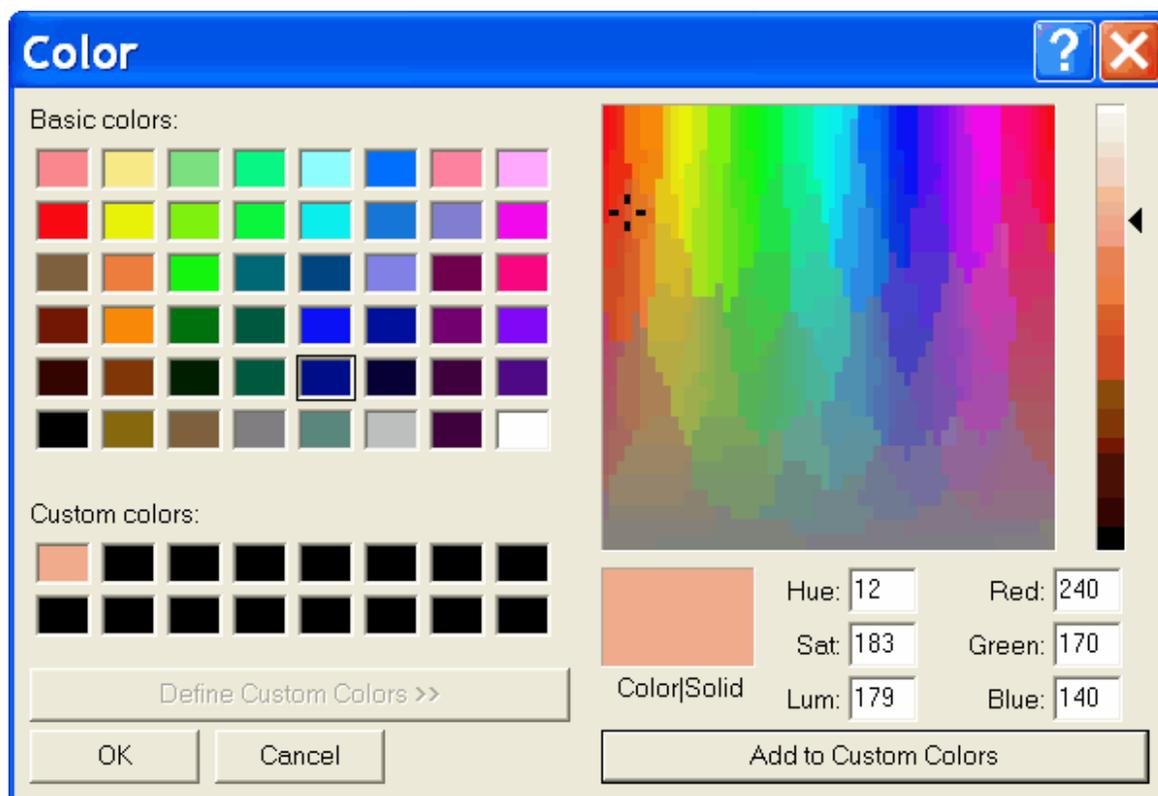
The image shows a dialog box titled "Shape Class Breaks" with a blue header and a red close button. The dialog is set for a layer named "Tutorial Visibility - Forecasted Visibility - all design v...". The "Value" dropdown is set to "base\_worst" and the "Date" dropdown is set to "2001". The "Bins" radio button is selected, and the "Class Count" is set to 5. The "Marker Sizing" is set to 1. The "Start Color" is a blue square and the "End Color" is a yellow square. At the bottom, there are three buttons: "Clear Breaks", "Apply", and "Close".

The **Start Color** option allows you to set the color of the markers for the lowest values. The **End Color** option allows you to set the color of the markers for the highest values. MATS uses a mix of these two colors for intermediate values. The default colors are blue and yellow for the start and end.

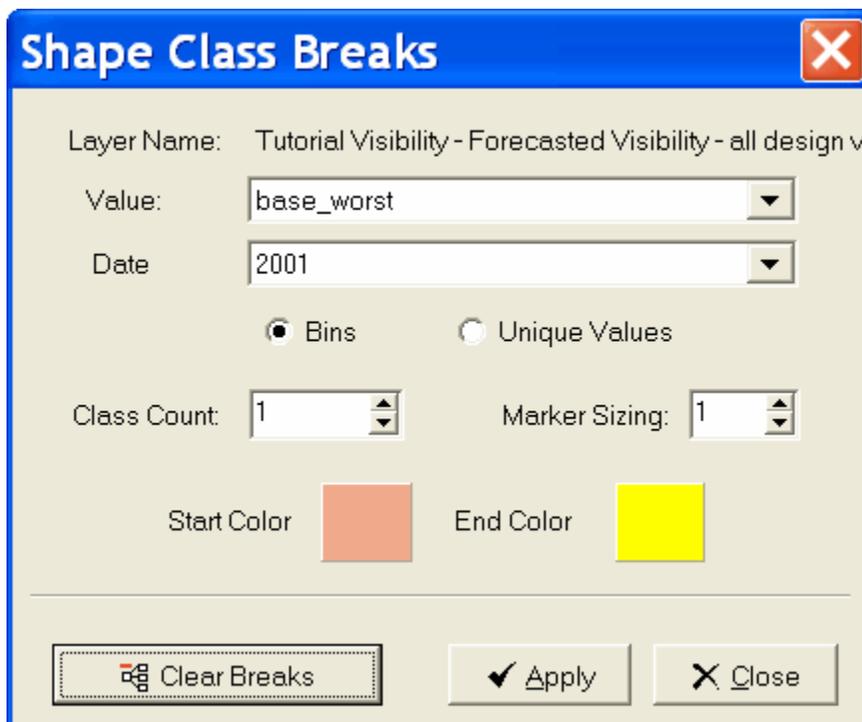
If you want to change the **Start Color**, click on the blue square. This will bring up the **Color** window. The simplest option is to click on the color you prefer from the pre-defined **Basic colors** panel (in the upper half of the **Color** window), and then click **OK**. (You can also double-click on desired color.)



If for some reason, you do not see the color you want to use in the **Basic colors** panel, you can click the **Define Custom Colors** button. Click in the large multi-color square to identify the color you want and then adjust the hue with the slider bar on the far right. You can save the color you generate by clicking the **Add to Custom Colors** button.



When satisfied, click **OK**. This will bring you back to the **Shape Class Breaks** window.



You can change the End Color through a similar process.

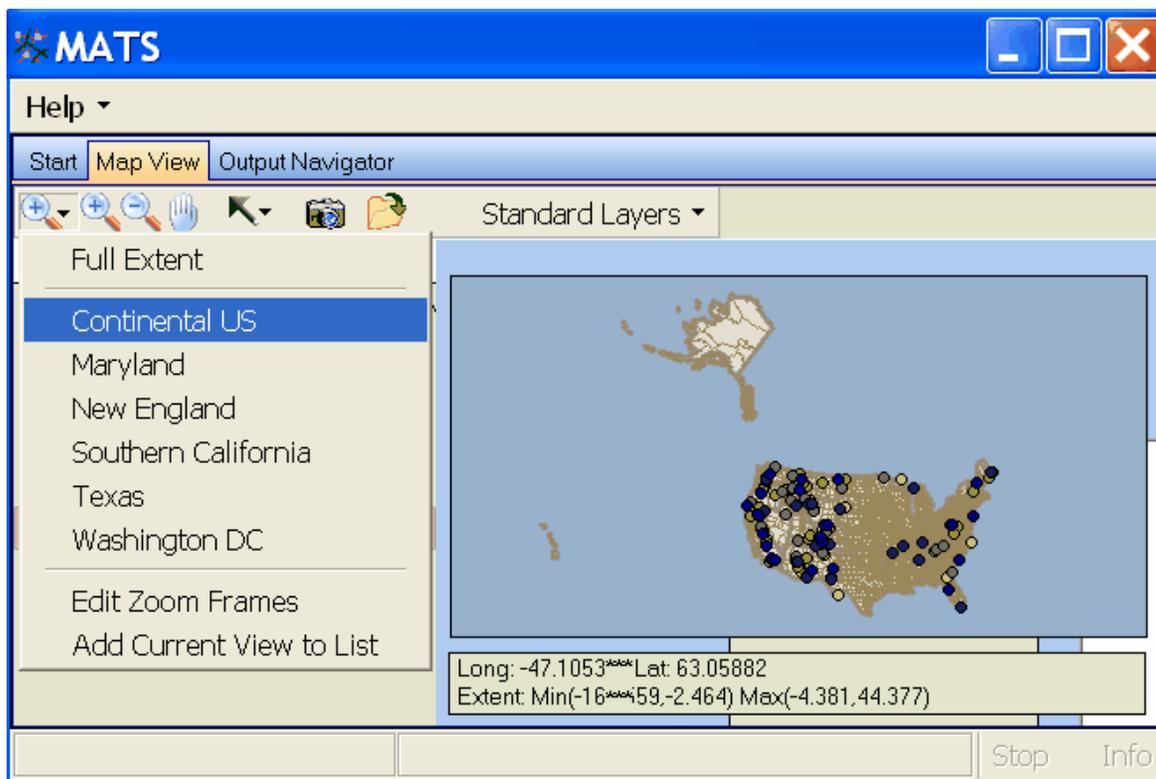
To test how your colors look, click the **Apply** button. If you do not like what you see, click the **Clear Breaks** button. When you are finally satisfied with the look of your map, click the **Close** button.

### 11.3 Zoom Options & Pan View

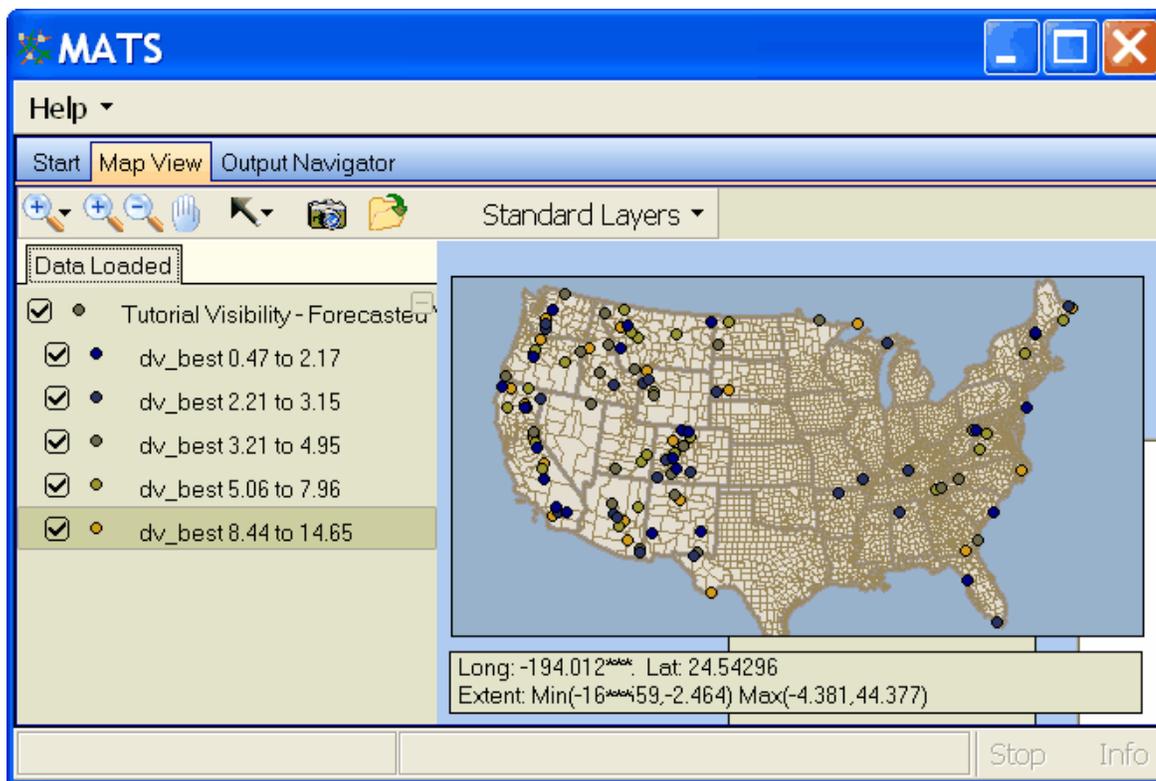
In addition to the [plotting options](#) available in the Shape Class Breaks window, there are various options on the task bar that you can choose to adjust the map. There are standard

Zoom in  and Zoom out  options, as well as a Pan option  that lets you manually move the map.

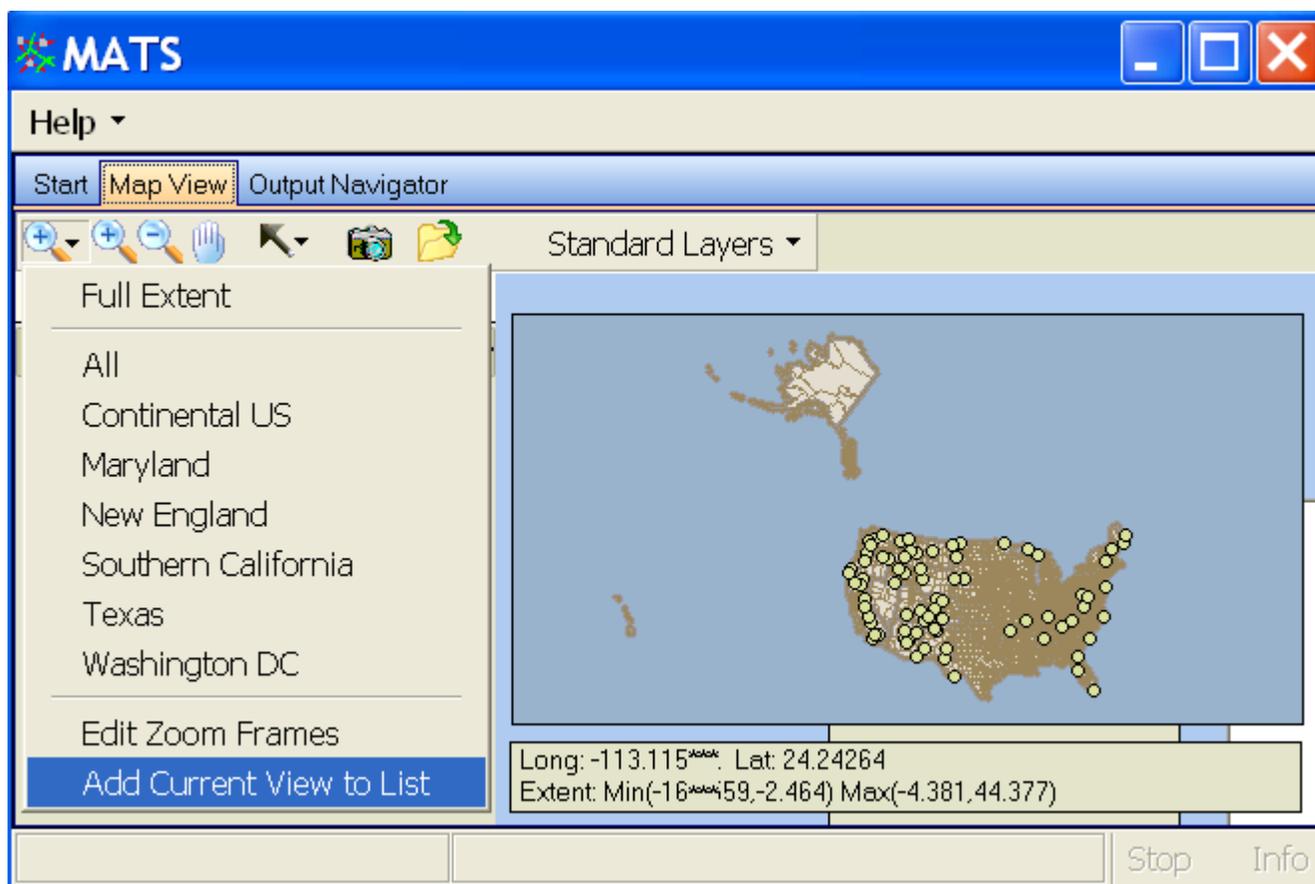
In addition, there is a **Zoom to an area** drop-down menu . This lets you zoom to pre-specified regions, or "zoom frames", such as the continental US.



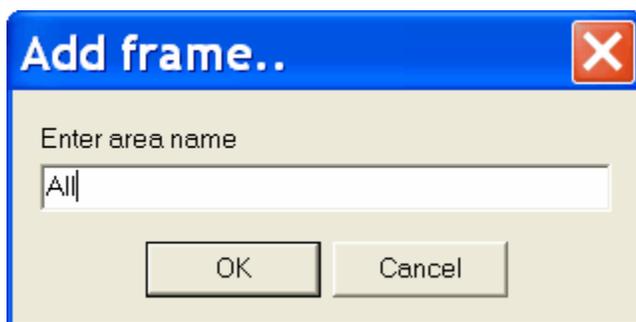
Choosing the *Continental US* zooms in so that you just see the continental US.



If desired, you can change the "Zoom Frames" to whatever you are currently viewing. Choose *Add Current View to List* from the list of options in the drop-down menu.



This will bring up the **Add Frame** window. Type in whatever name you want to use for this "zoom frame" and this will be available whenever you use MATS.

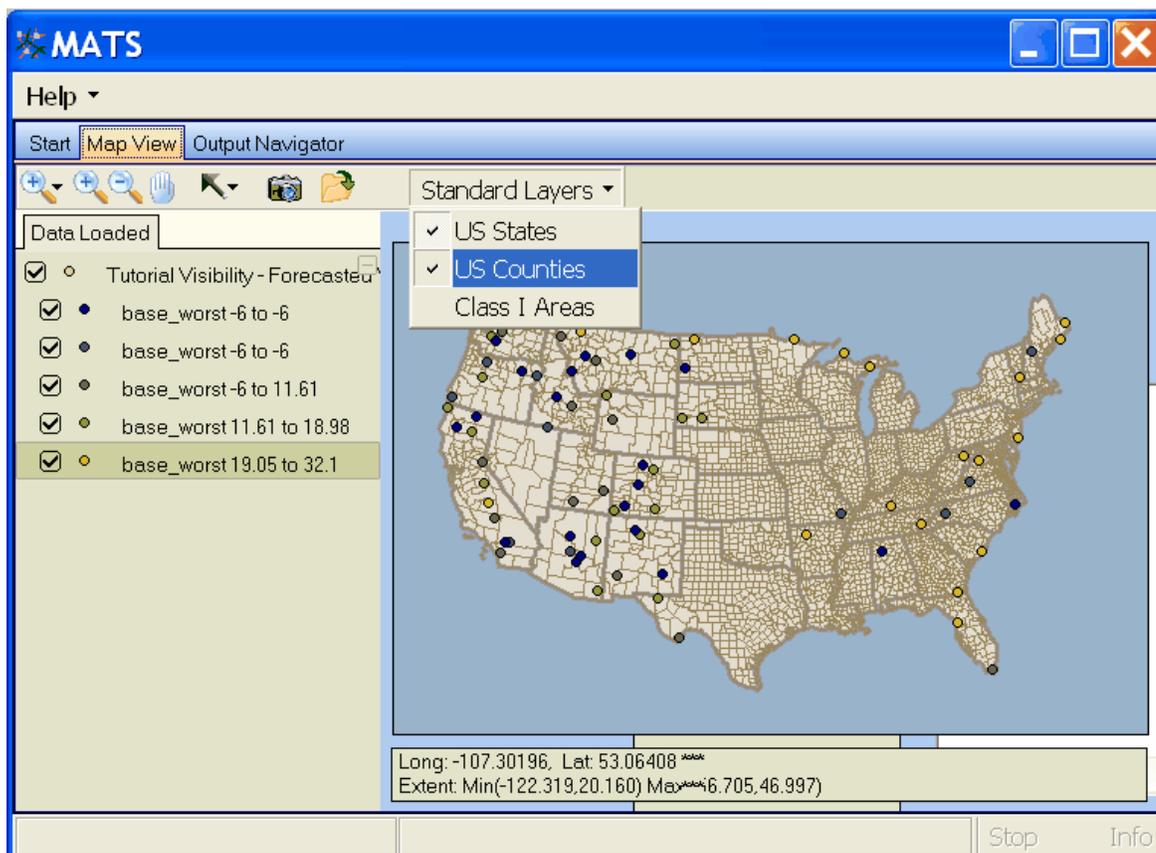


## 11.4 Standard Layers

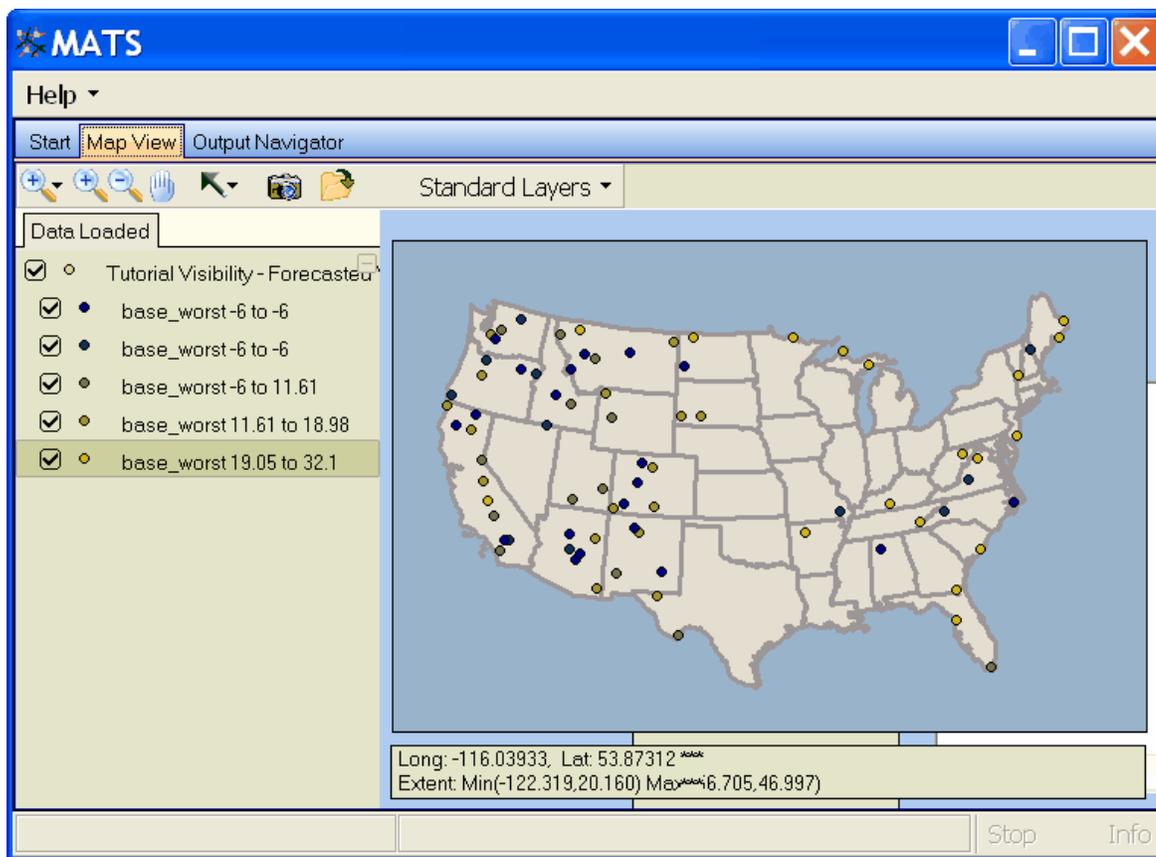
The **Standard Layers** drop-down menu allows you to add and remove state, county, and Class 1 area borders. By default, MATS displays the state and county borders. These can often provide useful context to maps, however, at times they can obscure the markers

somewhat -- this is most often a problem with the county boundaries.

To eliminate a layer, open the **Standard Layers** drop-down menu and click on the active layer that you want to remove.



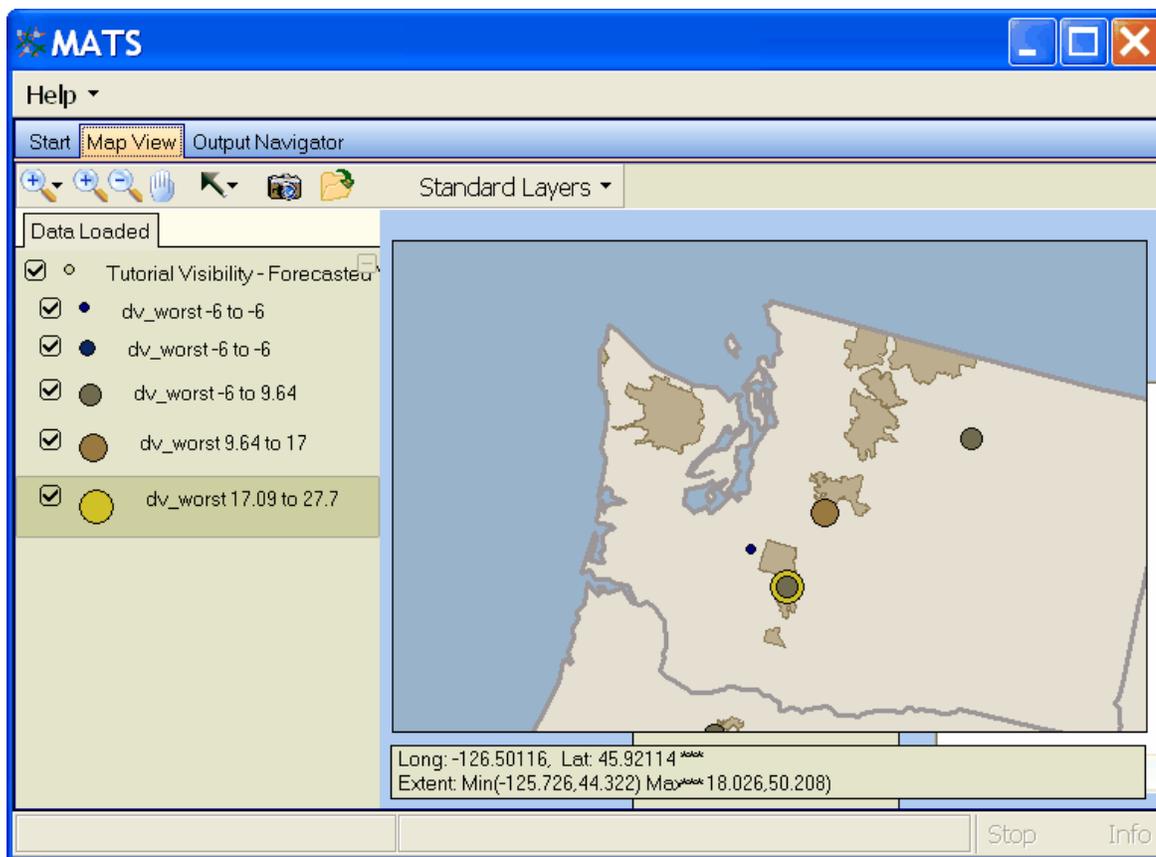
This will bring up a map view with the layer removed.



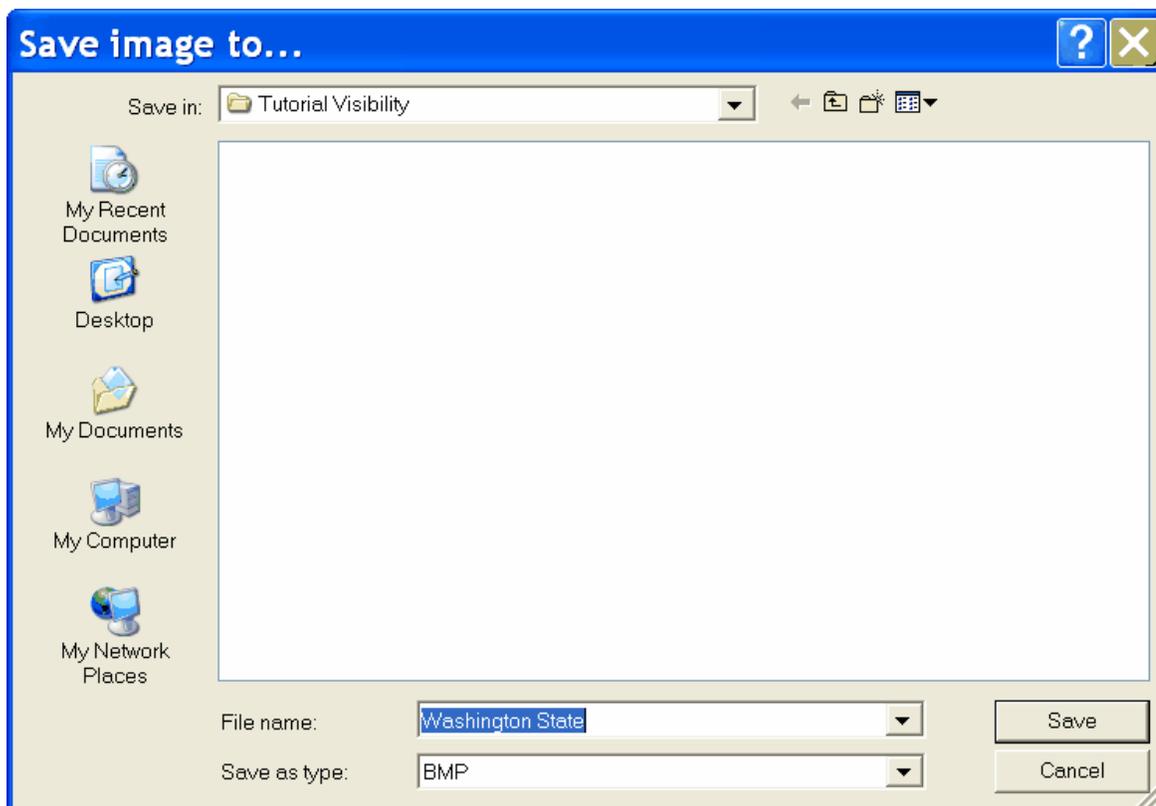
To add a layer back, choose the layer you want to add from the **Standard Layers** drop-down menu.

## 11.5 Exporting Maps & Data Files

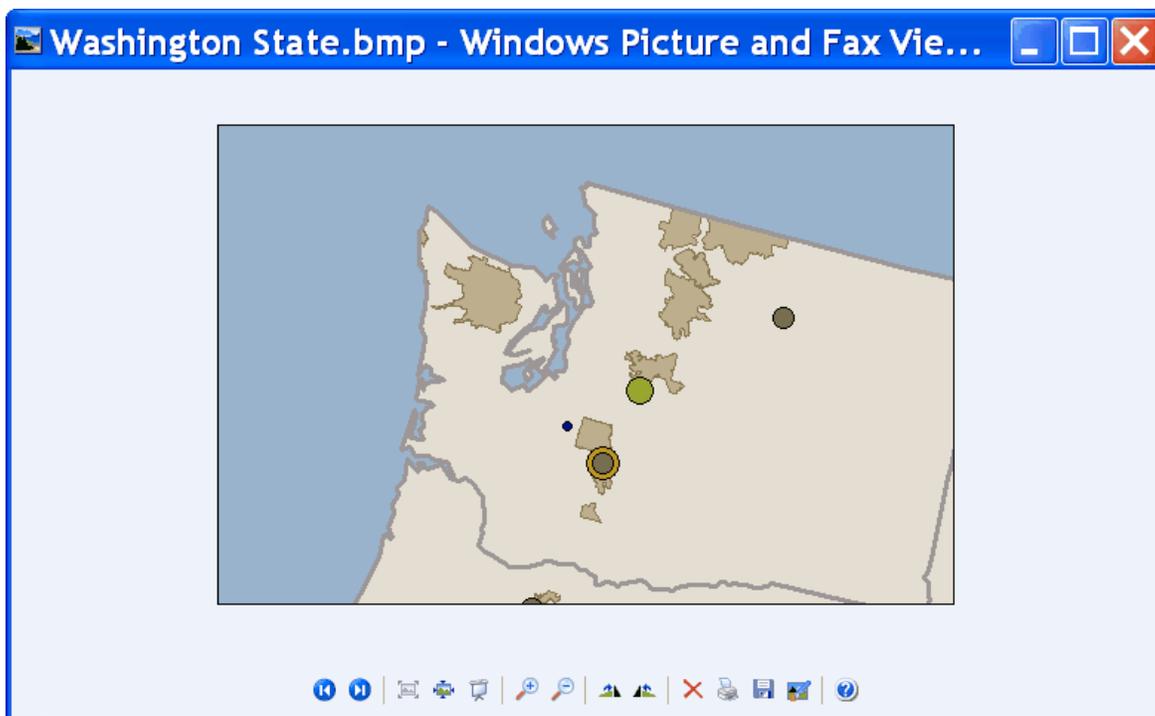
MATS allows you to export maps and data from the **Map View** tab. To export a [BMP file](#), click on the **Export current map view to an image file** option . (The [next subsection](#) discusses exporting the underlying data.)



This will up a window where you can name your image. Browse to whatever folder in which you want to store your image.

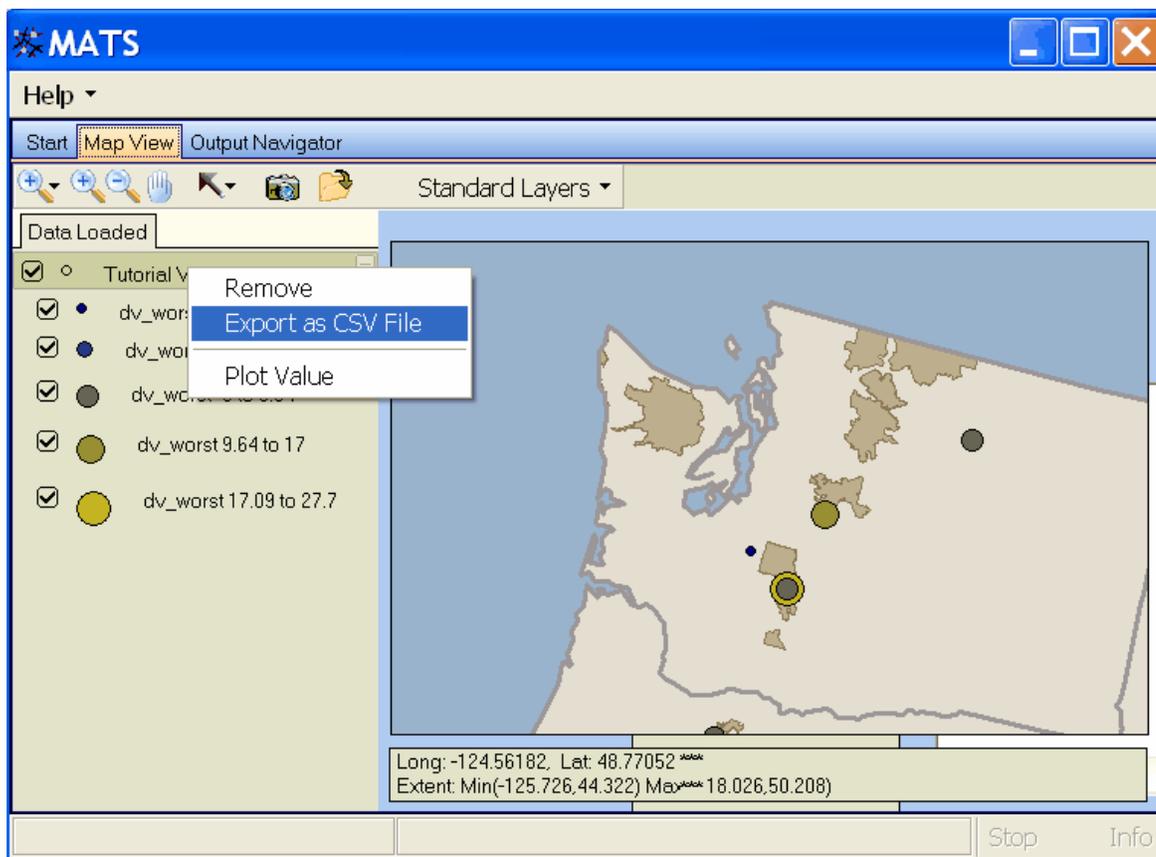


Your [.BMP file](#) can be easily viewed in a variety of software applications. Note however, that this is just an image, and you will not be able to work with it in a GIS program the way you might work with a .SHP file.



### 11.5.1 Exporting CSV Data File

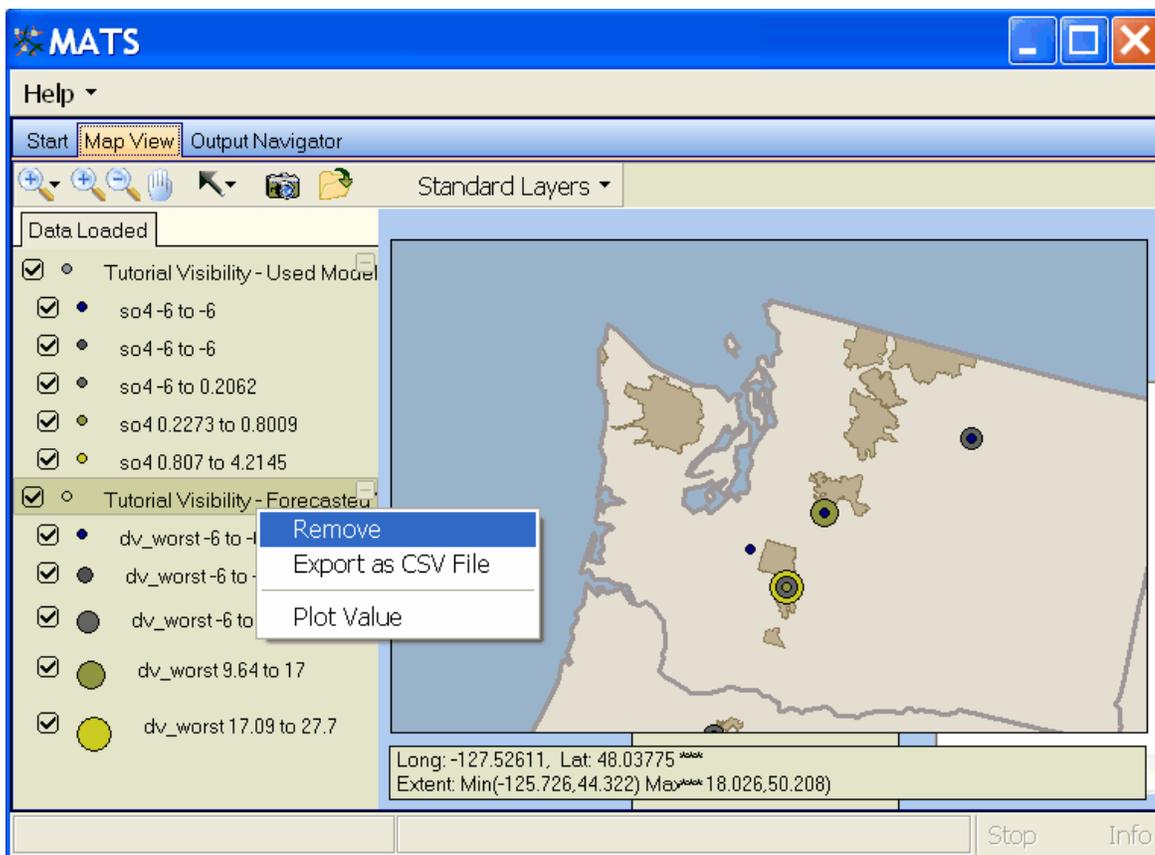
If desired, you can export a [CSV file](#) with the data used to generate your map. Just right click on variable of interest in the left panel, and choose the *Export as CSV File* option.



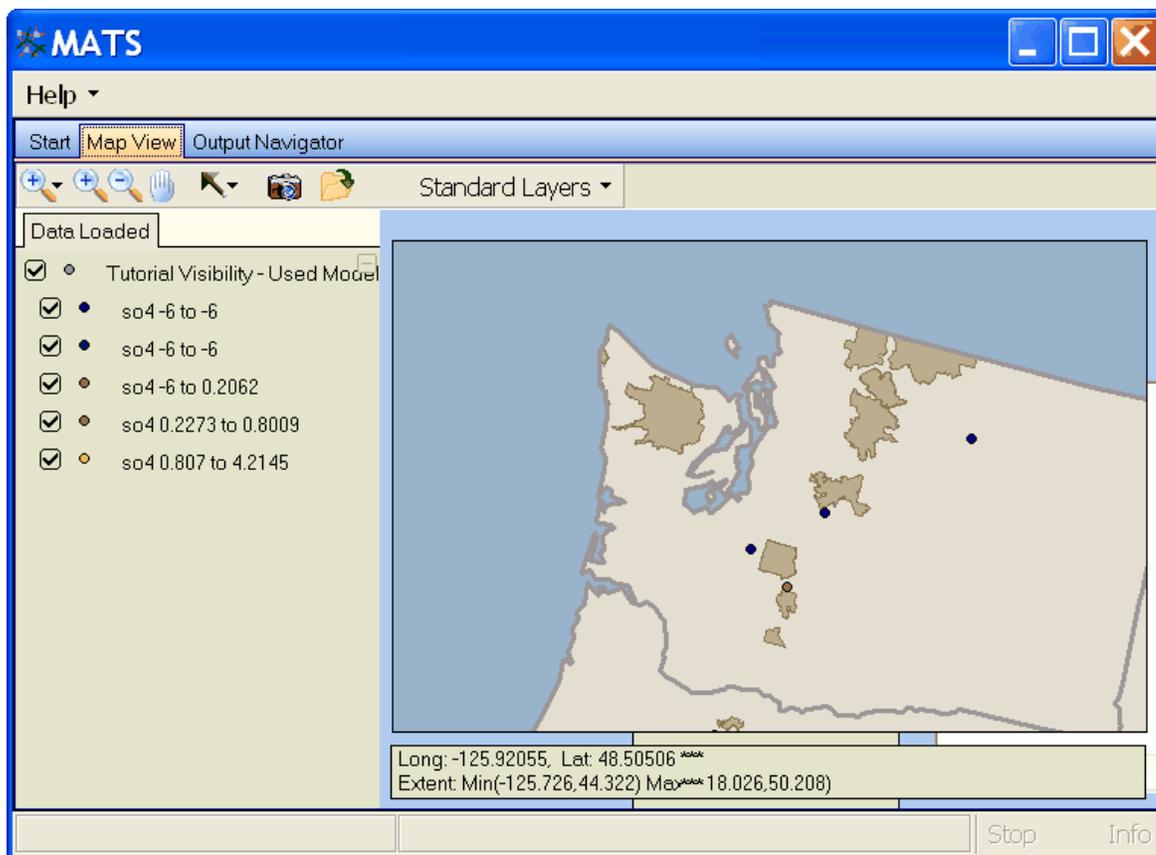
Note that this exports the same data that the [Output Navigator](#) would export. Choose whichever approach is easier.

## 11.6 Removing Data

You can have multiple data files in a map. If you decide to remove a datafile, right click on the variable that you want choose the *Remove* option.



This will bring back the map without the undesired data.

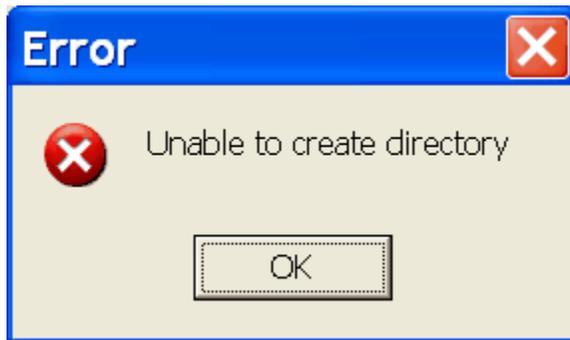


## 12 Frequently Asked Questions

This section answers questions that have arisen when running MATS.

### 12.1 Error: MATS will not create a folder for extracting files

If an output folder already exists MATS will return an error if you click the Extract All button. This occurs even if the pre-existing folder is empty.



This error can be avoided by using a different folder name or removing the pre-existing folder.

### 12.2 Where is there a description of output variables?

Descriptions of the output variables are in the separate "Details" sections for [PM](#), [Ozone](#), and [Visibility](#).

## 13 References

Frank, Neil, (2006): “Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities” JAWMA. Vol 56: 500-511.

IMPROVE, (2006), “Revised IMPROVE Algorithm for Estimating Light Extinction from Particle Speciation Data”, January 2006,  
[http://vista.cira.colostate.edu/improve/Publications/GrayLit/gray\\_literature.htm](http://vista.cira.colostate.edu/improve/Publications/GrayLit/gray_literature.htm)

U.S. EPA (2006), "Procedures for Estimating Future PM<sub>2.5</sub> Values for the PM NAAQS Final Rule by Application of the Speciated Modeled Attainment Test (SMAT)"  
[http://www.epa.gov/scram001/guidance\\_sip.htm](http://www.epa.gov/scram001/guidance_sip.htm).

U.S. EPA (2007), "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM<sub>2.5</sub> and Regional Haze", April 2007. EPA-454/B-07-002, [http://www.epa.gov/scram001/guidance\\_sip.htm](http://www.epa.gov/scram001/guidance_sip.htm).