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User's Guide for the AERMOD Terrain Preprocessor (AERMAP)

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User's Guide for the AERMOD Terrain Preprocessor (AERMAP)

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Preface

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS), developed the air quality dispersion model, the AMS/EPA Regulatory Model (AERMOD). AERMOD is a modeling system which contains: 1) an air dispersion model, 2) a meteorological data preprocessor called AERMET, and 3) a terrain data preprocessor called AERMAP. This user’s guide focuses on the AERMAP portion of the AERMOD modeling system.

This User's Guide for the AMS/EPA Regulatory Model Terrain Pre-processor (AERMAP), provides technical descriptions and user instructions. Receptor and source elevation data from AERMAP output is formatted for direct insertion into an AERMOD control file. The elevation data are used by AERMOD when calculating air pollutant concentrations.

Acknowledgments

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We are grateful to the staff of the United States Geological Survey for their helpful suggestions and understanding of the complex relationships between the various datum standards and their ability to convey that understanding for our programming purposes.

We also appreciate the National Geodetic Survey for posting their NADCON program to the internet. Without NADCON, we would have had a tremendously difficult time in writing a program to convert geographical coordinates between NAD 27 and NAD 83.

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1.0 Introduction

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS), developed the AMS/EPA Regulatory Model (AERMOD) air quality dispersion model. AERMOD is designed to calculate air pollutant concentrations in all types of terrain, from flat prairie to complex mountainous situations. AERMOD does not process its own terrain. A preprocessor program, AERMAP, was developed to process this terrain data in conjunction with a layout of receptors and sources to be used in AERMOD control files.

Terrain data is available, in the United States, from the United States Geological Survey (USGS) and commercial sources in the form of computer terrain elevation data files. The data have been standardized to several map scales and data formats. AERMAP has been designed to process several of these standardized data formats. AERMAP produces terrain base elevations for each receptor and source and a hill height scale value for each receptor. AERMAP outputs the elevation results in a format that can be directly inserted into an AERMOD control file.

The remainder of this section provides an overall introduction to the AERMAP terrain preprocessor including the basic input data and the hardware requirements. In Section 2, some basic concepts are presented followed by a brief tutorial demonstrating the fundamental requirements to run AERMAP, while in Section 3, a detailed description of each of the keywords is presented. A discussion of the technical aspects of obtaining the hill height scale and the DEM format are presented in Section 4.

1.1 Overview

Regulatory dispersion models applicable for simple to complex terrain situations require information about the surrounding terrain. With the assumption that terrain will affect air quality concentrations at individual receptors, AERMAP first determines the base elevation at each receptor and source. For complex terrain situations, AERMOD captures the essential physics of dispersion in complex terrain and therefore needs elevation data that convey the features of the surrounding terrain. In response to this need, AERMAP searches for the terrain height and location that has the greatest influence on dispersion for each individual receptor. This height is the referred to as the hill height scale. Both the base elevation and hill height scale data are produced by AERMAP as a file or files which can be directly inserted into an AERMOD input control file.

1.2 Input data requirements

There are two basic types of input data that are needed to run AERMAP. First, AERMAP requires an input runstream, or control, file that directs the actions of AERMAP through a set of instructions and options, and defines the receptor and source locations. The structure and syntax of an AERMAP input runstream file is based on the same pathways and keyword structures as in the control runstream files for AERMOD.

Second, AERMAP needs standardized computer files of terrain data. The data are available in multiple distinct formats. First is the National Elevation Dataset (NED) data, the seamless bare earth elevation layer of The National Map (http://nationalmap.gov/) that is updated frequently. NED data is available for importing into widely used commercial software packages in several formats such as ArcGrid, GridFloat, IMG (ERDAS IMAGINE), BILS, and GeoTIFF. AERMAP reads NED data in GeoTIFF format only. This format is explained in Section 2.2.1.

According to the geoCommunity[1] web site, "The USGS National Elevation Dataset … has been developed by merging the highest-resolution, best quality elevation data available across the United States into a seamless raster format. NED is the result of the maturation of the USGS effort to provide 1:24,000-scale Digital Elevation Model (DEM) data for the conterminous US and 1:63,360-scale DEM data for Alaska. The dataset provides seamless coverage of the United States, HI, AK, and the island territories. NED has a consistent

[1] *http://data.geocomm.com/readme/usda/ned10.html*

projection (Geographic), resolution 1/3 arc second (10m) and elevation units (meters). The horizontal datum is NAD83, except for AK, which is NAD27. The vertical datum is NAVD88, except for AK, which is NAVD29. NED is a living dataset that is updated bimonthly to incorporate the "best available" DEM data."

A second format is the older Digital Elevation Model (DEM) format which follows the old USGS "Blue Book" standard (see Section 4.2). This format originally was the terrain data format that was processed by AERMAP. AERMAP retains the capability to process the DEM format.

For those who are interested, the Blue Book format is provided in Section 4.2. It consists of an overall header followed by terrain profiles which consist of location based sub headers and evenly spaced terrain elevation points called nodes. Each DEM file covers a section of land based on latitude and longitude coordinates. These data files have been available through several commercial internet sites in the past but availability of the individual quadrangles with this release of the user's guide may be limited.

DEM data can be obtained in several different scales and horizontal data spacing resolutions. Currently AERMAP can process both the 7.5-minute and 1-degree, Blue Book formatted, DEM data scales with any uniform distance between nodes. AERMAP is no longer limited to spacings of 30 meters or 3 arc-seconds, respectively.

There are three levels of quality for DEM data. It is recommended that Level 1 data not be used and that Level 2 or Level 3 data be used. The level of quality has been incorporated into the DEM main header as Data Element 3. AERMAP prints this value in its output file. The user can view this value in the DEM file using a text editor. This value (e.g. 1, 2, or 3) is found in the main header record and has a Fortran format of I6 which begins at the 145^{th} byte and ends at the 150^{th} byte.

According the USGS Blue Book Data User's Guide 5, 1993: "Level 2 DEM's are elevation data sets that have been processed or smoothed for consistency and edited to remove identifiable systematic errors. DEM data derived from hypsographic and hydrographic data digitizing, either photogrammetrically or from existing maps, are entered into the Level 2 category after a review on a DEM Editing System. An RMSE of one-half contour interval is the maximum permitted. There are no errors greater than one contour interval in magnitude. The DEM record C contains the accuracy statistics acquired during quality control." Level 3 DEM's have a maximum permitted RMSE of one-third of the contour interval. There are no errors greater than two-thirds contour interval in magnitude.

According the USGS Blue Book : "All 1-degree [Defense Mapping Agency] (DMA) Data Terrain Elevation Data Level 1's (DTED-1's) have been classified as Level 3 because the hypsographic information, when plotted at 1:250,000 scale, is consistent with the planimetric features normally found on 1:250,000-scale topographic maps. Inconsistencies may exist, but these are regarded as isolated cases to be tempered by the 90-percent confidence level for the overall product. NOTE: The USGS classification of "level 3" for 1-degree DEM's is not to be confused with the DMA's "DTED level 1." In the DMA, the term [ed. DTED] level is related to the spatial resolution of the data and not to the source of the data."

The 1-degree DEM data are produced by the DMA in 1-degree by 1-degree units that correspond to the east or west half of 1:250,000 scale USGS topographic quadrangle map series. These data are complete and available for the entire contiguous United States, Hawaii, and portions of Alaska, Puerto Rico and the Virgin Islands. A file consists of a regular array of elevations referenced horizontally on the latitude/longitude coordinate system of the World Geodetic System (WGS). The array consists of profiles of terrain elevations, where a profile is a series of elevation points, or nodes, arranged from south to north for one longitude. Each profile for the 1-degree data has a constant number of elevation points. The horizontal spacing between each data point is 3 arc-seconds - the east-west distance is therefore latitude dependent and corresponds to about 70 - 90 meters for the North American continent. The elevations are expressed in meters.

Another format available to the user is a text file of horizontal location and elevation data, referred to as XYZ format in this user's guide. However, the data must first be converted to the "Blue Book" DEM format. A program is provided on EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website to convert XYZ data to the proper format readable by AERMAP.

Finally, there is the SDTS. According to the USGS, "[f]or most practical purposes, SDTS is a 'defunct' concept. USGS no longer supports it, nor has produced anything in that format for more than 15 years. There is not any format standard active today that … is analogous to SDTS. [USGS] continue[s] to make the SDTS web page (http://mcmcweb.er.usgs.gov/sdts/) available for technical and historical reference purposes only[2]." While considered a 'defunct concept', DEM data in SDTS format can be purchased from the geoCommunity web site (http://data.geocomm.com/dem/). For example, quadrangles in the SDTS format can be purchased from the geoCommunity web site in a bundle for the entire United States. However, if a user already has or obtains SDTS data and wants to use it in AERMAP, the data first must be converted to the "Blue Book" format. A conversion program is available on EPA's SCRAM web site for this purpose as well as on the geoCommunity web site.

Of these various data formats and standards, AERMAP is programmed to read files in NED format and the USGS Blue Book format (hereafter referred to the DEM format).

1.3 Computer hardware requirements

The AERMAP terrain preprocessor was developed using Fortran on an IBM-compatible personal computer (PC), with current versions of the program Fortran 90 compliant. AERMAP has been designed and compiled to run on a PC with a Pentium class or higher central processing unit (CPU)and Microsoft® Windows® operating system in a command prompt window. The executable available from EPA's SCRAM web site was

[2] Private communication, August 30, 2016.

compiled using the Intel® Visual Fortran 64 compiler. However, the user should be able to recompile AERMAP on other computer platforms such UNIX or Linux-based systems using Fortran compiler software specific to that platform.

The amount of hard disk drive storage space required for a particular application will depend on the number and type of raw terrain (NED or DEM) data files required to encompass the study area. A single 7.5-minute DEM file requires about 1.1 MB of space, while a single 1-degree DEM file requires about 10 MB of space. Additional hard disk drive space will be needed to store 7.5 minute SDTS formatted DEM data which requires about 110KB of space per file. With terabytes of storage available on personal computers, the storage of terrain files and preprocessor execution should not be an issue.

As noted above, SDTS data needs to be converted to the DEM ("Blue Book") format. Each conversion of an SDTS file produces a natively formatted DEM file of about 1.1 MB. A conversion program, SDTS2DEM, is located on the SCRAM website at https://www3.epa.gov/ttn/scram/models/aermod/aermap/demfilz.zip as part of the AERMAP package.

The executable found on EPA's SCRAM website is compiled as a 64-bit executable and therefore will not run on a 32-bit PC. To run on a 32-bit computer, the user will have to recompile AERMAP as a 32-bit executable with an appropriate Fortran compiler.

As an example of the time required by AERMAP to process a large number of receptors, about 8400 receptors over a 50 km x 40 km domain were processed in about 45 minutes on a 3.1 GHz Intel® Core ™ i3-2100 computer with 8 Gb of installed memory running Microsoft Corporation's 64-bit Windows 7 Professional operating system.

2.0 Overview of the AERMAP terrain preprocessor

This section presents the basic concepts, including the keyword approach, of the AERMAP preprocessor used in generating the runstream (control) file and a short tutorial on creating a simple AERMAP run.

2.1 Basic concepts

AERMAP supports two types of elevation input data: 1) DEM elevation data in the USGS DEM format (USGS, 1998); and 2) NED[3] data in GeoTIFF format (USGS, 2002). The more traditional type of elevation data is DEM, whereas NED is a newer type of elevation data that is actively quality assured and updated. While AERMAP can process both types of data (beginning with version 09040), AERMAP does not support processing both data formats (DEM and GeoTIFF) within a single application. Both DEM and NED data are available at different horizontal resolutions and may be retrieved based on geographic coordinates (latitude and longitude) or UTM coordinates, although standard NED data are expected to be in geographic coordinates. AERMAP was specifically designed to process NED data accessible through the USGS Multi-Resolution Land Characteristics Consortium (http://www.mrlc.gov/)[4], but the code has been developed to be as generic as reasonably possible to accommodate elevation data in GeoTIFF format from alternative sources. AERMAP does not support elevation data in GeoTIFF format based on non-UTM projections, such as Albers Equal Area or Lambert Conformal projections. Since USGS elevation data sets are continually being updated and a number of different options are currently available for obtaining digitized elevations, users are encouraged to clearly document the original source of elevation data used with AERMAP.

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[3] The seamless bare earth DEMs formerly called the National Elevation Dataset, or NED, have been renamed and are one component of elevation in The National Map's 3D Elevation Program (3DEP). The term "NED" will continue to be used throughout this manual.

[4] Terrain data are available from USGS's The National Map (http://nationalmap.gov/elevation.html), but are not available in GeoTIFF format from that site.

AERMAP relies on the Universal Transverse Mercator (UTM) coordinate system to identify the location of sources and receptors. This coordinate system is one method of portraying the meridians and parallels of the earth's surface on a flat plane. The UTM system is comprised of 60 zones numbered from 1 to 60 eastward from the 180 degree International Dateline meridian at 6-degree intervals of longitude. UTM zones 11-19 cover the contiguous United States (US DOI, 1993).

2.1.1 Horizontal datums

The Earth is a slightly flattened sphere often referred to as an oblate ellipsoid or spheroid. There are many mathematical methods and measurements that have been used to define the shape of the earth (Snyder,1987). The three most prevalent methods for the United States are the Clarke 1866 spheroid, the World Geodetic Systems (WGS) of 1972 and 1984, and Geodetic Reference System (GRS) of 1980. Projections of latitude and longitude have been placed on each one of these spheriod/reference systems. The projections are called datums. The North American Datum (NAD) of 1927, projected on the Clarke 1866 spheroid, was created using a triangulation method centered on Meades Ranch, Kansas. Beginning with NAD 83 and WGS72, the projections are Earth-centered. The NAD of 1983 is based on terrestrial and satellite data while WGS 72 and WGS 84 are based on satellite data. NAD 83 and WGS 84 are almost identical with no appreciable differences. For all practical purposes they are considered the same for AERMAP applications. Some common ellipsoid/reference system names and the datums associated with them are:

1. CLARKE 1866
   a. NAD27 datum
   b. Old Hawaiin datum
   c. PUERO RICAN datum
   d. GUAM datum

2. WGS72
   a. WGS72 datum

3. GRS80/WGS84
   a. NAD83 datum
   b. WGS84 datum

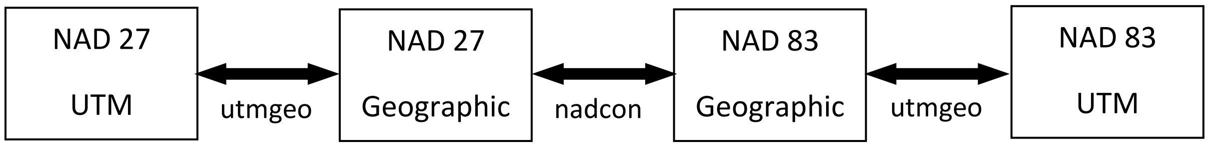
A location on Earth will have different coordinates depending upon the datum used to define that location.

The reference datum for NED data is normally NAD83, although NED data for Alaska may also be in NAD27. For NED data in GeoTIFF format, AERMAP will assume NAD83 if the reference datum identified in the TIFF file is not recognized, as long as the NADA=0 option is selected on the ANCHORXY keyword (see Section 3.2.7). The reference datums for USGS 1-degree DEM data are either WGS72 or WGS84, and 7.5-minute DEM data will be referenced to either the NAD27 or NAD83 datum. While more recent DEM files include the reference datum in the header record (logical record type A) of the data file (USGS, 1998), older files may not include that information. For DEM files without reference datum information, AERMAP will assume datums of WGS72 for 1-degree data and NAD27 for 7.5-minute data.

While there are some minor differences between the WGS72, WGS84, and NAD83 datums, these differences are considered inconsequential for AERMAP applications, and AERMAP treats WGS72, WGS84, and NAD83 datums as equivalent. Therefore, the focus of datum conversion in AERMAP is on the conversion of NAD27 coordinates to NAD83, and vice versa.

Since the AERMAP program is designed to process receptor (and possibly source) locations expressed in terms of Cartesian X- and Y-coordinates, such as UTM or plant coordinates, it is important to emphasize that the conversion of geographic coordinates due to different reference datums is only part of the process. The process of converting UTM coordinates from one datum to another actually involves three steps. The first step is to convert the UTM coordinates from the first datum to geographic coordinates ***based on the reference ellipsoid for that datum***. The second step is to convert the geographic coordinates from the first datum to the second datum to account for the datum shift. The final step is to convert the new geographic coordinates back to UTM coordinates ***based on the reference ellipsoid for the***

new datum. This process of converting coordinates between NAD27 and NAD83 is illustrated in the following diagram:



The diagram also identifies the AERMAP subroutines used to perform each of the steps in the process (the text below each arrow).

Versions of AERMAP prior to version 06341 only accounted for the middle step, or the datum conversion, and did not account for the effect of different reference ellipsoids between the two datums on the converted UTM coordinates. This typically accounts for an additional shift of about 200m in the Northing coordinate between NAD27 and NAD83, with the NAD83 Northing coordinate being larger than the NAD27 coordinate. This additional horizontal shift can result in significant discrepancies in calculated receptor elevations and critical hill heights, even in areas with only moderate terrain relief.

In order to successfully apply the AERMAP program for cases involving NAD conversions, the user should first be aware of the reference datum used to define the receptor and source coordinates for that application, and know the reference datum(s) for the DEM file(s) being processed. The user also needs to understand how AERMAP utilizes and interprets the user-specified modeling domain (DOMAINXY or DOMAINLL keywords, optional beginning with version 09040) and the user-specified anchor point (ANCHORXY keyword). These keywords on the CO pathway are described in detail in Sections 3.2.6 and 3.2.7, respectively. The basic information is reiterated here, with some additional clarifications. Changes to the DOMAINLL keyword introduced with version 09040 are also described. The following sections also document the assumptions incorporated into AERMAP for applications where the DEM file NAD is not identified, and provide suggestions for cases where the user is not certain of the reference datum for receptor and source coordinates being input to AERMAP.

2.1.2 Modeling domain

A modeling domain is the geographic extent that includes all the receptors and sources specified in a particular AERMAP run. The domain also defines the region of significant terrain elevations within which the terrain data points are included in the calculation of hill height scales. Specification of a domain with either of the keywords DOMAINXY or DOMAINLL in AERMAP is optional but can serve two possible functions:

1. in rare situations involving prominent terrain features (e.g., Mount Rainier) which would be selected as the hill height scale beyond a reasonable range of influence, the domain options can be used to exclude such features from the analysis; and/or

2. to optimize the AERMAP runtime by excluding portions of the terrain inputs that can reasonably be assumed to have no influence on hill height scales for the specified receptor network.

Unless the first situation is known to be of concern for a specific application, omitting the domain specification will simplify the AERMAP setup in most cases, without any adverse impact on the results other than somewhat longer runtimes. A discussion and use of the optional keywords DOMAINXY and DOMAINLL is in Section 3.2.6.

If a domain is specified by the user, it can span over multiple UTM zones and multiple adjacent DEM or NED files. The domain can be specified either in the UTM or the latitude/longitude coordinate system depending on the keyword (DOMAINXY or DOMAINLL). For DEM data, the preprocessor converts the domain coordinates to the units of the DEM data, i.e., UTM when using 7.5-minute data and latitude/longitude when using the 1-degree data. The domain must be a quadrilateral in the same orientation as the DEM coordinates. Figure 2-1 illustrates the relationship among the DEM data files, the domain, and receptors. A similar relationship would exist for one or more NED files.

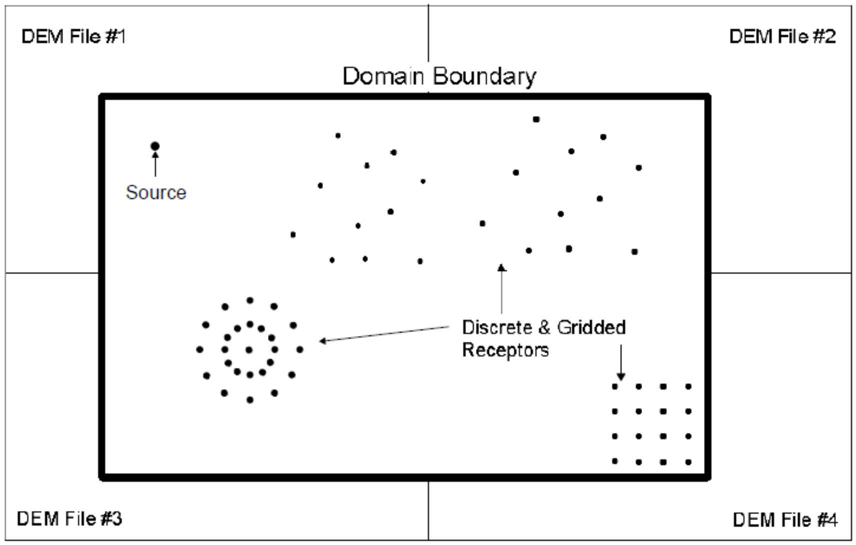


Figure 2-1. Relationship among DEM Files, Domain, Sources and Receptors

Significant terrain elevations include all the terrain that is at or above a 10% slope from each and every receptor. Additional DEM files or increasing the extent of the NED file(s) may be needed to perform these calculations. It is up to the user to assure all such terrain nodes are covered. Figure 2-2 shows the relationship of the receptor slope line to DEM terrain nodes for multiple DEM files. A similar figure would apply for one or more NED files.

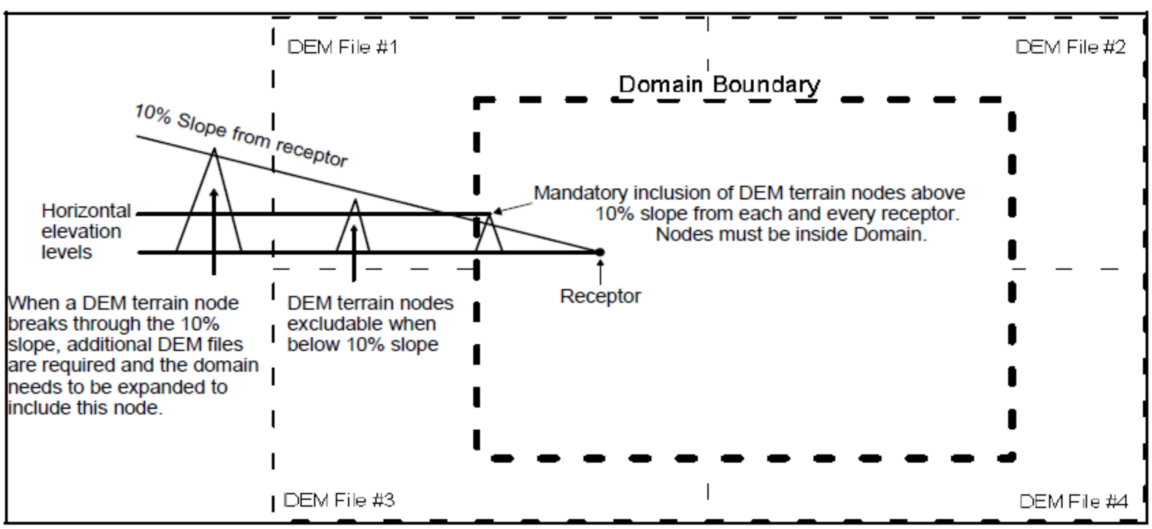


Figure 2-2. Relationship of Receptor Slope Line to DEM Terrain Nodes and DEM and Domain Boundaries

During setup processing AERMAP checks all of the sources and receptors specified to ensure that they are within the domain and within the area covered by the NED or DEM files. AERMAP generates a fatal error message and will stop before calculating elevations when:

1) a receptor or source is found to lie outside the domain,
2) a receptor or source is found to lie outside the NED or DEM files.

If the domain extends beyond the area covered by the terrain data, further processing will continue provided no fatal error messages are generated from the above two conditions. Smaller domains and fewer DEM files or smaller extents of the NED file(s) can decrease processing time. Appropriate error messages are produced if the domain corners do not lie within NED or DEM files or the receptors are outside the NED or DEM files.

2.1.3 Sources and receptors

Receptors are specified in AERMAP in a manner identical to the AERMOD dispersion model, i.e., discrete receptors as well as Cartesian and polar grid networks. However, there are some special considerations for AERMAP.

In AERMOD, when specifying discrete polar receptors, it is necessary to specify the position of a "source" relative to which the receptor is assigned. The locations of these sources can be specified on the optional source pathway in AERMAP (see Section 3.3).

All the source and receptor coordinates are referenced to a set of local coordinates called ANCHOR coordinates that are referenced to a set of UTM coordinates. The datum of the referenced UTM coordinates needs to be specified and will be used by the program to align the various sources and receptors coordinates to the node coordinates of the individual terrain files. In cases where the datums are different, the source and receptor coordinates will be shifted accordingly. A "0" datum specification needs to be used by international users or in the cases where the DEM files do not have a datum stated. This will cause the program to use the coordinates as found, with no shifting of coordinates due to datum differences. Fourteen conversion files for the 7.5 minute DEM data are available if "0" is not used. These files, discussed in detail in Section 3.2.8, cover coordinate shifts for the Continental United States (CONUS), Alaska, Hawaii, Guam, Puerto Rico and the Virgin Island.

The modeling domain can cross UTM zones. However, if the receptor locations are specified in UTM coordinates, then they must all be referenced to the same UTM zone. When using 7.5-minute DEM data and NED data, AERMAP will check for zone changes in the receptor network, and adjust the coordinates accordingly.

The user has the option of having AERMAP determine the terrain or base elevations for the receptors from the terrain data or to provide the receptor elevations. This option is set on the COntrol pathway. If the user requests AERMAP to determine the receptor base elevations from the terrain file(s) and provides the receptor elevations as well, the program will ignore the user input elevations. AERMAP determines the receptor elevation of each of the receptors by a distance-weighted two-dimensional interpolation of the elevation values at the four nearest terrain nodes surrounding the receptor location (See Section 4.4 for equations.). The same procedure is applied to source elevations if source locations are identified.

If the user provides the receptor elevations but does not specify the option on the CO pathway to use the elevations from the NED or DEM terrain files, AERMAP will use the user-provided elevations rather than extracting them from the digital data. Note that the terrain files are required even if the user is providing the receptor heights because the terrain data are used to obtain the hill height scale for each receptor. If the user specifies the receptor elevations, they can be entered in either feet, meters, or decimeters. The output receptor elevations ***will always be in meters***. If the user indicates that receptor heights are provided but does not have the receptor heights in the input file, then a height of 0 meters is written to the output file and a warning message will be generated.

2.1.4 Terrain data files

As discussed in Section 1.2, terrain data for AERMAP are available in multiple formats. Currently, the primary format for terrain files is the NED format. When AERMAP was first introduced, the DEM format was the most common format. The capability to process DEM files has been retained in AERMAP. In addition to these formats, AERMAP can process SDTS data and files of XYZ data (horizontal location and elevation). However, both of these formats must be converted to DEM format for AERMAP to be able to use the terrain data.

The user should note that formats change over time as well as web sites where data can be obtained. The formats described in this user's guide and the web sites are current with this release but may change in the future.

NED data can be obtained from the MRLC (http://www.mrlc.gov/) in GeoTiff format. The appropriate 7.5-minute and 1-degree DEM file(s) and DEM data can be obtained from commercial sites on the internet (e.g., http://data.geocomm.com/dem/demdownload.html).

The SDTS was being promoted by the USGS to eventually replace the old “native” DEM files. As noted in Section 1.2, SDTS is a 'defunct' concept that USGS no longer supports. The geoCommunity web site (www.geocomm.com) states that "The purpose of the SDTS is to promote and facilitate the transfer of digital spatial data between dissimilar computer systems, while preserving information meaning and minimizing the need for information external to the transfer." The SDTS files are available on the internet (e.g., http://data.geocomm.com/dem/demdownload.html) and can be found zipped in a “tar” format. Each SDTS file contains over a dozen native .DDF files that are used to reconstitute the SDTS data back into the old “native” DEM format. Each of the DDF files starts with the same 4 digit string of the base SDTS file name. The “native” DEM format is read directly by AERMAP. To reconstitute a DEM file: 1) unzip the SDTS file (most likely with a .gz extension), 2) un-“tar” the files, 3) use SDTS2DEM to convert the SDTS files back to the native DEM format. Double click on the executable (in a Windows File Explorer environment) and follow the prompts.

The NED and DEM data files are in a compressed format (e.g., with a .gz or .zip file extension) and must be uncompressed with a utility that can work with these files. These programs are widely available as shareware and freeware programs. One example is the commercial software program WINZIP ® program from WinZip Computing. Another is the freeware program 7-Zip. The uncompressed DEM file is a text file and does not include record delimiters that are recognized by the Windows operating system, and therefore may not be used directly with AERMAP. In early versions of AERMAP, for Windows users only, the utility program CRLF.EXE added a carriage return and line feed to the end of each record in the uncompressed DEM data file to create a DOS-compatible file. The current version of AERMAP has eliminated the need to run this program on DEM files.

2.2 Input elevation data

Due to the potential for gaps to occur between adjacent DEM files as a result of NAD conversions, users are encouraged to avoid using DEM files with different datums within the same application if possible. Since NED elevation data are in a consistent reference datum and horizontal resolution, the option introduced with version 09040 to process NED data instead of DEM data has the advantage of avoiding potential issues associated with inconsistent datums within the domain that may occur with DEM data.

Beginning with version 06341, the AERMAP program includes both mandatory and optional (user-specified) debug output files. Three mandatory debug files provide general information regarding the DEM or NED files and domain setup that may be useful in documenting and resolving problems with the terrain files, AERMAP code, or with the setup of the input data. Details on these files and the optional debug files are in Section 3.2.9

2.2.1 NED data

Beginning with version 09040, AERMOD supports NED elevation data in the GeoTIFF format, which is a binary file that includes data descriptors and geo-referencing information in the form of "TiffTags" and "GeoKeys." AERMAP processes these TiffTags and GeoKeys to determine the type and structure of the elevation data within the NED file. NED elevation files can be obtained for user-specified domains through the USGS Multi-Resolution Land Characteristics Consortium (http://www.mrlc.gov). Through this data resource, the user defines a domain for downloading through various options, and can download a single file to cover the entire modeling domain (up to 250 MB). The NED elevation files are downloaded as compressed files, and the only file needed for input to AERMAP is the file with the ".tif" file extension. **NOTE:** ***The default format for downloading NED data from the MRLC is currently ArcGRID, which AERMAP cannot read. The user must modify the file format to GeoTIFF before downloading the NED data in order to use the data in AERMAP.***

While the MRLC data server provides a mechanism to obtain data for the entire domain in a single data file, AERMAP will accept multiple NED files in a single run. There is no requirement for these files to be aligned according to a regular grid, similar to standard DEM data. If multiple NED files overlap, which is likely in most cases, AERMAP will assign the receptor to the first file encountered that contains the receptor for purposes of calculating receptor elevations. As discussed above, AERMAP checks to determine whether higher resolution elevation data are specified before lower resolution data in the AERMAP input file, to ensure the receptor elevations are based on the highest resolution data provided. A warning message will be generated if a lower resolution file is entered before a higher resolution file, but processing will continue. However, a fatal error message will be generated if a receptor is assigned to the lower resolution file within the region of overlap. The criteria for equivalence in resolution between geographic and UTM data are listed in the previous section.

2.2.2 DEM data

Versions of AERMAP prior to version 09040 were limited to only process one type of DEM data a time, either the original 1-degree DEM (specified with a secondary keyword of 'DEM1') or the finer resolution 7.5-minute DEM data (specified as 'DEM7'). AERMAP now allows for mixed DEM file inputs, including 1-degree and 7.5-minute DEM, as well as 15-minute DEM data available for portions of Alaska. As a result of this modification the secondary keyword has been changed to simply 'DEM'. Note that version 09040 of AERMAP will ignore the additional qualifier of '1' or '7' on the DEM data type used in previous versions, allowing backward compatibility with older input files. The option for mixed DEM file types allows for the use of the highest resolution data available for portions of the modeling domain, with the lower resolution data to fill in the gaps in coverage that may exist. For example, 7.5- minute DEM data are not available for quadrangles that are entirely water. In these cases, 1-degree DEM files may be included to fill in these gaps within the domain simplifying the application of AERMAP. However, AERMAP checks to determine whether the higher resolution data files are listed first in the AERMAP input file to ensure that receptor elevations will be based on the higher resolution data. For purposes of comparing the resolution of data files, AERMAP assumes that the following resolutions are equivalent: 1/9th arc-second and 3 meters; 1/3rd arc-second and 10 meters; 1 arc-second and 30 meters; and 3 arc-seconds and 90 meters.

If more than one DEM file is required, then each DEM file specified in the input runstream must have at least one other DEM file adjacent to it otherwise the isolated DEM file(s) will be flagged. AERMAP prints to the output file an array of DEM files and lets the user know that a DEM file is missing from the array by stating "No Map Present" in place of a DEM map name. This makes it easier for the user to troubleshoot for misspelled DEM map names, errant or missing DEM files.

2.3 Receptor elevations and handling of gaps

In addition to correcting several issues associated with NAD conversions, beginning with version 06341 the AERMAP program includes modifications to the procedure for calculating receptor elevations and for handling receptors that may be located within gaps between adjacent DEM files due to NAD conversions. The treatment and reporting of receptors located within gaps was further refined with version 09040 of AERMAP.

2.3.1 History of AERMAP development

The original version of AERMAP, dating from the early-1990's, did not account for NAD conversions since the early DEM data were based on consistent datums. The DEM data format at that time did not even include a field for the reference datum. Receptor elevations in the original version of AERMAP were also based on a 2-dimensional (bilinear) interpolation of elevations from the four closest terrain nodes surrounding each receptor location. At that time, the only complete DEM dataset for the continental U.S. was 1-degree data, where the node profiles follow latitude and longitude lines parallel to, and including the edges of the DEM file. While coverage of 7.5-minute DEM data was still limited at the time of the original AERMAP, the issue of receptors that fall along the edges of the 7.5-minute DEM quadrangle beyond the range of the node profiles was addressed by using the two closest nodes and flagging the resulting elevation calculation as an edge receptor. Given the horizontal resolution of 30 meters for 7.5-minute DEM data at that time, this

When the AERMAP program was first modified to include a NAD conversion capability to account for variations in reference datums, several changes were made to the structure of the program to address some of the issues that arose, including the possibility of receptors located in gaps between adjacent DEM files due to the NAD conversion. One of the modifications was to use an inverse distance weighted average for the receptor elevation, based on the closest four nodes in each quad (SW, NW, NE, and SE) relative to the receptor, including nodes from adjacent DEM files. With the corrections to the NAD conversion process, the potential magnitude of the gap between DEM files due to reference datums is limited to the datum shift only, and does not include the shift associated with the conversion between UTM and geographic coordinates based on different ellipsoids. The magnitude of the datum shift for NAD27 to NAD83 varies from about 10 meters or less over the Midwest region, to about 30 to 40 meters along much of the Gulf coast region, to about 80 to 100 meters in the Pacific Northwest region.

2.3.2 Calculating receptor elevations and treatment of edge receptors

The AERMAP program (beginning with version 06341) utilizes the original 2-dimensional (bilinear) interpolation method for calculating receptor elevations. This is a relatively simple, well-documented method that is appropriate for interpolating between regularly-spaced grid nodes, as in DEM or NED files. The bilinear interpolation has also been specified as the standard method for interpolating elevations from digital terrain data by the Federal Communications Commission (FCC, 1984). Some additional improvements have also been incorporated into AERMAP for handling of edge receptors located beyond the range of node profiles in 7.5-minute data, to account for proximity to nodes in both the Easting and Northing directions for partial profiles that occur near the edges of the quadrangle (e.g., ‘Profile1’ and ‘Profile n’ shown in Figure 2-3). Beginning with version 09040, AERMAP identifies the following four types of receptors, identified by the IERR code in subroutine FIND4:

1. IERR = 0, normal, non-edge, receptor located within the range of profiles in both the E-W and N-S directions, with elevations based on the four surrounding nodes;
2. IERR = -1, standard edge receptor no more than one Δx beyond the E-W range of the first or last profile, and/or no more than one Δy beyond the N-S range of nodes within the profiles (shown by solid arrows in Figure 2-1). AERMAP uses the closest 1 or 2 nodes to calculate the receptor elevation in these cases, with no adjustment for offsets in the y-direction from adjacent profiles;
3. IERR = -2, edge receptor no more than one Δx from the closest profile, but more than one Δy beyond the vertical range of one of the profiles that straddle the receptor (shown by the dashed arrow in Figure 2-1). AERMAP uses nodes from the closest profile that spans the N-S location of the receptor;
4. IERR = -3, edge receptor more than one Δx beyond the E-W range of all profiles and/or more than one Δy beyond the N-S range of all neighboring profiles. This

condition indicates that an ***internal data gap*** exists along one or more edges of the terrain file, and elevations for receptors in this category are suspect. This case should not occur for standard DEM, and is not shown in Figure 2-1.

An internal data gap could occur as a result of converting elevations from one format to another, such as from 1-degree DEM data to 7.5-minute DEM format, when NAD conversions are involved. Due to the datum shift, the profiles from the original DEM file may not fully cover the range of geographic coordinates specified for the converted file. These gaps will typically occur along the northern edge of the converted file, and the gap may be over 200 meters wide. Depending on the process used to generate the converted file, the gap area may be devoid of nodes or the area may be filled with nodes that are assigned a missing data code. AERMAP generates warning message number 400 to flag these internal gap receptors, and assigns a missing code of -9999.0 to the receptor elevation, unless the FILLGAPS option is specified on the CO DATATYPE keyword (see Section 3.2.4). If the FILLGAPS option is specified, and the gap has not been filled by nodes with missing values, then AERMAP will assign a receptor elevation based on the closest nodes within the file and issue warning message number 403. The FILLGAPS option will have no effect for files with internal gaps that are filled by nodes with missing values, and the receptor elevation will be assigned a missing code of -9999.0 in those cases. For applications with multiple overlapping DEM files, AERMAP will attempt to calculate an elevation for these internal gap receptors from any subsequent files that contain the receptor. An additional warning message (number 405) will be generated if AERMAP finds a non-missing elevation for these receptors from a subsequent file.

The IERR code for each receptor is identified in the optional RECELV debug output file. The RECELV debug file provides useful data for investigating potential problems with edge or gap receptors. With the introduction of finer resolution 10-meter 7.5-minute DEM files in recent years, the representativeness of elevations for the first two types of edge receptors is less of a concern. However, elevations for receptors located within internal gap areas (with the FILLGAPS option) may be based on elevations from nodes located over 200 meters away, and may not adequately represent terrain in that area. Elevations for gap receptors using the FILLGAPS option should therefore be reviewed for accuracy and representativeness before using them in AERMOD. The capability of processing NED elevation data should eliminate the potential for edge and gap receptors in AERMAP applications, and users are especially encouraged to update to NED elevation data for applications that include gap receptors. Note that the discussion in this section also applies to determination of source elevations in AERMAP.

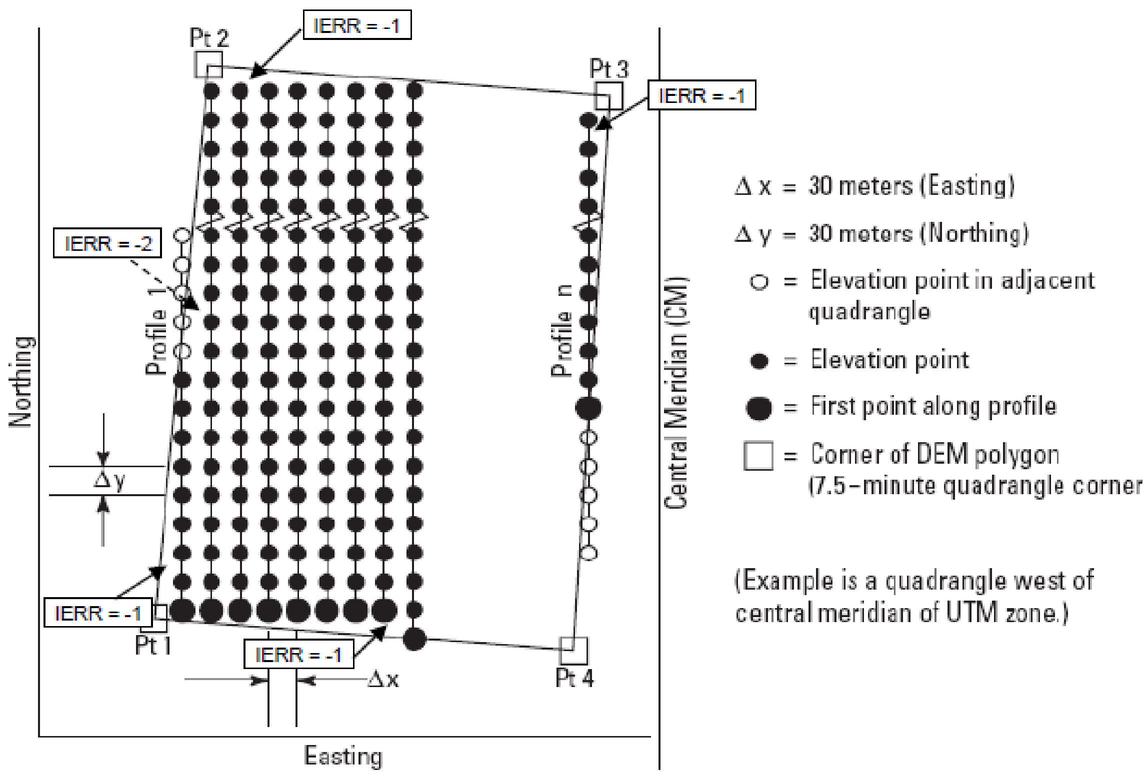


Figure 2-3. Structure of 7.5-minute DEM Data Illustrating Potential for 'edge' Receptors, Adapted from USGS (1998)

2.3.3 Gap receptors due to NAD conversions

Coordinate conversions to account for non-uniform datums can result in gaps between adjacent DEM files, ranging in size from a few meters in parts of the Midwest to around 100 meters in parts of the Pacific Northwest. Calculating elevations for receptors located within these gaps is problematic, and the representativeness of these gap calculations may be questionable, especially for areas with larger gap distances and/or areas with more significant terrain relief. Because of these concerns, users are encouraged to avoid using DEM files with different datums within the same application, if possible. The capability of processing NED elevation data should eliminate the potential for gap receptors associated with NAD conversions in AERMAP applications, and users are encouraged to update to NED elevation data for applications that include these NAD gap receptors. If a receptor located within a NAD-shift gap is no more than one Δx or Δy from profiles within the closest file, then the receptor will be treated the same as an edge receptor described in Section 2.3.2 for cases flagged with IERR = -1 or IERR = -2. These cases will be identified in the RECELV debug file. Otherwise, receptors located within these NAD-shift gaps are handled the same as receptors located within internal gaps, as described in Section 2.3.2. The receptor elevations will be assigned a missing code of -9999.0 unless the FILLGAPS option is specified. NAD gap receptor elevations filled with the FILLGAPS option based on the closest nodes will be flagged with warning message number 402.

While gaps between DEM files is the main concern, users should also be aware that portions of DEM files may overlap due to datum conversions, mirroring the datum gap, depending on the direction of the NAD conversion (NAD27 to NAD83 or vice versa) and depending on which side of the DEM file the receptors are located. The effect of this DEM file overlap is that elevations calculated for receptors located within the overlap region may vary slightly depending on the order in which the DEM files are listed in the AERMAP input file, since AERMAP will assign the receptor to the first DEM file that contains those coordinates.

The AERMAP program uses the following method for identifying and handling these NAD gap receptors:

1. AERMAP loops through each receptor to locate its local DEM file, initially using no distance tolerance on the location of the receptor relative to the edges of the DEM file. For applications with standard USGS DEM data files that do not involve NAD conversions this loop should uniquely assign each receptor to its local DEM file.

2. AERMAP issues a warning message identifying each receptor that is not located within a DEM file based on this initial loop.

3. AERMAP performs a second loop for all unassigned (potential "gap") receptors without applying the NAD shift. Any receptor that falls within the boundaries of a DEM file on this second loop is flagged as a "gap" receptor due to a NAD shift. AERMAP then loops through these "gap" receptors using a distance tolerance of one-half the datum shift in each direction (lat/lon or UTM-N/UTM-E), in order to assign the receptor to the closest DEM file.

4. AERMAP issues a fatal error message for any receptor that is not located within a DEM file based on this second loop.

5. If no fatal errors are encountered, AERMAP will continue with calculating elevations for all receptors, including gap receptors. If the distance between the NAD gap receptor and the closest DEM file node is no greater than the node spacing (Δx or Δy) for that file,then the elevation for that receptor is treated the same as a standard edge receptor (see Section 2.3.2). Otherwise, receptors located in NAD-shift gaps are handled the same as receptors located within gaps inside the DEM file boundaries (flagged with IERR = -3), as discussed in Section 2.3.2, although separate warning messages are generated for external NAD-shift gap receptors and receptors located within internal gaps. Unless the FILLGAPS option is selected, AERMAP will assign a missing code of -9999.0 for NAD- shift gap receptors.

Given the uncertainties regarding appropriate elevations for receptors located within the NAD-shift gap, users are encouraged to check the results for gap receptors relative to topographic maps of the area to ensure the representativeness of the elevations for use in AERMAP. As discussed above, the use of NED elevation data is encouraged in these cases, and should eliminate this problem.

Since two or more different datums can exist for each of the two DEM scales (1-degree and 7.5-minute) used in AERMAP, datum conversion was included with AERMAP. Datum conversion from NAD 27 to NAD 83 is performed using the National Geodetic Survey's NADCON software version 2.1. The main NADCON algorithms have been incorporated into AERMAP. NADCON is designed to convert coordinates in the Continental United States (CONUS), Old Hawaiian, Puerto Rico (and Virgin Islands), and four Alaskan datums to NAD 83 using 7 pairs of respective conversion parameter files that have LAS and LOS file extensions. These files need to be loaded along with the AERMAP executable. These files are used to convert receptors and sources coordinates of the old datum of the areas mentioned above to NAD83. The files are included with the AERMAP package on the SCRAM web site, (http://www.epa.gov/scram001/). NADCON is used only with the 7.5-minute DEM files. The datum of the anchor point is enter at the end of the ANCHOR keyword statement. For applications outside the NADCON coverage area, the user needs to enter “0". Inside one of the areas above, the user needs to enter the number representing the datum for the ANCHOR point. By selecting “0", no conversions will be done.

Datum conversion for the 1-degree data, from WGS 72 to GRS 80 / WGS 84, is not performed. Differences between the datums of around 7 meters are found in the arctic near Alaska and increase to around 17 meters in the tropics near Puerto Rico. Considering the differences are less than the approximate 93 meters between the 1-degree nodes, the conversion is considered inconsequential.

The difference in 7.5 minute DEM based horizontal datums can have an effect on receptor and source elevation points. The location of a point in one datum will be different from the location of a point under another datum (see Figure 2-4).

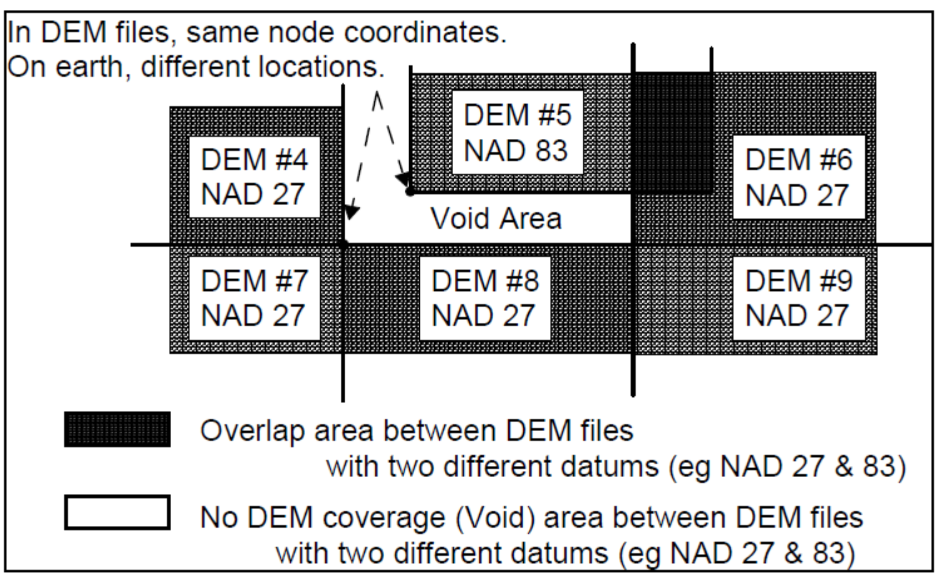


Figure 2-4. Depiction of Overlap and Void Areas Caused by Using DEM Files with Different Datums

For 7.5 minute DEM files of different datums, the datum coordinate difference for a given point in the CONUS can be close to zero in the Great Lakes region to more than 100 meters in the Pacific Northwest and down in Florida. In Hawaii, the difference is more than 300 meters. Since adjacent 7.5 minute DEM files have common map corners with each other (stated in latitude and longitude), the use of DEM files with different datums can shift a map so that gaps and overlaps occur between the adjacent DEM files as depicted in Figure 2-1. Receptors can fall into these gaps and overlaps.

From the NADCON subroutine in AERMAP, a 7.5-minute DEM coordinate shift from NAD27 to NAD83 is calculated for each receptor and source. The shift is applied in both directions so that each point has coordinates under both datums. This way, if the ANCHOR point is NAD 83, coordinates shifted to NAD 27 can be used with NAD 27 elevation files. AERMAP then determines the single closest DEM elevation value in each quadrant to the northwest, northeast, southeast and southwest of the receptor or source. These four elevations are weighted by distance to the receptor to estimate an elevation for that receptor (See Section 4.4 for equations). The resulting value is the elevation that is written to file for inclusion into an AERMOD input file. The source elevation is calculated the same way.

2.4 Keyword/parameter approach

The input runstream file needed to run the AERMAP preprocessor is based on an approach that uses descriptive keywords and parameters, and allows for a flexible structure and format. A brief overview of the approach is provided here. A complete description of this approach can be found in the AERMOD User's Guide (EPA, 2018a).

The input runstream file is divided into four functional "pathways." These pathways are identified by two-character identifiers at the beginning of each record in the runstream. The pathways for AERMAP are:

CO - for specifying overall job **CO**ntrol options;
SO - for specifying the **SO**urce location information (optional);

RE - for specifying the **RE**ceptor information; and

OU - for specifying the **OU**tput file information.

The optional source pathway may be used to specify source locations for the purpose of extracting source elevations from the DEM data and/or for specifying the origin of discrete or gridded polar receptors.

Each line, or image, in the input runstream consists of a pathway identifier, an eight-character keyword and a parameter list. The keywords and parameters that make up an input runstream file can be thought of as a command language through which the user communicates with the preprocessor what is to be accomplished for a particular run. The keywords specify the type of option or input/output data and the parameters following the keyword define the specific options or actual file names.here are several rules of syntax for structuring an input runstream. Briefly, they are:

1) All inputs for a particular pathway must be contiguous;
2) Each record in the runstream file must be 132 characters or less, which includes the pathway, the keyword and any parameters;
3) Alphabetic characters can be input as either upper or lower case because AERMAP converts all character input to upper case internally (except for the title parameters and filenames);
4) Several keywords are mandatory and must be present in every runstream file;
5) With a few exceptions, the order of the keywords is not critical;
6) Blank lines can be used to improve readability; asterisks in the first two columns (the pathway field) identify the record as a comment.

2.5 An example AERMAP input file

This section describes the three required pathways that constitute an AERMAP input file-- the control (CO) pathway, the receptor (RE) pathway, and the output (OU) pathway. The optional source (SO) pathway is described in Section 3.3.

2.5.1 Selecting Preprocessing Options - CO Pathway.

The mandatory keywords for the CO pathway are listed below. These keywords primarily control file types and names and the definition of the modeling domain. A complete discussion of all keywords is in Section 3 and a listing of all keywords is provided in Appendix B.

STARTING -	Indicates the beginning of inputs for the pathway; this keyword is mandatory on each of the pathways.
TITLEONE -	A user-specified title line (up to 68 characters) that will appear on each page of the printed output file (an optional second title line is also available with the keyword TITLETWO).
DATATYPE -	specifies the type of raw terrain data being supplied to the preprocessor.
DATAFILE -	Identifies the raw terrain files being supplied in this run.
ANCHORXY -	Defines the relationship between the user-coordinate system and the UTM coordinate system.
RUNORNOT -	A special keyword that tells the program whether to run the full preprocessor executions or not. If the user selects not to run, then the input runstream file will be processed and any input errors reported, but no calculations will be made.
FINISHED -	Indicates that the user is finished with the inputs for this pathway; this keyword is also mandatory on the other pathways.

The order of the keywords within this pathway is not critical, although the intent of the input runstream file may be easier to decipher if a consistent and logical order is followed. It is suggested that users follow the order in which the keywords are presented in Section 3, unless there is a clear advantage to doing otherwise.

A minimal but complete runstream file for the CO pathway may look something like this:

```
CO STARTING
   TITLEONE  10m NAD27 NW Durham DEM Data File With NAD27 Anchor Point
   DATATYPE  DEM
   DATAFILE  NWDurham_10m.dem
   DOMAINXY  683500.0 3990500.0 17  686500.0 3993500.0 17
   ANCHORXY  0.0      0.0     685000.0  3992000.0  17  1
   RUNORNOT  RUN
CO FINISHED
```

The first and last keywords identify the beginning and end of the COntrol pathway. The TITLEONE keyword provides a means of entering information about the run that will be included as a comment card in the output file. The parameter field for the TITLEONE keyword should not be in quotation marks. The preprocessor reads whatever appears in columns 13 - 80 of the TITLEONE record as the title field, without changing the lower case to upper case letters. Leading blanks are therefore significant if the user wishes to center the title within the field. Similar rules apply to the optional TITLETWO keyword.

Two types of raw terrain DATATYPE are allowed -- the DEM data (both 7.5-minute and 1-degree) and NED data. In this example, DEM data is being used, which is identified by the parameter DEM. The optional extent of the domain can be specified in one of two ways -- DOMAINXY or DOMAINLL -- depending on whether the user specifies the domain extent in UTM coordinates (DOMAINXY) or longitude/latitude coordinates (DOMAINLL). In this example, UTM coordinates are specified, with the southwest corner of the domain at 683500 Easting (E) and 3990500 Northing (N) in zone 17, while the northeast corner of the domain is at 686500 E and 3993500 N in zone 17. NOTE: Since longitude increases from east to west over North America, the domain is defined by the southwest and northeast corners when DOMAINLL is used.

As described above, the ANCHORXY keyword specifies the relationship between the coordinate system employed by the user to define source and receptor locations and the UTM coordinate system. The data provided on the ANCHORXY keyword are used to convert the source and receptor locations to UTM coordinates by AERMAP. If the UTM coordinate system is used for receptor locations, then the x- and y-coordinates for the point used to anchor the two systems are the same. In this example, the origin of a user-specified system (0.0, 0.0) is anchored to a point with UTM coordinates of 685000 E, 3922000 N in Zone 17. The entered datum value is 1 which indicates the anchor point is reference to NAD 27.

The only remaining mandatory keyword for the CO pathway is RUNORNOT. If the user is unsure about the syntax or operation of keywords or parameters, or is setting up a complex runstream file to run for the first time, it may be useful to set the preprocessor NOT to run. With this parameter set, AERMAP simply reads and analyzes the entire input file and reports any errors or warning messages that are generated. All of the inputs are summarized in the output file for the user to review just as if the parameter was set to RUN. Once the input file has been debugged using these descriptive error/warning messages, then the RUNORNOT switch can be set to RUN, as is done in this example.

Since the pathway ID is required to begin in column 1 (see Section 2.4.8 of the AERMOD user's guide for a discussion of this restriction), the preprocessor will assume that the previous pathway is in effect if the pathway field is left blank, as has been done in this example for all runstream images between the STARTING and FINISHED keywords. The preprocessor will do the same for blank keyword fields, which will be illustrated in the next section. In addition to these mandatory keywords on the CO pathway, the user may select optional keywords to specify whether or not receptor terrain elevations need to be generated or whether they are supplied (the default is to generate terrain elevations) and to allow the use of receptor heights above ground-level for flagpole receptors. These options are described in more detail in Section 3.

2.5.2 Specifying a receptor network - RE pathway

In this section, our example will illustrate the use of a single polar receptor network centered on the origin of the user-specified coordinate system, perhaps the stack location. Other options available on the REceptor pathway include specifying a Cartesian grid receptor network, and specifying discrete receptor locations in either a polar or a Cartesian system. These other options are described in more detail in Section 3.

For this example, a polar network with receptors located at five downwind distances for every 10-degree flow vector around a source is specified. The RE pathway for this example is:

```
RE STARTING
   GRIDPOLR POL1  STA
   POL1           ORIG  0.0   0.0
   POL1           DIST  100.  200.  300.  500.  1000.
   POL1           GDIR  36    10.   10.
   POL1           END
RE FINISHED
```

The GRIDPOLR keyword can be thought of as a "subpathway," in that all of the information for a particular polar network must be in contiguous records. Note, too, that there is a set of secondary keywords, including something that looks like a STArting and ENDing that identify the start and end of the subpathway. The order of secondary keywords within the subpathway is not critical, similar to the primary pathways. Each image in this subpathway must be identified with a network ID (up to eight alphanumeric characters), in this case it is "POL1." The “POL1" coordinates are referenced back to the ANCHOR point. Multiple networks may be specified in a single preprocessor run. The preprocessor waits until the END secondary keyword is encountered before processing begins. Other secondary keywords that may be used include terrain heights for receptors on elevated terrain or flagpole receptor heights if those options are being exercised by the user. The use of these optional secondary keywords is described in detail in Section 3.4.

For this example, the ORIG secondary keyword specifies the location of the origin, in (X,Y) coordinates, for the polar network being defined. The ORIG keyword is optional, and the program will default to an origin of (0.0, 0.0) if it is omitted. This is with respect to the ANCHOR coordinates. The DIST keyword identifies the distances in meters along each direction radial (flow vector) at which the receptors are located. In this example, there are five distances. More receptors could be added by adding values to the input image or by repeating the DIST secondary keyword with the additional distances. The GDIR keyword specifies that the program will Generate DIRection radials for the network. In this example, there are 36 directions, beginning with the 10-degree flow vector (the first parameter) and incrementing every 10 degrees clockwise (the last parameter). As a result, there are 36 directions and 5 distances, or 180 receptors for this example. Rather than let AERMAP generate the direction radials, the user may elect to define Discrete DIRection radials instead by using the DDIR keyword in place of the GDIR keyword (see Section 3.4.2.2).

2.5.3 Specifying the output file - OU pathway

The RECEPTOR keyword on the output pathway is used to specify the output filename for the receptor data generated by AERMAP. For this example, the output pathway may look like this:

```
OU STARTING
   RECEPTOR  AERMAP_NAD27_DEM.OUT
OU FINISHED
```

where AERMAP.OUT is the name of the file that will contain the receptor data, including receptor elevations and height scales, generated by AERMAP. The AERMAP.OUT file may then be included in a runstream for the AERMOD model. If the optional source pathway is used to specify source locations and terrain elevations are extracted from the DEM data, then the output filename for the source location data would be specified using the SOURCLOC keyword on the OU pathway (see Section 3.5).

2.6 Running AERMAP

Now that we have a complete and error-free runstream input file, the preprocessor is ready to run. The PC-executable file for AERMAP available on the EPA's Support Center for Regulatory Air Models (SCRAM) website on the Internet (www.epa.gov/scram001) opens the runstream input and output message files without the need to "redirect" the I/O on the command line using the DOS redirection symbols '<' and '>'. The command line to run the sample problem for all AERMAP versions might look something like this on the PC:

C:\>AERMAP

AERMAP assumes that the input runstream input file is named AERMAP.INP. AERMAP.OUT is opened as the output message file containing an echo of the input runstream and a listing of any warning or error messages generated by AERMAP. Note that for Linux or Unix systems, where the filenames are case-sensitive, the default filenames are aermap.inp and aermap.out

Beginning with version 18081, the user can also enter the input runstream input filename and optionally, the output filename as well. These options can be used when the runstream input file is not named AERMAP.INP and the output filename is not named AERMAP.OUT. If the user enters the input runstream filename, then the output filename uses the prefix of the input filename to name the output file. The command line to run the sample problem with optional input and output filenames might look something like this on the PC:

C\:>AERMAP *aermap_input_file*

Or,

C:\>AERMAP *aermap_input_file aemap_output_file*

The input and output filenames can be full or relative pathnames of the files, when they are in different directories than the current working directory or just the filenames when they are located in the current working directory

As described in Section 2.5.3, the filename for the data file containing the terrain elevations and height scales for all of the receptors is specified within the input runstream on the output pathway. The DOS prompt is represented by the characters "C:\>", but may appear different on different machines, depending on how the user configures his/her system. When not specifying the input file on the command line or not specifying a pathname for the input file, the input file must be located in the directory in which the user is working, i.e. the current working directory. The output file is written to the current working directory if the user is not specifying a pathname for the output file. Assuming that the 7.5-minute DEM data need to be converted to NAD83, the *.las and the *.los files are needed by the NADCON subroutine to perform the conversion. Although there are 14 files (7 .las and 7 .los), only the .las and .los files that correspond to the region for which AERMAP is being run may be needed. In the example above, Durham, NC is in the continental United States so the conus.las and conus.los files would be needed to convert the 7.5-minute datums to NAD 83. These files can be in the same subdirectory as the AERMAP executable, in which case AERMAP will locate them, or the NADGRIDS keyword can be used on the CO pathway to inform AERMAP where to find the files. In this example, the files were in the same folder where the input data (runstream file and DEM file) were located.

Note: If no conversion has to be performed, i.e., the 7.5-minute DEM files are already NAD83, then the .las and .los files are not needed.

When AERMAP is executed, an update on the status of processing is displayed on the computer monitor. AERMAP first indicates that the setup information in the input runstream file is being processed, followed by initializing the terrain data, and then displays the receptor number currently being processed. If the preprocessor stops after completing the setup processing, then either the RUNORNOT parameter was set to NOT, or a fatal error was encountered during the setup processing. The user should review the message file (AERMAP.OUT in this example) to determine why AERMAP was unsuccessful, correct the input and rerun AERMAP.

Any error message generated by the operating system rather than AERMAP is displayed on the screen and not written to the message file. One such message might be that there is insufficient memory available to run the program. Handling of system error messages may require some knowledge of user's operating system whether it be Windows, DOS, UNIX, Linux, MAC, etc. Sometimes the meaning of the message is obvious. Sometimes they can be obscure. The detailed description of the error messages in Appendix C may be useful in determining the meaning and cause of the message.

The message file will always be generated by the program which will contain any error, warning or diagnostic messages that were generated during the run. By default, the program will echo each line of the input runstream file to the message file to provide a convenient record of the inputs as originally read into the preprocessor. However, for some applications, the length of the input runstream file may be too cumbersome to include the entire set of inputs at the beginning of each output file. This situation may happen, for example, if a large number of discrete receptor locations are used. For this reason, the user is provided with the option to "turn off" the echoing of the input file at any point within the runstream file. This is accomplished by entering the keywords "NO ECHO" in the first two fields anywhere within the runstream file. In other words, place NO in the pathway field, followed by a space and then ECHO. None of the input runstream images after the NO ECHO will be echoed to the output file. Thus, a user may choose to place NO ECHO after the Control pathway in order to keep the control options echoed, but suppress echoing the rest of the input file.

If the original input file might be lost or destroyed, use of the NO ECHO option would not be a wise choice. If the NO ECHO is omitted, the original runstream (input) data are echoed to the message file. The runstream data can be copied to another filename and used as an input file to reproduce that particular application. The data are echoed at the beginning of this file and AERMAP keys on the "RE FINISHED" image to stop processing the runstream file.

The output data file specified on the output pathway of the input runstream contains the receptor pathway as entered by the user in the input file with the addition of the receptor terrain elevations (if requested) and receptor height scales as calculated by AERMAP. This output data file can now be used for the REceptor pathway of an AERMOD input file. Several header records are included in the output data file to identify the version of AERMAP used to generate the file and other information useful for interpreting the results. An example of the AERMAP output file for the sample problem is shown in Figure 2-5.

```
** AERMAP - VERSION 11103                                                  08/23/16
**                                                                         16:19:20
**  10m NAD27 NW Durham DEM Data File With NAD27 Anchor Point
**
** A total of       1  DEM files were used
** A total of     180  receptors were processed
** DOMAINXY  683500.0 3990500.0 17  686500.0 3993500.0 17
** ANCHORXY  0.0      0.0     685000.0  3992000.0  17  1
** Terrain heights were extracted by default

RE ELEVUNIT METERS
   GRIDPOLR POL1 STA
            POL1 ORIG   0.0   0.0
            POL1 DIST   100.   200.   300.   500.   1000.
            POL1 GDIR   36     10.    10.
   GRIDPOLR POL1     ELEV    1    120.3    123.8    128.5    140.8    129.6
   GRIDPOLR POL1     ELEV    2    122.1    126.8    132.1    143.8    131.3
   GRIDPOLR POL1     ELEV    3    123.3    130.2    132.3    140.4    126.2
   GRIDPOLR POL1     ELEV    4    124.2    131.8    131.7    133.7    128.8
   GRIDPOLR POL1     ELEV    5    124.5    130.4    127.2    127.9    128.5
   GRIDPOLR POL1     ELEV    6    124.0    128.1    124.0    125.4    119.4
   GRIDPOLR POL1     ELEV    7    121.9    124.4    121.5    121.5    105.0
   GRIDPOLR POL1     ELEV    8    119.4    121.4    122.1    117.9     98.9
   GRIDPOLR POL1     ELEV    9    117.4    117.5    122.0    117.5    104.5
.
.
.
   GRIDPOLR POL1     HILL    1    141.0    130.3    141.1    140.8    129.6
   GRIDPOLR POL1     HILL    2    132.0    131.1    132.1    143.8    131.3
   GRIDPOLR POL1     HILL    3    132.0    130.2    132.3    140.4    126.2
   GRIDPOLR POL1     HILL    4    132.0    131.8    131.7    133.7    128.8
   GRIDPOLR POL1     HILL    5    132.0    130.4    131.3    127.9    128.5
   GRIDPOLR POL1     HILL    6    132.0    131.8    124.0    125.4    122.0
   GRIDPOLR POL1     HILL    7    132.0    132.0    125.5    121.5    108.3
   GRIDPOLR POL1     HILL    8    141.8    132.0    125.9    117.9     98.9
   GRIDPOLR POL1     HILL    9    142.0    140.3    122.0    117.5    113.3
.
.
.
   GRIDPOLR POL1  END
```

Figure 2-5. Example of an AERMAP Output File for the Sample Problem

2.7 Memory management, storage limitations, and creating a new executable

Beginning with version 09040, AERMAP dynamically allocates array storage at runtime based on the number of receptors, sources, DEM or NED data files, and the maximum number of rows and columns of data within the elevation files. As a result, application of

AERMAP will only be limited by available memory. In general, AERMAP is not a very memory-intensive application. However, the processing of NED elevation data involves creating a two-dimensional, double-precision array to store the elevation data from the entire file for processing, regardless of whether a domain has been specified. This can require a significant amount of memory for a large NED file. For example, a NED file with 3,000 rows and 3,000 columns of data (representing a domain of about 90 kilometers on a side at 1 arc-second or 30 meter resolution) would require over 70 MB of memory (approximately = #rows * #columns * 8bytes). A domain of about 100,000 meters on a side (50 kilometers in each direction from the center) at $1/3^{rd}$ arc-second resolution (about 10 meters) would require about 800 MB of memory. For applications with NED data for large domains at high resolution (10 meters or less), it may be advantageous to split up the domain into smaller files. Since AERMAP allocates and deallocates the elevation array storage for each file as it is initialized, this will reduce overall memory requirements. Using multiple NED files to cover the domain of interest may also allow AERMAP to optimize the calculation of hill height scales (the most time-consuming portion of AERMAP) by skipping some files completely.

If users want to store a large number of DEM or NED files, the only limitation may be the computer's storage device capacity, e.g., a computer's hard drive. With modern day hard drive sizes on the order of a terabyte or more, the storage of terrain files should not be an issue. However, when designing a study and planning to download the required terrain data, keep several things in mind. A NED file with 1 arc- second resolution for a study about 100 kilometers on a side requires about 55 MB of storage in the GeoTIFF format (plus about 75 Kb for several ancillary files) and 1/3 arc-second resolution for the same area requires nearly 500 MB of storage. A 1-degree DEM file or a 7.5 minute DEM file (with node spacing of 10 meters), can be as large as 10 MB. AERMAP creates an additional temporary binary file corresponding to each DEM file which can also be as much as 6 MB each in size, depending on the size of the domain. A 7.5-minute DEM file, with 30 meter node spacing, can be as large as 1.2 MB but only covers 1/64th of the same area as a 1-degree DEM file. For an area extending 50 kilometers from a source, approximately 80 to 90 7.5-minute DEM files are needed.

AERMAP was written to Fortran 90 standards. A user should be able to recompile AERMAP for different operating systems without having to change any of the underlying source code. Batch files for recompiling the source code with the Intel® compiler as well as the gfortran Fortran compiler are packaged with the source code on SCRAM.

3.0 Detailed keyword reference

This section of the AERMAP User's Guide provides a detailed reference for all of the input keyword options for the AERMAP preprocessor. The information provided in this section is more complete and detailed than the information provided in Section 2. Since this section is intended to meet the needs of experienced modelers who may need to understand completely how particular options are implemented in the preprocessor, the information for each keyword should stand on its own. This section assumes that the reader has a basic understanding of the keyword/parameter approach used by the AERMOD model and the AERMAP preprocessor for specification of input options and data. Novice users should first review the contents of Section 2 or the AERMOD User's Guide in order to obtain that understanding.

3.1 Overview

The information in this section is organized by function, i.e., the keywords are grouped by pathway, and are in a logical order based on their function within the preprocessor. The order of keywords presented here is the same as the order used in the functional keyword reference in Appendix B, and the Quick Reference section at the end of the volume. The syntax for each keyword is provided, and the keyword type is specified - either mandatory or optional and either repeatable or non-repeatable. Unless noted otherwise, there are no special requirements for the order of keywords within each pathway, although the order in which the keywords are presented here and in Appendix B is recommended. Any keyword which has special requirements for its order within the pathway is so noted following the syntax and type description.

The syntax descriptions in the following sections use certain conventions. Parameters that are in all capital letters and underlined in the syntax description are secondary keywords that are to be entered as indicated for that keyword. Other parameters are given descriptive names to convey the meaning of the parameter, and are listed with an initial capital letter. Many of the parameter names used correspond to variable names used in the computer code of the preprocessor. Parentheses around a parameter indicate that the parameter is optional for that keyword. The default that is taken when an optional parameter is left blank is explained in the discussion for that keyword.

3.2 Control pathway inputs and options

The **CO**ntrol pathway contains the keywords that provide the overall control of the preprocessor run. These include the specification of the terrain data, the geographic extent of the scenario, and others that are described below. The CO pathway must be the first pathway in the runstream input file.

3.2.1 Title information

There are two keywords that allow the user to specify up to two lines of title information. The title is included as comment cards in the output data file. The first keyword, TITLEONE, is mandatory, while the second keyword, TITLETWO, is optional. The syntax and type for the keywords are summarized below:

Syntax:	CO TITLEONE Title1 CO TITLEONE Title2
Type:	TITLEONE - Mandatory, Non-repeatable TITLETWO - Optional, Non-repeatable

The parameters Title1 and Title2 are character parameters of length200, which are read as a single field from columns 13 to 200 of the input record. Only the first 68 characters are written to the printed output file. The title information is taken as it appears in the runstream file without any conversion of lower case to upper case letters. If the TITLETWO keyword is not included in the runstream file, then the second line of the title in the output data file will appear blank.

3.2.2 Options for elevated terrain

The optional TERRHGTS keyword controls whether the receptor elevations and optional source elevations should be extracted from the DEM data files or that the user-provided receptor terrain elevations should be used. The syntax and type of the TERRHGTS keyword are summarized below:

Syntax:	CO TERRHGTS EXTRACT or PROVIDED
Type:	Optional, Non-repeatable

where the EXTRACT secondary keyword instructs the preprocessor to determine the terrain heights from the DEM data files provided by the user. The PROVIDED secondary keyword forces the preprocessor to use the user-specified elevations that are entered on the receptor pathway and optional source pathway. Any terrain heights that are entered on the receptor pathway are ignored if EXTRACT terrain option is specified, and a non-fatal warning message is generated. The default option is to EXTRACT receptor elevations if no TERRHGTS keyword is present in the input runstream.

3.2.3 Flagpole receptor height option

The FLAGPOLE keyword specifies that receptor heights above local ground level (i.e. flagpole receptors) are allowed on the REceptor pathway. The FLAGPOLE keyword may also be used to specify a default flagpole receptor height other than 0.0 meters. The syntax and type of the FLAGPOLE keyword are summarized below:

Syntax:	CO FLAGPOLE (Flagdf)
Type:	Optional, Non-repeatable

where Flagdf is an optional parameter to specify a default flagpole receptor height. If no parameter is provided, then a default flagpole receptor height of 0.0 meters is used. Any flagpole receptor heights that are entered on the Receptor pathway are ignored if the FLAGPOLE keyword is not present on the Control pathway, and a non-fatal warning message is generated. In this case, the flagpole receptor heights are not included in the output file from AERMAP.

3.2.4 Terrain data type specifications

The DATATYPE keyword is required to specify the type of the raw terrain data being provided to the AERMAP terrain processor. The syntax and type of the keyword are summarized below:

Syntax:	CO DATATYPE DEM or (FILLGAPS) or CO DATATYPE NED
Type:	Mandatory, Non-repeatable

where the secondary keyword DEM specifies that DEM elevation data will be used, and NED specifies that NED elevation data (in the GeoTIFF format) will be used. The optional secondary keyword for DEM data, FILLGAPS, affects the processing of elevations for sources and/or receptors located within data gap areas. Without the FILLGAPS option, AERMAP will assign a missing code of -9999.0 for receptors and sources located within these gap areas. Note that the AERMOD dispersion model (up to version 07026) does not currently check for missing elevation codes, and will therefore not correctly simulate impacts for these cases. The next update to AERMOD will include a check for missing receptor elevations, and will issue fatal error messages for each case. More details regarding AERMAP's handling of receptors located within gaps is provided in Section 2.3. The FILLGAPS option is not available for the NED data option since gap areas should not occur with the use of standard NED data.

Versions of AERMAP prior to version 09040 were limited to only process one type of DEM data a time, either the original 1-degree DEM (specified with a secondary keyword of 'DEM1') or the finer resolution 7.5-minute DEM data (specified as 'DEM7'). AERMAP now allows for mixed DEM file inputs, including 1-degree and 7.5-minute DEM, as well as 15-

minute DEM data available for portions of Alaska. As a result of this modification the secondary keyword has been changed to simply 'DEM'. Note that version 09040 of AERMAP will ignore the additional qualifier of '1' or '7' on the DEM data type used in previous versions, allowing backward compatibility with older input files. The option for mixed DEM file types allows for the use of the highest resolution data available for portions of the modeling domain, with the lower resolution data to fill in the gaps in coverage that may exist. For example, 7.5-minute DEM data are not available for quadrangles that are entirely water. In these cases, 1-degree DEM files may be included to fill in these gaps within the domain simplifying the application of AERMAP. However, AERMAP checks to determine whether the higher resolution data files are listed first in the AERMAP input file to ensure that receptor elevations will be based on the higher resolution data. For purposes of comparing the resolution of data files, AERMAP assumes that the following resolutions are equivalent: 1/9th arc-second and 3 meters; 1/3rd arc-second and 10 meters; 1 arc-second and 30 meters; and 3 arc-seconds and 90 meters.

3.2.4.1 National Elevation Dataset data

Beginning with version 09040, AERMOD supports NED elevation data in the GeoTIFF format, which is a binary file that includes data descriptors and geo-referencing information in the form of "TiffTags" and "GeoKeys." AERMAP processes these TiffTags and GeoKeys to determine the type and structure of the elevation data within the NED file. NED elevation files can be obtained for user-specified domains through the USGS National Map (http://viewer.nationalmap.gov/launch/). Through this data resource, the user defines a domain for downloading through various options, and can download a single file to cover the entire modeling domain (up to 250 MB). The NED elevation files are downloaded as compressed files, and the only file needed for input to AERMAP is the file with the ".tif" file extension. **NOTE*****: The default format for downloading NED data from the MRLC is currently ArcGRID, which AERMAP cannot read. The user must modify the file format to GeoTIFF before downloading the NED data in order to use the data in AERMAP.***

While the USGS data server provides a mechanism to obtain data for the entire domain in a single data file, AERMAP will accept multiple NED files in a single run. There is no requirement for these files to be aligned according to a regular grid, similar to standard DEM data. If multiple NED files overlap, which is likely in most cases, AERMAP will assign the receptor to the first file encountered that contains the receptor for purposes of calculating receptor elevations. As discussed above, AERMAP checks to determine whether higher resolution elevation data are specified before lower resolution data in the AERMAP input file, to ensure the receptor elevations are based on the highest resolution data provided. A warning message will be generated if a lower resolution file is entered before a higher resolution file, but processing will continue. However, a fatal error message will be generated if a receptor is assigned to the lower resolution file within the region of overlap. The criteria for equivalence in resolution between geographic and UTM data are listed in the previous section.

3.2.5 Terrain data file names specifications

The DATAFILE keyword is needed to specify the names of the raw terrain data being provided to the preprocessor. The keyword is repeatable so that multiple raw terrain file names can be specified. The maximum allowable number of files is determined by the NDEM parameter in the computer code. The syntax and type of the keyword are summarized below:

Syntax:	CO DATAFILE filename
Type:	Mandatory, Repeatable

If the specified file is not found on the computer, the program will generate a fatal error message.

3.2.5.1 Option for checking contents of DEM files

An earlier version of AERMAP (dated 04300) incorporated a subroutine (DEMCHK) that performs detailed checks on the contents of each DEM file on a character-by-character basis. These checks serve two purposes: 1) to determine the structure of each DEM file by looking for carriage-return (CR) and line-feed (LF) characters and other non-alphanumeric characters for purposes of reading the file correctly; and 2) to document the contents of the DEM file for informational and/or debugging purposes. Based on these checks each DEM file is identified as either: 1) a continuous ASCII record file (with no CR or LF); 2) a file with record delimiters, such as a UNIX file (with LF but no CR) or a standard DOS file (with both CR and LF); or 3) a possible binary file (containing non-alphanumeric characters besides CR and LF). The AERMAP program supports DEM files as continuous ASCII records or with UNIX or DOS delimited records, but a fatal error message is generated if the third type is encountered. **NOTE:** ***The inclusion of the DEMCHK routine in AERMAP has eliminated the requirement for users to convert DEM files to the standard DOS format using the CRLF.EXE utility program.***

The full file check conducted in subroutine DEMCHK could be time consuming for applications with a large number of DEM files, and especially for 7.5-minute DEM files with 10 meter horizontal resolution due to the larger file sizes. In order to retain the capabilities of the DEMCHK routine, but to expedite processing where detailed checks of DEM file contents are not warranted, beginning with version 06341 the AERMAP program incorporates a more limited DEM check as the default operation, with a user option to request a full DEM check on a file-by-file basis. The limited DEM check performs the same processing as the full check, but is limited to the first 10240 characters (equivalent to the first 10 records of a DEM file). This limited check should be sufficient to identify the type of DEM file in order to successfully read the data. The complete check can be requested as needed to provide additional documentation if problems are encountered. Note that the check of DEM file contents is exited as soon as a valid record delimiter (UNIX LF or DOS CR/LF) is encountered.

The option to request a full DEM check for a particular DEM file has been added to the CO DATAFILE keyword. The syntax and type of the DATAFILE keyword for DEM data are:

Syntax:	CO DATAFILE DEM_FileName (CHECK)
Type:	Mandatory, Repeatable

where DEM_FileName is the DEM data filename, and the optional CHECK parameter indicates that the full DEM check will be performed for that file. The CHECK parameter is not case-sensitive. The DEM filename can be up to 200 characters in length based on the default parameters in AERMAP. Double quotes (") at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces.

3.2.5.2 Optional TIFF debug file and user-specified elevation units for NED data

Beginning with version 09040, AERMAP supports NED data in the GeoTIFF format. Historically, TIFF (Tagged-Image File Format) files were used as an efficient way to store information for graphical display. The utility of the TIFF file format was greatly expanded by incorporating additional codes that provide geo-referencing information related to the data. Such files are referred to as GeoTIFF files. Two types of codes are included in GeoTIFF files: 1) ***TiffTags***, which include information regarding the structure of the data within the file, including number of rows and columns, data organization (stripped or tiled), and data format (integer or floating point); and 2) ***GeoKeys***, which provide the geo-referencing information, including the type of projection (geographic or UTM) and horizontal reference datum. There are two TiffTags that serve as the link between the "raster space" of standard TIFF files and geographic space of GeoTIFF files. These codes provide the reference data to convert raster coordinates (row I, column J) to geographic or projected (UTM) coordinates, and the resolution of the pixels (grid cells) included in the file. Tables 2-2 and 2-3, respectively, list the TiffTags and GeoKeys that are processed by AERMAP. These tables identify whether the TiffTags and GeoKeys are required, optional, or whether their status is conditional based on other codes. The default values are specified for optional TiffTags and GeoKeys. All other TiffTags and GeoKeys are currently ignored by AERMAP. More information regarding TIFF and GeoTIFF files is provided in the specification documents (Aldus, 1992; and Ritter, N. and M. Ruth, 1995).

Table 3-1. List of TiffTags Processed by AERMAP for NED Data

TiffTags			
Tag ID	**Description**	**Status**	**Comments**
256	'ImageWidth'	Required	Number of columns
257	'ImageLength'	Required	Number of rows
258	'BitsPerSample'	Required	Must be 8, 16, 32, or 64 bits
259	'Compression'	Optional	Default = 1 (uncompressed)
273	'StripOffsets'	Conditional	Required for stripped data
274	'Orientation'	Optional	Default = 1 (row major starting from upper left corner of file)
277	'SamplesPerPixel'	Optional	Default = 1
278	'RowsPerStrip'	Optional	Default = 1 strip with nRows
322	'TileWidth'	Conditional	Required for tiled data
323	'TileLength'	Conditional	Required for tiled data
324	'TileOffsets'	Conditional	Required for tiled data
339	'SampleFormat'	Optional	Default = 1 (unsigned integer)[a]
33550	'ModelPixelScale'	Required	
33922	'ModelTiePoint'	Required	

[a] USGS NED data are expected to be in floating point format, but AERMAP will process all formats.

Table 3-2. List of GeoKeys Processed by AERMAP for NED Data

GeoKeys			
Key ID	**Description**	**Status**	**Comments**
1024	'GTModelTypeGeoKey'	Required	Projected (UTM) or Geographic (Lat/Lon)
1025	'GTRasterTypeGeoKey'	Required	
2048	'GeographicTypeGeoKey'	Conditional[a]	
2050	'GeogGeodeticDatumGeoKey'	Conditional[a]	
2054	'GeogAngularUnitsGeoKey'	Optional	Default = degrees
2056	'GeogEllipsoidGeoKey'	Conditional[a]	
3072	'ProjectedCSTypeGeoKey'	Conditional	Required for Projected GTModelType
3076	'ProjLinearUnitsGeoKey'	Optional	Default = meters
4099	'VerticalUnitsGeoKey'	Optional	Default = meters

[a] Either the GeographicType, GeogGeodeticDatum, or GeogEllipsoid GeoKey is required if GTModelType is Geographic

Given the binary nature of GeoTIFF files, the contents of the file cannot be "read" by standard text editors or word processors. AERMAP includes an option to generate a TIFF debug file for each NED data file specified with the DATAFILE keyword. The TIFF debug file includes a listing of all TiffTags and GeoKeys contained within the specified GeoTIFF file.

<u>**NOTE:**</u> ***While the GeoTIFF specifications provide a GeoKey for vertical elevation units*** (GeoKey ID 4099), most NED files currently do <u>not</u> include this GeoKey. If the elevation units GeoKey is missing, then AERMAP assumes that elevations are in units of meters based on the USGS documentation for NED data (USGS, 2002). Since non-USGS elevation files in GeoTIFF format have been encountered that are in units of feet rather than meters, but lack the appropriate GeoKey to specify the units, AERMAP includes an option for the user to specify elevation units on the DATAFILE keyword. The syntax and type of the DATAFILE keyword for NED data are:

Syntax:	CO DATAFILE NED_FileName (TIFFDEBUG) (ElevUnit)
Type:	Mandatory, Repeatable

where the NED_FileName parameter is the filename for the NED data in GeoTIFF format, the optional TIFFDEBUG parameter indicates that the TIFF debug file will be generated for this data file, and ElevUnits refers to the optional user-specified elevation units for the NED data. The TIFFDEBUG parameter is not case-sensitive. The NED filename can be up to 200 characters in length based on the default parameters in AERMAP. Double quotes (") at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces, and do not count toward the 200 character limit. Note that the TIFFDEBUG option must be included in order to specify elevation units. AERMAP generates a hard-coded filename for the optional TIFFDEBUG file(s) as follows: 'TiffDebugFile_nnnnn.dbg', where 'nnnnn' is the NED file number based on the order listed in the input file. Also note that the CHECK option available for DEM files is not applicable to NED data.

The options available for ElevUnits are FEET, DECIFEET, DECAFEET, METERS, DECIMETERS, and DECAMETERS. AERMAP will also recognize hyphenated fields for the deci- and deca- options, such as DECI-FEET. The ElevUnits parameter is not case-sensitive. Users are cautioned not to use the option for specifying elevation units unless the correct units are known with certainty. It is preferable to utilize the GeoKey available for documenting elevation units within the GeoTIFF file (GeoKey ID 4099). The user-specified elevation units will only be used if the NED file does not include the GeoKey for elevation units. If the NED file includes the elevation units code and the user-specified units (meters or feet) or vertical resolution (defined by the ModelPixelScale TiffTag, 33550) conflict with the data file, a fatal error will be issued. If the elevation units code and user-specified units agree, then an informational message is generated and processing continues. Note that most GeoTIFF elevation files specify a vertical resolution ("pixel scale") of '0' through the ModelPixelScale TiffTag, which is not meaningful for elevation data. AERMAP interprets a vertical pixel scale of 0 as a vertical resolution of 1.0

3.2.6 Domain extent specifications

The DOMAINXY or the DOMAINLL keyword is used to define the geographic extent of the domain that includes all the receptors and sources specified in this run and within which the raw terrain data points will be included in calculation of the hill height scales for the receptors. The DOMAINXY and DOMAINLL keywords are optional. If the DOMAINXY and DOMAINLL keywords are omitted, AERMAP will use all of the available data within the input data files in the calculation of the critical hill height scales.

The DOMAINXY keyword allows the user to specify the domain in UTM coordinates while the DOMAINLL keyword allows the user to specify it in the World Geodetic System (latitude / longitude). The syntax and type of the keywords are summarized below:

Syntax:	CO DOMAINXY Xdmin Ydmin Zonmin Xdmax Ydmax Zonmax or CO DOMAINLL Lonmin Latmin Lonmax Latmax
Type:	Mandatory, Non-repeatable

For the DOMAINXY keyword, Xdmin, Ydmin and Zonmin are the UTM Easting coordinate, UTM Northing coordinate and the UTM zone for the lower left (southwest) corner of the domain; Xdmax, Ydmax and Zonmax are the UTM Easting coordinate, UTM Northing coordinate and the UTM zone for the upper right (northeast) corner of the domain. The UTM coordinates are specified in meters. The UTM Northing coordinate for southern hemisphere locations is a positive number relative to a value of 10,000,000 meters at the equator. Southern hemisphere UTM coordinates are identified by a negative UTM zone.

Beginning with version 09040 of AERMAP, the standard convention of negative values for West longitude is used within the AERMAP code and output files. Based on this convention, for the DOMAINLL keyword, Lonmin and Latmin are the longitude and latitude in decimal degrees for the lower left (southwest) corner of the domain; and Lonmax and Latmax are the longitude and latitude in decimal degrees for the upper right (northeast) corner of the domain, consistent with the DOMAINXY keyword. Note that longitude is entered first, followed by latitude. In order to maintain backward compatibility with older AERMAP input files, code has been included within AERMAP to adjust the inputs for the DOMAINLL keyword if needed to conform to the new convention of negative for West longitude. AERMAP will issue a warning message in these cases and will print the adjusted DOMAINLL parameters in the main output file (aermap.out) as well as in the receptor and source elevation output files.

There are a few aspects regarding AERMAP's interpretation of the domain that deserve further explanation and clarification. First, while the user can specify the domain using either geographic coordinates (latitude and longitude) or UTM coordinates, the exact shape and extent of the domain will be based on the type of DEM or NED data used. When geographic data, such as 1-degree DEM data and standard NED data, are processed, AERMAP interprets the domain boundaries along lines of constant latitude and longitude consistent with the profiles and nodes within the data file. Conversely, when UTM data, such as 7.5-minute DEM data, are processed, AERMAP interprets the domain boundaries along lines of constant UTM Northing and Easting coordinates (note that Alaska 7.5-minute DEM data may be in either UTM or geographic coordinates). This means that the same DOMAINXY or DOMAINLL card will define slightly different geographical areas depending upon the type of elevation data being processed. This approach was taken in the initial design of AERMAP to simplify the process of extracting and analyzing the portion of a DEM file that falls within the domain since the domain will parallel the profiles of elevation nodes within the DEM file. The structure of the two types of DEM files is described in more detail in Section 4.2 of the AERMAP User's Guide (EPA, 2018b) , and in the USGS DEM documentation (USGS, 1998). To avoid confusion or uncertainty regarding the extent of the domain, users may wish to define the domain in a manner that is consistent with the type of DEM data, i.e., use DOMAINXY with UTM data and DOMAINLL with geographic data, although this is not a requirement. Beginning with version 09040, AERMAP also allows for mixed DEM files (e.g., 7.5-minute and 1-degree) to be used in the same run. Since the file type (geographic or UTM) may vary in these cases, AERMAP sets the "type" of data and shape of the domain based on the first data file specified.

Users should also be aware that the AERMAP program (beginning with version 06341) has been revised to account for NAD shifts in defining the extent of the domain, if needed. To accomplish this conversion AERMAP assumes that the domain coordinates are referenced to the datum specified by the user on the ANCHORXY keyword, described in the next section. This revision to AERMAP may result in AERMAP-generated errors related to the domain extent for some AERMAP applications that ran "successfully" with versions prior to version 06341.

3.2.7 Anchor point specification

AERMAP uses a Cartesian (X,Y) grid system to define relative location of sources and receptors in the East-West (X) and North-South (Y) directions. The ANCHORXY keyword is used to relate the user-specified coordinate system for the source and receptor locations to the UTM coordinate system, including specification of the reference datum for the source and receptor coordinates. The user has the option of specifying the receptor locations on the RE pathway in UTM coordinates or in some arbitrary user-specified coordinate system. For any further processing of the terrain data, the AERMAP program needs to determine the location of the receptors in UTM coordinates. This is accomplished using the ANCHORXY keyword by specifying the coordinates of any specific geographic location relative to both the user-specified coordinate system and the UTM coordinate system. The syntax and type of the keyword are summarized below:

Syntax:	CO ANCHORXY Xauser Yauser Xautm Yautm Zautm NADA
Type:	Mandatory, Non-repeatable

where Xauser and Yauser are the coordinates of any geographic location, such as the origin (0,0), in the user coordinate system, and Xautm, Yautm and Zautm are the UTM Easting, Northing and Zone coordinates for the same point. The UTM Easting and Northing coordinates are specified in meters. As noted in Section 2.1.1, UTM Northing coordinates for the southern hemisphere are referenced to a value of 10,000,000 meters at the equator, and the UTM zone is negative for the southern hemisphere. All receptor and source locations are referenced to this anchor point. The

NADA parameter specifies the horizontal datum that was used to establish the UTM coordinates of the anchor point. NADA values range from 0 to 6, and are described below.

AERMAP uses the difference between the specified "user" coordinates (Xauser and Yauser) and the UTM coordinates (Xautm and Yautm) to adjust the receptor coordinates included on the RE pathway (and optional source coordinates on the SO pathway) to full UTM coordinates. If the user specifies the receptor locations in UTM coordinates with the same UTM zone and reference datum as the anchor point, then the coordinates provided on the ANCHORXY keyword are arbitrary, as long as the values of Xauser and Xautm are identical, and the values of Yauser and Yautm are identical.

Table 3-3 provides a list of applicable NADA values and the horizontal datum that each NADA value references. These values follow the convention used in the USGS Standards for Digital Elevation Models (USGS, 1998), and the list also follows the convention used in the DEM file headers (logical record type A), except for the use of '0' (zero) to bypass the NAD conversion. Note that the terms 'ellipsoid' and 'spheroid' are often used interchangeably in the literature.

Based on the user-specified datum for the anchor point (NADA) and the datum code read from each DEM or NED file, AERMAP will apply the appropriate adjustment to receptor, source and domain coordinates to account for the shifts due to reference datums and reference ellipsoids. The National Geodetic Survey program, North American Datum Conversion (NADCON), version 2.1, has been incorporated into AERMAP and is used to calculate the datum shifts. The NADCON program requires additional parameter files containing the grid shift information. These grid shift files have *.las and *.los extensions, and files covering the contiguous U.S. (CONUS), Hawaii, Puerto Rico/Virgin Islands, Alaska and three Alaskan Island Groups (St. George, St. Paul, and St. Lawrence) are packaged with the AERMAP executable file. When datum shifts are required for a particular AERMAP application, the appropriate grid shift files (*.las and *.los) need to be included in the same folder as the AERMAP input file, unless the optional NADGRIDS keyword on the CO pathway is used to specify a separate pathname for the NADCON grid shift files (see Section 3.2.8 for more details regarding this optional keyword). AERMAP will issue a fatal error message if the necessary files are not found. Note that the grid shift files are only required if a NAD conversion is needed based on the specified NADA and reference datums among the input terrain files, and only the files needed for the domain of a particular application (such as ‘conus.las’ and ‘conus.los’ for the contiguous U. S.) are required. The grid shift files are not required when a NADA value of ‘0’ is specified on the ANCHORXY card. While a NADA value of ‘0’ can be specified to avoid the NAD conversion for AERMAP applications outside the United States where the grid shift files are not available, it is preferable to specify the appropriate reference datum if it can be determined. Most international terrain data bases will be referenced to either the WGS72 or the WGS84 datum, with WGS84 being more likely for recent data. Since AERMAP treats WGS72 and WGS84 as equivalent, the issues associated with datum conversion may not be very critical for non-US applications.

If the user is unsure regarding the reference datum for the receptors (and sources) to be used in a particular application, then the following suggestions may be helpful. Given the potential significance of NAD shifts on receptor elevation and hill height scale results, the user is first encouraged to make every effort to document the reference datum, perhaps by contacting the original provider of the information. When no reliable information is available regarding the datum, then the following assumptions are recommended. If the coordinates are from a previous application that dates back several years (mid-1990’s or earlier) or are likely to have been derived from printed USGS 7.5-minute (1:24,000 scale) topographic maps, then the best recommendation is to assume NAD27 as the reference datum. On the other hand, if the coordinates are from a recent application and are likely to have been derived from a global positioning system (GPS) device or a geographic information system (GIS), then the reference datum is more likely to be NAD83. Note that topographic maps available on the Internet will generally plot coordinates based on the NAD83 datum by default, but may also be able to plot coordinates in the NAD27 datum.

Table 3-3. Datum Switches for Anchor Location

NADA	Description
0	No conversion is performed between NAD 27 and NAD 83 for the DEM nodes, receptors, sources, or domain. This option may be used for international applications where NAD shift grid files are not available. However, the reference datum used to define the coordinates on ANCHORXY keyword should match the datum for terrain data. Recent non-US terrain data is likely based on WGS84 datum. While datum conversions are not performed with this option, conversion of UTM to geographic coordinates for receptors, sources and domain within AERMAP will be based on the appropriate ellipsoid for each data file. If the datum is not specified in the data file, AERMAP defaults to the Clarke 1866 ellipsoid for 7.5-minute DEM files and the GRS80 ellipsoid for 1-degree DEM files. If datum for NED data is not specified or not supported by AERMAP, the GRS80 ellipsoid will be used by default.
1	North American Datum of 1927, NAD27, based on Clarke 1866 ellipsoid. AERMAP accounts for shift from NAD27 to NAD83, as needed, for DEM nodes, receptors, sources, and domain.
2	World Geodetic System of 1972 datum, WGS72, based on WGS72* ellipsoid. AERMAP accounts for shift from WGS72 to NAD27, as needed, for DEM nodes, receptors, sources, and domain.
3	World Geodetic System of 1984 datum, WGS84, based on WGS84* ellipsoid. AERMAP accounts for shift from WGS84 to NAD27, as needed, for DEM nodes, receptors, sources, and domain.
4	North American Datum of 1983, NAD83, based on GRS80* ellipsoid. AERMAP accounts for shift from NAD83 to NAD27, as needed, for DEM nodes, receptors, sources, and domain.
5	Old Hawaii Datum, based on Clarke 1866 ellipsoid, but not NAD 27. AERMAP accounts for shift from the Old Hawaii Datum to NAD83, as needed, for DEM nodes, receptors, sources, and domain.
6	Puerto Rico/Virgin Island Datum, based on Clarke 1866 ellipsoid, but not NAD 27. AERMAP accounts for shift from the Puerto Rico/ Virgin Island Datum to NAD83, as needed, for DEM nodes, receptors, sources, and domain.

* The GRS80 and WGS84 ellipsoids are considered to be the same. There is a very small difference in the flattening which results in the semi-minor axis being different by 0.0001 meters. There is no known application for which this difference is significant. The WGS84 and NAD83 datum are considered the same for all practical purposes.

NADCON is used to convert from NAD 27, Old Hawaiian, or Puerto Rico datums to NAD83 and vice versa.

Internal to the AERMAP model, a datum code is read from each DEM header and all 7.5 minute data are converted to NAD 83. NADCON produces the shift values in both meters and degrees, minutes, seconds that are added to the receptor and source. NADCON is only called for converting 7.5-minute DEM coordinates from one datum to another. There are additional parameter files required which have the *.LAS and *.LOS extensions for the CONUS, Hawaii, Puerto Rico/Virgin Islands, Alaska and three Alaskan Island Groups (St. George, St. Paul, and St. Lawrence). These files need to be included in the same subdirectory as the AERMAP input file or the directory where they are located specified using the NADGRIDS keyword described in Section 3.2.8.

> Note: For international users, setting Nada to “0" will bypass NADCON and the need to enter any parameter files.

The two 1-degree datums, WGS 72 and WGS 84, are both Earth-centric datums. The difference in point locations varies with latitude from about 7 meters for areas north of Alaska to about 17 meters for areas near 20 degrees north latitude. With a node spacing of approximately 90 meters, the difference between the two 1-degree datums is thought to be inconsequential. No conversions are done between the two datum types.

3.2.8 NADCON grid shift files

Beginning with version 09040, the user has the option of specifying the pathname for the folder that contains the NADCON grid shift files (*.las and *.los files) needed for AERMAP applications involving NAD shift calculations. The pathname may be defined using the full path or using a relative path reference. As noted in Section 3.2.7, the NADCON grid shift files are only required when a NAD conversion is needed based on the user specified NADA and the reference datums among the input terrain files. The default location (path) for these grid shift files is the local folder where the AERMAP input file (aermap.inp) is located. This may require multiple copies of the grid shift files to be located in different folder locations on a computer. The optional NADGRIDS keyword on the CO pathway allows for the user to specify a single pathname for the folder containing the grid shift files that can be shared across multiple applications of AERMAP. The syntax and type of the NADGRIDS keyword are summarized below:

Syntax:	CO NADGRIDS NADGridPathname
Type:	Optional, Non-repeatable

where the NADGridPathname parameter is a character field that identifies the pathname for the folder that contains the NADCON grid shift files. The NADGridPathname field can be up to 200 characters in length based on the default parameters in AERMAP. Double quotes (“) at the beginning and end of the pathname can also be used as field delimiters to allow pathnames with embedded spaces, and do not count toward the 200 character limit. Note that the optional NAD grid pathname must include the trailing backslash (\) for Windows applications or forward slash(/) for Linux/UNIX applications. AERMAP also preserves the case for the pathname specified to accommodate case-sensitivity of filenames for Linux/UNIX applications.

3.2.9 Debug output files

Beginning with version 06341, the AERMAP program includes both mandatory and optional (user-specified) debug output files. The three mandatory debug files provide general information regarding the DEM or NED files and domain setup that may be useful in documenting and resolving problems with the AERMAP code or with the setup of the input data. The filenames for these mandatory debug output files are hardcoded as MAPDETAIL.OUT, MAPPARAMS.OUT, and DOMDETAIL.OUT. Beginning with version 18081, when using the command line option to specifiy the input runstream input file and optionally, the output filename, AERMAP will use the output file’s prefix as the filename of these files. If the output filename contains a full or relative pathname, that will be included in those filenames as well, i.e. these files will be in the same folder as the AERMAP output file.

The MAPDETAIL.OUT file contains a summary of information regarding each DEM or NED file based on the results of the DEMCHK or NEDCHK routines. In the case of NED data, the MAPDETAIL.OUT file will contain additional details related to any error or warning messages generated in the processing the TiffTags or GeoKeys. The MAPPARAMS.OUT file contains a summary of the parameters for each DEM or NED file, based on the contents of the header record (logical record type A) for DEM or the TiffTags and GeoKeys for NED data, and also documents the adjacency of the DEM or NED files within the application area.

The DOMDETAIL.OUT file contains information regarding the extent of the user-specified modeling domain, including which DEM or NED file contains each corner of the domain. The DOMDETAIL.OUT file also includes information regarding the direct access elevation files created for each DEM or NED file, which include only that portion of the file that is within the domain. This information can be helpful in resolving issues with the domain exceeding the extent of the DEM or NED files. Beginning with version 09040, a simple option to avoid problems with the domain exceeding the range of the data is to omit the DOMAINLL or DOMAINXY keyword. The DOMDETAIL.OUT file is not generated if a domain is not specified.

The MAPPARAMS.OUT file includes three separate adjacency tests with different distance tolerances for adjacency and with somewhat different purposes. The most stringent adjacency test uses a distance tolerance of 0.1 arc-second (about 3 meters), and is intended to identify possible “stray” files within the domain or files which have non-standard corner coordinates. A file must have two corners that meet this test to be considered adjacent to another file. For DEM data this adjacency test may flag files that were converted to DEM data from another data format or from DEM files with different resolutions (e.g., from 1-degree DEM to 7.5-minute DEM format). Failing this stringent adjacency test does not necessarily indicate a problem with the data, but may highlight potential issues for resolution. This stringent test is less meaningful for AERMAP applications with multiple NED files, since these files will typically not follow a regular grid pattern for file extents.

A second, less stringent test for adjacency in the MAPPARAMS.OUT file based on a tolerance of 45 arc-seconds (about 10 percent of the range of a 7.5-minute DEM file) is used to develop a 3x3 array of adjacent (neighboring) files for each data file to document relative locations within the application domain. For applications involving DEM or NED files with different horizontal resolutions, neighboring files with the same resolution as the reference file (center of the 3x3 grid) will be given preference over other files that may also meet the criterion.

The third adjacency test included in the MAPPARAMS.OUT file uses a tolerance of 0.03 degrees (about 3 kilometers) to create a grid showing the relative locations of all data files and potential data gaps covering the full application domain. For AERMAP applications that utilize files of the same resolution, interpretation of the full grid of files is straightforward. For applications involving files with mixed resolution, the “grid” resolution (area covered by each filename) is based on the horizontal coverage of the highest resolution data file included in the application. Higher resolution data are given preference over lower resolution data in the grid printout, and lower resolution files may not be printed as a result. The area covered by lower resolution data files may include more than one “grid cell”, and these filenames are positioned within the grid based on the southeast corner coordinates.

Optional debug output files are specified with the DEBUGOPT keyword that was added to the CO pathway beginning with version 06341. The specification of these files is optional. Separate debug files are available to document calculations related to the determination of the critical hill height scales, receptor elevations and coordinate conversions, and source elevations and coordinate conversions. Each debug output file has a default filename defined within the AERMAP program, but separate keywords on the OU pathway (see Section 3.5) may be used to specify alternative filenames for these files.

The syntax and type of the DEBUGOPT keyword are:

Syntax:	CO DEBUGOPT HILL and/or RECEPTOR and/or SOURCE or CO DEBUGOPT ALL
Type:	Optional, Non-repeatable

where the HILL, RECEPTOR and SOURCE keywords can be used to request specific types of debug outputs, while the ALL keyword can be used to request all three types of debug outputs. The keywords are not case-sensitive, and the order of keywords for the first option is not critical. Also note that SOURCE debug outputs will only be generated if source locations are included in the AERMAP input file.

The HILL debug option includes a single debug file that documents the calculations of the critical hill height scales. The default filename for the HILL debug output is 'CALCHCDET.OUT'. For each receptor, the HILL debug output file summarizes the search for critical hill heights for each DEM or NED file within the domain. In order to minimize the size of the HILL debug output file, only terrain nodes that factor into the critical hill height calculation are documented. A sample from a HILL debug output file is provided below in Figure 2-2.

The RECEPTOR and SOURCE debug options each produce three files with the same type of information for receptors or sources, respectively. The discussion here will focus on receptors but also applies to sources. The first file provides details regarding the NAD conversion results and domain checks (if a domain is specified) for each receptor, with a default filename of 'RECDETAIL.OUT'. The second file provides results of calculations to locate which DEM or NED file contains each receptor, with a default filename of 'RECNDEM.OUT'. The third file contains results of the receptor elevation calculations, with a default filename of 'RECELV.OUT'. Samples from each of these types of RECEPTOR debug files are provided in Figures 2-3 through 2-5.

3.2.10 To run or not to run - that is the question

Because of the error handling and the "defensive programming" that has been employed in the design of the AERMAP model, it is intended that the program will read through all of the inputs in the runstream file regardless of any errors or warnings that may be encountered. If a fatal error occurs in processing of the runstream information, then further program calculations will be aborted. Otherwise, the program will attempt to run. Because of the great many options available in the AERMAP preprocessor, and the potential for wasted resources if a large run is performed with some incorrect input data, the RUNORNOT keyword has been included on the Control pathway to allow the user to specify whether to RUN the preprocessor and perform all of the calculations, or NOT to run and only process the input runstream data and summarize the setup information. The syntax and type of the RUNORNOT keyword are summarized below:

Syntax:	CO RUNORNOT RUN or NOT
Type:	Mandatory, Non-repeatable

3.3 Source pathway inputs and options (optional)

The optional **SO**urce pathway is used to define source locations for the purpose of generating source elevations from the DEM data and/or for identifying the origins of discrete polar receptors. There is only one keyword available on the source pathway, besides STARTING and FINISHED. The syntax and type of the LOCATION keyword are summarized below:

Syntax:	SO LOCATION Srcid Srctyp Xs Ys (Zs)
Type:	Mandatory if using Discrete Polar Receptors, Mandatory if using source ID for origin of polar grid, Repeatable

where Srcid is an alphanumeric source ID of up to eight characters, Srctyp is the source type, which is identified by one of the secondary keywords - POINT, VOLUME, AREA, AREAPOLY, or AREACIRC, Xs and Ys are the x-coordinate (East) and y-coordinate (North) of the source location in meters, and Zs is the optional source elevation in meters above mean sea level. This keyword is mandatory if any discrete polar receptors are being used or if a source ID is used to specify the origin for a polar grid. Since allocatable arrays are used in AERMAP, the number of sources is limited only by the physical memory of the computer AERMAP is running on.

3.3.1 Including source data from an external file

Beginning with version 09040, the user has the option of including source data from an external file by using the INCLUDED keyword on the source (SO) pathway. An INCLUDED keyword may be placed anywhere within the SO pathway, after the STARTING card and before the FINISHED card (i.e., the SO STARTING and SO FINISHED keywords cannot be included in the external file). The data in the included file will be processed as though it were part of the runstream file. The syntax and type of the INCLUDED keyword are summarized below:

Syntax:	SO INCLUDED SrcIncFile
Type:	Optional, Repeatable

where the SrcIncfil parameter is a character field that identifies the filename for the included source file. The INCLUDED filenames can be up to 200 characters in length based on the default parameters in AERMAP. Double quotes (“) at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces. The contents of the included file must be valid runstream images for the appropriate pathway. If an error is generated during processing of the included file, the error message will report the line number of the included file. If more than one INCLUDED file is specified for a particular pathway, the user will first need to determine which file the error occurred in. If the starting column of the main runstream input file is shifted from column 1, then the runstream images in the included file must be offset by the same amount.

3.4 Receptor pathway inputs and options

The **RE**ceptor pathway contains keywords that define the receptor information for a particular run. The RE pathway contains keywords that allow the user to define Cartesian grid receptor networks and/or polar grid receptor networks, with either uniform or non-uniform grid spacing, as well as discrete receptor locations referenced to a Cartesian or a polar system. The program is initially setup to allow ten (10) gridded receptor networks of either (or both) types in a single run, plus discrete receptors of either type, up to a maximum limit on the total number of receptors. The limit on the total number of receptors in a given run is controlled by a Fortran PARAMETER in the computer code (AERMAP.INC). The number of receptor networks allowed is also controlled by a PARAMETER statement in AERMAP.INC, and may be easily changed by the user and the program recompiled.

The default units for receptor elevations input to the AERMAP preprocessor are in meters, however, the user may specify receptor elevations to be input in units of feet by adding the optional RE ELEVUNIT FEET card immediately after the RE STARTING card. Regardless of the input elevation units, AERMAP outputs all elevations in meters, and the RE ELEVUNIT METERS card is added to the output file following the RE STARTING card.

3.4.1 Including receptor data from an external file

Beginning with version 09040, the user has the option of including source data from an external file by using the INCLUDED keyword on the receptor (RE) pathway. An INCLUDED keyword may be placed anywhere within the RE pathway, after the STARTING card and before the FINISHED card (i.e., the RE STARTING and RE FINISHED keywords cannot be included in the external file). The data in the included file will be processed as though it were part of the runstream file. The syntax and type of the INCLUDED keyword are summarized below:

Syntax:	RE INCLUDED RecSrcIncFile
Type:	Optional, Repeatable

where the SrcIncfil parameter is a character field that identifies the filename for the included source file. The INCLUDED filenames can be up to 200 characters in length based on the default parameters in AERMAP. Double quotes (") at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces. The contents of the included file must be valid runstream images for the appropriate pathway. If an error is generated during processing of the included file, the error message will report the line number of the included file. If more than one INCLUDED file is specified for a particular pathway, the user will first need to determine which file the error occurred in. If the starting column of the main runstream input file is shifted from column 1, then the runstream images in the included file must be offset by the same amount.

3.4.2 Defining networks of gridded receptors

Two types of receptor networks are allowed by the AERMAP preprocessor. A Cartesian grid network, defined through the GRIDCART keyword, includes an array of points identified by their x (east-west) and y (north-south) coordinates. A polar network, defined by the GRIDPOLR keyword, is an array of points identified by direction and distance from a user-defined origin. Each of these keywords has a series of secondary keywords associated with it that are used to define the network, including any receptor elevations for elevated terrain and flagpole receptor heights. The GRIDCART and GRIDPOLR keywords can be thought of as "subpathways," since their secondary keywords include a STArt and an END card to define the start and end of inputs for a particular network.

3.4.2.1 Cartesian grid receptor networks.

Cartesian grid receptor networks are defined by use of the GRIDCART keyword. The GRIDCART keyword may be thought of as a "subpathway," in that there are a series of secondary keywords that are used to define the start and the end of the inputs for a particular network, and to select the options for defining the receptor locations that make up the network. The syntax and type of the GRIDCART keyword are summarized below:

Syntax:	RE GRIDCART Netid		STA					
			XYINC	Xinit	Xnum	Xdelta Yinit	Ynum	Ydelta
		or	XPNTS	Gridx1	Gridx2	Gridx3	...	Gridxn, and
			YPNTS	Gridy1	Gridy2	Gridy3	...	Gridyn
			ELEV	Row	Zelev1	Zelev2	...	Zelevn
			FLAG	Row	Zflag1	Zflag2	...	Zflagn
			END					
Type:	Optional, Repeatable							

where the parameters are defined as follows:

Netid	Receptor network identification code (up to eight alphanumeric characters)
STA	Indicates the STArt of GRIDCART inputs for a particular network, repeated for each new Netid
XYINC Xinit Xnum Xdelta Yinit Ynum Ydelta	Keyword identifying uniform grid network generated from x and y increments Starting x-axis grid location in meters Number of x-axis receptors Spacing in meters between x-axis receptors Starting y-axis grid location in meters Number of y-axis receptors Spacing in meters between y-axis receptors
XPNTS Gridx1 Gridxn	Keyword identifying grid network defined by a series of discrete x and y coordinates (used with YPNTS) Value of first x-coordinate for Cartesian grid (m) Value of 'nth' x-coordinate for Cartesian grid (m)
YPNTS Gridy1 Gridyn	Keyword identifying grid network defined by a series of discrete x and y coordinates (used with XPNTS) Value of first y-coordinate for Cartesian grid (m) Value of 'nth' y-coordinate for Cartesian grid (m)
ELEV Row Zelev	Keyword to specify that receptor elevations follow (optional) Indicates which row (y-coordinate fixed) is being input (Row=1 means first, i.e., southmost row) An array of receptor terrain elevations (m) for a particular Row (default units of meters may be changed to feet by use of RE ELEVUNIT keyword), number of entries per row equals the number of x-coordinates for that network
FLAG Row Zflag	Keyword to specify that flagpole receptor heights follow (optional) Indicates which row (y-coordinate fixed) is being input (Row=1 means first, i.e., southmost row) An array of receptor heights (m) above local terrain elevation for a particular Row (flagpole receptors), number of entries per row equals the number of x-coordinates for that network
END	Indicates the END of GRIDCART inputs for a particular network, repeated for each new Netid

The ELEV and FLAG keywords are optional inputs, and are only needed if elevated terrain or flagpole receptor heights are to be provided. If the ELEV keyword is used and the preprocessor is being run with the TERRHGTS option set to EXTRACT (see Section 3.2.2), then the elevated terrain height inputs will be ignored by the preprocessor, and a non-fatal warning message will be generated. If the TERRHGTS option is set to PROVIDED, and no elevated terrain heights are entered, the elevations will default to 0.0 meters, and warning messages will also be generated. If the FLAG keyword is used and the FLAGPOLE option has not been specified on the CO pathway (see Section 3.2.3), then the flagpole data will be ignored when the output receptor data are generated. If the FLAGPOLE option is selected, and the FLAG keyword is not used, then the default flagpole height will be output with the receptor data.

The order of cards within the GRIDCART subpathway is not important, as long as all inputs for a particular network are contiguous and start with the STA secondary keyword and end with the END secondary keyword. It is not even required that all ELEV cards be contiguous, although the input file will be more readable if a logical order is followed. The network ID is also not required to appear on each runstream image (except for the STA card). The program will assume the previous ID if none is entered, similar to the use of continuation cards for pathway and keywords. Thus, the following two examples produce the same 8-by-4 Cartesian grid network:

```
RE GRIDCART CAR1 STA
RE GRIDCART CAR1 XPNTS  -500. -400. -200. -100. 100.  200.  400.  500.
RE GRIDCART CAR1 YPNTS  -500. -250.  250.  500.
RE GRIDCART CAR1 ELEV  1  10.  10.  10.  10.  10.  10. 10.  10.
RE GRIDCART CAR1 ELEV  2  20.  20.  20.  20.  20.  20. 20.  20.
RE GRIDCART CAR1 ELEV  3  30.  30.  30.  30.  30.  30. 30.  30.
RE GRIDCART CAR1 ELEV  4  40.  40.  40.  40.  40.  40. 40.  40.
RE GRIDCART CAR1 FLAG  1  10.  10.  10.  10.  10.  10. 10.  10.
RE GRIDCART CAR1 FLAG  2  20.  20.  20.  20.  20.  20. 20.  20.
RE GRIDCART CAR1 FLAG  3  30.  30.  30.  30.  30.  30. 30.  30.
RE GRIDCART CAR1 FLAG  4  40.  40.  40.  40.  40.  40. 40.  40.
RE GRIDCART CAR1 END
```

```
RE GRIDCART CAR1  STA
                XPNTS -500.-400.  -200.  -100  100. 200. 400.  500
                YPNTS -500.-250.   250.   500.
                ELEV 1 8*10.
                FLAG 1 8*10.
                ELEV 2 8*20.
                FLAG 2 8*20.
                ELEV 3 8*30.
                FLAG 3 8*30.
                ELEV 4 8*40.
                FLAG 4 8*40.
RE GRIDCART CAR1  END
```

The Row parameter on the <u>ELEV</u> and <u>FLAG</u> inputs may be entered as either the row number, i.e., 1, 2, etc., or as the actual y-coordinate value, i.e., -500., -250., 250., 500. in the example above. The program sorts the inputs using Row as the index, so the result is the same. The above example could therefore be entered as follows, with the same result:

```
RE GRIDCART CAR1  STA
                XPNTS -500.-400.  -200.  -100. 100. 200. 400.  500.
                YPNTS -500.-250.    250.   500.
                ELEV  -500. 8*10.
                FLAG  -500. 8*10.
                ELEV  -250. 8*20.
                FLAG  -250. 8*20.
                ELEV   250. 8*30.
                FLAG   250. 8*30.
                ELEV   500. 8*40.
                FLAG   500. 8*40.
RE GRIDCART CAR1  END
```

Of course, one must use either the row number or y-coordinate value consistently within each network to have the desired result.

The following simple example illustrates the use of the XYINC secondary keyword to generate a uniformly spaced Cartesian grid network. The resulting grid is 11 x 11, with a uniform spacing of 1 kilometer (1000. meters), and is centered on the origin (0., 0.). No elevated terrain heights or flagpole receptor heights are included in this example.

```
RE   GRIDCART    CG1   STA
                       XYINC    -5000.  11   1000.    -5000.  11   1000.
RE   GRIDCART    CG1   END
```

3.4.2.2 Polar grid receptor networks

Polar receptor networks are defined by use of the GRIDPOLR keyword. The GRIDPOLR keyword may also be thought of as a "subpathway," in that there is a series of secondary keywords that are used to define the start and the end of the inputs for a particular network, and to select the options for defining the receptor locations that make up the network. The syntax and type of the GRIDPOLR keyword are summarized below:

Syntax:	RE GRIDPOLR Netid		STA					
		or	ORIG	Xinit	Yinit			
			ORIG	Srcid				
			DIST	Ring1	Ring2	Ring3	...	Ringn
		or	DDIR	Dir1	Dir2	Dir3	...	Dirn
			GDIR	Dirnum	Dirini	Dirinc		
			ELEV	Dir	Zelev1	Zelev2	...	Zelevn
			FLAG	Dir	Zflag1	Zflag2	...	Zflagn
			END					
Type:	Optional, Repeatable							

where the parameters are defined as follows:

Netid	Receptor network identification code (up to eight alphanumeric characters)
STA	Indicates STArt of GRIDPOLR inputs for a particular network, repeat for each new Netid
ORIG	Keyword to specify the origin of the polar network (optional)
Xinit	x-coordinate for origin of polar network
Yinit	y-coordinate for origin of polar network
Srcid	Source ID of source used as origin of polar network
DIST	Keyword to specify distances for the polar network
Ring1	Distance to the first ring of polar coordinates
Ringn	Distance to the 'nth' ring of polar coordinates
DDIR	Keyword to specify discrete direction radials for the polar network
Dir1	First direction radial in degrees (1 to 360)
Dirn	The 'nth' direction radial in degrees (1 to 360)
GDIR	Keyword to specify generated direction radials for the polar network
Dirnum	Number of directions used to define the polar system
Dirini	Starting direction of the polar system
Dirinc	Increment (in degrees) for defining directions
ELEV	Keyword to specify that receptor elevations follow (optional)
Dir	Indicates which direction is being input
Zelev	An array of receptor terrain elevations for a particular direction radial (default units of meters may be changed to feet by use of RE ELEVUNIT keyword), number of entries per radial equals the number of distances for that network
FLAG	Keyword to specify that flagpole receptor heights follow (optional)
Dir	Indicates which direction is being input
Zflag	An array of receptor heights above local terrain elevation for a particular direction (flagpole receptors)
END	Indicates END of GRIDPOLR subpathway, repeat for each new Netid

The ORIG secondary keyword is optional for the GRIDPOLR inputs. If omitted, the program assumes a default origin of (0.,0.,) in x,y coordinates. The ELEV and FLAG keywords are also optional inputs, and are only needed if elevated terrain or flagpole receptor heights are to be provided. If elevated terrain is being provided, then the ELEV inputs are needed for each receptor. If the ELEV keyword are used and the program is being run with the TERRHGTS option set to EXTRACT (see Section 3.2.2), then the elevated terrain height inputs will be ignored by the preprocessor, and a non-fatal warning message will be generated. If the TERRHGTS option is set to PROVIDED and no elevated terrain heights are entered, the elevations will default to 0.0 meters, and warning messages will also be generated. If the FLAG keyword is used and the FLAGPOLE option has not been specified on the CO pathway (see Section 3.2.3), then the flagpole data will be ignored when the output receptor data are generated. If the FLAGPOLE option is selected, and the FLAG keyword is not used, then the default flagpole height will be output with the receptor data.

As with the GRIDCART keyword described above, the order of cards within the GRIDPOLR subpathway is not important, as long as all inputs for a particular network are contiguous and start with the STA secondary keyword and end with the END secondary keyword. It is not even required that all ELEV cards be contiguous, although the input file will be more readable if a logical order is followed. The network ID is also not required to appear on each runstream image (except for the STA card). The program will assume the previous ID if none is entered, similar to the use of continuation cards for pathway and keywords.

The following example of the GRIDPOLR keyword generates a receptor network consisting of 180 receptor points on five concentric distance rings centered on an assumed default origin of (0.,0.). The receptor locations are placed along 36 direction radials, beginning with 10 degrees and incrementing by 10 degrees in a clockwise fashion.

```
RE GRIDPOLR POL1 STA
                 DIST   100.  300.  500.  1000. 2000.
                 GDIR   36    10.   10.
RE GRIDPOLR POL1 END
```

Another example is provided illustrating the use of a non-zero origin, discrete direction radials and the specification of elevated terrain and flagpole receptor heights:

```
RE GRIDPOLR POL1 STA
                   ORIG   500.   500.
                   DIST   100.   300.  500.   1000.   2000.
                   DDIR    90.   180.  270.    360.
                   ELEV    90.     5.   10.  15.  20.  25.
                   ELEV   180.     5.   10.  15.  20.  25.
                   ELEV   270.     5.   10.  15.  20.  25.
                   ELEV   360.     5.   10.  15.  20.  25.
                   FLAG    90.     5.   10.  15.  20.  25.
                   FLAG   180.     5.   10.  15.  20.  25.
                   FLAG   270.     5.   10.  15.  20.  25.
                   FLAG   360.     5.   10.  15.  20.  25.
RE GRIDPOLR POL1 END
```

As with the GRIDCART keyword described earlier, the user has the option of specifying the radial number (e.g. 1, 2, 3, etc.) on the ELEV and FLAG inputs, or the actual direction associated with each radial.

3.4.3 Using multiple receptor networks

For some modeling applications, the user may need a fairly coarsely spaced network covering a large area to identify the area of significant impacts for a plant, and a denser network covering a smaller area to identify the maximum impacts. To accommodate this modeling need, the AERMAP preprocessor allows the user to specify multiple receptor networks in a single run. The user can define either Cartesian grid networks or polar networks, or both. With the use of the ORIG option in the GRIDPOLR keyword, the user can easily place a receptor network centered on the facility being permitted, and also place a network centered on another background source known to be a significant contributor to high concentrations. Alternatively, the polar network may be centered on a receptor location of special concern, such as a nearby Class I area.

As noted in the introduction to this section, the program initially allows up to 10 receptor networks in a single run. This limit can be changed by modifying the Fortran PARAMETER statement in the AERMAP.INC file and recompiling the program. There are also limits on the number of distances or directions (or the number of x-points and the number of y-points for

Cartesian grids) that can be specified for each network. These are initially set to 100 distances or x-points and 100 directions or y-points. These limits are also controlled by Fortran PARAMETER statements in AERMAP.INC, and may be modified.

3.4.4 Specifying discrete receptor locations

In addition to the receptor networks defined by the GRIDCART and GRIDPOLR keywords described above, the user may also specify discrete receptor points for modeling impacts at specific locations of interest. This may be used to model critical receptors, such as the locations of schools or houses, nearby Class I areas, or locations identified as having high concentrations by previous modeling analyses. The discrete receptors may be input as either Cartesian x,y points (DISCCART keyword) or as polar distance and direction coordinates (DISCPOLR keyword). Both types of receptors may be identified in a single run. In addition, for discrete polar receptor points the user specifies the source location used as the origin for the receptor on the SO LOCATION card (see Section 3.3).

3.4.5 Discrete Cartesian receptors

Discrete Cartesian receptors are defined by use of the DISCCART keyword. The syntax and type of this keyword are summarized below:

Syntax:	RE DISCCART Xcoord Ycoord (Zelev) (Zflag)
Type:	Optional, Repeatable

where the Xcoord and Ycoord parameters are the x-coordinate and y-coordinate (m), respectively, for the receptor location. The Zelev parameter is an optional terrain elevation (m). The Zflag parameter is the optional receptor height above ground (m) for modeling flagpole receptors. All of the parameters are in units of meters, except for Zelev, which defaults to meters but may be specified in feet by use of the RE ELEVUNIT keyword. Note that the output elevations will always be in meters, regardless of input units.

If neither the elevated terrain option (Section 3.2.7) nor the flagpole receptor height option (Section 3.2.8) are used, then the optional parameters are ignored if present. If only the elevated terrain height option is used (no flagpoles), then the third parameter (the field after the Ycoord) is read as the Zelev parameter. If only the flagpole receptor height option is used (no elevated terrain), then the third parameter is read as the Zflag parameter. If both options are used, then the parameters are read in the order indicated for the syntax above. If the optional parameters are left blank, then default values will be used. The default value for Zelev is 0.0, and the default value for Zflag is defined by the CO FLAGPOLE card (see Section 3.2.8). Note: If both the elevated terrain and flagpole receptor height options are used, then the third parameter will always be used as Zelev, and it is not possible to use a default value for Zelev while entering a specific value for the Zflag parameter.

3.4.5.1 Discrete polar receptors

Discrete polar receptors are defined by use of the DISCPOLR keyword. The syntax and type of this keyword are summarized below:

Syntax:	RE DISCPOLR	Srcid	Dist	Direct	(Zelev)	(Zflag)
Type:	Optional, Repeatable					

where the Srcid is the alphanumeric source identification for one of the sources defined on the SO pathway which will be used to define the origin for the polar receptor location. The Dist and Direct parameters are the distance in meters and direction in degrees for the discrete receptor location. Degrees are measured clockwise from north. The Zelev parameter is an optional terrain elevation for the receptor. The unit of Zelev is in meters, unless specified as feet by the RE ELEVUNIT keyword. The Zflag parameter is the optional receptor height above ground (meters) for modeling flagpole receptors.

If neither the elevated terrain option (Section 3.2.7) nor the flagpole receptor height option (Section 3.2.8) is used, then the optional parameters are ignored if present. If only the elevated terrain height option is used (no flagpoles), then the third parameter (the field after the Ycoord) is read as the Zelev parameter. If only the flagpole receptor height option is used (no elevated terrain), then the third parameter is read as the Zflag parameter. If both options are used, then the parameters are read in the order indicated for the syntax above. If the optional parameters are left blank, then default values will be used. The default value for Zelev is 0.0, and the default value for Zflag is defined by the CO FLAGPOLE card (see Section 3.2.8). Note: If both the elevated terrain and flagpole receptor height options are used, then the fourth parameter will always be used as Zelev, and it is not possible to use a default value for Zelev while entering a specific value for the Zflag parameter.

3.4.5.2 Discrete Cartesian receptors for EVALFILE output.

The EVALCART keyword is used to define discrete Cartesian receptor locations, similar to the DISCCART keyword, but it also allows for grouping of receptors, e.g., along arcs. It is designed to be used with the EVALFILE option of AERMOD. The syntax and type for the EVALCART keyword are summarized below:

Syntax:	RE EVALCART Xcoord Ycoord Zelev Zflag Arcid (Name)
Type:	Optional, Repeatable

where the Xcoord and Ycoord parameters are the x-coordinate and y-coordinate (m), respectively, for the receptor location. The Zelev parameter is the terrain elevation (m) for the receptor. The Zflag parameter is the receptor height above ground (m) for modeling flagpole receptors. All of the parameters are in units of meters, except for Zelev, which default to meters but may be specified in feet by use of the RE ELEVUNIT keyword. Note that the output elevations will always be in meters, regardless of the input units. The Arcid parameter is the receptor grouping identification, which may be up to eight characters long, and may be used to group receptors by arc. The Name parameter is an optional name field that may be included to further identify a particular receptor location. The Name parameter is ignored by the preprocessor program and the AERMOD model.

3.5 Output pathway inputs and options

The **OU**tput pathway is used to define filenames for the receptor and optional source location output data. There are only two keywords available on the output pathway, besides STARTING and FINISHED, one for receptor output data and the other for source location output data. The syntax and type of the RECEPTOR keyword are summarized below:

Syntax:	OU RECEPTOR Recfil
Type:	Mandatory, Non-repeatable

where Recfil specifies the filename (up to 60 characters) for the receptor output data.

The syntax and type of the SOURCLOC keyword are summarized below:

Syntax:	OU SOURCLOC Srcfil
Type:	Mandatory, Non-repeatable

where Srcfil specifies the filename (up to 60 characters) for the source location output data. The SOURCLOC keyword must be specified if the runstream contains a source pathway and the user specifies that terrain heights are to be extracted from the DEM data.

The options for user-specified filenames are provided with the DEBUGHIL, DEBUGREC, and DEBUGSRC keywords on the OU pathway. The syntax and type of the DEBUGHIL keyword are:

Syntax:	OU DEBUGHIL HillDebug
Type:	Optional, Non-repeatable

where the HillDebug parameter is the user-specified name for the HILL debug file. The syntax and type of the DEBUGREC and DEBUGSRC keywords are:

Syntax:	OU DEBUGREC	RecDetail	RecNDem	RecElv
	OU DEBUGSRC	SrcDetail	SrcNDem	SrcElv
Type:	Optional, Non-repeatable			

where the RecDetail, RecNDem, and RecElv parameters are the debug filenames for the NAD conversion and domain check file, the DEM/NED assignment file, and the receptor elevation file, respectively. The source debug files and naming convention follow the same pattern as the receptor debug files. All debug filenames can be up to 200 characters in length, up to a maximum record length of 512 characters, based on the default parameters in AERMAP. Double quotes (“) at the beginning and end of the filename can also be used as field delimiters to allow filenames with embedded spaces. Figure 3-1 shows a sample of the HILL debug output file and Figure 3-2 through Figure 3-4 show samples of the RECEPTOR output debug files.

```
** AERMAP - VERSION 11103                                                  08/25/16
**                                                                         15:19:43

 Entering CALCHC for Receptor:  1
 Starting with Local DEM File:  1


 Checking DEM File     1 : NWDurham_10m.dem                        ;  for Receptor No.:       1
                                                                                            DEM
        RECLAT      RECLON     DEM_SELAT   DEM_SELON                          DIST(m)  MAXELEV  RECELEV
        36.058     -78.946        36.000     -78.875                             0.00   227.40   120.34

    REC NADA DEM NADD         Map Name               Latitude   Longitude      Northing     Easting  Zone
      1    1   1    1  NORTHWEST DURHAM, NC-240    129807.66  -284205.06    3992098.48   685017.36    17

            DEM    PROF   NODE       NODE-Y      NODE-X      DIST     ZNODE     RELEV    HEFMAX
              1     135    169   3992180.00   684840.00    195.20    140.00    120.34    140.00
              1     135    170   3992190.00   684840.00    199.58    140.30    120.34    140.30
              1     136    169   3992180.00   684850.00    186.16    140.60    120.34    140.60
              1     136    170   3992190.00   684850.00    190.75    140.80    120.34    140.80
              1     136    171   3992200.00   684850.00    195.75    141.00    120.34    141.00

The Critical Hill Height for Receptor:     1 is   141.00 meters.

---------

 Checking DEM File     1 : NWDurham_10m.dem                        ;  for Receptor No.:       2
                                                                                            DEM
        RECLAT      RECLON     DEM_SELAT   DEM_SELON                          DIST(m)  MAXELEV  RECELEV
        36.059     -78.946        36.000     -78.875                             0.00   227.40   123.76

    REC NADA DEM NADD         Map Name               Latitude   Longitude      Northing     Easting  Zone
      2    1   1    1  NORTHWEST DURHAM, NC-240    129810.85  -284204.29    3992196.96   685034.73    17

            DEM    PROF   NODE       NODE-Y      NODE-X      DIST     ZNODE     RELEV    HEFMAX
              1     161    171   3992200.00   685100.00     65.34    130.30    123.76    130.30

The Critical Hill Height for Receptor:     2 is   130.30 meters.

---------

 Checking DEM File     1 : NWDurham_10m.dem                        ;  for Receptor No.:       3
                                                                                            DEM
        RECLAT      RECLON     DEM_SELAT   DEM_SELON                          DIST(m)  MAXELEV  RECELEV
        36.059     -78.945        36.000     -78.875                             0.00   227.40   128.51

    REC NADA DEM NADD         Map Name               Latitude   Longitude      Northing     Easting  Zone
      3    1   1    1  NORTHWEST DURHAM, NC-240    129814.03  -284203.51    3992295.44   685052.09    17

            DEM    PROF   NODE       NODE-Y      NODE-X      DIST     ZNODE     RELEV    HEFMAX
              1     157    181   3992300.00   685060.00      9.13    129.60    128.51    129.60
              1     158    180   3992290.00   685070.00     18.71    130.50    128.51    130.50
              1     158    181   3992300.00   685070.00     18.48    130.60    128.51    130.60
              1     158    186   3992350.00   685070.00     57.42    134.30    128.51    134.30
              1     158    187   3992360.00   685070.00     66.99    135.60    128.51    135.60
              1     158    188   3992370.00   685070.00     76.68    136.80    128.51    136.80
              1     158    189   3992380.00   685070.00     86.43    137.60    128.51    137.60
              1     159    189   3992380.00   685080.00     89.04    138.30    128.51    138.30
              1     159    190   3992390.00   685080.00     98.59    138.80    128.51    138.80
              1     160    189   3992380.00   685090.00     92.67    139.00    128.51    139.00
              1     160    190   3992390.00   685090.00    101.87    139.60    128.51    139.60
              1     160    191   3992400.00   685090.00    111.22    140.10    128.51    140.10
              1     161    191   3992400.00   685100.00    115.01    140.60    128.51    140.60
              1     162    191   3992400.00   685110.00    119.52    140.80    128.51    140.80
              1     163    191   3992400.00   685120.00    124.67    141.10    128.51    141.10
The Critical Hill Height for Receptor:     3 is   141.10 meters.
```

Figure 3-1. Sample from HILL Debug Output File

```
** AERMAP - VERSION 11103                                              08/25/16
**                                                                     15:19:43


 Processing Receptor Location Data in RECCNV:
   Determining North American Datum (NAD) shift values in arc-seconds.
   Total shift (meters) includes both datum shift and projection shift
   for Lat/Lon to UTM coordinates.

   No NAD conversions required. All files are consistent with NADA =   1

 Checking Receptor Locations Relative to the Domain in CHKEXT;
   Domain and Receptor Coordinates in UTM Meters:

                          REC  ZONE   UTM-Y (m)   UTM-X (m)

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      1    17 3992098.481  685017.365
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      2    17 3992196.962  685034.730
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      3    17 3992295.442  685052.094
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      4    17 3992492.404  685086.824
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      5    17 3992984.808  685173.648
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      6    17 3992093.969  685034.202
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      7    17 3992187.939  685068.404
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      8    17 3992281.908  685102.606
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:      9    17 3992469.846  685171.010
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000

 DOM ZONE/NORTH/EAST#:           17 3993500.000  686500.000
 REC ZONE/NORTH/EAST#:     10    17 3992939.693  685342.020
 DOM ZONE/NORTH/EAST#:           17 3990500.000  683500.000
.
.
.
```

Figure 3-2. Sample from the RecDetail Debug File for NAD Conversions and Domain Check

```
** AERMAP - VERSION 11103                                                   08/25/16
**                                                                          15:19:43

LOOKING AT DEMs FOR REC:       1
REC#:      1    RLAT/LON:         36.05768403        -78.94585057
             SHIFTL/L(S):          0.00000000          0.00000000
            UTM(E/N/Zon):          685017.365         3992098.481   17
             SHIFTX/Y(M):          0.00000000          0.00000000   REC NAD:  1

   DEM No.:    1 DEM Name: NORTHWEST DURHAM, NC-24000               DEM NAD:  1
        DEM Max. LAT/LON(D.D):       36.12500      -78.87500
             Rec LAT/LON(D.D):       36.05768      -78.94585
        DEM Min. LAT/LON(D.D):       36.00000      -79.00000

        DEM Max. LAT/LON(Sec):   130050.00000  -283950.00000
             Rec LAT/LON(Sec):   129807.66252  -284205.06207
        DEM Min. LAT/LON(Sec):   129600.00000  -284400.00000

DEM No.:    1 Contains Rec No.:      1

LOOKING AT DEMs FOR REC:       2
REC#:      2    RLAT/LON:         36.05856807        -78.94563482
             SHIFTL/L(S):          0.00000000          0.00000000
            UTM(E/N/Zon):          685034.730         3992196.962   17
             SHIFTX/Y(M):          0.00000000          0.00000000   REC NAD:  1

   DEM No.:    1 DEM Name: NORTHWEST DURHAM, NC-24000               DEM NAD:  1
        DEM Max. LAT/LON(D.D):       36.12500      -78.87500
             Rec LAT/LON(D.D):       36.05857      -78.94563
        DEM Min. LAT/LON(D.D):       36.00000      -79.00000

        DEM Max. LAT/LON(Sec):   130050.00000  -283950.00000
             Rec LAT/LON(Sec):   129810.84505  -284204.28536
        DEM Min. LAT/LON(Sec):   129600.00000  -284400.00000

DEM No.:    1 Contains Rec No.:      2

LOOKING AT DEMs FOR REC:       3
REC#:      3    RLAT/LON:         36.05945210        -78.94541906
             SHIFTL/L(S):          0.00000000          0.00000000
            UTM(E/N/Zon):          685052.094         3992295.442   17
             SHIFTX/Y(M):          0.00000000          0.00000000   REC NAD:  1

   DEM No.:    1 DEM Name: NORTHWEST DURHAM, NC-24000               DEM NAD:  1
        DEM Max. LAT/LON(D.D):       36.12500      -78.87500
             Rec LAT/LON(D.D):       36.05945      -78.94542
        DEM Min. LAT/LON(D.D):       36.00000      -79.00000

        DEM Max. LAT/LON(Sec):   130050.00000  -283950.00000
             Rec LAT/LON(Sec):   129814.02757  -284203.50863
        DEM Min. LAT/LON(Sec):   129600.00000  -284400.00000

DEM No.:    1 Contains Rec No.:      3

LOOKING AT DEMs FOR REC:       4
REC#:      4    RLAT/LON:         36.06122017        -78.94498753
             SHIFTL/L(S):          0.00000000          0.00000000
            UTM(E/N/Zon):          685086.824         3992492.404   17
             SHIFTX/Y(M):          0.00000000          0.00000000   REC NAD:  1
.
.
.
```

Figure 3-3. Sample from the RecNDem Debug File for Assigning Local DEM/NED File

```
** AERMAP - VERSION 11103                                                      08/25/16
**                                                                             15:19:43

From RECELV:
     Receptor elevation calculations for     180 receptors
     IERR =  0: normal (non-edge) case
     IERR = -1: edge receptor, no y-adjustment
     IERR = -2: edge receptor, w/ y-adjustment
     IERR = -3: receptor beyond range of data;
                possible gap within data file;
                flagged with warning message 400

RECEPTOR ELEVATION CALCS FOR REC#      1

LOCATED IN DEM FILE:     1 ;  NWDurham_10m.dem

DEM FILE NAD:    1 ;  ANCHOR POINT NAD:   1

DEM FILE ZONE:  17 ;  RECEPTOR LOCATION (Lon, Lat, arc-seconds):    -284205.0621    129807.6625
                                        (Lon, Lat, dec-degrees):      -78.945851      36.057684
                                             (UTMx, UTMy, Zone):       685017.36     3992098.48  17

      CALLING FIND4 w/ IREC, JDEM:       1   1

       FIND4:
        DEM  REC        XRR             YRR
          1    1     685017.3648    3992098.4808

           NORTHWEST DURHAM, NC-24000
                           SW Corner     NW Corner     NE Corner     SE Corner
             Easting:     680270.939    679985.884    691236.541    691539.436
             Northing:   3985597.778   3999464.516   3999703.384   3985836.309
             Latitude:       36.0000       36.1250       36.1250       36.0000
             Longitude:     -79.0000      -79.0000      -78.8750      -78.8750

           Based on the Find4 Coding of:

             IP= 4----3
                 |    |
             IP= 1----2

         IP    xbase      nx       xx     X-Receptor       ybase      ny       yy     Y-Receptor
          1   683500.00  152   685010.00   685017.36     3990500.00  160  3992090.00  3992098.48
          2   683500.00  153   685020.00   685017.36     3990500.00  160  3992090.00  3992098.48
          3   683500.00  153   685020.00   685017.36     3990500.00  161  3992100.00  3992098.48
          4   683500.00  152   685010.00   685017.36     3990500.00  161  3992100.00  3992098.48

       DEM RECNUM:
           IERR =  0
            IP    JREC   NX   NY
             1   45611  152  160
             2   45912  153  160
             3   45913  153  161
             4   45612  152  161

           Based on the DEM Coding of:

             IP= 2----3
                 |    |
             IP= 1----4

       RECELV:              X-Rec       Y-Rec
                           685017.36  3992098.48

         IP    JREC  DEM      XDM         YDM         ELEV
          1   45611    1   685010.00  3992090.00    119.00
          2   45612    1   685010.00  3992100.00    119.30
          3   45913    1   685020.00  3992100.00    120.80
          4   45912    1   685020.00  3992090.00    120.30

ELEVATION (M) FOR IREC       1 =       120.34

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

Figure 3-4. Sample from the RecElv Debug File for Receptor Elevation Calculations

4.0 Technical description

This section describes the technical details of the AERMAP preprocessor. This is meant to give the user a better understanding of the working of this preprocessor.

4.1 Determining receptor hill height scales

For applications involving elevated terrain, the AERMOD model requires a hill height scale which is used to calculate the critical dividing streamline height, H_{crit}, for each receptor. The primary purpose of the AERMAP terrain preprocessor is to determine the hill height scale (h_c) for each receptor, based on the following procedure:

1. Read the header record of each DEM file named in the runstream (input) and retain the "highest elevation" value found in each record.

2. Determine and store the elevation height for each receptor (and source).

3. For each receptor, use the receptor elevation height as the initial controlling hill height scale.

4. Search for the controlling hill height in the DEM file in which the receptor is located. This is done by calculating the slope between the receptor and each node based on respective distance and elevation difference (see Figure 2-2). If the slope is 10% or greater, the DEM node elevation is compared to the controlling hill height scale. If higher, the controlling hill height scale is replaced by the node elevation value as the new controlling hill height scale. All the nodes within the DEM file that are within the DOMAIN are searched.

5. Using the respective highest elevation value of each remaining DEM file, calculate the slope between the receptor and the nearest point on each of the remaining DEM files. Use the respective highest elevation and the receptor elevation to calculate an initial slope. If the initial slope is greater than 10% for a particular DEM file, use the steps in procedure 4 to search for a controlling hill height in this DEM file. If a higher value is found, update the controlling hill height.

6. Repeat Procedure 5 until all applicable DEM files have been searched for a controlling hill height scale for each receptor.

4.2 Digital elevation model (DEM) data

The USGS distributes DEM data in several scales from the 1-degree series at a scale of1:250,000 down to the 7.5-minute series at a scale of 1:24,000. AERMAP can process any of these scales. However, AERMAP has not been programmed to process more than one scale at a time nor has it been yet tested using more than one basic quadrangle size (e.g., 7.5 x 18 minutes, 7.5 x 15 minutes, 7.5 x 11.5 minutes, and 7.5 x 10 minutes) as found in the State of Alaska. Outside of Alaska, the normal block size for a 7.5-minute series file is 7.5 x 7.5 minutes. It is preferred that the user use the 7.5-minute data whenever possible. The 1-degree DEM series provides coverage in 1 x 1 degree blocks; two such files provide the same coverage as a standard 1:250,000-scale map series quadrangle. The 1-degree data also has different block size for the State of Alaska and like the 7.5-minute series, the block sizes are dependent upon latitude. The 1-degree block sizes are discussed below.

A 7.5-minute DEM has the following characteristics:

- The data consist of a regular array of elevations referenced horizontally in the UTM coordinate system.
- The unit of coverage is a 7.5-minute quadrangle.
- The data are ordered from south to north in profiles that are ordered from west to east.
- The data are stored as profiles in which the horizontal spacing of the elevations along and between each profile is either 10 or 30 m.
- The profiles do not always have the same number of elevations (nodes) as a result of the variable angle between the quadrangle's true north and the grid north of the UTM coordinate system.
- Elevations for the continental U.S. are either meters, feet, decimeters, or decifeet referenced to mean sea level. DEM's of low-relief terrain or generated from contour maps with intervals of 10 ft (3 m) or less are generally recorded in feet. DEM's of moderate to high-relief terrain or generated from maps with terrain contour intervals greater than 10 ft are generally recorded in meters. A rare few are in decifeet or decimeters.

Profiles for 7.5-minute DEM's are generated by using a UTM Cartesian coordinate system as a base. The profiles are clipped to the straight-line intercept among the four geographic corners of the quadrangle -- an approximation of the geographic map boundary as shown in Figure 4-1.

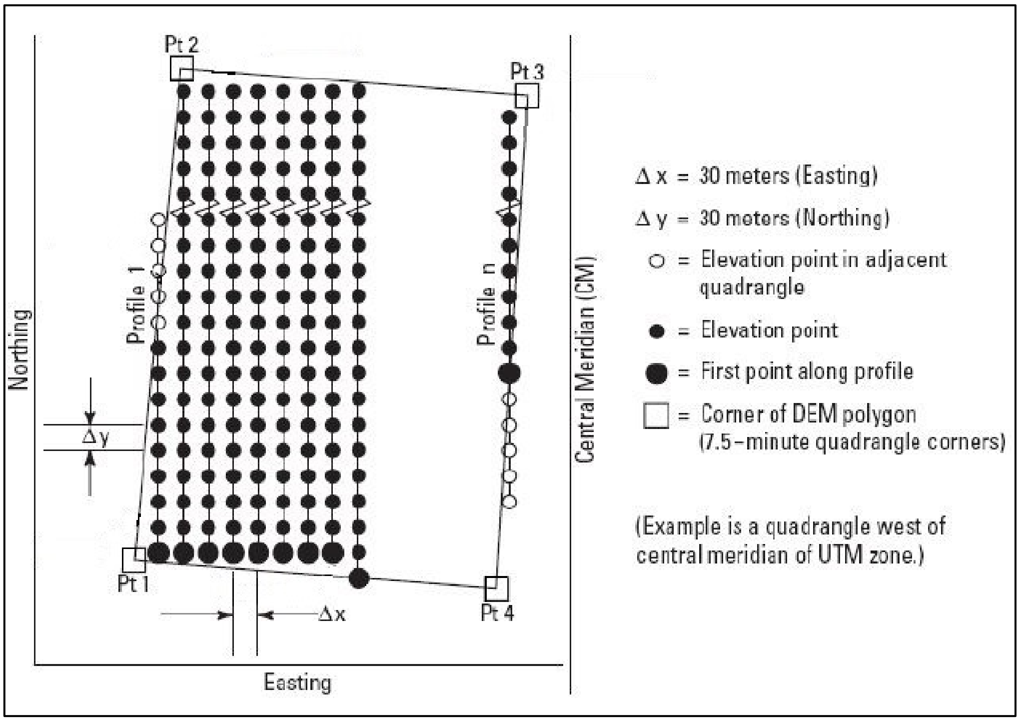


Figure 4-1. Structure of a 7.5-minute DEM Data File.

The UTM coordinates of the four corners (i.e., Pt 1, Pt 2, Pt 3 and Pt 4 in Figure 4-1) of the 7.5-minute DEM's are listed in the type A (header) record, shown in Table 4-1, data element 11. The UTM coordinates of the starting points of each profile are listed in the type B record (profiles), shown in Table 4-2, data element 3. Because of the variable orientation of the quadrilateral in relation to the UTM coordinate system, profiles intersect the east and west boundaries of the quadrangle, as well as the north and south boundaries, as shown in Figure 4-1. In addition, 7.5-minute DEM's have profile easting values that are continuous from one DEM to the adjoining DEM only if the adjoining DEM is contained within the same UTM zone. This is illustrated in Figure 4-1 with the use of non-filled circles outside the border of the quadrangle.

The non-filled circles represent nodes located in DEM files. Note: the spacing in the x and y directions can also be 10 meters as well as the stated 30 meters. Finer resolutions may exist in the future and AERMAP should be able to process them.

The 1-degree DEM data has the following characteristics (U.S. Dept. of Interior, 1993):

- The data consist of a rectangular array of elevations referenced horizontally on the geographic (latitude/longitude) coordinate system (Figure 4-2).
- The unit of coverage is a 1-degree by 1-degree block. Elevation data on the integer degree lines (all four sides of the DEM file) correspond with the same node elevations of the surrounding eight DEM blocks. Four blocks are located on the DEM sides and four DEMs have a common point in the corners.
- Elevations are in meters relative to mean sea level.
- The data are ordered from south to north in profiles that are ordered from west to east.
- Spacing of the elevations along each profile is 3 arc-seconds. The first and the last data points are the integer degrees of latitude. A profile, therefore, contains 1201 elevations.
- Spacing between profiles varies by latitude; however, the first and last data points are at the integer degrees of longitude. For the contiguous United States, the spacing is 3 arc-seconds. Between 50 degrees N and 70 degrees N, the spacing is 6 arc-seconds. For the remainder of Alaska, north of 70 degrees N the spacing is 9 arc-seconds.

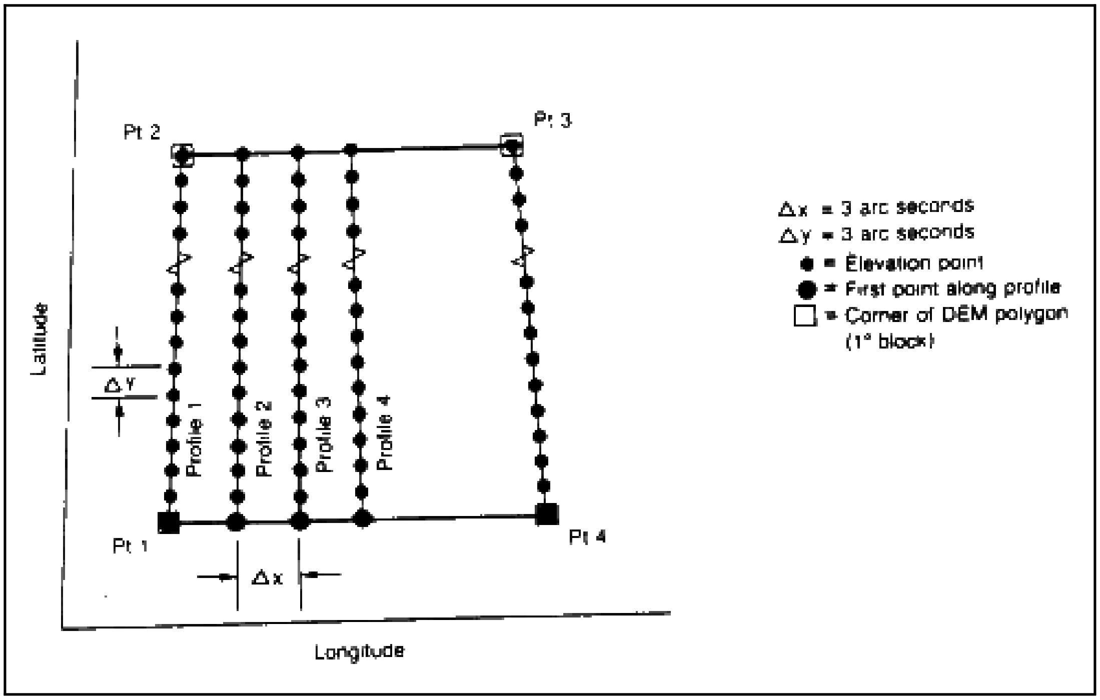


Figure 4-2. Structure of a 1-degree DEM data file for the lower latitudes.

There are two types of records in the DEM files. The first is a header record consisting of general information about the DEM data file. This record appears only once in the file and is always the first record. The second record type contains the elevation data along each profile. This second record is repeated for each profile. The structure of these two record types are described in Table 4-1 and Table 4-2, respectively. A complete description of the record structure is in a publication issued by the USGS (U.S. Dept. of Interior, 1993) and available on the Internet.

Table 4-1. DEM Data Elements - Logical Record Type A

			Physical Record Format			
Data Element	Description	Type (Fortran Notation)	ASCII Format	Starting Byte	Ending Byte	Comment
1	File name	ALPHA	A40	1	40	DEM quadrangle name.
	Free Format Text	ALPHA	A40	41	80	Free format descriptor field, contains useful information related to digital process such as digitizing instrument, photo codes, slot widths, etc.
	Filler	---	---	81	135	
	Process Code	ALPHA	A1	136		Code 1=GPM 2=Manual Profile 3=DLG2DEM (includes any DLG type process such as CTOG or LINETRACE) 4=DCASS
2	MC origin code	ALPHA	A4	141	144	Mapping Center origin Code. Valid codes are EMC, WMC, MCMC, RMMC, FS, GPM2
3	DEM level code	INTEGER*2	I6	145	150	Code 1=DEM-1 =DEM-2 3=DEM-3
4	Code defining	INTEGER*2	I6	151	156	Code 1=regular
	elevation pattern					2=random is reserved for future use
	(regular or random)					
5	Code defining ground planimetric reference system	INTEGER*2	I6	157	162	Code 0=Geographic 1=UTM 2=State plane Code 0 represents the geographic (latitude/longitude) system for 1-degree DEM's. Code 1 represents the current use of the UTM coordinate system for 7.5-minute DEM's.
6	Code defining zone in ground planimetric reference system	INTEGER*2	I6	163	168	Codes for State plane and UTM coordinate zones for 7.5-minute DEM's. Code is set to zero for 1-degree DEM's.
7	Map projection parameters	REAL*8	15D24.15	169	528	Definition of parameters for various projections. All 15 fields of this element are set to zero and should be ignored.
8	Code defining unit of measure for ground planimetric coordinates through- out the file	INTEGER*2	I6	529	534	Code 0=radians 1=feet 2=meters 3=arc-seconds Normally set to code 2 for 7.5-minute DEM's. Always set to code 3 for 1-degree DEM's
9	Code defining unit of measure for elevation coordinates throughout the file	INTEGER*2	I6	535	540	Code 1=feet for elevation coordinates, 2=meters Normally code 2, meters, for 7.5-minute and 1-degree DEM's

			Physical Record Format			
Data Element	**Description**	**Type (Fortran Notation)**	**ASCII Format**	**Starting Byte**	**Ending Byte**	**Comment**
10	Number (n) of sides in the polygon which defines the coverage of the DEM file	INTEGER*2	I6	541	546	n=4.
11	A 4,2 array containing the ground coordinates of the four corners for the DEM	REAL*8	4(2D24.15)	547	738	The coordinates of the quadrangle corners are ordered in a clockwise direction beginning with the southwest corner, in units specified in data element 8.
12	A two-element array containing minimum and maximum elevations for the DEM	REAL*8	2D24.15	739	786	The values are in the unit of measure given by data element 9 in this record.
13	Counterclockwise angle (in radians) from the primary axis of ground planimetric reference to the primary axis of the DEM local reference system	REAL*8	D24.15	787	810	Set to zero to align with the coordinate system specified in element 5.
14	Accuracy code for elevations	INTEGER*2	I6	811	816	Code 0=unknown accuracy elevations 1=accuracy information is given in logical record type C (not used)
15	A three element array of DEM spatial resolution for x, y, z. Units of measure are consistent with those indicated by data elements 8 and 9 in this record	REAL*4	3E12.6	817	852	These elements are usually set to; 30, 30, 1 for 7.5-minute DEM's, 2,2,1 for 30-minute DEM's 3, 3, 1 for 1-degree DEM's 2, 1, 1 for high resolution DEM's in Alaska 3, 2, 1 for low resolution DEM's in Alaska 7.5 minute DEM's will eventually be converted to geographics, i.e., 1, 1 ,1
16	A two-element array containing the number of rows and columns (m,n) of profiles in the DEM	INTEGER*2	2I6	853	864	When the row value m is set to 1 the n value describes the number of columns in the DEM file. Raw GPM data files are set to m=16, n=16
Note: Old format stops here						
17	Largest primary contour interval	INTEGER*2	I5	865	869	Present only if two or more contour interval primary intervals exist.
18	Source contour	INTEGER*1	I1	870		Corresponds to the units of the map interval largest primary contour interval: 0=N.A., 1=feet, 2=meters
19	Smallest primary	INTEGER*2	I5	871	875	Smallest or only primary contour interval
20	Source contour units	INTEGER*1	I1	876		Corresponds to the units of the map interval smallest primary contour interval: 1=feet, 2=meters
21	Data source date	INTEGER*2	I4	877	880	YYMM two-digit year and two-digit month; MM = 00 for source having year only
22	Data inspection/ revision date	INTEGER*2	I4	881	884	YYMM two-digit year and two-digit month
23	Inspection/revision flag	ALPHA*1	A1	885	"I" or "R"	23

			Physical Record Format			
Data Element	**Description**	**Type (Fortran Notation)**	**ASCII Format**	**Starting Byte**	**Ending Byte**	**Comment**
24	Data validation flag	INTEGER*1	I1	886		0= No validation performed. 1=TESDEM (record C added) no qualitative test (no DEM Edit System [DES] review) 2=Water body edit and TESDEM run 3=DES (includes water edit) no qualitative test (no TESDEM 4=DES with record C added, qualitative and quantitative tests for level 1 DEM 5=DES and TESDEM qualitative and quantitative tests for levels 2 and 3 DEM's.
25	Suspect and void area flag	INTEGER*1	I2	887	888	0=none 1=suspect areas 2=void areas 3=suspect and void areas
26	Vertical datum	INTEGER*1	I2	889	890	1=local mean sea level 2=National Geodetic Vertical Datum 1929 (NGVD 29) 3=North American Vertical Datum 1988 (NAVD 88)
27	Horizontal datum	INTEGER*1	I2	891	892	1=North American Datum 1927 (NAD 27) 2=World Geodetic System 1972 (WGS 72) 3=WGS 84 4=NAD 83 5=Old Hawaii Datum 6=Puerto Rico Datum 7=NAD 83 Provisional (shifts in horizontal coordinates are computed, but old DEM nodes are not resampled)
28	Data Edition	INTEGER*2	I4	893	896	01-99 Primarily a DMA specific field.
29	Percent Void	INTEGER*2	I4	897	900	If element 25 indicates a void, this field (right justified) contains the percentage of nodes in the file set to void (-32,767).

Table 4-2. DEM Data Elements - Logical Record Type B (Data Record)

			Physical Record Format			
Data Element	**Description**	**Type (Fortran Notation)**	**ASCII Format**	**Starting Byte**	**Ending Byte**	**Comment**
1	A two-element array containing the row and column identification number of the DEM profile contained in this record	INTEGER*2	2I6	1	12	The row/column numbers may range from 1 to m and 1 to n. The row number is normally set to 1. The column identification is the profile sequence number.
2	A two-element array containing the number (m,n) of elevations in the DEM profile	INTEGER*2	2I6	13	24	The first element in the field corresponds to the number of rows and columns of nodes in this profile. The second element is set to 1, specifying one column per B record
3	A two-element array containing the ground planimetric coordinates (X,Y) of the first elevation in the profile	REAL*8	2D24.15	25	72	See Figures 4-1 and 4-2.
4	Elevation of local datum for profile	REAL*8	D24.15	73	96	The values are in the units of measure given by data element 9, logical record type A
5	A two-element array of minimum and maximum elevations for the profile	REAL*8	2D24.15	97	144	The values are in the unit of measure given by data element 9, logical record type A
6	A m,n array of elevations for the profile. Elevations are expressed in units of resolution.	INTEGER*2	mn(I6)	6x(146 or 170) 146 = max for first block. 170 = ma for subsequent blocks		A value in this array would be multiplied by the spatial resolution value and added to the elevation of the local elevation datum for the element profile (data element 4 in this record) to obtain the elevation for the point

4.3 Data manipulation of DEM files by AERMAP

The AERMAP preprocessor creates a direct access binary file and an index file for each DEM file containing only that portion of the DEM file that falls within the user-specified domain. These files are temporary, and enable the program to determine the elevation at a DEM node very efficiently. For example, if four adjacent DEM files are specified and a domain is defined as shown in Figure 2-1, then AERMAP will produce four direct access binary files, one for each DEM file, containing a subset of the terrain elevation data that lies within the domain (files 1, 2, 3 and 4 in Figure 2-1). The elevations in the direct access files are stored in meters. The order of the elevation points in these files will be the same as that of the original DEM file except that the coordinates of the baseline of the profile and the number of nodes in the profiles might be different. The new values for the baseline location and number of nodes are written to the index file corresponding to each DEM file. The program creates the direct access files using the same name as the DEM file but with an extension of 'DIR'. Similarly the index file corresponding to a DEM file will be the same file name but with an extension of 'IDX'. These files are deleted when the program ends.

If 7.5 minute DEM data are used and Nada is not set to zero, AERMAP will convert NAD 27 data to NAD 83. This will assure that all the receptors, sources, and elevations are using the same geodetic reference (i.e. NAD83). Otherwise, some of the elevations extracted could be more than 100 meters in error in the horizontal as depicted in Figure 4-3. This is because of the difference in geodetic reference. The NAD 27 datum is based on a mathematical representation of the earth while the NAD 83 data is based on satellite and earth-centric data. This creates physical location differences when coordinate systems are laid on top of the theoretic representation of the earth to where the DEM datasets will have noticeable overlaps and/or no coverage areas between adjacent DEM maps (See Figure 2-4). In other words, even though each adjacent map may have the same corner coordinates with the same latitude and longitude, the underlying point with respect to the earth may be different by more than 100 meters. It may also reside between maps where there are no nearby elevation nodes.

4.4 Determining receptor (source) elevations using DEM data

If the user requests the preprocessor to extract the receptor (and optional source) elevations from the DEM data using the CO TERRHGTS EXTRACT card, or if the CO TERRHGTS keyword is omitted, the following procedure is used to determine the elevation:

- For each receptor, the program searches through the DEM data index files to determine the two profiles (longitudes or eastings) that straddle this receptor.
- For each of these two profiles, the program then searches through the nodes in the index file to determine which two rows (latitudes or northings) straddle the receptor.
- The program then calculates the coordinates of these four points and determines the DEM direct access file and the record numbers that correspond to these points.
- It reads the elevations for these four points from the appropriate direct access file.
- If there are less than four points, the program will search the other adjacent DEM files following the above steps. The program will retain the closest node found in the northwest, northeast, southeast, and southwest quadrants. The quadrants' common point is the receptor location. Distances to, and the elevations of these DEM nodes are retained.
- A 2-dimensional distance-weighted interpolation is used to determine the elevation at the receptor location based on the elevations at the four nodes. The weighting equation is:

  Weighing Factor (w) = 1/dist1 + 1/dist2 + 1/dist3 + 1/dist4
  Elevation = elev1/(dist1*w) + elev2/(dist2*w) + elev3/(dist3*w) + elev4/(dist4*w).

When 7.5-minute DEM data are used, a receptor or source location may fall outside the range of the profiles but remain inside a DEM file boundaries (see Figure 4-1) or they may fall between the DEM files when the DEM files are from different datums. Elevations for all receptors or sources located near the edges of a DEM file are assigned values based on the nodes that are closest to the receptor or source location and may include elevations from two or more DEM files.

5.0 References

Aldus, 1992: TIFF, Revision 6.0. Aldus Corporation, Seattle, WA. www.alternatiff.com/resources/TIFF6.pdf

Cimorelli, A.J., Perry, S.G., Venkatram, A., Weil, J.C., Paine, R.J., Wilson, R.B., Lee, R.F., Peters, W.D., Brode, R.W., Paumier, J.O., 2004: AERMOD: Description of Model Formulation. EPA-454/R-03-004, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

Environmental Protection Agency, 2018a: User's Guide for the AMS/EPA Regulatory Model - AERMOD. - EPA-454/B-18-001. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

Environmental Protection Agency, 2018b: User=s Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-18-004. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

Environmental Protection Agency, 1995: Industrial Source Complex (ISC3) Dispersion Model User's Guide - Volume II. EPA-454/B-95-003b, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

Environmental Research and Technology, 1987: User's Guide to the Rough Terrain Diffusion Model (RTDM), Rev. 3.20. ERT Document No. P-D535-585. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 88-171467)

Federal Communications Commission, 1984: Use of Computer-Generated Terrain Data for Determining Antenna Height Above Average Terrain, Interim Procedure Per General Docket 84-705. Federal Communications Commission, Washington, DC 20554.

Perry, S.G., D.J. Burns, L.H. Adams, R.J. Paine, M.G. Dennis, M.T. Mills, D.J. Strimaitis, R.J. Yamartino and E.M. Insley, 1989: User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) Volume 1; Model Description and User Instructions. EPA Publication No. EPA-600/8-89-041. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89-181424)

Ritter, N. and M. Ruth, 1995: GeoTIFF Format Specification. www.remotesensing.org/geotiff/spec/geotiffhome.html

Snyder, J., 1987: Map Projections - A Working Manual, U.S. Geological Survey Professional Paper 1395. U.S. Government Printing Office, Washington, D.C.

U.S. Department of the Interior, 1993: Digital Elevation Models Data User's Guide 5 (“Blue Book”), U.S. Geological Survey, Earth Science Information Center.

U.S. Geological Survey, 1998: Standards for Digital Elevation Models, National Mapping Program Technical Instructions, http://rockyweb.cr.usgs.gov/nmpstds/demstds.html, U.S. Department of the Interior, Reston, Virginia 20192.

U.S. Geological Survey, 2002: The National Map – Elevation, Fact Sheet 106-02 (November 2002). http://egsc.usgs.gov/isb/pubs/factsheets/fs10602.html, U.S. Department of the Interior, Reston, Virginia 20192.

U.S. National Geodetic Survey, NADCON - North American Datum Conversion Utility, http://www.ngs.noaa.gov:80/TOOLS/Nadcon/Nadcon.html

Appendix A. Alphabetical keyword reference

This appendix provides an alphabetical listing of all of the keywords used by the AERMAP preprocessor. Each keyword is identified as to the pathway for which it applies, the keyword type (either mandatory or optional, and either repeatable or non-repeatable), and with a brief description of the function of the keyword. For a more complete description of the keywords, including a list of associated parameters, refer to the Detailed Keyword Reference in Section 3 or the Functional Keyword/Parameter Reference in Appendix B.

Table A-1. All Keywords Available in AERMAP

Keyword	Path	Type	Keyword Description
ANCHORXY	CO	M - N	Relates the origin of the user-specified coordinate system for receptors to the UTM coordinate system
DATAFILE	CO	M - R	Specifies the names of the raw terrain data being provided to the preprocessor
DATATYPE	CO	M - N	Specifies the type of the raw terrain data being provided to the preprocessor
DEBUGHIL	OU	O - N	Specifies filename for the optional hill height debug output file
DEBUGOPT	CO	O - N	Specifies whether additional debug output files will be generated for receptors, sources, and/or hill heights
DEBUGREC	OU	O - N	Specifies filenames for optional receptor debug output files
DEBUGSRC	OU	O - N	Specifies filenames for optional source debug output files
DISCCART	RE	O - R	Defines discrete receptor locations referenced to a Cartesian system
DISCPOLR	RE	O - R	Defines discrete receptor locations referenced to a polar system
DOMAINLL	CO	M - N	Allows the user to specify the domain extent in the latitude / longitude coordinate system
DOMAINXY	CO	M - N	Allows the user to specify the domain extent in the UTM coordinate system
ELEVUNIT	SO RE	O - N O - N	Defines the input units for the source elevations (SO pathway) or receptor elevations (RE pathway)
EVALCART	RE	O - R	Defines discrete Cartesian receptors for use with EVALFILE output
FINISHED	ALL	M - N	Identifies the end of inputs for a particular pathway
FLAGPOLE	CO	O - N	Specifies whether to accept receptor heights above local terrain (m) for use with flagpole receptors, and allows for a default flagpole height to be specified
GRIDCART	RE	O - R	Defines a Cartesian grid receptor network
GRIDPOLR	RE	O - R	Defines a polar receptor network
INCLUDED	SO, RE	O - R	Allows sources and/or receptors from external files to be included in the inputs
LOCATION	SO	O - R	Specifies the location of sources
NADGRIDS	CO	O - N	Specifies optional pathname for the location of NADCON grid shift files
RECEPTOR	OU	M - N	Specifies the output filename for the receptor data
RUNORNOT	CO	M - N	Identifies whether to run program or process setup information only

Keyword	Path	Type	Keyword Description
SOURCLOC	OU	O - N	Specifies the output filename for the source location data
STARTING	ALL	M - N	Identifies the start of inputs for a particular pathway
TERRHGTS	CO	O - N	Controls whether the receptor elevations should be extracted from the terrain data or that the user-provided receptor elevations should be used
TITLEONE	CO	M - N	First line of title for output
TITLETWO	CO	O - N	Optional second line of output title

Appendix B. Functional keyword/parameter reference

This appendix provides a functional reference for the keywords and parameters used by the input runstream files for the AERMAP preprocessor. The keywords are organized by functional pathway, and within each pathway the order of the keywords is based on the function of the keyword within the preprocessor. The pathways used by the preprocessor are as follows, in the order in which they appear in the runstream file and in the tables that follow:

CO - for specifying overall job **CO**ntrol options; and
SO - for specifying **SO**urce location information (optional);
RE - for specifying **RE**ceptor information; and
OU - for specifying **OU**tput file information.

The pathways and keywords are presented in the same order as in the Detailed Keyword Reference in Section 3, and in the Quick Reference at the end of the manual.

Two types of tables are provided for each pathway. The first table lists all of the keywords for that pathway, identifies each keyword as to its type (either mandatory or optional and either repeatable or non-repeatable), and provides a brief description of the function of the keyword. The second type of table presents the parameters for each keyword, in the order in which they should appear in the runstream file where order is important, and describes each parameter in detail.

The following convention is used for identifying the different types of input parameters. Parameters corresponding to secondary keywords which should be input "as is" are listed on the tables with all capital letters (they are underlined in the table). Other parameter names are given with an initial capital letter and are not input "as is." In all cases, the parameter names are intended to be descriptive of the input variable being represented, and they often correspond to the Fortran variable names used in the preprocessor code. Parentheses around a parameter indicate that the parameter is optional for that keyword. The default that is taken when an optional parameter is left blank is explained in the discussion for that parameter.

Table B-1. Description of Control Pathway Keywords

CO Keywords	Type	Keyword Description
STARTING	M - N	Identifies the start of CONTROL pathway inputs
TITLEONE	M - N	First line of title for output
TITLETWO	O - N	Optional second line of title for output
TERRHGTS	O - N	Controls whether the receptor elevations should be extracted from the user-provided terrain data or that the user-provided receptor terrain elevations should be used
FLAGPOLE	O - N	Specifies whether to accept receptor heights above local terrain (m) for use with flagpole receptors, and allows for default flagpole height to be specified
DATATYPE	M - N	Specifies the type of the raw terrain data being provided to the preprocessor
DATAFILE	M - R	Specifies the names of the raw terrain data being provided to the preprocessor
DOMAINLL	O [1] - N	Allows the user to specify the domain extent in the latitude/longitude coordinate system
DOMAINXY	O [1] - N	Allows the user to specify the domain extent in the UTM coordinate system
ANCHORXY	M - N	Relates the origin of the user-specified coordinate system for receptors to the UTM coordinate system
DEBUGOPT	O - N	Specifies whether the optional debug output files for sources, receptors, and/or hill heights will be generated
NADGRIDS	O - N	Specifies optional pathname for location of NADCON grid shift files (*.las and *.los)
RUNORNOT	M - N	Identifies whether to run program or process setup information only
FINISHED	M - N	Identifies the end of CONTROL pathway inputs

Type: M - Mandatory N - Non-Repeatable
O - Optional R - Repeatable

1) DOMAINLL and DOMAINXY are optional but only one can be used in an AERMAP. run

Table B-2. Description of Control Pathway Keywords and Parameters

Keyword	Parameters	
TITLEONE	Title1	
where:	Title1	First line of title for output, character string of up to 68 characters
TITLETWO	Title2	
where:	Title2	Second line of title for output, character string of up to 68 characters
TERRHGTS	EXTRACT or PROVIDED	
where:	EXTRACT	Instructs the preprocessor to determine the terrain heights from the DEM data files provided by the user (default)
	PROVIDED	Forces the preprocessor to use the user-specified receptor elevations that are entered on the receptor pathway (also applies to source elevations specified on the optional source pathway)
FLAGPOLE	(Flagdf)	
where:	Flagdf	Default value for height of (flagpole) receptors above local ground level, a default value of 0.0 m is used if this optional parameter is omitted
DATATYPE	DEM (FILLGAPS) or NED	
where:	DEM	Specifies that Digital Elevation Model (DEM) data will be used (including 7.5-minute, 15-minute, and/or 1-degree DEM data)
	FILLGAPS	Option for AERMAP to calculate elevations for receptors (and/or sources) located within gap areas based on closest nodes for DEM data; gap receptor/source elevations will otherwise be assigned a missing code of -9999.0
	NED	Specifies that National Elevation Dataset (NED) data in GeoTIFF format will be used
DATAFILE	DEM: Demfil (CHECK) or NED: Nedfil (TIFFDEBUG) (ElevUnits)	
where:	Demfil	Identifies the name of the DEM data file
	(CHECK)	Option to perform check on the full DEM file
	Nedfil	Identifies the name of the NED data file
	(TIFFDEBUG)	Option to generate a debug file with all the TiffTags and GeoKeys included within the NED file (uses hardcoded filename)
	ElevUnits	Option for user-speified elevation units (accepts FEET, DECIFEET, DECI-FEET, DECAFEET, DECA-FEET, METERS, DECIMETERS, DECI-METERS, DECAMETERS, or DECA-METERS, not case sensitive)

Keyword	Parameters	
DOMAINLL	Lonmin Latmin Lonmax Latmax	
where:	Lonmin	Longitude in decimal degrees for the lower right (SE) corner of the domain **(negative for West longitude)**
	Latmin	Latitude in decimal degrees for the lower right (SE) corner of the domain
	Lonmax	Longitude in decimal degrees for the upper left (NW) corner of the domain **(negative for West longitude)**
	Latmax	Latitude in decimal degrees for the upper left (NW) corner of the domain
DOMAINXY	Xdmin Ydmin Zonmin Xdmax Ydmax Zonmax	
where:	Xdmin	UTM East coordinate for the lower left (SW) corner of the domain in meters
	Ydmin	UTM North coordinate for the lower left (SW) corner of the domain in meters
	Zonmin	UTM Zone for the lower left (SW) corner of the domain
	Xdmax	UTM East coordinate for the upper right (NE) corner of the domain in meters
	Ydmax	UTM North coordinate for the upper right (NE) corner of the domain in meters
	Zonmax	UTM Zone for the upper right (NE) corner of the domain
ANCHORXY	Xauser Yauser Xautm Yautm Zautm	
where:	Xauser	The X coordinate of any geographic location (typically the origin 0,0) in the user coordinate system in meters
	Yauser	The Y coordinate of any geographic location (typically the origin 0,0) in the user coordinate system in meters
	Xautm	The UTM East coordinate of the same geographic location specified as Xauser,Yauser in meters
	Yautm	The UTM North coordinate of the same geographic location specified as Xauser,Yauser in meters
	Zautm	The UTM Zone of the same geographic location corresponding to Xautm, Yautm
	Nada	The datum from which the Xautm, Yautm coordinates were drawn
DEBUGOPT	(HILL) and/or (RECEPTOR) and/or (SOURCE) (Order is not important) or ALL	

Keyword	Parameters	
where:	RECEPTOR	Specifies that receptor debug output files will be generated
	SOURCE	Specifies that source debug output files will be generated
	HILL	Specifies that hill height scale debug output file will be generated
	ALL	Specifies that ALL types of debug output files will be generated, including RECEPTOR, SOURCE (if applicable) and HILL
NADGRIDS	NADGridPathname	
where:	NADGridPathname	Optional pathname for folder containing the NADCON grid shift files (*.las and *.los). Without the NADGRIDS keyword, the default path is **the local folder containing the AERMAP.INP file.**
RUNORNOT	RUN or NOT	
where:	RUN	Indicates to run full preprocessor calculations
	NOT	Indicates to process setup data and report errors, but to not run full preprocessor calculations

Table B-3. Description of Source Pathway Keywords

SO Keywords	Type	Keyword Description
STARTING	M - N	Identifies the start of SOURCE pathway inputs
LOCATION	O[1] - R	Identifies source locations for use in extracting source elevations and/or to define the origin of discrete polar receptors
INCLUDED	O - R	Identifies an external file containing source locations to be included in the inputs
FINISHED	M - N	Identifies the end of SOURCE pathway inputs

1) The LOCATION keyword is optional if location inputs are specified through the INCLUDED file option.

Note: AERMAP will ignore the SRCPARAM keyword within the SO pathway. This may facilitate including portions of an AERMOD input file to determine source elevations, without having to remove the SRCPARAM records

Table B-4. Description of Source Pathway Keywords and Parameters

Keyword	Parameters	
LOCATION	Srcid Srctyp Xs Ys (Zs)	
where:	Srcid	Alphanumeric source ID, up to eight characters
	Srctyp	Source type: POINT, VOLUME, AREA, AREAPOLY, AREACIRC
	Xs	x-coordinate (Easting) of source location, corner for AREA, vertex for AREAPOLY, center for AREACIRC (m)
	Ys	y-coordinate (Northing) of source location (m)
	Zs	Optional z-coordinate of source location (elevation above mean sea level in meters)
INCLUDED	SrcIncFile	
where	SrcIncFile	Identifies the filename for the included source file, up to 200 characters in length; double quotes (“) may be used as delimiters for the filename to allow for embedded spaces; and quotes don’t count toward the limit of 200

Table B-5. Description of Receptor Pathway Keywords

RE Keywords	Type	Keyword Description
STARTING	M - N	Identifies the start of RECEPTOR pathway inputs
ELEVUNIT	O - N	Defines input units for receptor elevations (defaults to meters), must be first keyword after RE STARTING if used.
GRIDCART	O[1] - R	Defines a Cartesian grid receptor network
GRIDPOLR	O[1] - R	Defines a polar receptor network
DISCCART	O[1] - R	Defines the discretely placed receptor locations referenced to a Cartesian system
DISCPOLR	O[1] - R	Defines the discretely placed receptor locations referenced to a polar system
EVALCART	O[1] - R	Defines discrete Cartesian receptor locations for use with EVALFILE output option
INCLUDED	O - R	Identifies an external file containing receptor locations to be included in the inputs
FINISHED	M - N	Identifies the end of RECEPTOR pathway inputs

1) At least one of the following must be present: GRIDCART, GRIDPOLR, DISCCART, DISCPOLR, or EVALCART. Multiple receptor networks can be specified in a single run, including both Cartesian and polar, up to an overall maximum controlled by the NREC parameter.

Table B-6. Description of Receptor Pathway Keywords and Parameters

Keyword	Parameters	
ELEVUNIT	<u>METERS</u> or <u>FEET</u>	
where:	<u>METERS</u>	Specifies input units for receptor elevations of meters
	<u>FEET</u>	Specifies input units for receptor elevations of feet Note: This keyword applies to receptor elevations only.
GRIDCART	Netid STA XYINC Xinit Xnum Xdelta Yinit Ynum Ydelta or XPNTS Gridx1 Gridx2 Gridx3 .... GridxN, and YPNTS Gridy1 Gridy2 Gridy3 .... GridyN ELEV Row Zelev1 Zelev2 Zelev3 ... ZelevN <u>FLAG</u> Row Zflag1 Zflag2 Zflag3 ... ZflagN <u>END</u>	
where:	Netid	Receptor network identification code (up to eight alphanumeric characters)
	STA	Indicates STArt of GRIDCART subpathway, repeat for each new Netid
	XYINC	Keyword identifying grid network generated from x and y increments
	Xinit	Starting local x-axis grid location in meters
	Xnum	Number of x-axis receptors
	Xdelta	Spacing in meters between x-axis receptors
	Yinit	Starting local y-axis grid location in meters
	Ynum	Number of y-axis receptors
	Ydelta	Spacing in meters between y-axis receptors
	XPNTS	Keyword identifying grid network defined by a series of x and y coordinates
	Gridx1	Value of first x-coordinate for Cartesian grid
	GridxN	Value of 'nth' x-coordinate for Cartesian grid
	YPNTS	Keyword identifying grid network defined by a series of x and y coordinates
	Gridy1	Value of first y-coordinate for Cartesian grid
	GridyN	Value of 'nth' y-coordinate for Cartesian grid
	ELEV	Keyword to specify that receptor elevations follow
	Row	Indicates which row (y-coordinate fixed) is being input
	Zelev	An array of receptor terrain elevations for a particular Row
	FLAG	Keyword to specify that flagpole receptor heights follow
	Row	Indicates which row (y-coordinate fixed) is being input
	Zflag	An array of receptor heights above local terrain elevation for a particular Row (flagpole receptors)
	END	Indicates END of GRIDCART subpathway, repeat for each new Netid

Table B-6 (cont'd)

Description of Receptor Pathway Keywords and Parameters

GRIDPOLR	Netid STA ORIG Xinit Yinit, or ORIG Srcid DIST Ring1 Ring2 Ring3 ... RingN DDIR Dir1 Dir2 Dir3 ... DirN, or GDIR Dirnum Dirini Dirinc ELEV Dir Zelev1 Zelev2 Zelev3 ... ZelevN FLAG Dir Zflag1 Zflag2 Zflag3 ... ZflagN END	
where:	Netid	Receptor network identification code (up to eight alphanumeric characters)
	STA	Indicates STArt of GRIDPOLR subpathway, repeat for each new Netid
	ORIG	Optional keyword to specify the origin of the polar network (assumed to be at x=0, y=0 if omitted)
	Xinit	Local x-coordinate for origin of polar network (m)
	Yinit	Local y-coordinate for origin of polar network (m)
	Srcid	Source ID of source used as origin of polar network (up to 12 characters)
	DIST	Keyword to specify distances for the polar network
	Ring1	Distance to the first ring of polar coordinates (m)
	RingN	Distance to the 'nth' ring of polar coordinates (m)
	DDIR	Keyword to specify discrete direction radials for the polar network
	Dir1	First direction radial in degrees (1 to 360)
	DirN	The 'nth' direction radial in degrees (1 to 360)
	GDIR	Keyword to specify generated direction radials for the polar network
	Dirnum	Number of directions used to define the polar system
	Dirini	Starting direction of the polar system
	Dirinc	Increment (in degrees) for defining directions
	ELEV	Keyword to specify that receptor elevations follow
	Dir	Indicates which direction is being input
	Zelev	An array of receptor terrain elevations for a particular direction radial
	FLAG	Keyword to specify that flagpole receptor heights follow
	Dir	Indicates which direction is being input
	Zflag	An array of receptor heights above local terrain elevation for a particular direction (flagpole receptors)
	END	Indicates END of GRIDPOLR subpathway, repeat for each new Netid

Table B-6 (concluded)

Description of Receptor Pathway Keywords and Parameters

DISCCART	Xcoord Ycoord (Zelev) (Zflag)	
where:	Xcoord	Local x-coordinate for discrete receptor location (m)
	Ycoord	Local y-coordinate for discrete receptor location (m)
	Zelev	Elevation above sea level for discrete receptor location (optional), used only for ELEV terrain
	Zflag	Receptor height (flagpole) above local terrain (optional), used only with FLAGPOLE keyword
DISCPOLR	Srcid Dist Direct (Zelev) (Zflag)	
where:	Srcid	Specifies source identification for which discrete polar receptor locations apply (used to define the origin for the discrete polar receptor)
	Dist	Downwind distance to receptor location (m)
	Direct	Direction to receptor location, in degrees clockwise from North
	Zelev	Elevation above sea level for receptor location (optional), used only for ELEV terrain
	Zflag	Receptor height (flagpole) above local terrain (optional), used only with FLAGPOLE keyword
EVALCART	Xcoord Ycoord Zelev Zflag Arcid (Name)	
where:	Xcoord	Local x-coordinate for discrete receptor location (m)
	Ycoord	Local y-coordinate for discrete receptor location (m)
	Zelev	Elevation above sea level for discrete receptor location (optional), used only for ELEV terrain
	Zflag	Receptor height (flagpole) above local terrain (optional), used only with FLAGPOLE keyword
	Arcid	Receptor arc ID used to group receptors along an arc or other grouping (up to eight characters)
	(Name)	Optional name for receptor (up to eight characters)
INCLUDED	RecIncFile	
Where	RecIncFile	Identifies the filename for the included receptor file, up to 200 characters in length; double quotes (") may be used as delimiters for the filename to allow for embedded spaces; and quotes don't count toward the limit of 200

Table B-7. Description of Output Pathway Keywords

OU Keywords	Type	Keyword Description
STARTING	M - N	Identifies the start of OUTPUT pathway inputs
RECEPTOR	M - N	Identifies the output filename for receptor data
SOURCLOC	O - N	Identifies the output filename for source location data
DEBUGHIL	O - N	Identifies the output filename for the optional hill height scale debug file
DEBUGREC	O - N	Identifies the output filename for the receptor debug file
DEBUGSRC	O - N	Identifies the output filename for the optional source debug file
FINISHED	M - N	Identifies the end of OUTPUT pathway inputs

Table B-8. Description of Output Pathway Keywords and Parameters

Keyword	Parameters	
RECEPTOR	Recfil	
where:	Recfil	Specifies output filename for receptor elevation and hill height scale data
SOURCLOC	Srcfil	
where:	Srcfil	Specifies output filename for source elevation data
DEBUGHIL	HillDebug	
where:	HillDebug	Specifies the hill height scale debug file
DEBUGREC	RecDetail RecNDem RecElv	
where:	RecDetail	Specifies the filename for the RecDetail debug file, which provides information on NAD conversions and domain check
	RecNDem	Specifies the filename for the RecNDem debug file, which provides information on the DEM/NED file assignment
	RecElv	Specifies the filename for the RecElv debug file, which provides information on the receptor elevation calculations
DEBUGSRC	SrcDetail SrcNDem SrcElv	
where:	SrcDetail	Specifies the filename for the SrcDetail debug file, which provides information on NAD conversions and domain check
	SrcNDem	Specifies the filename for the SrcNDem debug file, which provides information on the DEM/NED file assignment
	SrcElv	Specifies the filename for the SrcElv debug file, which provides information on the source elevation calculations

Note: Receptor elevation, source elevation, and debug output filenames can be up to 200 characters in length, up to a limit of 512 characters for the full input record; double quotes (“) may be used as delimiters for the filename to allow for embedded spaces; and quotes don’t count toward the limit of 200.

Appendix C. Explanation of error message codes

C.1 Introduction

The AERMAP preprocessor uses a "defensive programming" approach to eliminate as much as possible of the user's work in debugging the input runstream file. Also, a great deal of effort has been made to eliminate the possibility of run time errors, such as "divide by zero," and to point out questionable input data.

Message Summary: The AERMAP preprocessor outputs a summary of messages to the message file specified on the command line. This message table gives the number of messages of each type, together with a detailed list of all the fatal errors and warning messages. During setup processing, if no errors or warnings are generated, then the program simply reports to the user that "SETUP Finishes Successfully."

C.2 Output error log message summary

There are two message summaries provided in the message file generated by the AERMAP preprocessor. The first one is located after the echo of input runstream file images. This summary will take one of two forms, depending on whether any fatal error or non-fatal warning messages were generated, and also depending on whether the option to RUN or NOT to run was selected on the CO RUNORNOT card. If there are no errors or warnings generated during the setup processing, and the RUN option was selected, then the program simply reports that "SETUP Finishes Successfully." If any fatal errors or warning messages were generated during the setup processing, or if the option NOT to run was selected, then a more detailed summary is provided. This summary provides a message count for each type of message, and a detailed listing of each fatal error and warning message generated. The second message summary table is located at the very end of the message file, and it sums up the messages generated by the complete preprocessor run - both setup processing and run-time processing.

An example of a setup processing message summary is shown in Figure C-1.

```
*** Message Summary For AERMAP Execution ***

 --------- Summary of Total Messages --------

 A Total of          0 Fatal Error Message(s)
 A Total of          0 Warning Message(s)
 A Total of          0 Informational Message(s)


    ******** FATAL ERROR MESSAGES ********
               ***  NONE  ***


    ********   WARNING MESSAGES   ********
               ***  NONE  ***


    ************************************
    *** AERMAP Finishes Successfully ***
    ************************************
```

Figure C-1. Example of an AERMAP Message Summary

C.3 Description of the detailed message layout

Two types of messages can be produced by the program during the processing of input runstream images and during preprocessor calculations. These are described briefly below:

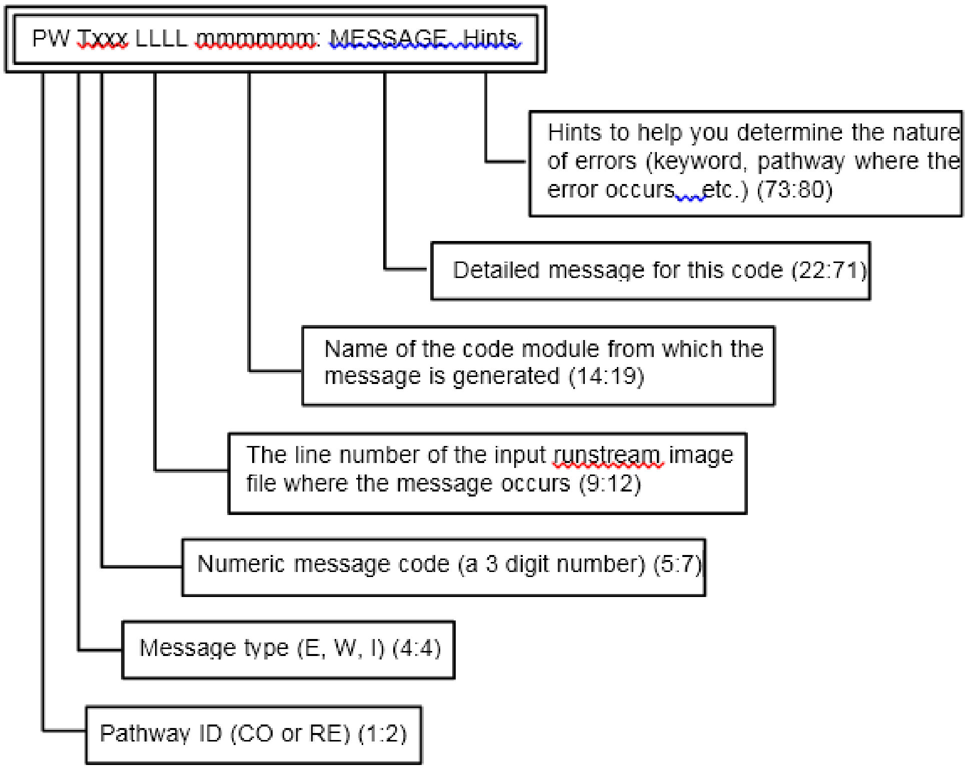
- Errors that will halt any further processing, except to identify additional error conditions (type E); and
- Warnings that do not halt processing but indicate possible errors or suspect conditions (type W).

The messages have a consistent structure which contains the pathway ID, indicating which pathway the messages are generated from; the message type followed by a three-digit message number; the line number of the input runstream image file for setup messages; the name of the module (e.g. the subroutine name) from which the message is generated; a detailed message corresponding to the message code; and an 8-character simple hint to help the user spot the possible source of the problem.

The following is an example of a detailed message generated from the CO pathway:

```
CO E100    8 EXPATH: Invalid Pathway Specified. The Troubled Pathway is FF
```

The message syntax is explained in more detail below (values in parentheses give the column numbers within the message line for each element):



The two message types are identified with the letters E (for errors) and W (for warnings). A detailed description of each of the message codes currently used in the program is provided in the next section.

C.4 Detailed description of the error/message codes

The messages codes and messages that may be issued when AERMAP is run are described in this section. The codes are divided into five groups: input runstream image structure processing (100-199), parameter setup processing (200-299), setup data and quality assurance processing (300-399), runtime message processing (400-499), and input/output message processing (500-599).

INPUT RUNSTREAM IMAGE STRUCTURE PROCESSING

This type of message indicates problems with the basic syntax and/or structure of the input runstream image. Typical messages include errors like "Missing mandatory keyword", "Illegal Keyword", ..., etc. If a fatal error of this kind is detected in a runstream image, a fatal error message is written to the message file and any attempt to process data is prohibited, although the remainder of the runstream file is examined for other possible errors. If a warning occurs, data may still be processed, although the inputs should be checked carefully to be sure that the condition causing the warning does not indicate an error.

100 Invalid Pathway Specified. The pathway ID should be a 2 character string. It should be one of the following: CO for control pathway or RE for receptor pathway. Its position is normally confined to columns 1 and 2 (1:2) of the input runstream file. However, the program does allow for a shift of the entire input runstream file of up to 3 columns. If the inputs are shifted, then <u>all</u> input records <u>must</u> be shifted by the same amount. The invalid pathway is repeated at the end of the message.

105 Invalid Keyword Specified. The keyword ID should be an 8-character string. Its position is normally confined to columns 4 to 11 (4:11) of the input runstream file. However, the program does allow for a shift of the entire input runstream file of up to 3 columns. If the inputs are shifted, then <u>all</u> input records <u>must</u> be shifted by the same amount. There should be a space between keyword ID and any other data fields. For a list of valid keywords, refer to Appendix A or Appendix B. The invalid keyword is repeated at the end of the message.

110 Keyword is Not Valid for This Pathway. The input keyword is a valid 8-character string, but it is not valid for the particular pathway. Refer to Appendix A, Appendix B or Section 3 for the correct usage of the keyword. The invalid keyword is repeated at the end of the message.

115 Starting and Finishing Statements do not match. Only One STARTING and one FINISHED statement, respectively, is allowed at the very beginning and the very end of each pathway block. Check the position and frequency to make sure the input runstream file meets the format requirement. The pathway during which the error occurs is included at the end of the message.

120 Pathway is Out of Sequence. The pathways are not input in the correct order. The correct order is CO, SO (optional), RE, and OU for the AERMAP preprocessor. The offending pathway is given as a hint.

125 Missing FINISHED Statement - Runstream file is incomplete. One or more FINISHED statements are missing.

130 Missing Mandatory Keyword. To run the program, certain mandatory keywords must present in the input runstream file. For a list of mandatory keywords, see Appendix A or Appendix B. For more detailed information on keyword setup, see the description of message code 105. The missing keyword is included with the message.

135 Duplicate Non-repeatable Keyword Encountered. More than one instance of a non-repeatable keyword is encountered. For a list of non-repeatable keywords, see Appendix A or Appendix B. The repeated keyword is included with the message.

140 Invalid Order of Keyword. A keyword has been placed out of the acceptable order. The order for most keywords is not critical, but the relative order of a few keywords is important for the proper interpretation of the input data. The keyword reference in Section 3 identifies any requirements for the order of keywords. The keyword that was out of order is included with the message.

152 ELEVUNIT card must be first for this pathway. The ELEVUNIT card must be the first non-commented card after STARTING when used on the RE pathway. This requirement is made in order to simplify reviewing runstream files to determine the elevation units used for sources and receptors.

153 Cannot use obsolescent CO ELEVUNIT card with RE ELEVUNIT card.

160 Duplicate ORIG Secondary Keyword for GRIDPOLR. Only one origin card may be specified for each grid of polar receptors. The network ID for the affected grid is included with the message.

170 Invalid Secondary Keyword for Receptor GRID. The network ID for the affected grid is included with this message. Refer to Appendix B for the correct syntax of secondary keywords.

175 Missing Secondary Keyword END for Receptor Grid. The END secondary keyword is required for each grid of receptors input by the user (keywords GRIDCART and GRIDPOLR). It signals the end of inputs and triggers the processing of data for that particular network.

180 Conflicting Secondary Keyword for Receptor Grid. Two incompatible secondary keywords have been input for the same grid of receptors, e.g. GDIR and DDIR for the keyword GRIDPOLR, where GDIR specifies to generate directions with uniform spacing, and DDIR specifies that discrete, non-uniform directions are being specified.

185 Missing Receptor Keywords. No Receptors Specified. Since none of the RE pathway keywords are mandatory, a separate error check is made to determine if any of the RE keywords are specified. At least one of the following keywords must be present: GRIDCART, GRIDPOLR, DISCCART, DISCPOLR, or EVALCART.

PARAMETER SETUP PROCESSING

This type of message indicates problems with processing of the parameter fields for the runstream images. Some messages are specific to certain keywords, while others indicate general problems, such as an invalid numeric data field. If a fatal error of this kind is detected in a runstream image, a fatal error message is written to the message file and any attempt to process data is prohibited, although the remainder of the runstream file is examined for other possible errors. If a warning occurs, data may still be processed, although the inputs should be checked carefully to be sure that the condition causing the warning does not indicate an error.

200 Missing Parameter(s). No options were selected for the indicated keyword. Check Appendix B for the list of parameters for the keyword in question.

201 Not Enough Parameters Specified For The Keyword. Check if there are any missing parameters following the indicated keyword. See Appendix B for the required keyword parameters.

202 Too Many Parameters Specified For The Keyword. Refer to Appendix B or Section 3 for the list of acceptable parameters.

203 Invalid Parameter Specified. The inputs for a particular parameter are not valid for some reason. Refer to Appendix B or Section 3. The invalid parameter is included with the message.

205 No Option Parameter Setting. Forced by Default to: No setting was specified for a particular parameter. Refer to Appendix B or Section 3 for the correct parameter usage. The default setting is specified with the message.

206 Two or more DEM types exist. Check IPLAN values. The program detected more than one type of DEM file. As an example, the program found a 1-degree and a 7.5-minute DEM file. The program can only have one type of DEM file.

207 No Parameters Specified. Default Values Used For. The keyword for which no parameters are specified is included with the message. Refer to Appendix B or Section 3 for a discussion of the default condition.

208 Illegal Numerical Field Encountered. The program may have encountered a non-numerical character for a numerical input, or the numerical value may exceed the limit on the size of the exponent, which could potentially cause an underflow or an overflow error.

209 Negative Value Appears For A Non-negative Variable. The affected variable name is provided with the message.

212 END Encountered Without (X,Y) Points Properly Set. This error occurs during setting up the grid of receptors for a Cartesian Network. This message may occur for example if X-coordinate points have been specified without any Y-coordinate points for a particular network ID.

213 NOT USED CURRENTLY - ELEV Input Inconsistent With Option: Input Ignored.

214 ELEV Inputs Inconsistent With Option: Defaults Used. This message occurs when the user does not input elevated terrain heights for receptors when the TERRHGTS option is PROVIDED. The program assumes that the missing terrain heights are at 0.0 meters for those receptors and proceeds with ELEV terrain modeling.

215 FLAG Inputs Inconsistent With Option: Input Ignored. This message occurs when the user inputs receptor heights above ground for flagpole receptors when the FLAGPOLE keyword option has not been specified. The input flagpole heights are ignored in the program

calculations.

216 FLAG Inputs Inconsistent With Option: Defaults Used. This happens when the user does not input receptor heights above ground for flagpole receptors when the FLAGPOLE keyword option has been specified. The program assumes that the missing flagpole heights are equal to the default value specified on the CO FLAGPOLE card. If no default height is specified on the FLAGPOLE card, then a default of 0.0 meters is assumed.

217 More Than One Delimiter In A Field.

218 Number of (X,Y) Points Not Match With Number Of ELEV Or FLAG. Check the number of elevated terrain heights or flagpole receptor heights for the gridded network associated with the indicated line number in the runstream file.

219 Number Of Receptors Specified Exceeds Maximum. The user has specified more receptors on the RE pathway than the program array limits allow. This array limit is controlled by the NREC PARAMETER specified in the AERMAP.INC file. The value of NREC is provided with the message.

220 Missing Origin (Use Default = 0,0) In GRIDPOLR. This is a non-fatal warning message to indicate that the ORIG secondary keyword has not been specified for a particular grid of polar receptors. The program will assume a default origin of (X=0, Y=0).

221 Missing Distance Setting In Polar Network. No distances have been provided (secondary keyword DIST) for the specified grid of polar receptors.

222 Missing Direction Setting In Polar Network. Missing a secondary keyword (secondary keyword GRIR or DDIR) for the specified grid of polar receptors.

223 Missing Elevations or Flagpole Fields. No data fields have been specified for the indicated secondary keyword.

224 Number of Receptor Networks Exceeds Maximum. The user has specified more receptor networks of gridded receptors on the RE pathway than the program array limits allow. This array limit is controlled by the NNET PARAMETER specified in the AERMAP.INC file. The value of NNET is provided with the message.

225 Number of X-Coords Specified Exceeds Maximum. The user has specified more X-coordinate values for a particular grid of receptors than the program array limits allow. This array limit is controlled by the IXM PARAMETER specified in the AERMAP.INC file. The value of IXM is provided with the message.

226 Number of Y-Coords Specified Exceeds Maximum. The user has specified more Y-coordinate values for a particular grid of receptors than the program array limits allow. This array limit is controlled by the IYM PARAMETER specified in the AERMAP.INC file. The value of IYM is provided with the message.

227 No Receptors Were Defined on the RE Pathway. Either through lack of inputs or through errors on the inputs, no receptors have been defined.

228 Default(s) Used for Missing Parameters on Keyword. Either an elevated terrain height or a flagpole receptor height or both are missing for a discrete receptor location. Default value(s) will be used for the missing parameter(s).

229 Too Many Parameters - Inputs Ignored on Keyword. Either an elevated terrain height or a flagpole receptor height or both are provided when the corresponding option has not been specified. The unneeded inputs are ignored.

232 Number of Specified Sources Exceeds Maximum. The user has specified more sources than the array limits allow. This array limit is controlled by the NSRC PARAMETER specified in the AERMAP.INC file. The value of NSRC is provided with the message.

250 Duplicate XPNT/DIST or YPNT/DIR Specified for GRID. One of the grid inputs, either an X-coordinate, Y-coordinate, polar distance range or polar direction, has been specified more than once for the same grid of receptors. This generates a non-fatal warning message.

252 Duplicate Receptor Network ID Specified. A network ID for a grid of receptors (GRIDCART or GRIDPOLR keyword) has been used for more than one network.

254 Number of Receptor Arcs Exceeds Maximum. The user has input more than the number of receptors arcs specified by the NARC PARAMETER in the AERMAP.INC file. The value of NARC is provided with the message.

SETUP DATA AND QUALITY ASSURANCE PROCESSING

This type of message indicates problems with the actual values of the parameter data on the input runstream image. The basic structure and syntax of the input card is correct, but one or more of the inputs is invalid or suspicious. These messages include quality assurance checks on various preprocessor inputs. Typical messages will tell the consistency of parameters and data for the setup and run of the program. If a fatal error of this kind is detected in a runstream image, a fatal error message is written to the message file and any attempt to process data is prohibited. If a warning occurs, data may or may not be processed, depending on the processing requirements specified within the runsteam input data.

300 Receptor Not Inside Domain. This is a fatal error generated when one of the receptors specified in the RE pathway lies outside the domain specified on the CO pathway. The receptor number is given with the message.

305 Source Not Inside Domain. This is a fatal error generated when one of the source locations specified in the SO pathway lies outside the domain specified on the CO pathway. The source number is given with the message.

310 Domain Coordinate is NOT Inside a DEM File. This is a fatal error generated when one of the domain coordinates lies outside the range of data covered by the DEM files included on the CO pathway.

320 DEM File Does Not Exist. This is a fatal error generated when one of the DEM data files specified on the CO pathway is not found.

330 Receptor is Not Inside a DEM File. This is a fatal error generated when one of the receptors lies outside all of the DEM files specified by the user. The receptor number is included with the message.

335 Source is Not Inside a DEM File. This is a fatal error generated when one of the source locations lies outside all of the DEM files specified by the user. The source number is included with the message.

340 No Terrain File Adjacent to This One. This is a fatal error generated when one of the DEM data files is found to not be adjacent to any of the other data files specified. The DEM file number is reported, and the file number represents the order of the file in the runstream.

350 Number of Nodes Exceeds Maximum. The number of nodes specified for a given profile exceeds the maximum number set by the MAXNOD parameter in AERMAP.INC. The profile number is specified with the message.

360 Latitude Specified on DOMAINLL Exceeds 60 Degrees. This is a non-fatal warning message issued if a latitude of greater than 60 degrees is specified for the domain on the DOMAINLL card. It may indicate that the order of longitude and latitude are reversed on the input data.

370 DATATYPE Card Does Not Match DEM Data File. The message indicates that the type of DEM data, as determined from the file header record, for the file number specified does not match the type specified on the DATATYPE card.

375 Specified Source ID Has Not Been Defined Yet. The message indicates that the user attempts to use a source ID on a keyword before defining this source ID on a SO LOCATION card. It could indicate an error in specifying the source ID, an omission of a LOCATION card, or an error in the order of inputs.

377 Duplicate LOCATION Card Specified for Source. There can be only one LOCATION card for each source ID specified. The source ID is included with the message.

380 This Input Variable is Out-of-Range. The indicated value may be too large or too small. Use the line number to locate the card in question, and check the variable for a possible error.

RUNTIME MESSAGE PROCESSING, 400-499

This type of message is generated during the preprocessor run. Setup processing has been completed successfully, and the message is generated during the performance of calculations. If a fatal error of this kind is detected during model execution, a fatal error message is written to the message file and any further processing of the data is prohibited. The rest of the data file(s) will be read and quality assurance checked to identify additional errors. If a warning occurs, data will still be processed.

410 Receptor Location Outside Range of Profiles. This is a non-fatal warning message indicating that a receptor location falls near the edge of a 7.5-minute DEM file and is outside the range of the data profiles. If receptor elevations are being extracted from the DEM data, the nodes from the nearest profile are used for this receptor.

420 Source Location Outside Range of Profiles. This is a non-fatal warning message indicating that a source location falls near the edge of a 7.5-minute DEM file and is outside the range of the data profiles. If source elevations are being extracted from the DEM data, the nodes from the nearest profile are used for this source.

INPUT/OUTPUT MESSAGE PROCESSING

This type of message is generated during the preprocessor input and output. Typical messages will tell the type of I/O operation (e.g., opening, reading or writing to a file), and the type of file. If a fatal error of this kind is detected in a runstream image, a fatal error message is written to the message file and any attempt to process data is prohibited. If a warning occurs, data may or may not be processed, depending on the processing requirements specified within the runsteam input data.

500 Fatal Error Occurs During Opening of the Data File. The file specified cannot be opened properly. This may be the runstream file itself, or one of the DEM input data files. This may happen when the file called is not in the specified path, or an illegal filename is specified. Refer to the line number included in the error message to identify which file caused the error. If no errors are found in the filename specification, then this message may also indicate that there is not enough memory available to run the program, since opening a file causes a buffer to be opened which takes up additional memory in RAM.

505 File is Already in Use, Cannot be Opened. The specified data file is already in use and could not be opened. This error may indicate that a duplicate data filename has been specified.

510 Fatal Error Occurs During Reading of the File. File type is incorrect, or illegal data field encountered. Check the indicated file for possible problems. For a DEM data file, be sure that file has been converted to a DOS-compatible format using the CRLF.EXE program (provided with the AERMAP package). As with error number 500, this message may also indicate that there is not enough memory available to run the program if no other source of the problem can be identified.

520 Fatal Error Occurs During Writing to the File. Similar to message 510, except that it occurs during a write operation.

550 DEM File Conflict for Specified DEM File Number. This error indicates a conflict in the specification of DEM data files. It may be caused by entering a duplicate filename for a DEM file.

580 End-of-File Reached Trying to Read a Data File. The AERMAP preprocessor has unexpectedly encountered an end-of-file trying the read the indicated file. Check the data file for the correct filename.

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