

**USING DIGITAL ELEVATION MODEL
ARC/INFO COVERAGES
CREATED AT THE KANSAS GEOLOGICAL SURVEY**

***James E. Mitchell
Hydrologic Data Manager, Geohydrology Section
Kansas Geological Survey***

***Kansas Geological Survey Open-file Report 92-50
December 22, 1992***

**USING DIGITAL ELEVATION MODEL
ARC/INFO COVERAGES
CREATED AT THE KANSAS GEOLOGICAL SURVEY**

James E. Mitchell
Hydrologic Data Manager, Geohydrology Section
Kansas Geological Survey

ABSTRACT

Digital elevation Models (DEM) are one format for representing three-dimensional surfaces. It is commonly used to represent the earth's surface topography and in modeling of three-dimensional features in geographic information systems (GIS).

The Kansas Geological Survey, in cooperation with the Kansas State GIS Policy Board, has generated ARC/INFO coverages for the three arc-second DEMs covering the entire state. This provides approximately 90 meter spacing on the ground with an elevation for each point expressed in integer meters.

The ARC/INFO coverages are large, containing 1,442,401 points. They are created in units of decimal degrees and have row and column identification. The elements of each DEM coverage are described, along with some suggested cautions for processing the data.

KEY TERMS: Digital Elevation Model, DEM, ARC/INFO, Kansas, topography.

INTRODUCTION

General

Digital Elevation Models (DEM) are one format for representing elevations on three-dimensional surfaces. It consists of point information representing the x, y, and z coordinates across the surface. Thus, it represents a, so-called, "raster" or grid format. This can be particularly useful when processing information about three-dimensional surfaces using two-dimensional geographic information systems (GIS). Among the uses for DEM data are contouring, slope determination, aspect determination, volumetric calculations for constriction and earthmoving, watershed delineation, and other applications which require the characterization of surface data.

As part of database development activities for the Kansas GIS Policy Board, DEM data from the US Geological Survey (USGS) were converted from their native form into ARC/INFO coverages (US Geological Survey, 1987). Using the ARC/INFO software, these data can be converted into a number of different formats for distribution. For information on access to these data, contact the Data Access and Support Center (DASC), directly.

Data Description

DEM data are available at several different levels of resolution. The scale selected for this project is 3 arc-seconds spacing of elevation points. The areas covered are blocked in units of one degree square. This corresponds to the USGS 1:250,000 scale map series. This series represents the surface of the US in one degree (north and south) by two degrees (east and west) blocks. Each is split into an east and west half. Each dataset is a 1201 by 1201 square grid, in longitude-latitude units. Because of the geographic coordinate system, the points, when projected, define a grid spacing of approximately 90 meters. Depending on the projection used, the "grid" will be slightly closer in the northern rows than in the southern rows. Elevations are reported in meters. The elevations are reported as integer values, rounded off to the nearest meter.

The source of the data are the 1:250,000 scale topographic maps maintained by the USGS. point elevations are arrived at by oversampling points along a "profile" and interpolating the elevation at the grid positions. A profile is a series of points along a south to north line (a column) in the data grid. The first profile begins in the southwest corner, running north. In these coverages, an elevation point is assigned every 3 arc- seconds. A second is 1/3600th of a degree.. As a result, there are 1200 sample points per degree of longitude or latitude (a 1201 X 1201 grid). Degree-seconds are the native units of these data, however, for this purpose they have been converted to decimal degrees.

The accuracy of these data are subject to the standards of the USGS National Mapping Division. Detailed information about each dataset are kept in what is referred to as "RECORD A", a listing of specific information for each half quadrangle. Specific information about the elements of RECORD A can be obtained in the documentation for the DEM data (US Geological Survey, 1987).

ARC/INFO COVERAGES

Creating ARC/INFO GIS Coverages from Native USGS DEM Files

DEM data are provided by the USGS in ASCII files and must be processed to create a format which ARC/INFO can accept. The first step was performed using the Statistical Analysis System (SAS) to read the raw data and create an ARC/INFO Generate format file (SAS Institute Inc. , 1990). This file is read by the ARC/INFO GENERATE command to create a coverage in degree-second geographic units. A Point Attribute Table (PAT) is constructed from the corresponding elevation data in step two. The third step uses ARC/INFO to convert the degree seconds to decimal degrees. The final product is a coverage with 1,442,401 points and 20 bytes of point attribute data.

The processing first encounters RECORD A and retrieves those data. Next, it finds RECORD B which contains information on the location of the first profile in the DEM grid. This begins with the southwest corner and ends with the northwest corner (column one). It processes one column at a time starting with row 1 to row 1202 in each of the 1201 columns.

For documentation, RECORD A is included as an ASCII file in the INFO directory of the coverages workspace. It is named "<coverage_name>.RECORDA" and is linked the coverage (using the INFO command, GET), as an INFO table with the internal INFO name "<coverage_name>.A". The items are described in Table 1. Each element of RECORD A is stored as a character string. This is done because of incompatibilities between the USGS DEM format and the data handling capabilities of ARC/INFO. Some of the raw data are

TABLE 1
SAMPLE ITEMS LISTING FROM THE RECORD A INFO TABLE

| COL | ITEM NAME | WDTH | OPUT | TYP | N.DEC |
|-----|-----------|------|------|-----|-------|
| 1 | NAME | 144 | 144 | C | - |
| 145 | LEVEL | 6 | 6 | C | - |
| 151 | ELEVPAT | 6 | 6 | C | - |
| 157 | PLANSYS | 6 | 6 | C | - |
| 163 | PLANZONE | 6 | 6 | C | - |
| 169 | PROJP1 | 24 | 24 | C | - |
| 193 | PROJP2 | 24 | 24 | C | - |
| 217 | PROJP3 | 24 | 24 | C | - |
| 241 | PROJP4 | 24 | 24 | C | - |
| 265 | PROJP5 | 24 | 24 | C | - |
| 289 | PROJP6 | 24 | 24 | C | - |
| 313 | PROJP7 | 24 | 24 | C | - |
| 337 | PROJP8 | 24 | 24 | C | - |
| 361 | PROJP9 | 24 | 24 | C | - |
| 385 | PROJP10 | 24 | 24 | C | - |
| 409 | PROJP11 | 24 | 24 | C | - |
| 433 | PROJP12 | 24 | 24 | C | - |
| 457 | PROJP13 | 24 | 24 | C | - |
| 481 | PROJP14 | 24 | 24 | C | - |
| 505 | PROJP15 | 24 | 24 | C | - |
| 529 | GROUNDU | 6 | 6 | C | - |
| 535 | ELEVU | 6 | 6 | C | - |
| 541 | NSIDES | 6 | 6 | C | - |
| 547 | CORNER1X | 24 | 24 | C | - |
| 571 | CORNER1Y | 24 | 24 | C | - |
| 595 | CORNER2X | 24 | 24 | C | - |
| 619 | CORNER2Y | 24 | 24 | C | - |
| 643 | CORNER3X | 24 | 24 | C | - |
| 667 | CORNER3Y | 24 | 24 | C | - |
| 691 | CORNER4X | 24 | 24 | C | - |
| 715 | CORNER4Y | 24 | 24 | C | - |
| 739 | MIN | 24 | 24 | C | - |
| 763 | MAX | 24 | 24 | C | - |
| 787 | AXISANG | 24 | 24 | C | - |
| 811 | ACCELEV | 6 | 6 | C | - |
| 817 | XRES | 12 | 12 | C | - |
| 829 | YRES | 12 | 12 | C | - |
| 841 | ZRES | 12 | 12 | C | - |
| 853 | ROWS | 6 | 6 | C | - |
| 859 | COLS | 6 | 6 | C | - |

NOTE: Definitions for these items can be found in: US Geological Survey (1987).

represented in double precision formats or with exponents which are not able to be read or stored. If desired, most of the numeric fields can be accessed as numbers by using the INFO command, REDEFINE, and specifying either an I or N format for integer or real numbers, respectively. Consult the DEM documentation for more information about the data in RECORD A (US Geological Survey, 1987).

PAT Definition

The PAT has several features with which the user should become familiar. The elevation attribute is called METERS. It is stored as a single precision real binary number. All these data are reported by USGS as integer numbers, without decimal places. In Kansas, these numbers are all three digits long. The Item Named <coverage_name># is ordered sequentially starting with the first point in the first profile and ending with the last point in the last profile. That is 1 to 1,442,401. The item named <coverage_name>-ID represents the concatenation of the row and column number of the grid point it represents. The first point is assigned 10001 and the last point receives 12021201. In this manner, any grid location in the DEM can be determined by decomposing the <coverage_name>-ID item:

$$\text{ROW} = \text{INT}(\text{<coverage_name>-ID} / 10000)$$

$$\text{COLUMN} = (\text{<coverage_name>-ID}) - \text{ROW} * 10000$$

The PAT is in the standard ARC/INFO form, with the METERS item added to the end of each record. The items list can be seen in Table 2.

TABLE 2
SAMPLE LISTING FROM THE POINT ATTRIBUTE TABLE

| | COL | ITEM NAME | WDTH | OPUT | TYP | N.DEC |
|----|--------------------|-----------|------|------|-----|-------|
| 1 | AREA | | 4 | 12 | F | 2 |
| 5 | PERIMETER | | 4 | 12 | F | 2 |
| 9 | <coverage_name># | | 4 | 8 | B | 0 |
| 13 | <coverage_name>-ID | | 4 | 8 | B | 0 |
| 17 | METERS | | 4 | 4 | F | 0 |

Coverage Storage Format

The coverages are stored on 9-track magnetic tape, with a density of 6250 bytes per inch (BPI). Each tape contains a single DEM coverage in Data General, AOS DUMP format. In this manner a coverage is stored in a workspace (AOS directory) named for that coverage. In this directory, there is the coverage directory and an INFO directory containing all of the associated files.

This approach used to avoid creating any inadvertent cross-links between coverages. It is necessary because of the external names which ARC/INFO constructs for the various elements of a coverage. Coverages generated at different times and/or in different workspaces, are subject to receiving the same sequence numbers in the naming convention.

TO AVOID ANY PROBLEMS WITH CONFLICTING EXTERNAL (OPERATING SYSTEM) NAMES EACH DEM COVERAGE SHOULD BE RESTORED INTO ITS OWN WORKSPACE.

If an INFO directory already exists in the workspace, restoring a DEM to that location may overwrite existing data. In addition, the ARC/INFO command, EXTERNAL, should be executed on the coverage, as soon as the restore (an AOS LOAD command is completed. Once online in this manner, the coverage can be operated on in a normal fashion without danger of loosing data. Approximately 69 Mb should be available in the workspace to accommodate the data. A typical restore session should follow this pattern:

In AOS issue the following commands (a ") represents the AOS prompt, UPPERCASE letters are necessary commands, and lowercase letters are names the user must provide):

```
)CREATE/DIR new_dir_name
)DIR new_dir_name
)MOUNT/DIR=[!DIR]/READONLY/DEN=6250 demtape PLEASE MOUNT tape_name
)LOAD_II/V demtape:0 #
    [Loading takes 10 to 15 minutes, once the tape is mounted]
)DISMOUNT/DIR=[!DIR] demtape
)ARC EXTERNAL coverage_name
```

AVAILABLE COVERAGES

At present, the 1:250,000 scale quadrangles which overlay the state of Kansas are available. These include those listed in Table 3 and are shown in Figure 1.

**TABLE 3
NAMES OF 1:250,000 SCALE HALF-QUADRANGLE DEM COVERAGES**

| | | | | |
|-----------|--------------|--------------|--------------|--------------|
| LIMON.E | GOODLAND.E | BELOIT.E | MANHATTAN.E | KANSAS.CTY.E |
| LIMON.W | GOODLAND.W | BELOIT.W | MANHATTAN.W | KANSAS.CTY.W |
| LAMAR.E | SCOTT.CITY.E | GREAT.BEND.E | HUTCHINSON.E | LAWRENCE.E |
| LAMAR.W | SCOTT.CITY.W | GREAT.BEND.W | HUTCHINSON.W | LAWRENCE.W |
| LAJUNTA.E | DODGE.CITY.E | PRATT.E | WICHITA.E | JOPLIN.E |
| LAJUNTA.W | DODGE.CITY.W | PRATT.W | WICHITA.W | JOPLIN.W |
| DALHART.E | PERRYTON.E | WOODWARD.E | ENID.E | TULSA.E |
| DALHART.W | PERRYTON.W | WOODWARD.W | ENID.W | TULSA.W |

NOTE: The western column of quadrangles do not include any Kansas territory in their western half.

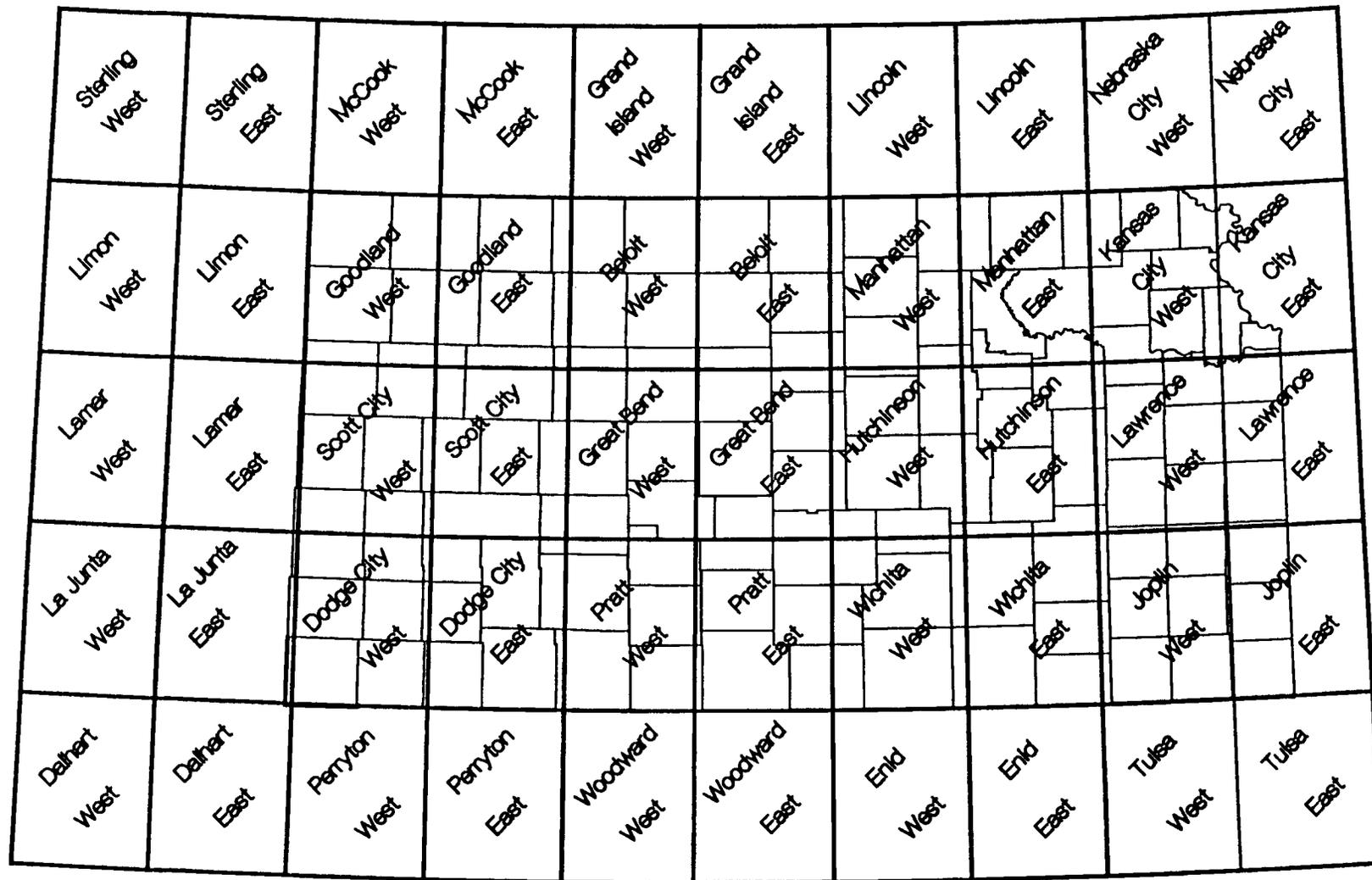


Figure 1.0 Three arc-second DEM's covering Kansas

SPECIAL COMMENTS

There are two types of ARC/INFO operations which should be approached with care when using the DEM coverages. They both involve the combination of two, or more, DEMs into a single coverage.

Because each grid is 1201 X 1201 points and it begins and ends on an integer degree of latitude or longitude, each grid shares its outermost rows and columns with the adjacent DEM. To avoid duplication of points, a system should be developed by the user to eliminate one of the common elements from the coverage(s). This can avoid confusion which might result from two points which share the exact x,y location (and should also have the same elevation).

The second note of caution is the use of the item named <coverage_name>-ID to identify row and column location. If two DEMs are combined, care should be taken to see that this item does not create ambiguous IDs. This can create problems with some ARC/INFO functions. To avoid this, carefully choose the means for combining data and check the various options concerning processing of the "USER-IDs" which are available for each. A possible fix for this problem is to renumber new DEMs with the appropriate row and columns by adding an appropriate integer value to each additional coverage to reflect its relative position in the concatenation.

REFERENCES

SAS Institute, Inc. *SAS Language: Reference, Version 6, First Edition*. Published by SAS Institute, Cary, NC. 1042 pages. 1990.

US Geological Survey *Digital Elevation Models*. US Geological Survey National Mapping Program Technical Instructions, Users Guide 5, Reston, VA, 1987.