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Interfaces Between Statistical Analysis Packages and the ESRI Geographic Information System

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OCTOBER 1980

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Greenbelt, Maryland 20771
INTERFACES BETWEEN STATISTICAL ANALYSIS PACKAGES
AND THE ESRI GEOGRAPHIC INFORMATION SYSTEM

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Abstract

The Environmental Systems Research Institute (ESRI) geographic information system (GIS) in use at Goddard Space Flight Center provides users with the means of combining remote sensing data with ancillary data (soils maps, geologic maps, topographic maps, etc.) and performing qualitative analyses on the resulting multivariable data base. However, statistical techniques such as multiple regression, analysis of variance and spatial autocorrelation analyses are not available in the GIS. This paper describes interfaces between ESRI's GIS data files and real valued data files written to facilitate statistical analysis and display of spatially referenced multivariable data. An example of data analysis which utilized the GIS and the Statistical Analysis System (SAS) is presented to illustrate the utility of combining the analytic capability of a statistical package with the data management and display features of the GIS.
INTERFACES BETWEEN STATISTICAL ANALYSIS PACKAGES
AND THE ESRI GEOGRAPHIC INFORMATION SYSTEM

INTRODUCTION

Automated geographic information systems provide a framework in which spatially referenced data (maps and remote sensing imagery) may be manipulated, displayed and analyzed (Knapp, 1979). The utility of a geographic information system (GIS) lies in its ability to create and analyze a multivariable file derived from maps and images of a study area. Geographic information systems have been used by land planners to select sites for campgrounds in Canadian national parks (Arbour, 1980), by researchers at the National Cancer Institute to study patterns of mortality (Mason, 1980) and by geologists to examine relationships between petrologic and geophysical information on the moon (Andre et al., 1977).

The Environmental Systems Research Institute (ESRI) GIS provides the user with a tool for creating multivariable files from digitized map data and digital remote sensing data. A GIS multivariable file may be thought of as a cube made up of data cells. The horizontal axes of the cube correspond to geographic location. Along the vertical axes are the different variables in the multivariable file. Thus, each column of cells in the cube has a unique geographic location and each layer of cells in the cube corresponds to a unique thematic map variable, such as soil type, vegetation type or topographic elevations (see Figure 1). Analyses which can be performed on the multivariable files include: slope and aspect calculations, proximity analyses and the creation of qualitative models based on user supplied weights (ESRI staff, 1979). However, statistical analyses, such as multiple regression, analysis of variance and spatial autocorrelation analysis can not be performed within the GIS. Further, since observations in a GIS multivariable file are stored as sixteen bit integers, real values and integers outside the range ±32,768 can not be manipulated by the GIS.

The inability to perform statistical analyses on GIS multivariable files, precludes the development of powerful quantitative models for resource exploration or land use planning with the
GIS package. However, statistical packages, such as SAS, provide tools for performing a range of statistical analyses from the computation of simple descriptive statistics to complex multivariate techniques (Helwig and Council, 1979).

To provide a means of performing statistical analyses on variables in GIS files and to allow the results of these analyses to be merged with GIS multivariable files, interfaces between the ESRI GIS and real valued data files were created.

DESCRIPTION OF INTERFACES

SAS2GIS is a computer program which converts gridded real valued data into the single variable file (SVF) format used by the ESRI geographic information system. The data file of real values that is to be converted to an integer SVF must be sorted so that for a SVF file n rows by m columns, the real value for cell (i, j) in the SVF will correspond to entry (i*m+j) in the real valued data file. The conversion is accomplished by a linear transformation, \( y = ax + b \), which maps a real valued variable \( X \) into an integer variable \( Y \). The program provides the user with two options for converting the data into integer format. First, the user may supply the \( a \) and \( b \) terms of \( y = ax + b \). Second the user may specify a range for the transformed data. The original data will be mapped into this range using the linear transformation and the transformed data will be checked to insure that the conversion did not truncate the values more than a user specified amount. After the transformed data have been written to a disk file, an additional record is added to the file which contains the \( a \) and \( b \) terms that were used to make the transformation. This record is not read by any GIS software but may be used by the interface GIS2SAS to convert the SVF file to a real valued data file.

GIS2SAS is a computer program which transforms integer data in ESRI's SVF format into real valued data with row column references. The formula used to convert integer data to real valued data is \( x = (y-b)/a \); where \( x \) is a real value, \( y \) is an integer and \( a \) and \( b \) are constants. The user has two options for converting integers to real values. First, the user may specify \( a \) and \( b \)
terms for the transformation. This is required if the SVF file was not created by SAS2GIS.

Second, if no a and b values were provided by the user the program will use the a and b values in the last record written by SAS2GIS when the file was created. Program output consists of a real valued data file in a format specified by the user.

RUNNING SAS2GIS AND GIS2SAS

SAS2GIS and GIS2SAS are interactive computer programs written in FORTRAN IV. At Goddard Space Flight Center they run in the foreground on an IBM 360/91 and an IBM 360/75. Listings of these programs appear in Appendix 1. The clists (files which contain TSO commands and subcommands) used to set up and run the interfaces are presented in Appendix 1. To run a program the user types the program's name, SAS2GIS or GIS2SAS, followed by I ("input filename") and O ("output filename"). For example if the user types:

SAS2GIS I(BOTANY.DATA) O(GIS.DATA)

the program SAS2GIS will be run to create an SVF file GIS.DATA from a real valued data file BOTANY.DATA.

When the programs are running in the foreground they will prompt the user for two lines of input. The first line contains parameters used to make the transformations and the second line is the format of the real valued data file. Tables 1 and 2 summarize the input parameters for these interfaces.

Should the user wish to convert these interfaces to run in a batch environment, he must make two modifications. First, the clists must be replaced by JCL statements which assign disk files for input and output to logical units 8 and 10, as shown in Figures 2 and 3. Second, the write statements which prompt the user for input should be removed.

COMBINING THE GIS AND A STATISTICAL PACKAGE FOR DATA ANALYSIS

Some preliminary results in an analysis of gravity and elevation data from the Rio Grande rift are presented here to illustrate the utility of combining a package of statistical analysis
programs, SAS, with the ESRI geographic information system (GIS). The objective of this study was to remove the relationship between Bouguer gravity and topographic relief which was present in a data set of elevation and gravity observations compiled by Keller and Conrad at the University of Texas.

The gravitational field measured at a given point on the earth's surface includes effects unrelated to geology. These effects are due to: variations in the distance between the earth's center and the station where the gravity field was measured and the contribution of local topography to the observed gravity (Grant and West, 1965). Once corrections for these effects have been applied to the data, the resulting values are termed Bouguer gravity data and reflect the contribution of underlying geologic structures.

At present there is no agreement on the best method for computing Bouguer gravity from the observed gravity which is measured at a station. However, Nettleton (1940) has suggested that when the corrections to reduce observed gravity to Bouguer gravity are properly applied, the correlation between station elevation and Bouguer gravity should be low. A striking similarity between the Bouguer gravity and station elevation was first observed in three dimensional plots of these two data types produced by the GIS. In order to determine the degree of correlation between the gridded elevation data from the rift (Figure 4) and gridded Bouguer data (Figure 5), the statistical analysis package SAS76 was used to compute a Pearson product moment correlation coefficient. The correlation between Bouguer gravity and elevation was high, −0.903, and a linear regression was computed to remove the variation in Bouguer gravity due to elevation. The residuals from the regression provide a better estimate of Bouguer gravity because the effect of station elevation has been removed. A plot of these residuals, Figure 6, reveals regions of high positive residuals in the North-west and South-east corners of the Rio Grande study area. This suggests that there are regional variations in rock density in the study area and that individual Bouguer gravity corrections should be calculated for each region.
In this analysis the Statistical Analysis System (SAS) and the ESRI GIS proved useful tools for examining the relationship between variables in a spatially referenced multivariable database.

With these interfaces the researcher can utilize the extensive database management and graphics capabilities of the GIS to complement existing software in the analysis of real valued multivariate data.

Table 1
Input Parameters for SAS2GIS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Column</th>
<th>Format</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Input Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROW</td>
<td>1-5</td>
<td>I5</td>
<td>Number of rows in the SVF which will be created from the input data file,</td>
</tr>
<tr>
<td>COLUMN</td>
<td>6-10</td>
<td>I5</td>
<td>Number of columns in SVF.</td>
</tr>
<tr>
<td>A</td>
<td>11-15</td>
<td>F5.0</td>
<td>Multiplicative term in y=ax+b, used to map real x into integer y.</td>
</tr>
<tr>
<td>B</td>
<td>16-20</td>
<td>F5.0</td>
<td>Additive term in y=ax+b, if A and B are omitted NEWMIN and NEWMAX must be specified.</td>
</tr>
<tr>
<td>MIN</td>
<td>26-30</td>
<td>F5.0</td>
<td>Minimum value of input data default: value calculated by the program.</td>
</tr>
<tr>
<td>MAX</td>
<td>26-30</td>
<td>F5.0</td>
<td>Maximum value of input data default: value calculated by program.</td>
</tr>
<tr>
<td>NEWMIN</td>
<td>31-37</td>
<td>I5</td>
<td>New minimum value after transformation to integers.</td>
</tr>
<tr>
<td>NEWMAX</td>
<td>38-44</td>
<td>I5</td>
<td>New maximum value after transformation to integers.</td>
</tr>
<tr>
<td>TOLER</td>
<td>45-49</td>
<td>F5.0</td>
<td>User specified tolerance for truncation resulting from conversion of real values to integer format.</td>
</tr>
<tr>
<td>MISVAL</td>
<td>50-55</td>
<td>F6.0</td>
<td>Value indicating missing observations in the data.</td>
</tr>
<tr>
<td>NEWVAL</td>
<td>56-61</td>
<td>F6.0</td>
<td>Value which will be assigned to missing observations in the SVF file, default: 0.</td>
</tr>
<tr>
<td>Second Input Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMT</td>
<td>1-80</td>
<td>80A1</td>
<td>User supplied input format for data in real data set.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Column</td>
<td>Format</td>
<td>Function</td>
</tr>
<tr>
<td>-----------</td>
<td>--------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>First Line of Input</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>1-6</td>
<td>F6.0</td>
<td>Divisor in ( x = (y - b)/a ) used to transform integer values into real values default: use first value in last record of SVF file.</td>
</tr>
<tr>
<td>B</td>
<td>7-12</td>
<td>F6.0</td>
<td>( b ) term in ( x = (y - b)/a ) used to transform integer values into real values default: use second value in last record of SVF file.</td>
</tr>
<tr>
<td><strong>Second Line of Input</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCOL</td>
<td>1-3</td>
<td>I3</td>
<td># columns in output file.</td>
</tr>
<tr>
<td><strong>Third Line of Input</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMT</td>
<td>1-80</td>
<td>80A1</td>
<td>User supplied output format for real valued data set.</td>
</tr>
</tbody>
</table>
REFERENCES


3. Environmental Systems Research Institute staff, 1979, ESRI geographic information software descriptions. 79 p.


Figure 1. Structure of an ESRI GIS Multivariable File (MVF)

Figure 2. Logical Units Required by SAS2GIS
Figure 3. Logical Units Required by GIS2SAS

<table>
<thead>
<tr>
<th>UNIT</th>
<th>STRUCTURE</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>CARD</td>
<td>USER CONTROL CARDS</td>
</tr>
<tr>
<td>6</td>
<td>PRINTER</td>
<td>JOB LISTING</td>
</tr>
<tr>
<td>8</td>
<td>SVF</td>
<td>INTEGER SINGLE VARIABLE FILE</td>
</tr>
<tr>
<td>10</td>
<td>CARD</td>
<td>REAL VALUED DATA FILE</td>
</tr>
</tbody>
</table>

Figure 4. A Plot of Elevations in the Rio Grande Rift Study Area Produced by the ESRI GIS
Figure 5. Bouguer Gravity Values from the Rio Grande Rift Study Area

Figure 6. Residuals from a Regression of Elevation and Bouguer Gravity
APPENDIX 1

PROGRAM LISTINGS OF THE INTERACTIVE INTERFACES BETWEEN REAL VALUED DATA SETS AND THE ESRI GEOGRAPHIC INFORMATION SYSTEM

A. SAS2GIS PROGRAM LISTING

```
**
** TITLE: INTERFACE FOR REAL VALUE DATA AND ESRI GIS SINGLE VARIABLE FILES (SVF'S)
** PROGRAMMER: MARCIANO
** DATE: AUGUST 1, 1979
**
** THIS PROGRAM TRANSFORMS REAL VALUE DATA SETS INTO INTERGER DATA IN GIS FORMAT IN 3 STEPS:
** 1. PROJECTS USER FOR FORMAT OF INPUT DATA AND PARAMETERS NEEDED TO MAP REAL VALUES INTO INTEGERS
** 2. MAPS REAL VALUES INTO INTEGER WITHIN THE RANGE -32,768 TO +32,768 WITH A LINEAR TRANSFORMATION
** 3. WRITES THE ESRI GIS FILE AND INFORMATION REQUIRED TO TRANSFORM THE GIS FILE TO REAL VALUE DATA, AS THE LAST RECORD OF THE SVF FILE.
**
** USER INPUT:
** CARD 1 1-5 NRW * ROWS IN INPUT FILE
** 5-10 NCOL * COLUMNS IN INPUT FILE
** 11-15 A * MULTIPlicative TERN IN Y=AX+B
** 16-20 B * ADDITIVE TERN IN Y=AX+B
** 21-25 MIN * MINIMUM VALUE OF INPUT DATA
** DEFAULT: CALCULATED
** 26-30 MAX * MAXIMUM VALUE OF INPUT DATA
** DEFAULT: CALCULATED
** 31-37 MININT * INTEGER MINIMUM AFTER TRANSFORMATION
** 38-44 MAXINT * INTEGER MAXIMUM AFTER TRANSFORMATION
** 45-49 TOL % TOLERANCE FOR TRANSFORMATION RESULTING FROM THE TRANSFORMATION OF REAL VALUES TO INTEGERS
** DEFAULT: 0
** 50-55 MVAL * VALUE FOR MISSING
** DEFAULT: -9991
** 56-61 MVAL * VALUE ASSIGNED TO MISSY IN SVF FILE
** DEFAULT: 1
**
** MAPS 1-60 FOR TEST SUPPLIED FORMAT (2194)
**
**
```
REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)

REAL*4 P1T^20 , DATA (500), AB (2), MAX, MIN, VISUAL/-9999/, NEWVAL/0/, R1NGER (2), RNCUL (2), ROW (500)
EQUVALENCE (AB (1), A), (AB (2), B)
DO 22 J=1,NCOL
   IF (DATA(J) .LT. MIN) MIN=DATA(J)
   IF (DATA(J) .GT. MAX) MAX=DATA(J)
   CONTINUE
   IF (MIN .GE. NEWVAL) .OR. (MIN .GE. MISOAL) MIN=NEWVAL
   IF (MAX .LT. NEWVAL) .OR. (MAX .GE. MISOAL) MAX=NEWVAL
   REWIND 8
   CALCULATE A AND B FOR SCALING FUNCTION Y=AX+B

   RANGE=NEWMAX-NEWMIN
   IF (NEWMAX+NEWMIN .LT. MIN) A=RANGE/(MAX-MIN)
   F=RANGE-A*MAX

   *********************************************
   *  PRINT INTERMEDIATE RESULTS             *
   *********************************************

   WRITE (6,9) A,B
   IF (A .LT. 1.0) THEN
      WRITE (6,9) A,B
   ELSE
      WRITE (6,9) A,B
   END IF

   *********************************************
   *  WRITE THE SVF                           *
   *********************************************

   CHECK TO INSURE THAT THE TRANSFORMED VALUES HAVE NOT
   BEEN TRANSCENDENT MORE THAN A USER SPECIFIED TOLERANCE

   CALL CA9ICD (DATA,NCOL,A,B,TOLER)
   WRITE NOW AND COLUMN INFORMATION ON THE BIS FILE

   WRITE (10) NCOL
   SCALE THE DATA FROM RANGE TO - RANGE

   DC 30 I=1,NCOL
   READ (8,END=9) (DATA(J),J=1,NCOL)
   DC 40 J=1,NCOL

   IF (DATA(J) .GE. MISOAL) DATA(J)=NEWVAL
   WRITE (J)/(A*DATA(J)+B)
   CONTINUE

   WRITE THE TRANSFORMED COLUMNS IN A ROW AT A TIME
   CALL WRITEC (ROW,NCOL)

   A1-3
3C CONTINUE

WRITE THE COEFFICIENTS USED TO MAKE THE TRANSFORMATION
AND THE FORMAT OF THE REAL VALUE DATA SET
AS THE LAST RECORDS OF THE TRANSFORMED FILE

WRITE (10) AD
WRITE (10) FMT
11 FORMAT (15H1/***** SUCCESSFUL CONVERSION TO ESRI SYF FILE *****)
STOP 1

ERROR MESSAGES FOR INCORRECT CONTROL CARDS

99 FORMAT (1H1, 'TOC FEI OBSERVATIONS ')
STOP 2
END

******************
* THIS SUBROUTINE WRITES THE INTEGERS *
* AS A SINGLE VARIABLE FILE *
******************

SUBROUTINE WRITEC(SCW, NCCL)
INTEGER*2 RCW(NCCL)
WRITE (10) RCW
RETURN
END

******************
* THIS SUBROUTINE COMPARIS THE ORIGINAL REAL VALUED *
* DATA FILE WITH THE REAL VALUED FILE WHICH WILL BE *
* PRODUCED IF THE SYF IS TRANSFORMED BACK TO A REAL *
* VALUES IF THE DIFFERENCE BETWEEN *
* ENTRIES IN INFSF FILES EXCEEDS A USER SPECIFIED *
* TOLERANCE AN ERROR MESSAGE IS WRITTEN AND THE JOB *
* IS ABORTED. *
******************

SUBROUTINE CHKCL(TDAT, NCCL, A, B, TOL3B)
INTEGER*4 NCCL
REAL*4 DAT(NCCL), A, B, TOL3, TDAT
INTEGER*2 IDAT

CALCULATE EFFECT OF TRANSFORMATION ON
VALUES OF THE INPUT DATA

DC 10 I=1, NCCL
TDAT=TDAT(I) * A + B
READ (NDA - 1, 1)
C GIVE CRITICAL PROCESSING FROM REALIZED DATA
RETURN
END

IF (ABS(EQAT-DA(1)) > IT - TOL(3)) TO 10
ELSE WRITE AN ERROR MESSAGE AND STOP

WRITE (9, 1)
**** CVHARE CRITICAL PROCESSING FROM REALIZED DATA
WRITE (9, 1)
**** TOLERANCE EXCEEDING TRANSFORMATION
B. GIS2SAS PROGRAM LISTING

**TITLE:** INTERFACE BETWEEN ESRI GEOGRAPHIC INFORMATION SYSTEM GIS DATA SETS AND REAL VALUED DATA SETS USED BY STATISTICAL PACKAGES

**PROGRAMMER:** EDWARD NASUKA

**DATE:** AUGUST 1, 1979

**THIS PROGRAM TRANSFORMS GIS FILES IN INTEGRAL2 INTO THE ORIGINAL REAL VALUED DATA IN 3 STEPS:**

1. READS ROW COLUMN INFORMATION FROM RECORD 1

2. TRANSFORMS INTEGRALS TO REAL VALUES USING A LINEAR TRANSFORMATION: REAL = (INTEGER-2) / A

3. WRITES THE REAL DATA TO A FILE WITH A USER SUPPLIED FORMAT

**VARIABLE FUNCTION**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA</td>
<td>STORES REAL DATA</td>
</tr>
<tr>
<td>ROWCOL</td>
<td>STORES 1 CF RC#S AND COLUMNS IN THE INPUT FILE</td>
</tr>
<tr>
<td>ROW</td>
<td># OF RC#S IN DATA AND GIS FILE</td>
</tr>
<tr>
<td>COLUMN</td>
<td># COLUMNS IN DATA &amp; GIS FILE</td>
</tr>
<tr>
<td>A</td>
<td>STORES LINEAR TRANSFORM PARAMS</td>
</tr>
<tr>
<td>SLOPE</td>
<td>SLOPE OF LINEAR FUNCTION USED TO TRANSFORM REAL DATA</td>
</tr>
<tr>
<td>INTER</td>
<td>INTERCEPT OF LINEAR TRANSFORM</td>
</tr>
<tr>
<td>IROW</td>
<td>STORES # OF THE TRANSFORMED DATA</td>
</tr>
<tr>
<td>FAT</td>
<td>USER SUPPLIED FORMAT FOR REAL VALUED DATA SET</td>
</tr>
</tbody>
</table>

**REAL** 4 DATA (150), A (2), SLOPE, INTER
**INTEGER** 2 RC, COLUMNS, FAT (2), ELK/1
**LOGICAL** 1 BUFFER (2)
**EQUIVALENCE** (A (1), SLOPE), (A (2), INTER), (BUFFER (1), FAT (1))

READ USER SUPPLIED OUTPUT FORMAT AND PARAMETERS

WRITE (4, 4)

**FORMAT** (140 T10, 'PLEASE INPUT A (25.7) B (25.5) FOR THE TRANSFORMATION')
IH 11 (DEFAULT: IF ZERC, PROGRAM WILL USE LAST RECORD OF SVF) /
IH 11 A R
READ (5, 11) SLOPE, INTER
FORMAT (2F5.3)
WRITE (6, 2)
FORMAT (/ 'PLEASE INPUT # OF COLUMNS FOR OUTPUT DATA SET: (I3)' /
   ' DEFAULT: IF ZERC, PROGRAM WILL USE # COLUMNS IN SVF')
READ (5, 6) NCIL
FORMAT (12)
WRITE (6, 8)
FORMAT (/ 'PLEASE INPUT FORMAT FOR REAL VALUED DATA SET: (AOA1)' /
   ' DEFAULT: LAST RECORD OF SVF WILL BE USED')
READ (5, 1) FMT
FORMAT (AOA1)
READ AND ECHO # NUMERIC COLUMNS IN DATA FILE
READ (3), ROWCCL
ROW=TC*xCOL(1)
COL=TC*xCOL(2)
WRITE (6, 3) RCW, COLUMN
FORMAT (1HO/T10, 'RCW= ', T22, T5/1X, T10, 'COLUMNS= ', T22, T5)
IF (SLOPE .NE. 0 .OR. INTER .NE. 0) 50 TC 40
SPACE FAST TRANSFORMED DATA
DO 30 I=1, RCW
CALL REAC (IRW, COLN, 9)
READ AND ECHO PARAMETERS USED TO TRANSFORM ORIGINAL REAL DATA
READ (8) A
WRITE (6, 5) SLOPE, INTER
FORMAT (1H, 'T10, 'SLOPE= ', T19, F8.3/1X, T10, 'INTERSECT= ', T21, F8.3)
CHECK FOR USER SPECIFIED FORMAT
DO 50 I=1, 20
IF (END(I) .NE. BLNK) GC TC67
CONTINUE
NCNE FOUND USE LAST RECORD OF SVF
READ (8, END=99) FAT
FRIND 8
TRANSFORM THE DATA INTO ORIGINAL VALUES
A ROW AT A TIME
IF (NCOL .EQ. 0) NCOL=COLUMN
READ (3) A, NCIL
GO TO 10 I=1, RCW
CALL READC(IRCW, COLUMN, 9)
DO 20 J = 1, COLUMN
   DATA(J) = (IRCW(J) - INTR)/SLOPE
20 WRITE THE REAL VALUED DATA FILE

10 CALL WRITEC(DATA, NCCL, FMT, 10)
WRITE(9,14)
14 FORMW(/1100++++ S READ DATA FOR FILE","STOP 1
99 WRITE(9,100), '**** SUCCESSFUL CONVERSION TO REAL VALUED FILE ****'
90 FORMAT (110, 'FATAL ERROR: NC FORMAT SPECIFIED.
STOP 2
STOP 2
END

******************************************************************
* THIS SUBROUTINE READS A SVF FORMAT FILE
******************************************************************

SUBROUTINE READC(IRCW, COLUMN, UNIT)
INTEGER*4 COLUMN
INTEGER*2 IRCW(COLUMN)
READ(UNIT) IRCW
RETURN
END

******************************************************************
* THIS SUBROUTINE WRITES THE REAL VALUED DATA
* WITH A USER SPECIFIED FORMAT
******************************************************************

SUBROUTINE WRITEC(DATA, COLUMN, FMT, UNIT)
INTEGER*4 COLUMN
REAL*4 DATA(COLUMN), FMT(20)
WRITE(UNIT, FMT) DATA
RETURN
END
APPENDIX 2
CLISTS

A. CLIST FOR SAS2GIS

```
PROG O INFILE (REAL.DATA) OUTFILE (SAS.GIS)
CALLOC DA (&INFILE.) F(FT08F001)
ALLOC DA (&OUTFILE.) N SP (10, 1) TR U (GIS)
CALLOC DA (&OUTFILE.) F (FT10F001)
DO SAS2SVF LIB (PROG.LOAD)
```

B. CLIST FOR GIS2SAS

```
PROG O INFILE (SAS.GIS) OUTFILE (REAL.DATA)
CALLOC DA (&INFILE.) F (FT08F001)
CALLOC DA (&OUTFILE.) N SP (10, 10) TR U (FORT)
CALLOC DA (&OUTFILE.) F (FT10F001)
ALLOC DA (*) F (FT05F001)
ALLOC DA (*) F (FT06F001)
DO SVF2SAS LIB (PROG.LOAD)
```
APPENDIX 3

AN EXAMPLE OF THE OUTPUT FROM THE INTERACTIVE PROGRAMS, SAS2GIS AND GIS2SAS. PROGRAM OUTPUT IS IN UPPERCASE AND USER INPUT IS IN LOWERCASE LETTERS.

A. EXAMPLE OF RUNNING SAS2GIS

sas2gis infile (real.data) outfile (elev2.svf)

INPUT: ROW COLUMN A B MIN MAX NEW_MIN NEW_MAX TOLERANCE MISS VAL NEW_VAL USING.
(215, 2F5.0, 2F5.0, 2F7.0, F5.0, 2F6.0)

... 5 ... 10 ... 15 ... 20 ... 25 ... 30 ... 35 ... 40 ... 45 ... 50 ... 55 ... 60
+ + + + + + + + + +
36 48 1 . 0 .

ROWS = 36
COLUMNS = 48
SLOPE = 1.000
INTERCEPT = 0.0

PLEASE INPUT FORMAT OF REAL VALUED DATA
(10f8.0)

+++ SUCCESSFUL CONVERSION TO ESRI SVF FILE ++++
IH00021 STOP 1
CONDITION CODE = 01

B. EXAMPLE OF RUNNING GIS2SAS

gis2sas infile (elev.svf) outfile (real.data)

PLEASE INPUT A (F5.0) B (F5.0) TERMS WHICH WILL BE USED TO MAKE THE TRANSFORMATION
(DEFAULT: IF ZERO, PROGRAM WILL USE LAST RECORD OF SVF)

A B
... + ... +
1 . 0 .

PLEASE INPUT # OF COLUMNS FOR OUTPUT DATA SET: (13)
DEFAULT: IF ZERO, PROGRAM WILL USE # COLUMNS IN SVF

PLEASE INPUT FORMAT FOR REAL VALUED DATA SET: (80A1)
DEFAULT: LAST RECORD OF SVF WILL BE USED
(10f8.0)
ROWS = 36
COLUMNS = 48
SLOPE = 1.000
INTERCEPT = 0.0

++++ SUCCESSFUL CONVERSION TO REAL VALUED FILE ++++

IH0002I STOP 1
CONDITION CODE = 01