

OUTLINE OF BASIC PROCEDURES FOR
REMOTE SENSING INFORMATION SUBSYSTEM (RSIS)
ANALYSIS OF LANDSAT DATA

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REFLECTANCE DATA DISPLAY

- I. Locate Area of Interest
 - A. Use 7-inch Landsat transparency
 1. Overlay with grid showing strips within each scene, lines and samples (fig. 1)
 2. Select line and sample numbers (fig. 1)
 - B. Determine origin which will display that window from desired center point
 - C. Record line and sample number of origin for entry in ORIGIN, SCAN, command of CLRTAB
 - D. Note that bottom 30 lines of data are not displayed during image analysis because this space is used to display the current color table and the spectrum of colors for color change
 1. These data can be displayed at any stage of the analysis with color changes included up to that stage
- II. Run LARSYS Histogram Processor
 - A. Review output to understand frequency distribution of pixels among radiance values of 0 to 62
 - B. Consider grouping of radiance value classes
 1. Radiance values with large associated numbers of pixels should be assigned a unique color from the 98 available, even if only one radiance value apart
 2. Select highly contrasting colors for large, important pixel groups
 - a. green-to-blue gradations are very difficult to distinguish

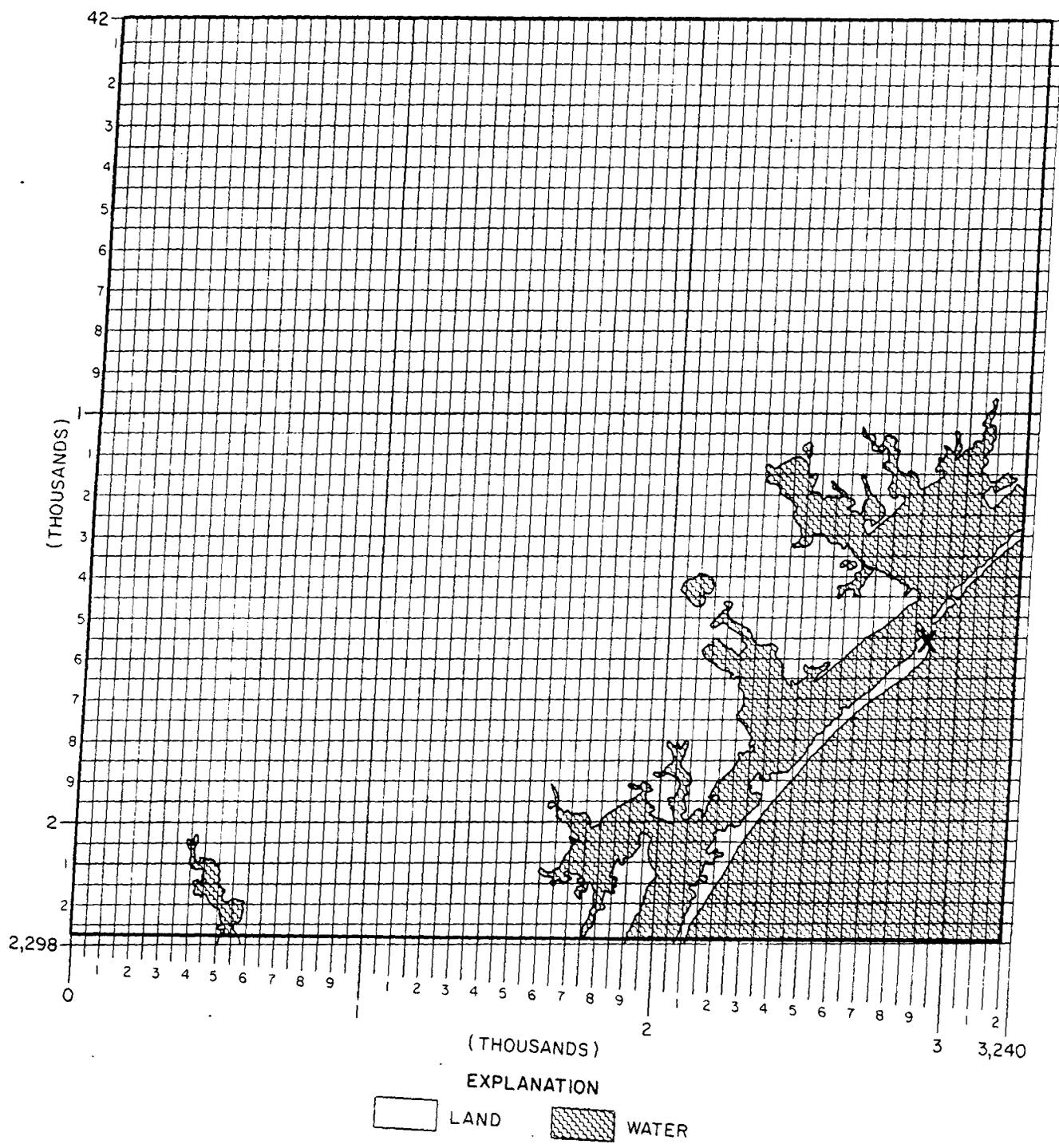


Figure 1. A 7½-inch Landsat image with line and sample overlays used to select coordinates for the origin of a selected window. In this example, the coordinates of the point marked with an "X" near Pass Cavallo (lower right) are line 1,550, sample 2,900.

- b. gradations of green-yellow are very difficult to distinguish

III. Set Up Ramtek Display Tape Using CLRTAB

- A. Review major user commands in section 2.0, Univac Software User's Guide
 1. Four files would be created in order to view each of the four Landsat channels
- B. Assign colors from 98 current valid color gun settings
 1. Select colors based on analysis of histogram processor output

IV. Display and Analyze CLRTAB Output on Ramtek

- A. Operator assists in bringing up Interdata/Ramtek system
- B. Display review by analyst using all procedures and options of the Interim Interactive Graphics Subsystem as described in the IIGS User's Guide
 1. Files will normally be on tape so the procedure that is required after IIGS outputs Query 3 is
 - a. answer "Y" to Query 3
 - b. continue query sequence
 - c. file numbers require two digits, such as 01, 02, 03
 2. User-supplied initialization has not been utilized yet
 3. The major part of analyst activity is related to Action 2: COLOR TABLE REPORT/CHANGES REQUIRED, using color bars displayed
 4. Analyst may request a printed RSIS CURRENT COLOR TABLE REPORT

- a. before replying "Y" to: DOES USER WANT THE CURRENT COLOR TABLE OUTPUT TO A PRINT FILE, use break key
 - b. enter "COPYA RAM2:COLOR.DAT,PR:"
 - c. turn on printer
 - d. respond "Y" to item a above
5. File heading as entered during CLRTAB run will be output at head of color table report
- a. the color number on the report correlates with colors on the current color display, as read from left to right
 - b. color number 1 is black, the background for the CRT display
 - c. in a sequence of pixel radiance values from 0 to 62 where every value is represented, radiance 0 is represented by color number 2, radiance 1 by color number 3, etc.
 - d. there is, therefore, always a difference of 2 between the color number in the color table report and the sequential radiance number in the frequency table of the CLRTAB output
- C. Analyst changes color display using Action 2 in IIGS menu
1. Analyst imposes contrasting colors for major pixel groups
 - a. orange hues contrast poorly with shades of red
 - b. gradations of green and yellow-green contrast poorly
 - c. purple and green hues contrast well
 - d. an effectively contrasting sequence for water classes is: aqua - light blue - medium blue - dark blue - purple

- e. dark colors should not be assigned to clusters with less than 2 percent of the pixels
 2. Correlation between color displayed, color display bar, and its cluster assignment is facilitated by selecting a color on the Ramtek screen, answering "Y" to the query: "IS CURSOR POSITIONED TO A COLOR TO BE REPLACED?" That color will flash on screen in the color bar, and its color gun settings (table 1) are output to the terminal
 3. Review Landsat hard-copy imagery, aerial photography and/or supplementary map data to associate radiance with land cover/land use class
 4. To end display analysis under Action 2, analyst turns cursor control off, enters a "Y", and menu of five actions under Query 9 (p. 17, IIGS User's Guide) is redisplayed
- D. Analyst may save colors currently on display in a standard color file
1. Select Action "4" - Display Processing Complete (for the image presently on the CRT)
 - a. the image data are not saved on a disc file because it is already contained on the CLRTAB output tape
 - b. the analyst answers "Y" to query on saving the current color table (p. 23, IIGS User's Guide), and assigns a file name
 - c. the file name may be up to 8 characters and has the form: "RAM2:file name.COL" with no blank spaces
 2. All IIGS processing may be continued or completed

Table 1. Standard color menu used for assigning colors to clusters generated by ISOCLS program.
 Selected from original 98 colors. Unnamed colors are on a continuum
 between adjacent named colors.

Color No.	Gun Setting	Color Name	Color No.	Gun Setting	Color Name	Color No.	Gun Setting	Color Name
	R G B			R G B			R G B	
1	000015	True blue	22	000905	Pale green	43	150000	Red
2	000013		23	000704		44	110000	
3	000011		24	000503	Gray-green	45	090000	
4	000009		25	001500	Bright green	46	050000	Burgundy
5	000007		26	001100		47	030000	Red-brown
6	000005	Midnight blue	27	000700		48	150008	Hot pink
7	000003	Blue-black	28	000300	Forest green	49	110006	Light scarlet
8	000815	Light blue	29	081500	Lime green	50	090005	
9	000713	Light blue-gray	30	061100		51	050003	Magenta
10	000611		31	040700		52	150015	Mauve
11	000407		32	030500	Olive green	53	090009	
12	000305	Dark blue-gray	33	151500	Yellow	54	070007	
13	001515	Aqua	34	131300		55	050005	Lavender-mauve
14	001313		35	090900		56	080015	Lavender
15	001111		36	050500	Yellow-brown	57	060011	Light purple
16	000909		37	030300	Brown	58	040007	
17	000707		38	150800	Orange	59	030005	Dark purple
18	000505	Gray-aqua	39	130700		60	141414	Light gray
19	001508	Pale green	40	110600	Ochre	61	080808	
20	001307		41	050300	Chocolate	62	050505	Dark gray
21	001106		42	030200	Miss. brown			

- E. Processing may continue with additional files from the CLRTAB output tape
1. Analyst may create a new color table for this file by repeating IV. A-D above
 2. Analyst may impose the color changes made and saved in a previous run by answering "Y" to Query 7 (p. 16, IIGS User's Guide) and entering the file name

CLASSIFIED DATA DISPLAY

- I. Locate Area of Interest Employing Same Procedures Used in Preparing Display of Raw Reflectance Data (Reflectance Data Display, Section I. A-D)
- II. Run ISOCLS Processor to Assign MSS Data to Specific Sample Clusters (Appendix A)
 - A. Select parameters for appropriate control card options (Appendix, p. A-7)
 1. ISTOP: usual default value for number of iterations: 10
 2. NMIN: delete any clusters with fewer than 50 pixels, or more if a smaller number of clusters is desired
 3. DLMIN: any two clusters whose means are closer than this value are combined; higher DLMIN values result in fewer clusters; values less than 2.0 are usually not functional
 4. STDMAX: any cluster whose maximum standard deviation is larger than this value is split; higher STDMAX values result in fewer classes, also; values less than 3.0 tend to produce very large numbers of clusters

5. MAXCLS: set maximum number of clusters to be defined at 40
 6. Other control card parameters usually set to default values, or commonly used values at TNRIS as listed in section 4.4.4.3 of ISOCLS documentation (Appendix, p. A-6)
 7. Select line and sample spacing for clustering procedure, usually every third line and third sample; a 2 x 2 spacing would run, but every line, every sample would not due to hardware limitations. (A 2 x 2 spacing is displayed on the Ramtek at a scale of about 1:200,000)
 8. Note that when ISOCLS deletes a cluster it regroups the data into other clusters and does not delete them
- B. Review ISOCLS output and delete inappropriate classes, such as small classes with excessive standard deviations
1. Reduce number of classes to about 25 or less so as not to exceed data processing capacity of ELLTAB program
 - a. cannot exceed 20,000 words in ELLTAB look-up table
 2. Review all class statistics; these must be considered suitable before proceeding. To eliminate classes with little information, consider the following methods:
 - a. eliminate all classes with less than 1 percent of the total number of pixels
 - b. eliminate all classes with standard deviations in any channel greater than 10.0
 3. For classes to be removed, pull MN (mean) and CVA and CVB (covariance) cards (produced as part of ISOCLS output) for each cluster rejected for any reason

4. A new set of sequential class numbers will be generated by ELLTAB after cards are deleted from ISOCLS deck
5. Those clusters judged useful should be analyzed with a channel 2 versus channel 4 plot on arithmetic graph paper (fig. 2). Use mean radiance values from the table at the end of the ISOCLS output for channels 2 and 4. Multiply channel 4 values by 2 in order to adjust both channel readings to the same scale. The output should have three lines of clusters extending from a point near the channel 2 axis.

Each of these lines represents a different category of land cover types (Edward A. Weisblatt, personal communication, 1980). Clusters aligned subparallel to the channel 2 axis are water (fig. 2). Clusters aligned subparallel to the channel 4 axis are vegetation. Clusters aligned about halfway between the two axes represent substrate, and clusters between the substrate and vegetation lines are informally named "hybrid" clusters.

A color should be assigned to each cluster according to its position on the graph and its position relative to other clusters. Colors are chosen from a preselected color menu. We suggest a menu with 62 colors (table 1).

Water clusters are assigned blue colors, but all other clusters have colors that may or may not correspond to natural colors because subtle shades of green and brown are difficult to distinguish on the Ramtek. It is recommended that highly contrasting color pairs (e.g., yellow/

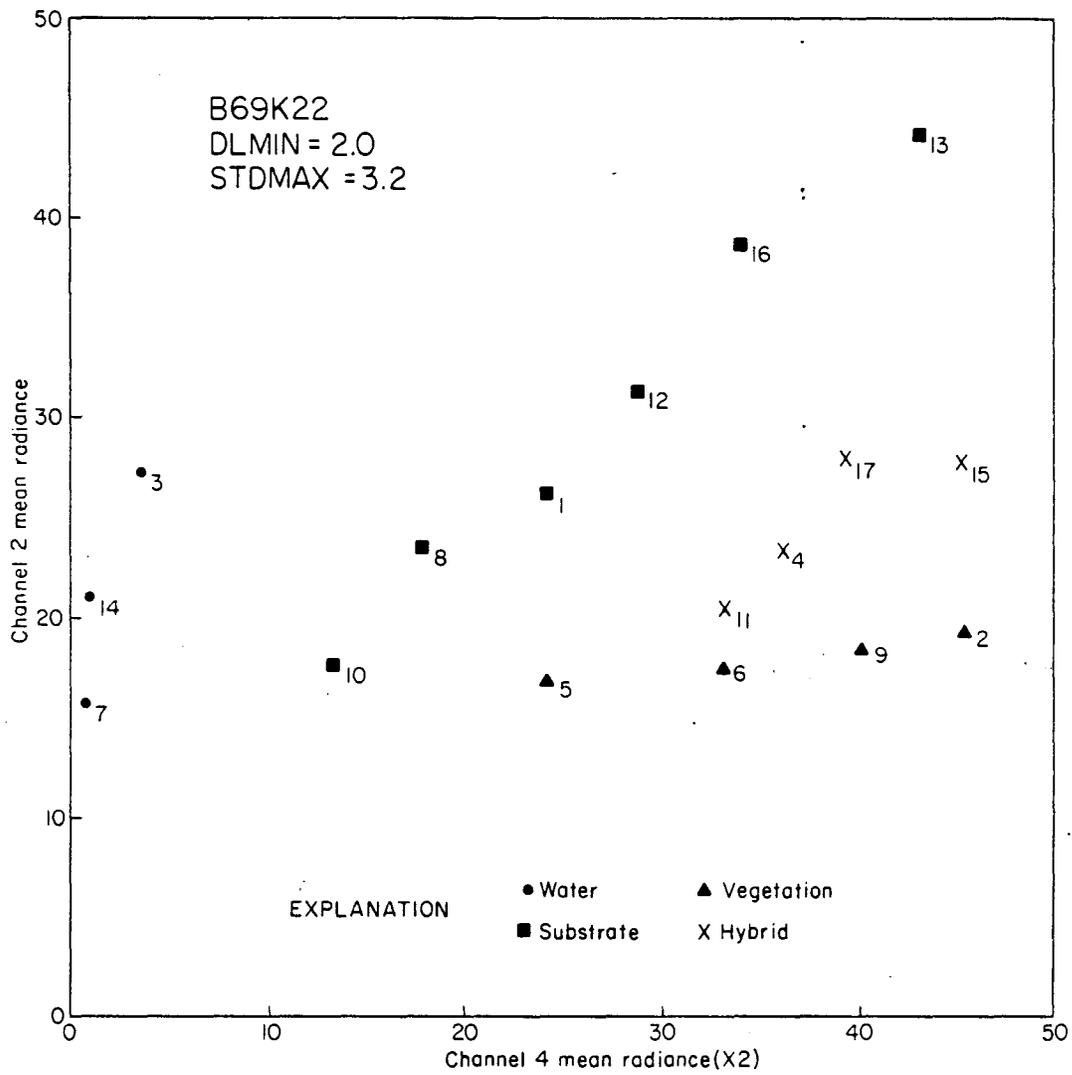


Figure 2. Channel 2 versus channel 4 mean radiance values for an ISOCLS run with 17 clusters. Channel 4 values are doubled to adjust to scale on y-axis. Each cluster falls into one of four major categories: water, vegetation, substrate, or hybrid. Radiance values range from 0 to 127 on Landsat computer tapes.

purple, brown/red, green/purple) be assigned to neighboring clusters, and that dark colors not be assigned to clusters with fewer than 2 percent of the pixels. In general, colors with gun settings (table 1) which are less than two units different are difficult to distinguish, especially when separated by large areas of other colors.

- III. Create ELLTAB Look-Up Table Based on ISOCLS Output (Appendix, p. A-12)
- IV. Run ELLTAB for Entire Data Window
- V. Prepare for Analysis and Set Up Ramtek Display Tape Using CLRTAB
 - A. Review major user commands in Section 2.0, Univac Software User's Guide
 1. Follow steps IV. A and IV. B. 1-4, listed in procedures, to prepare display of raw reflectance data and to bring up image on Ramtek CRT
- VI. Analyze Data Using Capabilities of Interim Interactive Graphics Subsystem (IIGS)
 - A. Review channel 2 versus channel 4 radiance plots, as well as other band combinations (fig. 2)
 1. A plot of mean radiance (y-axis) against each channel, 1 through 4, (x-axis) illustrates changes in reflectance between clusters and over all channels (fig. 3)
 2. Water, bare substrate, and vegetation clusters have distinctive shapes to their spectral reflectance curves

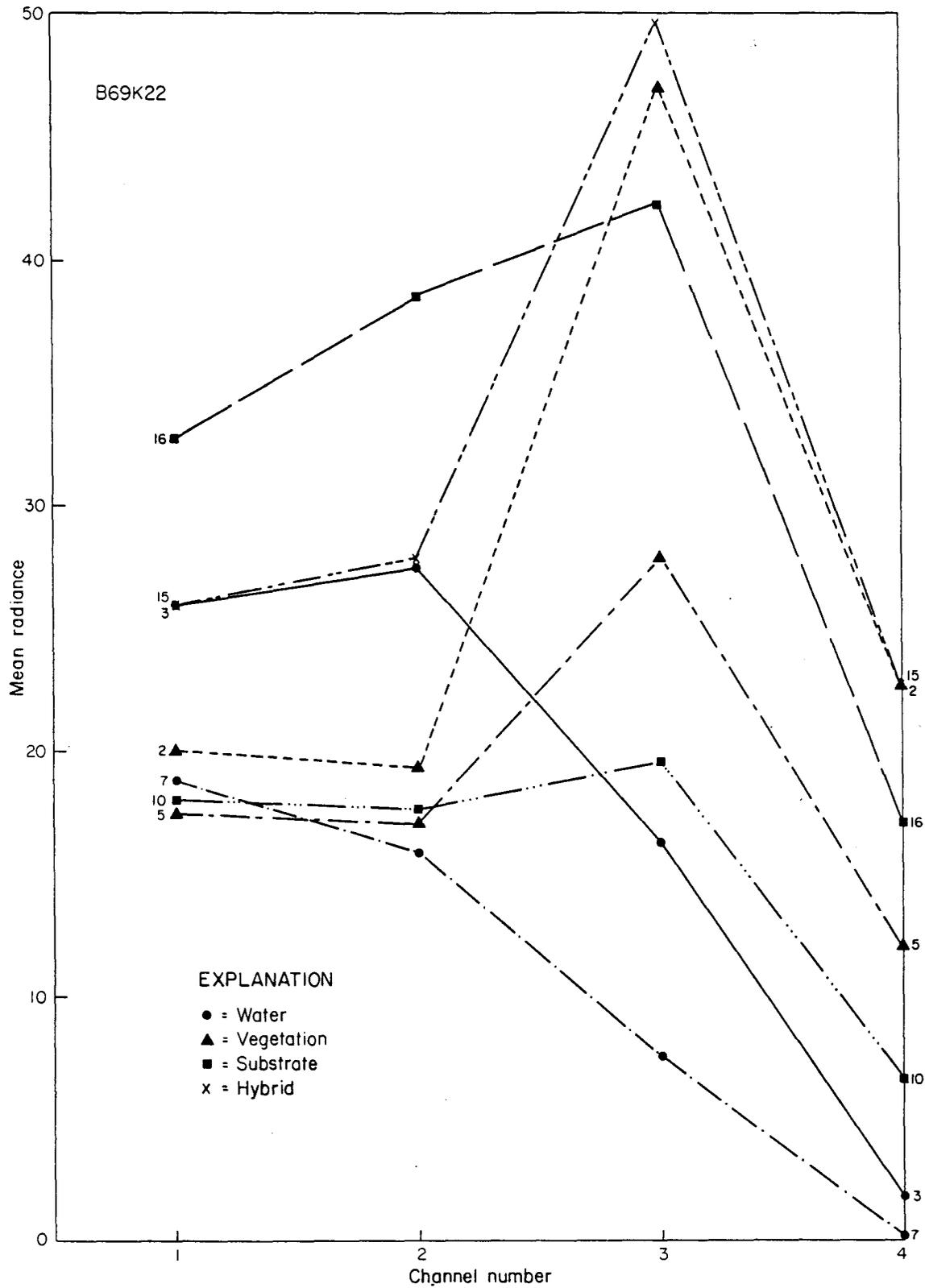


Figure 3. Mean radiance versus Landsat channel for selected clusters in run B69K22. Clusters 7 and 3 represent clear and turbid water, respectively. Cluster 2 is rangeland with high IR reflectance, and cluster 5 is trees with low IR reflectance. Clusters 10 and 16 represent low and high IR reflectance substrate types, such as wet, barren, muddy soil, and dry, sandy, or shell-covered surfaces. Cluster 15 represents a hybrid cluster, a mixture of substrate and vegetation reflectance values.

3. Associate clusters based on spectral characteristics and spatial relationships of the image data
- B. At the Ramtek refine image using display processing capabilities of IIGS, usually attempting to reduce the number of different-colored classes, and associating clusters with land cover or land use
1. Review Landsat hard-copy imagery, aerial photography, and/or supplementary map data to associate spectral clusters with land cover/land use classes
 2. Analyst should keep running notes on color changes made; it may be desirable to reverse some changes in a later stage of the analysis
 3. To end display analysis under Action 2, analyst turns cursor control off, enters a "Y", and menu of five actions under Query 9 (p. 17, IIGS User's Guide) is redisplayed
- C. Analyst may save colors currently on display in a standard color file
1. Select Action "4" - Display Processing Complete (for the image presently on the CRT)
 - a. the image data is not saved on a disc file because it is already contained on the CLRTAB output tape
 - b. the analyst answers "Y" to query on saving the current color table (p. 23, IIGS User's Guide), and assigns a file name
 - c. the file name may be up to eight characters and has the form: "RAM2:file name.COL" with no blank spaces

- d. if the user does not know what names have already been used, he must find out before assigning a name to the file he wishes to save; to do this he inputs "RAM2:NONE" in response to the query "FILE NAME="; the program then will display all file names already used
2. All IIGS processing may be continued or completed
 3. Analyst may save color files sequentially as data are processed rather than retaining only the "final" image display
 - a. saving intermediate color files allows for easy reversal of class combinations and sequential color file review at later stages of processing
 - b. intermediate color files can be reproduced in hard-copy format as documentation of analytical steps
 - c. intermediate color files can be applied sequentially to other windows being analyzed for the same objectives
 4. Analyst may rapidly review color files representing sequential stages in the analysis by repetitively utilizing Action 5 under Query 9 (p. 17, IIGS User's Guide)
 - a. attempts to load a standard color file in answer to Query 7 (p. 16, IISG User's Guide) do not bring up color files saved as part of analytical processing
- D. Processing may continue with additional files from the CLRTAB output tape; file numbers always have two digits: 01, 02, etc.
- E. Image analysis may suggest changes in ISOCLS control card parameters which may be implemented on successive classification runs

APPENDIX A
ISOCLS PROCEDURES AND RSIS RUNSTREAMS

APPENDIX A
ISOCLS PROCEDURES AND RSIS RUNSTREAMS

RSIS Runstreams

There are two basic runstreams used by the present RSIS procedure; for convenience, these will be identified as runstreams 1 and 2. The runstreams are set up on card decks and submitted to the TDWR Computation Center. Following is a flowchart and short description of each runstream.

The procedure described here is only one of many ways that RSIS software can be used; as the analyst becomes more familiar with the capabilities of RSIS (and when those capabilities are fully realized), he/she will certainly want to develop new procedures.

Runstream 1

The only program executed in this runstream is ISOCLS. The analyst can use this runstream as often as he/she wishes for the same window, varying the set of input parameters to find those sets which result in potentially useful sets of clusters.

An explanation of the operation of ISOCLS is contained in the accompanying excerpt from the NASA/JSC/EOD-LARSYS User Documentation Manual.

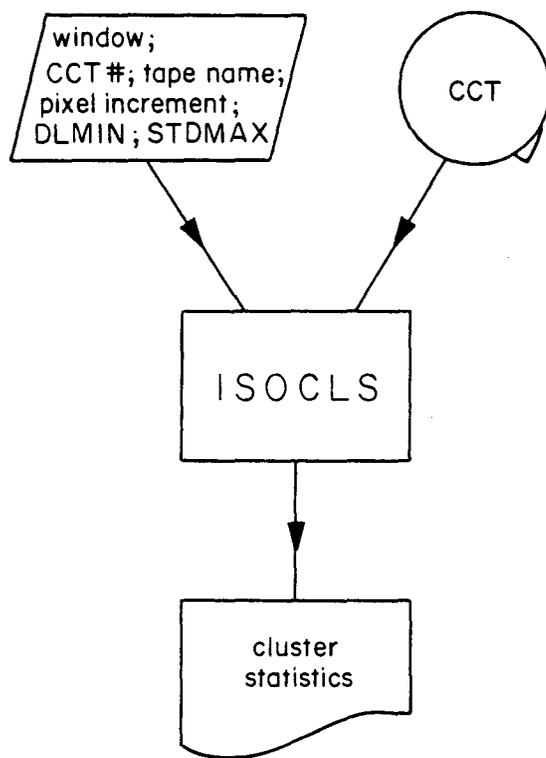


Figure A-1. Runstream 1.

4.4 ISOCLS Processor

The clustering procedure used in ISOCLS is an iterative procedure which assigns each MSS data sample to a specific cluster by determining the nearest (in absolute distance) cluster center and assigning the sample to it. At the end of each iteration (i.e. when all samples have been assigned to a cluster), the cluster centers are redefined by computing the mean vector for the data samples actually assigned to the cluster. Clusters are split and combined on alternate iterations according to user specified threshold values (see STDMAX and DLMIN control cards - Section 4.4.4.3).

The procedure terminates only when the maximum number of iterations occurs. The user may control the number of iterations with the control card ISTOP. The user also has control over the maximum number of clusters via the control card MAXCLS. When the maximum number of clusters has been reached cluster splitting is discontinued.

After the final iteration, the covariance matrix for each cluster is computed and output. Chaining of clusters for the final map print-out is performed only if the user has requested the option (see CHAIN control card). Statistics for the chained clusters are not computed.

The processor allows the user to control the amount of line-printer output he receives via the MAP and KRN control cards. A final map of the clustered data is always output along with a statistical summary of the clusters. The summary includes mean and standard deviation vectors, total points assigned to each cluster and intercluster distances.

The user may optionally input initial cluster centers to hasten the clustering process (see control card MEANS, Section 4.4.4.3 and Cluster MEAN deck Section 3.1.4.3), or he may allow the program to initialize the

process by assigning all the data to one cluster, obtaining the mean and standard deviation, then splitting. For the first execution of ISOCLS in a particular run, if initial means are input they must be input by cards (Cluster MEANS Deck - Section 3.1.4.3). Each execution of ISOCLS causes the ISOFIL (Section 3.3.6) file to be written with updated cluster means. Successive executions of ISOCLS may or may not use this file to initialize cluster centers for a new data set to be clustered. The control cards [sic] MEANS (Section 4.4.4.3) allows the user to request cluster centers from the last previous execution of ISOCLS to be read from the file and used as initial centers for a new data set.

4.4.1 Input Files

The INPUT/OUTPUT file ISOFIL is an internal file used only by ISOCLS. The internal file contains the updated mean vector for each cluster. Like the cluster MEANS deck, ISOFIL may be used (optionally) to initialize cluster centers for any call to the ISOCLS processor except the first call. To use the cluster centers from a previous execution of ISOCLS to initialize the procedure for a new data set the control card 'MEANS FILE' must be included in the deck setup.

For the means file logical unit 0 (Fortran unit 18) must always be assigned to Fastrand or tape when executing ISOCLS. The file cannot be allowed to default to drum.

A MSS image data tape (Formats Section 3.2) must be assigned to logical unit C (Fortran unit 3).

4.4.2 Output Files

A cluster map tape may optionally (control card OPTIONS DAS) be generated for displaying the results of the clustering on the PMIS DAS.

Logical unit N (Fortran unit 16) should be assigned to a 9-track tape drive when this option is exercised. See Section 3.4.1.

The statistics of the clusters may optionally be written on tape (control card OPTION ERIPS). This tape is an interface between the ISOCLS processor and a preprocessor for the Earth Resources Interactive Processing System (ERIPS). See Section 3.4.2.

Logical unit M (Fortran unit 15) should be assigned to a 7-track tape drive with the BCD converter option when this option is exercised. Example assign card (@C ASG M = tape #).

A cluster mean file is created on logical unit 0 (Fortran unit 18). (See sections 4.4.1 and 3.3.6).

4.4.3 Scratch Files

The program dynamically assigns drum storage on logical units D and E (Fortran units 4 & 7) for the image data. Any other processor requiring one of those units as a scratch file cannot be executed with ISOCLS in the same run. In addition all other required files must be assigned to either Fastrand or tape.

4.4.4 Card Input

4.4.4.1 Processor Card

Indicates to the monitor routine which processor to call. The key word is left justified starting in column 1.

<u>Keyword</u>	<u>Function</u>
\$ISOCLS	Causes all routines used by the ISOCLS processor to be loaded into the system.

4.4.4.2 System Card Deck

The processor will read a 'Cluster Means Deck' in the format defined in Section 3.1.4.3. The deck may be used to initialize cluster centers for the clustering procedure.

4.4.4.3 Control Cards

Allows the user to input various options. These cards are identified by a key word that is left justified in columns 1-10 of the card, with parameter value(s) or additional key words in column 11-72 (beginning in any column past 10). These control cards may be in any order, but they must be the first cards after the processor card \$ISOCLS. The following is a list of all available options along with the default value.

<u>Keyword</u>	<u>Parameter Value</u>	<u>Function</u>
CHANNELS	C ₁ , C ₂ , C ₃ , . . . (DEFAULT: none)	Channels to be used in clustering C ₁ , C ₂ , C ₃ , . . . should be integer numbers separated by commas. If Cluster MEANS deck is input, channels on this card must be a subset of channels in MEAN deck. If internal file ISOFIL is input, channels should be a subset of channels on internal file created by previous call to ISOCLS processor.

<u>Keyword</u>	<u>Parameter Value</u>	<u>Function</u>
OPTION	DAS (DEFAULT: no DAS tape)	Creates a DAS tape for PMIS. DAS on unit N(16). A 9-track tape must be assigned to unit N in the deck setup.
OPTION	ERIPS (DEFAULT: no ERIPS tape)	Creates a BCD tape for the ERIPS preprocessor on unit M(15). A 7-track tape must be assigned to unit M with the BCD converter on.
OPTION	PUNCH=N (DEFAULT: If PUNCH omitted no cards are punched; if N is omitted it defaults to 1	Punches the means and covariance matrix for each cluster in the Module STAT deck format defined in Section 3.1.4.1. N=1 - Punch Module STAT deck N=2 - Punch ERIPS interface deck N=3 - Both decks punched
SYMBOLS	S_1, S_2, S_3, \dots [DEFAULT (1, 2 . . . 9, A, B . . . Z, %, #, Δ , /, -, *, +, \$, @, =, &, ?, ', ., blank)]	Symbols used to identify clusters in the printout.
ISTOP	N (DEFAULT = 10)	Perform N iterations in the clustering procedure and stop.

<u>Keyword</u>	<u>Parameter Value</u>	<u>Function</u>
NMIN	N (DEFAULT = 50)	Delete any cluster with fewer than N members.
DLMIN	X (DEFAULT = 2.0)	Combine any two clusters whose means are closer than X units.
SEP	X (DEFAULT - maximum of the channel's standard deviations in the cluster)	Upon splitting a cluster, separate the new clusters by a distance of X units.
STDMAX	X (DEFAULT = 3.0)	Split any cluster whose maximum standard deviation is greater than X units.
MAXCLS	N (DEFAULT = 50)	Maximum number of clusters. N must be less than or equal to 50.
KRN	N (DEFAULT = 10)	Print out a summary of the clusters at every Nth iteration.
MAP	N (DEFAULT = 20)	Print out a map of the clustered data along with the summary every Nth iteration. A final cluster map is printed regardless of this parameter.

<u>Keyword</u>	<u>Parameter Value</u>	<u>Function</u>
CHAIN	X (DEFAULT: chaining not performed)	Chain all clusters within X units of each other to form one cluster. Chaining of clusters affects only the final map print-out and DAS tape.
HED1	Any 60 characters beginning in col. 11 (DEFAULT: LYNDON B. JOHNSON SPACE CENTER)	Replace first line of the standard heading with indicated 60 char- acters.
HED2	Any 60 characters beginning in col. 11 (DEFAULT: HOUSTON, TEXAS)	Replace second line of the standard heading with indicated 60 char- acters.
COMMENT	Any 60 characters beginning in col. 11 (DEFAULT: no comment)	Print the indicated comment along with the header.
DATE	Any 12 characters beginning in col. 11 (DEFAULT: present date)	Print the indicated 12 characters in the heading in place of the current date.

<u>Keyword</u>	<u>Parameter Value</u>	<u>Function</u>
MEANS	CARDS (DEFAULT: clustering procedure automatically initialized if this deck of 'MEANS FILE' not input)	Triggers input of the Cluster MEAN deck defined in Section 3.1.4.3. This deck is used to initialize cluster centers for the clustering procedure.
MEANS	FILE (DEFAULT: cluster centers are automatically initialized if this card or the 'MEANS CARDS' not input.)	Indicates means for initial clusters are on internal file which was created by a previous call to ISOCLS processor, the mean vectors on the file are to be used to initialize the process for a new data set.
END	(Blank)	Indicates the end of control cards.
\$END*		Indicates the end of all input for this call to ISOCLS.

Runstream 2

This runstream creates a class file with classes corresponding to the statistical clusters derived from ISOCLS. The class file is prepared for display on a video screen; specifications such as scale and colors are made by the analyst. The final produce is a file on a magnetic tape which can be read by the Interim Interactive Graphics Subsystem (IIGS) to generate a display on the Ramtek unit.

Runstream 2 uses these programs:

ISOCLS	generates cluster statistics for a specified window according to a set of specified parameters.
SHUFFLE	is a minor routine that rearranges the cluster statistics file for use by TABLE.
DELETE	allows the analyst to delete any subset of clusters from ISOCLS.
TABLE	builds a look-up table file which is used by ASSIGN.
ASSIGN	classifies data in a specified window according to the look-up.
CONTROL	establishes transformation matrix for the Landsat scene; used by CLASSIFY.
CLASSIFY	reformats data to produce a geographic registered file.
CRLCLASS	generates a Ramtek tape file with scale, colors, etc. defined by analyst.

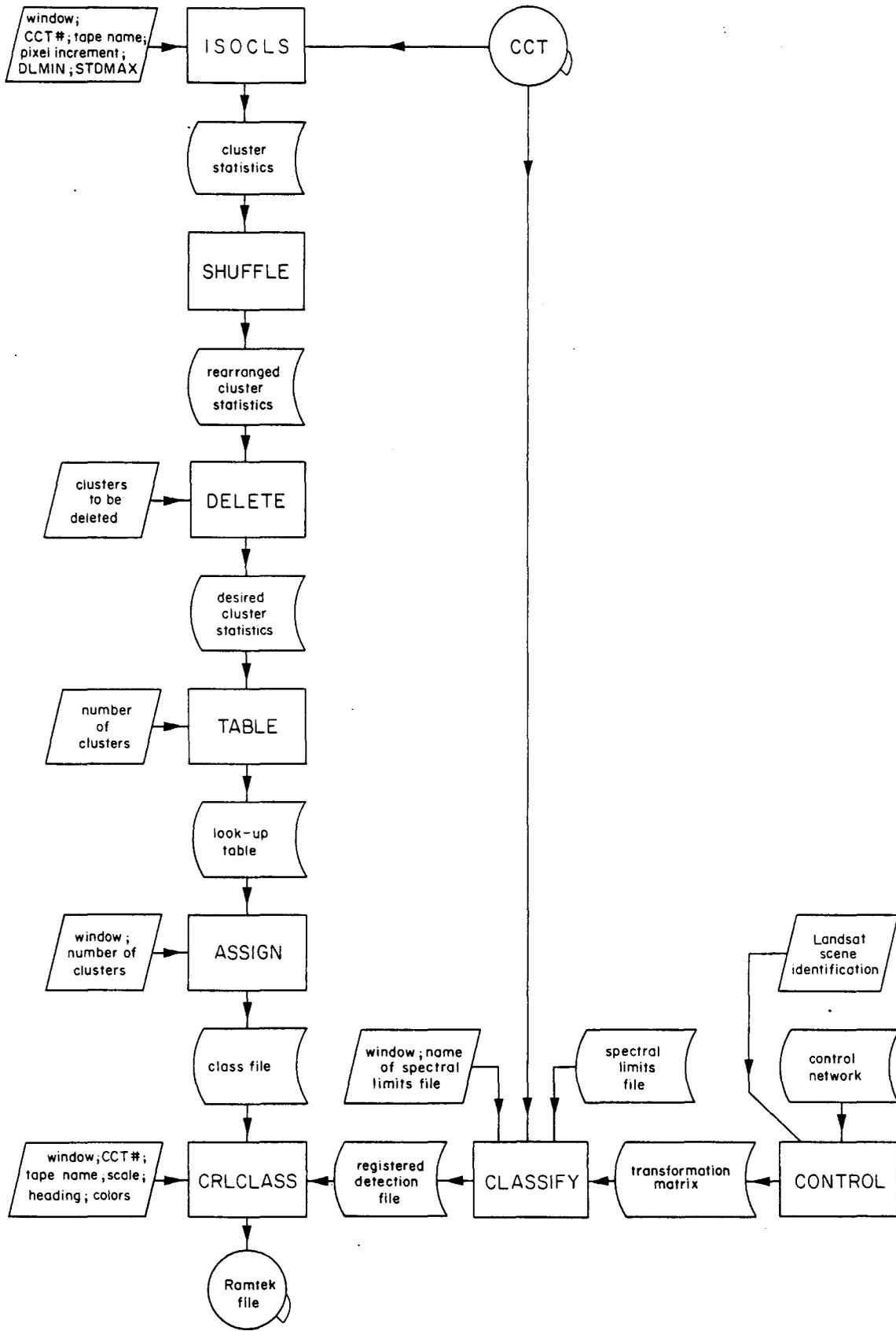


Figure A-2. Runstream 2.

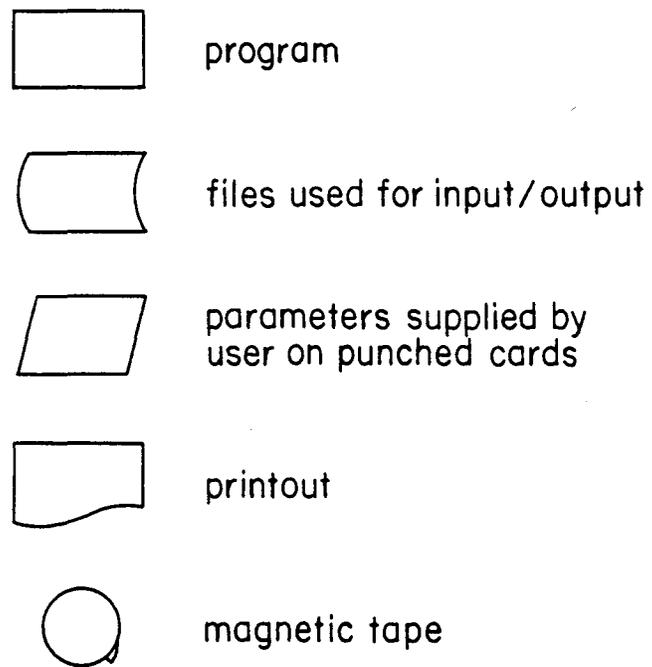


Figure A-3. Symbols used in figures A-1 and A-2.