
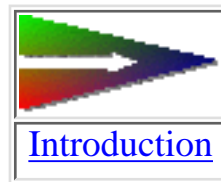


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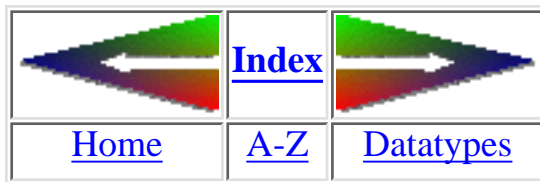
ATTENTION: to get the most out of these tutorial pages you'll need a javascript enabled browser, I did not test the pages against Netscape or Microsoft browser generations below version 4

More and more pages will be enriched with Macromedia Shockwave a/o Shockwave Flash animations or interactivities. To get the most

out of these pages, you should have the [Shockwave Flash / Shockwave plugins](#) installed.

**** The Author ****

last modified: Wednesday, 07-Apr-99 02:47:38 MET DST | [Comments to Eric J. LORUP](#)



Introduction

After a long time having announced this tutorial I have decided to build this IDRISI guide piece by piece now. Putting it together like modules makes it somewhat similar to the IDRISI package, which consists of approximately 120 single programs, called 'modules'.

IDRISI is a rasterbased GIS & image processing software serving a broad range of tasks. Its [filestructure](#) is rather simple and transparent such making it easy to cope with.

The tutorial will try to give you an overview to IDRISI's capabilities, and show you some ways how to solve spatial problems. It cannot replace the shipped manual(s) or the online helpsystem for the technical reference, and by no means this tutorial claims completeness!

It offers you two ways to discover: the pages are arranged in a somewhat linear sequence. You will find four direction-links at the top/bottom of each page. The left one guides you back to a previous page (not always strictly the last one) and the right lets you go on. Clicking the 'Index'-link points you to a page with the tutorial contents plus short descriptions of all issues, and finally the 'A-Z'-link puts you to a summary of all IDRISI modules, either alphabetically or thematically.

Each page shows the last-modified-date and a mail link for sending comments to the author.

This guide does not intend to teach you GIS-principles, so I presuppose a basic knowledge of GIS-terminology. Having access to an IDRISI license will be very helpful but not necessary. With a view to avoid heavy net-loads, I try to spare with graphics, and resize them to just legible. The ftp-downloadable tutorial version is likely to operate more prodigal (higher resolution graphics, animation sequences) - not released yet.

If you have problems to read the tutorial, it could be attributed to a WWW-viewer which cannot handle specific HTML-commands. I have implemented some inofficial HTML 3.0-extensions. For testing and developing I use Netscape Navigator together with WIN/NT 3.51 and WINDOWS 95.



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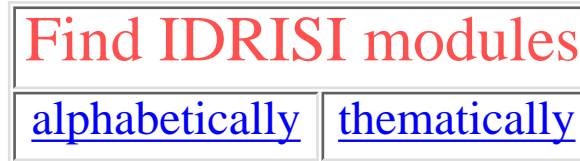
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IDRISI Program Modules

it's your choice:



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IDRISI Modules A - Z



pick the little *i* to return to the index * * * in which menues to find the module

<u>i</u>	ALLOCATE Analysis/Distance Operators	Performs spatial allocation using either DISTANCE or COST surfaces.
<u>i</u>	ARCIDRIS File/Import-Export/Software-Specific Formats	Converts files to and from Arc/Info GENERATE/UNGEN format.
<u>i</u>	AREA Analysis/Database Query	Creates a new image by giving each output pixel the value of the area of the class to which the input pixel belonged. Output can also be produced as a table or an attribute values file in a range of measurement units.
<u>i</u>	ASSIGN Analysis/Database Query Data Entry	Creates an image from an attribute values file by assigning the data values contained in the attribute values file to the cells belonging to defined regions. ASSIGN can also be used to reclassify integer images.
<u>i</u>	ATLIDRIS File/Import-Export/Software-Specific Formats	Converts ATLAS BNA files to IDRISI vector format.
<u>i</u>	AUTOCORR Analysis/Statistics	Computes Moran+s -I+ first lag autocorrelation statistic for an image, along with confidence tests. Non-rectangular regions can be analyzed by defining a binary mask.
<u>i</u>	BATCH324 DOS version only	Converts groups of Version 3 data files to Version 4 format.

<i>i</i>	BAYES Analysis/Decision Support	evaluates Bayes' Theorem. Multiple evidence maps (such as that produced by PCLASS) are permitted as long as they are conditionally independent. Prior probabilities may be input in map form (and thus, like the evidence maps, may vary continuously over space). The user is also able to specify the confidence in the decision rule, I. e., the belief that the evidence supportive of the hypothesis is truly reflected in the evidence at hand -- $p(e e')$. BAYES is an extension to what is sometimes called a <i>Bayesian Weight of Evidence</i> approach.
<i>i</i>	BBKIDRIS File/Import/US Government Data Formats	Converts National Survey Blue Book format (*80* and *81* records) to IDRISI vector format.
<i>i</i>	BILIDRIS File/Import/General Conversion Tools	Converts generic band-interleaved by line images to IDRISI format.
<i>i</i>	BIPIDRIS File/Import/General Conversion Tools	Converts generic band-interleaved by pixel images to IDRISI format.
<i>i</i>	BMPIDRIS WINDOWS version only File/Import-Export/Desktop Publishing Formats	BMPIDRIS converts bitmaps from graphics packages which support the .bmp format into IDRISI for Windows images and vice versa. BMPIDRIS should be used as a companion to WMFIDRIS for the conversion of vector images.
<i>i</i>	CENTER Analysis/Statistics	Computes mean center (weighted or not) of a point distribution and standard radius (the two-dimensional equivalent of a standard deviation).
<i>i</i>	CLUSTER Analysis/Image Processing	Performs unsupervised classification.
<i>i</i>	COLOR DOS version only	Produces color output of raster images with integrated vector display on EGA, VGA and SuperVGA graphics systems. COLOR also provides interactive inquiry, on-screen digitizing, interactive zoom, vector file overlay, interactive palette selection and adjustment and interactive legend editing. With SuperVGA graphics adaptors, high resolution displays (up to 1024 ´ 768) of color composite images (256 color) can be produced.(in WINDOWS version: DISPLAY LAUNCHER)
<i>i</i>	COLOR85 DOS version only	A special version of COLOR for the 8514/A graphics adaptor capable of displaying color composite images (256 color) at high resolution (1024 ´ 768) (in WINDOWS version: DISPLAY LAUNCHER)

<i>i</i>	COLSPACE <i>Analysis/Image Processing</i>	Performs HLS/RGB color space transformations.
<i>i</i>	COMPOSIT <i>Analysis/Image Processing</i>	Produces color composite images.
<i>i</i>	CONCAT <i>Reformat</i>	Concatenates multiple images to produce a larger image.
<i>i</i>	CONFIG DOS version only	A hardware configuration utility.
<i>i</i>	CONTRACT <i>Reformat</i>	Reduces image resolution by pixel thinning or aggregation.
<i>i</i>	CONV3TO4 <i>File/Import</i>	Converts Version 3 data files to Version 4 format.
<i>i</i>	CONVERT <i>Reformat</i>	Converts between all of the image storage formats supported by IDRISI. Files may be converted to any combination of the byte, integer and real (floating point) data types and the ASCII, binary and packed (run-length encoded) file structures.
<i>i</i>	COPY WINDOWS version only	COPY provides the file management capability of copying IDRISI for Windows data files.
<i>i</i>	COST <i>Analysis/Distance Operators</i>	Generates a distance/proximity surface where distance is measured as the least cost distance in moving over a friction surface.
<i>i</i>	CRATIO <i>Analysis/Statistics</i>	Computes the compactness ratio of polygons given corresponding area and perimeter images.
<i>i</i>	CRLF <i>File/Import/General Conversion Tools</i>	Adds or removes carriage return and line feed symbols.
<i>i</i>	CROSSTAB <i>Analysis/Database Query</i> <i>Analysis/Statistics</i> <i>Analysis/Change-Time Series</i>	Performs image crosstabulation and crosscorrelation.
<i>i</i>	CTG <i>File/Import/US Government Data Formats</i>	Imports USGS CTG (Composite Theme Grid) data files into IDRISI.
<i>i</i>	DATABASE WORKSHOP WINDOWS version only <i>Analysis/Database Query</i>	DATABASE WORKSHOP provides IDRISI for Windows with an integrated relational database management system.

<i>i</i>	DBIDRIS DOS version only	Used to import dBASE files into IDRISI values files, and move IDRISI values files back into dBASE format.
<i>i</i>	DECOMP Analysis/Distance Operators	Decomposes a force vector (as a magnitude and direction image pair) into X and Y component images. Also takes X and Y component images and produces a force vector image pair.
<i>i</i>	DELETE WINDOWS version only	DELETE provides the file management capability of deleting IDRISI for Windows data files.
<i>i</i>	DEMIDRIS DEM in WINDOWS version File/Import/US Government Data Formats	Reads USGS 1:24,000 and 1:250,000 Digital Elevation Models.
<i>i</i>	DESCREF DOS version only (in WINDOWS version integrated in DESCRIBE)	Describes the contents of a reference system parameter file.
<i>i</i>	DESCRIBE	Describes the contents of any image, vector or values files.
<i>i</i>	DESTRIPE Analysis/Image Processing	Removes band striping due to variable detector output.
<i>i</i>	DISPERSE Analysis/Distance Operators	DISPERSE is a companion to VARCOST that calculates dispersion distances. The procedure is essentially the same as that of VARCOST except that the emphasis is on forces acting to disperse a body (e. g., a point-source contaminant spill) and the time taken to disperse it to a specified distance. DISPERSE is released as an experimental module in Version 4.1 and all users are invited to comment upon their experiences with this procedure and provide suggestions for modifications.
<i>i</i>	DISPLAY LAUNCHER WINDOWS version only	DISPLAY LAUNCHER is the module that allows you to open a new display window.
<i>i</i>	DISPLAY DOS version only	A universal display routine using ASCII characters.
<i>i</i>	DISTANCE Analysis/Distance Operators	Calculates the distance/proximity of each pixel to the nearest of a set of target pixels.
<i>i</i>	DLG File/Import/US Government Data Formats	Scans and extracts features from USGS DLG (Digital Line Graph) files into IDRISI vector format.

<i>i</i>	DOCUMENT	Creates a documentation file for a new imported data file, or revises the documentation files of an existing data file.
<i>i</i>	DUMP File/Import/General Conversion Tools	Displays byte-level contents of any file.
<i>i</i>	DXFIDRIS File/Import-Export/Desktop Publishing Formats	Reads and writes DXF format vector files.
<i>i</i>	EDIT Analysis/Database Query Data Entry	A simple ASCII text editor for use with creating a variety of IDRISI data files. With values files, EDIT creates and maintains proper documentation files automatically.
<i>i</i>	EDITSIG Analysis/Image Processing	Edits signatures created with MAKESIG.
<i>i</i>	ENVIRON	Changes the prevailing IDRISI operating environment.
<i>i</i>	ERDIDRIS File/Import-Export/Software-Specific Formats	Converts files to and from ERDAS ".lan" and ".gis" format.
<i>i</i>	ERRMAT Analysis/Decision Support	Produces an error matrix analysis of categorical map data compared to ground truth information. Tabulates error of omission and commission, marginal and total errors and selected confidence intervals. <i>Per Category Kappa Index of Agreement figures are also provided. This module is a substatial revision and replacement for CONFUSE.</i>
<i>i</i>	EXPAND Reformat	Increases image resolution by pixel duplication.
<i>i</i>	EXTRACT Analysis/Database Query	Creates an attribute values file from an image by extracting a summary of data values found within defined regions. The summary (minimum, maximum, range, total, mean, or standard deviation) may also be output as a table.
<i>i</i>	FILTER Analysis/Context Operators Analysis/Image Processing	Convolve (strictly correlates) an image with a digital filter. Mean, median, mode, edge-enhancement, low-pass, high-pass and user-defined filters are accommodated.
<i>i</i>	FLIP File/Import/General Conversion Tools	Reverses the byte order of 2-byte integer files.

<i>i</i>	FUZZY Analysis/Decision Support	Evaluates the fuzzy set membership values (possibilities) of data cells based on any of three membership functions: sigmoidal, j-shaped and linear. Monotonically increasing, monotonically decreasing, symmetric and asymmetric variants are supported. Other Fuzzy Set operations such as CON (concentration), DIL (dilation), AND and OR are covered by the standard modules TRANSFOR and OVERLAY .
<i>i</i>	GRASSIDR File/Import-Export/Software-Specific Formats	Converts raster files between GRASS and IDRISI.
<i>i</i>	GROUP Analysis/Context Operators	Classifies pixels according to contiguous groups.
<i>i</i>	GSPIDRIS WINDOWS version only File/Import	GSPIDRIS extracts image data from SpotImage 's SPOTView 1.5 and 4.1 format data volumes.
<i>i</i>	HISTO Analysis/Database Query Analysis/Statistics	Produces histograms of image file values. In addition to the graphic output, numeric output includes proportional and cumulative frequencies along with simple statistics.
<i>i</i>	HNTRLAND Analysis/Context Operators	Determines the supply areas dominated by, or the hinterlands of, point demand centers.
<i>i</i>	IDRISI IDRISIW in WINDOWS version	The main IDRISI menu system.
<i>i</i>	IMAGE DOS version only	Produces a grey-scale image (up to 32 levels) using a half-tone procedure on dot-matrix, ink-jet and laser printers.
<i>i</i>	INITIAL Data Entry	Initializes a new image with a constant value.
<i>i</i>	INTERCON Data Entry/Surface Interpolation	Interpolates a surface from a set of contours by linear interpolation.
<i>i</i>	INTERPOL Data Entry/Surface Interpolation	Interpolates a surface from point data using either a weighted-distance or potential surface model.
<i>i</i>	LANDSAT DOS version only	Facilitates the downloading of LANDSAT CCT-X data.
<i>i</i>	LINEGEN Reformat	Generalizes vector lines by point selection, low-pass filtering or tolerance band selection.

<i>i</i>	LINERAS Reformat/Raster-Vector Conversion	Line-to-Raster conversion.
<i>i</i>	LIST	Lists the names and titles of all image, vector and values files.(<i>all files in WINDOWS version</i>)
<i>i</i>	LISTPAL DOS version only (in WINDOWS version integrated in DESCRIBE)	Lists color palette files in the active data directory.
<i>i</i>	LISTREF DOS version only (in WINDOWS version integrated in DESCRIBE)	Lists reference system parameter files.
<i>i</i>	LISTSCR DOS version only (in WINDOWS version integrated in DESCRIBE)	Lists vector script files used with PLOT.
<i>i</i>	LISTSIG DOS version only (in WINDOWS version integrated in DESCRIBE)	Lists supervised classification signature files.
<i>i</i>	MAINT DOS version only (in WINDOWS version separated into COPY , RENAME and DELETE)	A file maintenance utility.
<i>i</i>	MAKESIG Analysis/Image Processing	Creates signature files for each informational class for which you have created training sites.
<i>i</i>	MAPIDRIS File/Import-Export/Software-Specific Formats	Converts to and from Map Analysis Package files (both mainframe and micro versions).
<i>i</i>	MAXLIKE Analysis/Image Processing	A Maximum Likelihood classifier.
<i>i</i>	MCE Analysis/Decision Support	Computes a Multi-Criteria Avaluation by means of a weighted linear combination of factors, subsequently masked by a set of constraints. Factor uncertainty information is propagated to the result to compute the uncertainty in the suitabilities derived.
<i>i</i>	MDCHOICE Analysis/Decision Support	MDCHOICE is a multi-dimensional choice procedure that produces an output map indicating, for each cell, which of a series of input maps has the highest value. In cases where the input maps represent suitabilities for different objectives, the procedure provides one alternative to the multi-objective decision problem (although the MOLA procedure is preferable in most instances). In these cases, input maps should be standardized either with STANDARD or by means of the histogram equalization procedure in STRETCH .

<i>i</i>	MINDIST Analysis/Image Processing	A Minimum Distance to Means classifier.
<i>i</i>	MOLA Analysis/Decision Support	An iterative Multi-Objective Land Allocation routine. Input maps are ranked suitability maps such as would be produced by ranking (using RANK) the output from a multi-criteria evaluation (using MCE). The procedure uses a decision heuristic to resolve conflicts and is suitable for use with massive data sets.
<i>i</i>	NDVICOMP Analysis/Change-Time Series	Composites images (eg. NDVI) using either a maximum value procedure or a quadratic mean.
<i>i</i>	NEWMOD DOS version only	NEWMOD is a program shell to aid in the creation of new modules. Two versions are supplied: one in PASCAL and the other in BASIC.
<i>i</i>	ODYIDRIS File/Import/Software-Specific Formats	Converts ODYSSEY vector files to IDRISI vector format.
<i>i</i>	ORTHO	Produces a 3-D orthographic perspective plot of surface data with optional draping of a second color image.
<i>i</i>	ORTHO85 DOS version only	A special version of ORTHO for the 8514/A graphics adaptor capable of displaying color composite images at high resolution.
<i>i</i>	OSUIDRIS File/Import-Export/Software-Specific Formats	Converts to and from OSU Map files.
<i>i</i>	OUTPOST File/Export/Desktop Publishing Formats	OUTPOST creates PostScript output from IDRISI vector files for export to desktop publishing software. OUTPOST also allows for the creation of PostScript groups based on a sorting of identifiers or of values in an attribute values file.
<i>i</i>	OVERLAY Analysis/Database Query Analysis/Mathematical Operators Analysis/Change-Time Series	Undertakes pixel-wise addition, subtraction, multiplication, division and exponentiation of paired images. Maximum, minimum, -normalized ratio+ and -cover+ are also supported. On binary images, logical AND and OR operations are supported by means of the multiply and maximum operation. Other boolean operations are supported through various binary image overlay combinations.
<i>i</i>	PAINT DOS version only	A color output module for the HP Paintjet, Paintjet XL, XL300 and the Deskjet 500C, 550C and 1200C.

<u>i</u>	PALETTE WORKSHOP WINDOWS version only	PALETTE WORKSHOP facilitates the creation and modification of color palettes.
<u>i</u>	PALIDRIS File/Import-Export/Software-Specific Formats	Converts palette files between IDRISI, ERDAS, ILWIS and IAX.
<u>i</u>	PARE File/Import/General Conversion Tools	Converts generic files with headers to IDRISI format.
<u>i</u>	PATHWAY Analysis/Distance Operators	Finds the shortest path between one or more specified points and a destination specified as the lowest point on a cost surface.
<u>i</u>	PATTERN Analysis/Statistics Analysis/Context Operators	Evaluates pattern measures of relative richness, diversity, dominance index, fragmentation index, NDC, CVN and BCM.
<u>i</u>	PCA Analysis/Image Processing	Principal Components Analysis (standardized and unstandardized).
<u>i</u>	PCLASS Analysis/Database Query Analysis/Decision Support	Evaluates the probability that pixels exceed or are exceeded by a specified threshold using the stated RMS error or the data set and a normal probability distribution error model.
<u>i</u>	PERIM Analysis/Database Query	Creates a new image by giving each output pixel the value of the perimeter of the class to which the input pixel belongs. Output can also be produced as a table or an attribute values file in a range of measurement units.
<u>i</u>	PIPED Analysis/Image Processing	A Parallelepiped classifier.
<u>i</u>	PLOT DOS version only	Produces vector plots on screen, HPGL plotters and selected printers.
<u>i</u>	POINTRAS Reformat/Raster-Vector Conversion	Point-to-Raster conversion.
<u>i</u>	POINTVEC Reformat/Raster-Vector Conversion	Produces a vector point file from raster image (a companion to <u>POLYVEC</u>).
<u>i</u>	POLYRAS Reformat/Raster-Vector Conversion	Polygon-to-Raster conversion.
<u>i</u>	POLYVEC Reformat/Raster-Vector Conversion	Raster-to-Polygon conversion.

<i>i</i>	PROFILE Analysis/Database Query Analysis/Change-Time Series	Creates profiles over space or over time.
<i>i</i>	PROJECT Reformat	Undertakes conversions between reference systems for both vector and raster files. With raster images, a resampling is undertaken using either a nearest-neighbor or bilinear interpolation. Supported projections include the Mercator, Transverse Mercator, Lambert Conformal Conic and Plate Carree. By using reference system parameter files, a limitless number of reference system conversions can be undertaken. Full forward and backward transformations are accommodated using ellipsoidal formulas. PROJECT also incorporates the US National Geodetic Survey's NADCON procedure for converting between NAD27 AND NAD83 and the Molodensky transform equations for all other datums. Over 200 reference system parameter files are supplied with the module, including all US State Plane (SPC) systems for NAD27 and NAD83 and a complete set of UTM zones based on WGS84 for the northern and southern hemispheres. In addition, users can construct reference system parameter files for any system based on a supported projection.
<i>i</i>	QUADRAT Analysis/Statistics	Computes the density, variance and variance-mean ratio of quadrat cell counts.
<i>i</i>	QUERY Analysis/Database Query	Extracts pixels designated by an independent mask into a sequential file for subsequent statistical analysis.
<i>i</i>	RADIANCE Analysis/Image Processing	Converts raw values to calibrated radiances for LANDSAT images.
<i>i</i>	RANDOM Analysis/Statistics Analysis/Decision Support	Creates random images according to either a rectilinear or normal distribution. In the case of a normal distribution, the mean and standard deviation to be used may be specified.
<i>i</i>	RANK Analysis/Decision Support	Rank orders the cells in a raster image. Ties may optionally be resolved by using the rank order of a second image. Both primary and secondary ranks may be in ascending or descending order. The procedure is used extensively in optimization problems such as with RECLASS for single objective decisions and MOLA for mulit-objective decisions.

<i>i</i>	RASLNVEC	Produces plottable vector output from images.
<i>i</i>	RECLASS <i>Analysis/Database Query</i>	Reclassifies pixels by equal intervals or user-defined schemes. RECLASS is commonly used as a database query routine by reclassifying images into Boolean maps of areas meeting the specified conditions.
<i>i</i>	REGRESS <i>Analysis/Statistics</i> <i>Analysis/Change-Time Series</i>	Performs regression analysis on images or attribute values files.
<i>i</i>	RENAME	RENAME provides the file management capability of renaming IDRISI for Windows data files.
<i>i</i>	RESAMPLE <i>Reformat</i>	Determines the data values for a rectangular grid by interpolation of the values in a different (and possibly warped) grid. Linear, quadratic and cubic mappings between the grids are provided, along with nearest-neighbor and bi-linear interpolations. Vector files may also be trans- formed with this 'rubber sheet' procedure.
<i>i</i>	RESULTAN <i>Analysis/Distance Operators</i>	Computes the resultant force vector (as a magnitude and direction image pair) from two input force vector image pairs.
<i>i</i>	SAMPLE <i>Analysis/Statistics</i> <i>Analysis/Decision Support</i>	Creates systematic, random and stratified random point sampling schemes.
<i>i</i>	SCALAR <i>Analysis/Mathematical Operators</i>	Adds, subtracts, multiplies, divides and exponentiates pixels by a constant value.
<i>i</i>	SCATTER DOS version only; single program file, not in the menu!	Creates XY-scatterplots as images.
<i>i</i>	SIGCOMP <i>Analysis/Image Processing</i>	A signature comparison utility.
<i>i</i>	SPDIST <i>Analysis/Distance Operators</i>	A companion to the DISTANCE module, SPDIST calculates spherical distances on the surface of the earth from designated features using spherical trigonometry.
<i>i</i>	SRFIDRIS <i>File/Import-Export/Software-Specific Formats</i>	SRFIDRIS will import Surfer GRID raster files into IDRISI for Windows image format. It will also export IDRISI vector point files into the Surfer DAT format.

<i>i</i>	SSTIDRIS File/Import	Converts raster images entered with a spreadsheet to IDRISI. Can be used to read any ASCII image format with CR/LF characters at the end of each row.
<i>i</i>	STANDARD Analysis/Statistics Analysis/Decision Support	Converts an image to standard scores.
<i>i</i>	STRETCH Analysis/Decision Support Analysis/Image Processing	Produces linear, linear with saturation and histogram equalization contrast stretches in preparation for image display.
<i>i</i>	SUBSET DOS version only (in WINDOWS version integrated in WINDOW)	Windows sub-images from groups of images.
<i>i</i>	SURFACE Analysis/Context Operators	Produces slope gradient and aspect images from a surface. Can also be used to create analytical hillshading.
<i>i</i>	SYMBOL WORKSHOP WINDOWS version only	SYMBOL WORKSHOP is used for the creation and editing of IDRISI symbol files.
<i>i</i>	THERMAL Analysis/Image Processing	Converts LANDSAT TM Band 6 raw data to blackbody temperatures.
<i>i</i>	THIESSEN Analysis/Distance Operators Data Entry/Surface Interpolation	Produces Thiessen polygons (a Voronoi Tessellation) about a set of irregularly distributed points.
<i>i</i>	TIFIDRIS File/Import-Export/Desktop Publishing Formats	Reads and writes TIFF format files.
<i>i</i>	TOSCA	An independent universal digitizing module distributed with IDRISI.
<i>i</i>	TRANSFOR Analysis/Mathematical Operators	Transforms the attributes of images such as log transformation, using any of 14 operations.
<i>i</i>	TRANSPOS Reformat	Image transposition by row or column reversal, or by rotation.
<i>i</i>	TREND Analysis/Statistics Data Entry/Surface Interpolation	Calculates the best fit linear, quadratic or cubic trend surface to a set of irregular cell control points by least-squares procedures. Produces new images of the trend surfaces in addition to surface statistics.

<i>i</i>	TSA Analysis/Change-Time Series	TSA is a spatial time series analysis procedure based on Standardized Principal Components. Up to 84 input images can be analyzed as a group with the production of an equal number of resulting components. Loadings graph are output either as IDRISI profiles or as a DIF-format data file that can be read by virtually all spreadsheet software systems.
<i>i</i>	UPDATE Data Entry	Keyboard entry/update of image data.
<i>i</i>	UTMREF Data Entry	is used to facilitate the creation of reference system parameter files based on the Universal Transverse Mercator system, for use with PROJECT
<i>i</i>	VAR2FIX File/Import/General Conversion Tools	Converts variable length ASCII files to fixed length.
<i>i</i>	VARCOST Analysis/Distance Operators	Computes an anisotropic cost surface. This module is the equivalent of COST (specifically the COSTPUSH algorithm) except that it recognizes that frictions may have different strengths in different directions. Frictions are entered as force vectors described by a pair of images - a magnitude image and a direction image. VARCOST also allows the specification of an isotropic friction image for omni-directional elements.
<i>i</i>	VGACOMP DOS version only	Produces color composite images for standard VGA systems.
<i>i</i>	VIEW	Allows direct examination of the data values in any portion of an image. Output precision is user-specified.
<i>i</i>	VIEWSHED Analysis/Context Operators	Creates an image of all points visible from one or more viewpoints over a given surface.
<i>i</i>	WATRSBED Analysis/Context Operators	Determines the watersheds of one or more specified locations.
<i>i</i>	WEIGHT Analysis/Decision Support	Computes a best-fit set of weights by calculation of the principal eigenvector of a pairwise reciprocal comparison matrix in which each factor in a multi-criteria evaluation is compared to every other factor. Information on consensus and procedures for resolving lack of consensus are provided.
<i>i</i>	WINDOW Reformat	Extracts a rectangular sub-image.(in WINDOWS version direct batch processing possible)

<i>i</i>	WMFIDRIS WINDOWS version only File/Export/Desktop Publishing Formats	WMFIDRIS is an export module that creates Windows Meta Files from IDRISI for Windows vector files as a means of facilitating the movement of IDRISI for Windows data to graphics packages (such as CorelDRAW! and Adobe Illustrator)
<i>i</i>	XYZIDRIS File/Import	XYZIDRIS converts data in X, Y and Z format (e.g., spreadsheet data) to IDRISI for Windows vector point files.

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IDRISI Specifications

for a updated list see [A - Z list](#) (61 KB)

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-



CORE MODULES

The CORE modules provide basic facilities for the manipulation of raster images

Project Management

IDRISI

The main IDRISI menu system.

ENVIRON

Changes the prevailing IDRISI operating environment.

LIST

Lists the names and titles of all image, vector and values files.

LISTPAL

Lists color palette files in the active data directory.

LISTSIG

Lists supervised classification signature files.

LISTSCR

Lists vector script files used with PLOT.

LISTREF

Lists reference system parameter files.

DESCRIBE

Describes the contents of any image, vector or values files.

DESCREF

Describes the contents of a reference system parameter file.

DOCUMENT

Creates a documentation file for a new imported data file, or revises the documentation files of an existing data file.

CONVERT

Converts between all of the image storage formats supported by IDRISI. Files may be converted to any combination of the byte, integer and real (floating point) data types and the ASCII, binary and packed (run-length encoded) file structures.

MAINT

A file maintenance utility.

CONFIG

A hardware configuration utility.

CONV3TO4

Converts Version 3 data files to Version 4 format.

BATCH324

Converts groups of Version 3 data files to Version 4 format.

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Display Modules

COLOR

Produces color output of raster images with integrated vector display on EGA, VGA and SuperVGA graphics systems. COLOR also provides interactive inquiry, on-screen digitizing, interactive zoom, vector file overlay, interactive palette selection and adjustment and interactive legend editing. With SuperVGA graphics adaptors, high resolution displays (up to 1024 ´ 768) of color composite images (256 color) can be produced.

COLOR85

A special version of COLOR for the 8514/A graphics adaptor capable of displaying color composite images (256 color) at high resolution (1024 ´ 768).

ORTHO

Produces a 3-D orthographic perspective plot of surface data with optional draping of a second color image.

ORTHO85

A special version of ORTHO for the 8514/A graphics adaptor capable of displaying color composite images at high resolution.

IMAGE

Produces a grey-scale image (up to 32 levels) using a half-tone procedure on dot-matrix, ink-jet and laser printers.

PLOT

Produces vector plots on screen, HPGL plotters and selected printers.

PAINT

A color output module for the HP Paintjet, Paintjet XL, XL300 and the Deskjet 500C, 550C and 1200C.

DISPLAY

A universal display routine using ASCII characters.

VIEW

Allows direct examination of the data values in any portion of an image. Output precision is user-specified.

HISTO

Produces histograms of image file values. In addition to the graphic output, numeric output includes proportional and cumulative frequencies along with simple statistics.

STRETCH

Produces linear, linear with saturation and histogram equalization contrast stretches in preparation for image display.

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Data Entry

TOSCA

An independent universal digitizing module distributed with IDRISI.

POINTRAS

Point-to-Raster conversion.

LINERAS

Line-to-Raster conversion.

POLYRAS

Polygon-to-Raster conversion.

INITIAL

Initializes a new image with a constant value.

UPDATE

Keyboard entry/update of image data.

EDIT

A simple ASCII text editor for use with creating a variety of IDRISI data files. With values files, EDIT creates and maintains proper documentation files automatically.

INTERPOL

Interpolates a surface from point data using either a weighted-distance or potential surface model.

INTERCON

Interpolates a surface from a set of contours by linear interpolation.

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Attribute Data Management

ASSIGN

Creates an image from an attribute values file by assigning the data values contained in the attribute values file to the cells belonging to defined regions. ASSIGN can also be used to reclassify integer images.

EXTRACT

Creates an attribute values file from an image by extracting a summary of data values found within defined regions. The summary (minimum, maximum, range, total, mean, or standard deviation) may also be output as a table.

DBIDRIS

Used to import dBASE files into IDRISI values files, and move IDRISI values files back into dBASE format.

see also [EDIT](#) , [UPDATE](#) , [RECLASS](#) and [COLSPACE](#) .

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Spatial Data Management

PROJECT

Undertakes conversions between reference systems for both vector and raster files. With raster images, a resampling is undertaken using either a nearest-neighbor or bilinear interpolation. Supported projections include the Mercator, Transverse Mercator, Lambert Conformal Conic and Plate Carree. By using reference system parameter files, a limitless number of reference system conversions can be undertaken. Full forward and backward transformations are accommodated using ellipsoidal formulas. PROJECT also incorporates the US National Geodetic Survey's NADCON procedure for converting between NAD27 AND NAD83 and the Molodensky transform equations for all other datums. Over 200 reference system parameter files are supplied with the module, including all US State Plane (SPC) systems for NAD27 and NAD83 and a complete set of UTM zones based on WGS84 for the northern and southern hemispheres. In addition, users can construct reference system parameter files for any system based on a supported projection.

RESAMPLE

Determines the data values for a rectangular grid by interpolation of the values in a different (and possibly warped) grid. Linear, quadratic and cubic mappings between the grids are provided, along with nearest-neighbor and bi-linear interpolations. Vector files may also be trans- formed with this 'rubber sheet' procedure.

EXPAND

Increases image resolution by pixel duplication.

CONTRACT

Reduces image resolution by pixel thinning or aggregation.

TRANSPOS

Image transposition by row or column reversal, or by rotation.

CONCAT

Concatenates multiple images to produce a larger image.

WINDOW

Extracts a rectangular sub-image.

SUBSET

Windows sub-images from groups of images.

POINTVEC

Produces a vector point file from raster image (a companion to [POLYVEC](#)).

POLYVEC

Raster-to-Polygon conversion.

LINEGEN

Generalizes vector lines by point selection, low-pass filtering or tolerance band selection.

RASLNVEC

Produces plottable vector output from images.

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GEOGRAPHIC ANALYSIS MODULES

Database Query

RECLASS

Reclassifies pixels by equal intervals or user-defined schemes. RECLASS is commonly used as a database query routine by reclassifying images into Boolean maps of areas meeting the specified conditions.

OVERLAY

Undertakes pixel-wise addition, subtraction, multiplication, division and exponentiation of paired images. Maximum, minimum, -normalized ratio+ and -cover+ are also supported. On binary images, logical AND and OR operations are supported by means of the multiply and maximum operation. Other boolean operations are supported through various binary image overlay combinations.

PCLASS

Evaluates the probability that pixels exceed or are exceeded by a specified threshold using the stated RMS error or the data set and a normal probability distribution error model.

QUERY

Extracts pixels designated by an independent mask into a sequential file for subsequent statistical analysis.

AREA

Creates a new image by giving each output pixel the value of the area of the class to which the input pixel belonged. Output can also be produced as a table or an attribute values file in a range of measurement units.

PERIM

Creates a new image by giving each output pixel the value of the perimeter of the class to which the input pixel belongs. Output can also be produced as a table or an attribute values file in a range of measurement units.

see also [ASSIGN](#) (as an optional reclassification routine), [EXTRACT](#), [HISTO](#) and [CROSSTAB](#).

Map Algebra

SCALAR

Adds, subtracts, multiplies, divides and exponentiates pixels by a constant value.

TRANSFOR

Transforms the attributes of images such as log transformation, using any of 14 operations.

see also [OVERLAY](#).

Distance Operators

DISTANCE

Calculates the distance/proximity of each pixel to the nearest of a set of target pixels.

COST

Generates a distance/proximity surface where distance is measured as the least cost distance in moving over a friction surface.

VARCOST

Computes an anisotropic cost surface. This module is the equivalent of [COST](#) (specifically the COSTPUSH algorithm) except that it recognizes that frictions may have different strengths in different directions. Frictions are entered as force vectors described by a pair of images - a magnitude image and a direction image. VARCOST also allows the specification of an isotropic friction image for omni-directional elements.

DISPERSE

DISPERSE is a companion to [VARCOST](#) that calculates dispersion distances. The procedure is essentially the same as that of [VARCOST](#) except that the emphasis is on forces acting to disperse a body (e. g., a point-source contaminant spill) and the time taken to disperse it to a specified distance. DISPERSE is released as an experimental module in Version 4.1 and all users are invited to comment upon their experiences with this procedure and provide suggestions for modifications.

RESULTAN

Computes the resultant force vector (as a magnitude and direction image pair) from two input force vector image pairs.

DECOMP

Decomposes a force vector (as a magnitude and direction image pair) into X and Y component images. Also takes X and Y component images and produces a force vector image pair.

SPDIST

A companion to the [DISTANCE](#) module, SPDIST calculates spherical distances on the surface of the earth from designated features using spherical trigonometry.

PATHWAY

Finds the shortest path between one or more specified points and a destination specified as the lowest point on a cost surface.

ALLOCATE

Performs spatial allocation using either [DISTANCE](#) or [COST](#) surfaces.

THIESSEN

Produces Thiessen polygons (a Voronoi Tessellation) about a set of irregularly distributed points.

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Context Operators

SURFACE

Produces slope gradient and aspect images from a surface. Can also be used to create analytical hillshading.

GROUP

Classifies pixels according to contiguous groups.

VIEWSHED

Creates an image of all points visible from one or more viewpoints over a given surface.

WATRSHED

Determines the watersheds of one or more specified locations.

HNTRLAND

Determines the supply areas dominated by, or the hinterlands of, point demand centers.

see also [FILTER](#).

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STATISTICAL ANALYSIS MODULES

AUTOCORR

Computes Moran's I first lag autocorrelation statistic for an image, along with confidence tests. Non-rectangular regions can be analyzed by defining a binary mask.

CENTER

Computes mean center (weighted or not) of a point distribution and standard radius (the two-dimensional equivalent of a standard deviation).

CRATIO

Computes the compactness ratio of polygons given corresponding area and perimeter images.

QUADRAT

Computes the density, variance and variance-mean ratio of quadrat cell counts.

TREND

Calculates the best fit linear, quadratic or cubic trend surface to a set of irregular cell control points by least-squares procedures. Produces new images of the trend surfaces in addition to surface statistics.

CROSSTAB

Performs image crosstabulation and crosscorrelation.

RANDOM

Creates random images according to either a rectilinear or normal distribution. In the case of a normal distribution, the mean and standard deviation to be used may be specified.

PROFILE

Creates profiles over space or over time.

REGRESS

Performs regression analysis on images or attribute values files.

SAMPLE

Creates systematic, random and stratified random point sampling schemes.

PATTERN

Evaluates pattern measures of relative richness, diversity, dominance index, fragmentation index, NDC, CVN and BCM.

see also [HISTO](#) and [EXTRACT](#).

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IMAGE PROCESSING MODULES

MAKESIG

Creates signatures from training sites delineated using COLOR.

EDITSIG

Edits signatures created with MAKESIG.

SIGCOMP

A signature comparison utility.

PIPED

A Parallelepiped classifier.

MINDIST

A Minimum Distance to Means classifier.

MAXLIKE

A Maximum Likelihood classifier.

COMPOSIT

Produces color composite images.

VGACOMP

Produces color composite images for standard VGA systems.

CLUSTER

Performs unsupervised classification.

LANDSAT

Facilitates the downloading of LANDSAT CCT-X data.

RADIANCE

Converts raw values to calibrated radiances for LANDSAT images.

FILTER

Convolves (strictly correlates) an image with a digital filter. Mean, median, mode, edge-enhancement, low-pass, high-pass and user-defined filters are accommodated.

DESTRIPE

Removes band striping due to variable detector output.

COLSPACE

Performs HLS/RGB color space transformations.

PCA

Principal Components Analysis (standardized and unstandardized).

THERMAL

Converts LANDSAT TM Band 6 raw data to blackbody temperatures.

NDVICOMP

Composites images (eg. NDVI) using either a maximum value procedure or a quadratic mean.

see also [RESAMPLE](#) , [STRETCH](#) , [LISTSIG](#) and [ERRMAT](#) .

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DECISION SUPPORT ANALYSIS MODULES

BAYES

BAYES evaluates Bayes' Theorem. Multiple evidence maps (such as that produced by [PCLASS](#)) are permitted as long as they are conditionally independent. Prior probabilities may be input in map form (and thus, like the evidence maps, may vary continuously over space). The user is also able to specify the confidence in the decision rule, i. e., the belief that the evidence supportive of the hypothesis is truly reflected in the evidence at hand -- $p(e|e')$. BAYES is an extension to what is sometimes called a *Bayesian Weight of Evidence* approach.

FUZZY

Evaluates the fuzzy set membership values (possibilities) of data cells based on any of three membership functions: sigmoidal, j-shaped and linear. Monotonically increasing, monotonically decreasing, symmetric and asymmetric variants are supported. Other Fuzzy Set operations such as CON (concentration), DIL (dilation), AND and OR are covered by the standard modules [TRANSFOR](#) and [OVERLAY](#).

ERRMAT

Produces an error matrix analysis of categorical map data compared to ground truth information. Tabulates error of omission and commission, marginal and total errors and selected confidence intervals. *Per Category* Kappa Index of Agreement figures are also provided. This module is a substantial revision and replacement for CONFUSE.

WEIGHT

Computes a best-fit set of weights by calculation of the principal eigenvector of a pairwise reciprocal comparison matrix in which each factor in a multi-criteria evaluation is compared to every other factor. Information on consensus and procedures for resolving lack of consensus are provided.

MCE

Computes a Multi-Criteria Avaluation by means of a weighted linear combination of factors, subsequently masked by a set of constraints. Factor uncertainty information is propagated to the result to compute the uncertainty in the suitabilities derived.

RANK

Rank orders the cells in a raster image. Ties may optionally be resolved by using the rank order of a second image. Both primary and secondary ranks may be in ascending or descending order. The procedure is used extensively in optimization problems such as with [RECLASS](#) for single objective decisions and [MOLA](#) for multi-objective decisions.

MDCHOICE

MDCHOICE is a multi-dimensional choice procedure that produces an output map indicating, for each cell, which of a series of input maps has the highest value. In cases where the input maps represent suitabilities for different objectives, the procedure provides one alternative to the multi-objective decision problem (although the [MOLA](#) procedure is preferable in most instances). In these cases, input maps should be standardized either with [STANDARD](#) or by means of the histogram equalization procedure in [STRETCH](#).

STANDARD

Converts an image to standard scores.

MOLA

An iterative Multi-Objective Land Allocation routine. Input maps are ranked suitability maps such as would be produced by ranking (using [RANK](#)) the output from a multi-criteria evaluation (using [MCE](#)). The procedure uses a decision heuristic to resolve conflicts and is suitable for use with massive data sets.

see also [PCLASS](#), [RANDOM](#), [SAMPLE](#).

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THE TIME SERIES / CHANGE ANALYSIS MODULES

TSA

TSA is a spatial time series analysis procedure based on Standardized Principal Components. Up to 84 input images can be analyzed as a group with the production of an equal number of resulting components. *Loadings* graph are output either as **IDRISI profiles** or as **a DIF-format data file that can be read by virtually all spreadsheet software systems.**

see also [PROFILE](#)

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PERIPHERAL MODULES

File Exploration / Conversion

DUMP

Displays byte-level contents of any file.

PARE

Converts generic files with headers to IDRISI format.

BILIDRIS

Converts generic band-interleaved by line images to IDRISI format.

BIPIDRIS

Converts generic band-interleaved by pixel images to IDRISI format.

VAR2FIX

Converts variable length ASCII files to fixed length.

CRLF

Adds or removes carriage return and line feed symbols.

FLIP

Reverses the byte order of 2-byte integer files.

see also [SSTIDRIS](#).

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Import / Export

ARCIDRIS

Converts files to and from Arc/Info GENERATE/UNGEN format.

ERDIDRIS

Converts files to and from ERDAS ".lan" and ".gis" format.

TIFIDRIS

Reads andf writes TIFF format files.

DLG

Scans and extracts features from USGS DLG (Digital Line Graph) files into IDRISI vector format.

DEMIDRIS

Reads USGS 1:24,000 and 1:250,000 Digital Elevation Models.

CTG

Imports USGS CTG (Composite Theme Grid) data files into IDRISI.

MAPIDRIS

Converts to and from Map Analysis Package files (both mainframe and micro versions).

OSUIDRIS

Converts to and from OSU-Map files.

ODYIDRIS

Converts ODYSSEY vector files to IDRISI vector format.

SSTIDRIS

Converts raster images entered with a spreadsheet to IDRISI. Can be used to read any ASCII image format with CR/LF characters at the end of each row.

PALIDRIS

Converts palette files between IDRISI, ERDAS, ILWIS and IAX.

GRASSIDR

Converts raster files between GRASS and IDRISI.

BBKIDRIS

Converts National Survey Blue Book format (*80* and *81* records) to IDRISI vector format.

ATLIDRIS

Converts ATLAS BNA files to IDRISI vector format.

DXFIDRIS

Reads and writes DXF format vector files.

OUTPOST

OUTPOST creates PostScript output from IDRISI vector files for export to desktop publishing software. OUTPOST also allows for the creation of PostScript groups based on a sorting of identifiers or of values in an attribute values file.

NEWMOD

NEWMOD is a program shell to aid in the creation of new modules. Two versions are supplied: one in PASCAL and the other in BASIC.

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unordered :-(- and even incomplete :-((- list of things to do ...

will I ever have the time ...

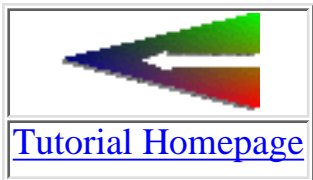
red colored italic text indicates enhancements available in IfW V2 (= IDRISI for WINDOWS Version 2), note: not all new functions are listed here!

- **Animated GIFs will be added where appropriate**
- *usage of Image Calculator*
- **Analysis methods for single images**
 - **FUZZY sets**
 - **concepts, uses, membership functions (linear, j-shaped, sigmoidal, *user defined*)**
 - **BAYESian module (*with new multiple hypotheses evaluation*)**
 - **Space PROFILEs**
 - **Probability classification (PCLASS *revised version*)**
- **Analysis methods for image pairs**
 - **Linear REGRESSION**
- **Analysis methods for multiple images**
 - **PCA**
 - **TSA**
 - **Decision support modules (*with new functions, e.g., MCE with OWA-option, BELIEF, etc.*)**
 - *multiple regression analysis*
- **Other analysis methods**

- **COST distance surfaces**
 - **Isotropic ([COST](#))**
 - **Anisotropic ([VARCOST](#), [DISPERSE](#), ...)**
- **checking for the least cost path with [PATHWAY](#), *RELOCATE***
- **Monte-Carlo approach (using [RANDOM](#) *revised version*)**
- **Image processing**
 - **rubber sheet transformation with [RESAMPLE](#)**
 - **Unsupervised ([COMPOSIT](#) + [CLUSTER](#)) image classification**
 - *CLUSTER to be reworked due to new method*
 - **Supervised image classification**
 - *x-y scatterplots with SCATTER (implemented again as in IDRISI for DOS 4.1)*
 - *soft classifiers vs. hard classifiers*
 - *hyperspectral image analysis*
 - *texture analysis*
- **Georeferencing with [PROJECT](#) (*covering new ones*)**
- **Tips and hints on importing and exporting several data formats (raster/vector, ASCII/binary, *including all the capabilities, e. g., ArcView Shapefile support, ...*)**
- **DATABASE Workshop**
- *new DISPLAY capabilities, multiple windows cursor inquiry mode,*



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Downloading the IDRISI WWW Tutorial

Due to several inquiries from internetters around the world, who have slower connections, and due to the growing size of the whole project and especially its images I decided to provide a WINZIPed version of these pages.



One file download	Piecewise download
IDRTUTOR.ZIP (HTTP) IDRTUTOR.ZIP (FTP)	ITUTOR1.ZIP , ITUTOR2.ZIP , ITUTOR3.ZIP , ITUTOR4.ZIP (HTTP) ITUTOR1.ZIP , ITUTOR2.ZIP , ITUTOR3.ZIP , ITUTOR4.ZIP (FTP)

Installation instructions

Simply copy the file (or the 4 files) to a new empty directory and unpack. **tuthome.htm (the same as index.htm) is the first starting file.**



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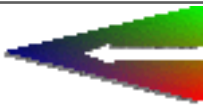
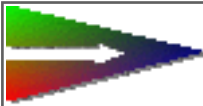
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Datatypes, Filestructures

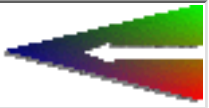
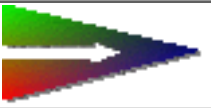
IDRISI handles its files such that the user won't get in touch with internal structures too often.

But: basically knowing how your data are being stored can help considerably in understanding the procedures they underlay. Solutions to dataimport or -export problems are gained more easily. Especially educational purposes profit by the very simple and straightforward filestructures that IDRISI uses. Be aware of much more IDRISI-specific filetypes than those presented. Most of them are very simple and need not be documented in detail here. So our focus will be upon the following essential filetypes:

Raster Files	Raster Documentation
Vector Files	Vector Documentation
Attribute Value File	Values Documentation

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	Raster Documentation Files	

Raster File Structure

IDRISI names raster files as **images**. Each image consists of a defined count of rows and columns thus forming cells. These cells are stored as a sequence of numbers (byte, integer or real) representing values (vegetation classcodes, reflectance numbers, political units, z-values in a DEM, ...).

Let us imagine a very simple image:

	0	1	2	3	4
0	22	22	18	18	18
1	15	15	18	16	16
2	11	15	15	18	16
3	11	15	12	12	12

5 columns, 4 rows. The values may represent some code for land usage. IDRISI is starting in the upper-left corner (row 0/column 0), then advances column by column and row by row. In the simplest format - ASCII - the cellvalues are stored one in each line:

```
22
22
18
18
18
15
15
(...)
11
```

15
12
12
12

Commonly the images are stored binary, one value after the other. Depending on the datatype a value occupies more or less of memory. Simple RLC (run length compression) is supported as packed binary (i.e., the cellvalue is followed by the number of occurrences in the series):



- not packed: 22 22 18 18 18 15 15 18 16 16 11 15 15 18 16 11 15 12 12 12
- packed: 22 2 18 3 15 2 18 1 16 2 11 1 15 2 18 1 16 1 11 1 15 1 12 3

Unfortunately our image is not well suited for compression. The compressed image requires 4 additional bytes! But images with large areas of the same values can show packing ratios up to 1:100 and more.


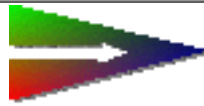
The table shows IDRISI's datatypes (except compression they apply to [vectorfiles](#) as well):

	memory required	range	compression
byte	1 byte	0 to 255	yes
integer	2 bytes	-32768 to +32767	yes
real	IEEE 4 bytes	$\pm 1 \cdot 10^{38}$, 7 significant figures precision	no

Evidently the image 'does not know' about its dimensions or about the area one cell covers in real. So we need a 'header file', the [documentation file](#), which corresponds with a image.

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Raster Files	A-Z	Attribute Value Files

Vector File Structure

primarily IDRISI is raster-based, but vectors can be used to get data from other sources into IDRISI. Further they serve as overlays for better visual orientation. We can digitize vector-polygons onscreen during the process of supervised image classification to define our training areas, and we will tell IDRISI where to put texts in our maps through vector-points.

See how IDRISI vector-files are structured:

```

Id      n
  x1    y1
  x2    y2
  x3    y3
  . . . . .
  xn    yn
Id      n
  x1    y1
  x2    y2
  . . . . .
  . . . . .
0      0

```

2 columns, 1st line holds an identifier (integer or real) plus the number of coordinates following (in case of point-files = 1). As many lines as specified before define the vertex-coordinates. Each vector-file has to end with 0 0 (zero zero).

Polygon-vectors are cycled in that the last X/Y-pair equals the first one for each single polygon.

Let us take height-data (eg. from a GPS) as an example for a point-vector file:

```

1211    1

```

```
212328.0 424876.0
1250 1
212400.0 425090.0
1283 1
213222.5 426112.5
.....
1423 1
215089.2 428987.6
1423 1
215234.0 429876.7
0 0
```

See? Identifiers need not be unequivocal. In this case they mean the heights of the points.

Vector Documentation Files

The vector-file too is a 'dumb thing', that has to be told about its nature, so every IDRISI vector-file (*.VEC) comes with a vector documentation file (*.DVC). The module **DOCUMENT** **again helps to input the metadata:**

DOCUMENT - basinvec

Title :

ID type : Reference system :

File type : Reference units :

Object type :

Pos'n error :

Resolution :

Minimum X coordinate :

Maximum X coordinate :

Minimum Y coordinate :

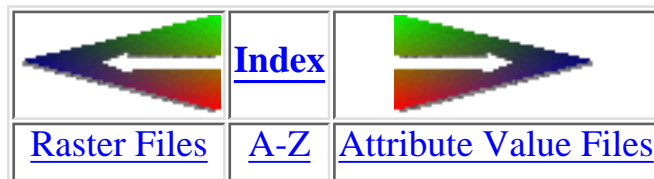
Maximum Y coordinate :

Unit distance :


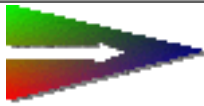
Completeness... Consistency... Comments... Lineage...

OK Cancel Help

You'll find one additional field - Object type - which can be Point, Line, Polygon or Text. Of course you can not automatically calculate the vectors resolution. It is your responsibility to put in a value if known. The remaining fields have same meanings as with [raster documentation](#).



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Attribute Value Files

Future versions of IDRISI will eventually allow for multicolumn ASCII attribute tables, but in this version of IDRISI it is 2-columned ASCII-table:

```
1 12.5
2 11.3
3  9.7
4  8.1
5  7.6
6  6.1
7  4.9
8  3.4
9  2.0
```

The first column lists region- or feature-identifiers (eg. measuring points, political districts, landcover types, ...), the second is an assignment of some attribute (temperature at measuring point, birth rate in districts, ...). These files are used in a lot of IDRISI modules, so you will meet them later on.

Attribute Value File Documentation

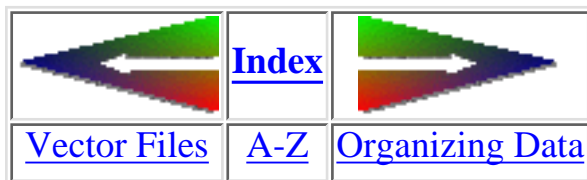
DOCUMENT - bldguse

Title :

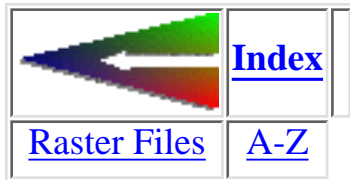
File type :	<input type="text" value="Ascii"/>	Minimum value :	<input type="text" value="1"/>
Records :	<input type="text" value="438"/>	Maximum value :	<input type="text" value="15"/>
Fields :	<input type="text" value="2"/>	Flag value :	<input type="text" value="none"/>
Field 0 :	<input type="text" value="identifiers"/>	Flag definition :	<input type="text" value="none"/>
Data type :	<input type="text" value="Integer"/>	Value units :	<input type="text" value="classes"/>
Format :	<input type="text" value="0"/>	Value error :	<input type="text" value="unknown"/>
Field 1 :	<input type="text" value="attribute"/>		
Data type :	<input type="text" value="Integer"/>		
Format :	<input type="text" value="0"/>		

Now after being experts in the IDRISI-specific documentation-system, you won't have difficulties to interpret the fields. The out-shaded are restricted to the default values in this version. The number of fields (= columns) can only be 2 - identifiers and attributes.

IDRISI for WINDOWS has an integrated **DATABASE WORKSHOP**, a module for handling more complex attribute-tables in popular formats (MS ACCESS 1.x, 2.x / dBASE / FoxPro / ...). We will take a closer look on it later in the tutorial.



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Raster Documentation Files

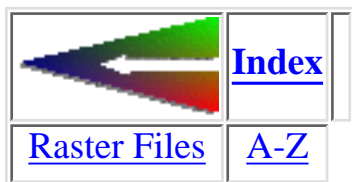
remember, a raster in IDRISI carries no information about 'itself' - we need to store that *metadata* **separately**. This is done by so-called raster documentation files (*.DOC). All images must have their corresponding DOC-files. These are ASCII files made up by a sequence of lines, each representing metadata. To ease handling, IDRISI comes with a tool called DOCUMENT:

You see a lot of fields which can be divided into obligate and facultative ones.

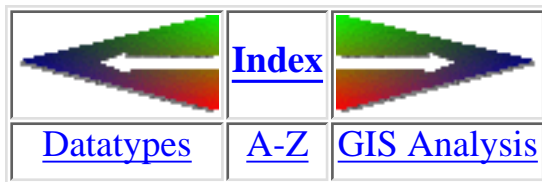
	obligate	facultative	notes

Titel		X	purely descriptiv, use it!
Columns / Rows	X		determines raster structure
Data type	X		type of values
File type	X		how is the file stored
Minimum / Maximum value	X		automatic checking of limits possible
Pos'n error		X	x,y-position error assessment as RMS error
Resolution		X	resolution of each cell; automatic calculation: $\text{MaxX} - \text{MinX} / \text{columns}$; does not always mean the 'true' spatial resolution
Value error		X	attribute value error, proportional or RMS, used in the calculation of the module PCLASS
Value units		X	m, classes, $\text{kg} \cdot \text{ha}^{-1} \cdot \text{a}^{-1}$ or any other unit
Reference system	X		projectioninformation
Reference units	X		m, ft, km, mi, deg, rad
Minimum / Maximum X/Y coordinates	X		image extents
Unit distance	X		a scaling factor, usually 1.0; eg. 2.0 and reference units meters would mean: a distance of 1 unit represents 2 meters in real
Flag value		X	a value in your raster with special meaning (background value, nodata, ...); analytically used by SURFACE , FILTER
Flag definition		X	description of above values meaning
Legend categories		X	text for legend
Completness, Consistency, Comments and Lineage		X	descriptive, use it if you have information

As indicated, several fields are purely descriptive. Nevertheless it is highly recommended to provide any additional information about the data to help assure higher accuracy.

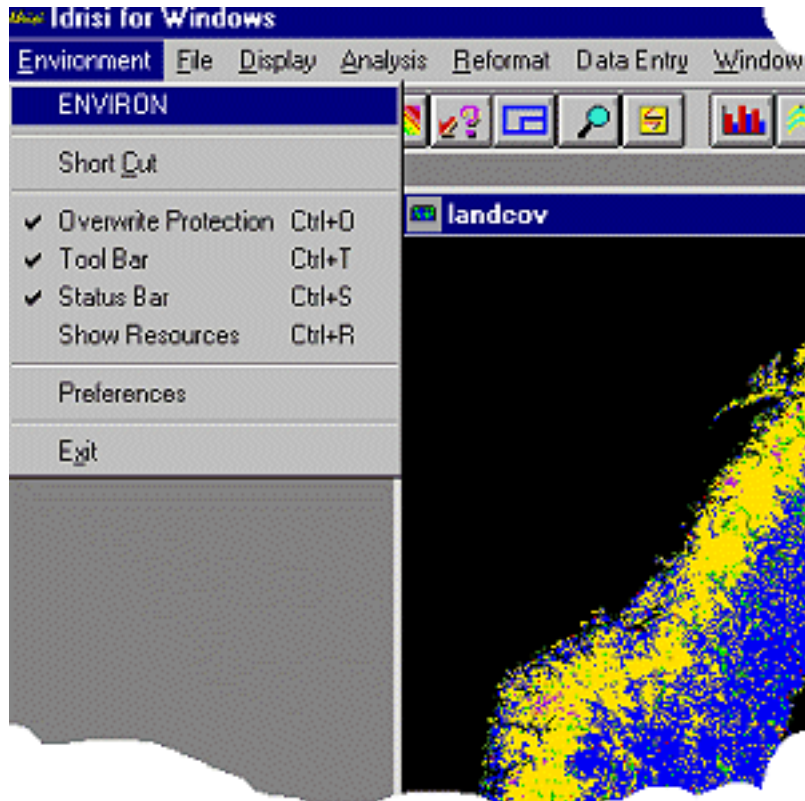


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Organizing Data

Before starting to analyze, process and squeeze your data with IDRISI, you have to tell it where to find them. All working data (eg. for a project) are commonly stored in one directory. That's the reason, why IDRISI does not meet the conventional menu structure of most WINDOWS programs (File, Edit, ...) - instead of opening files first, you have to point IDRISI to the directory holding your project data. This is done by **ENVIRON**. IDRISI stores that path until you change it, in a simple ASCII-file (IDRISI.ENV) which resides in the IDRISIW program directory:



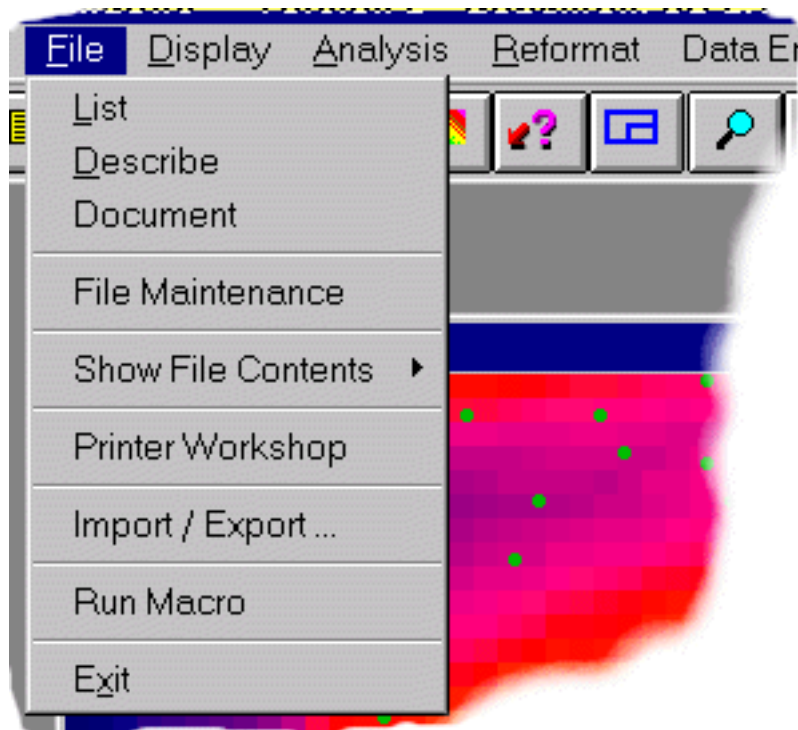
Be careful, where to put the data, as you will get problems if the path is too deep (more than 28 characters). Avoid Windows 95 or Windows NT compliant file naming schemes for your IDRISI data, as of now IDRISI is still a 16-bit software and does not allow longer file names.

If you are new to IDRISI make use of the Shortcut module, which opens up a list of all the modules available within IDRISI, so you do not have to remember the exact way how to find the function in the menu jungle.

How does IDRISI work?

In general IDRISI modules take(s) one (to many) image(s) as input and calculate one (to many) output raster file(s). Several modules face you with table results or both. Others output graphs. To avoid inadvertently overwriting, switch on the Overwrite Protection in the ENVIRONMENT menu.

The main suite of data organizing modules is found in the File menu:



LIST

lists the files in your data directory

DESCRIBE

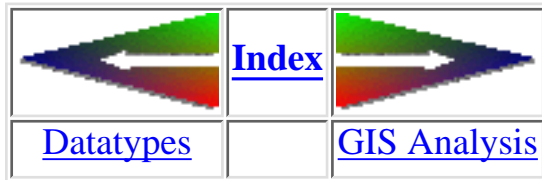
shows the contents of header files for [images](#), [vectors](#), [attribute value](#) and project reference files

DOCUMENT



allows making changes or creating new [image](#), [vector](#) and [attribute value documentation files](#)

File Maintenance

Helps managing your IDRISI data on the file basis (copying, renaming, deleting, moving of file(s)). Of particular importance is the fact, that they act on file-pairs - *.IMG/*.DOC, *.VEC/*.DVC, *.VAL/*.DVL, ...



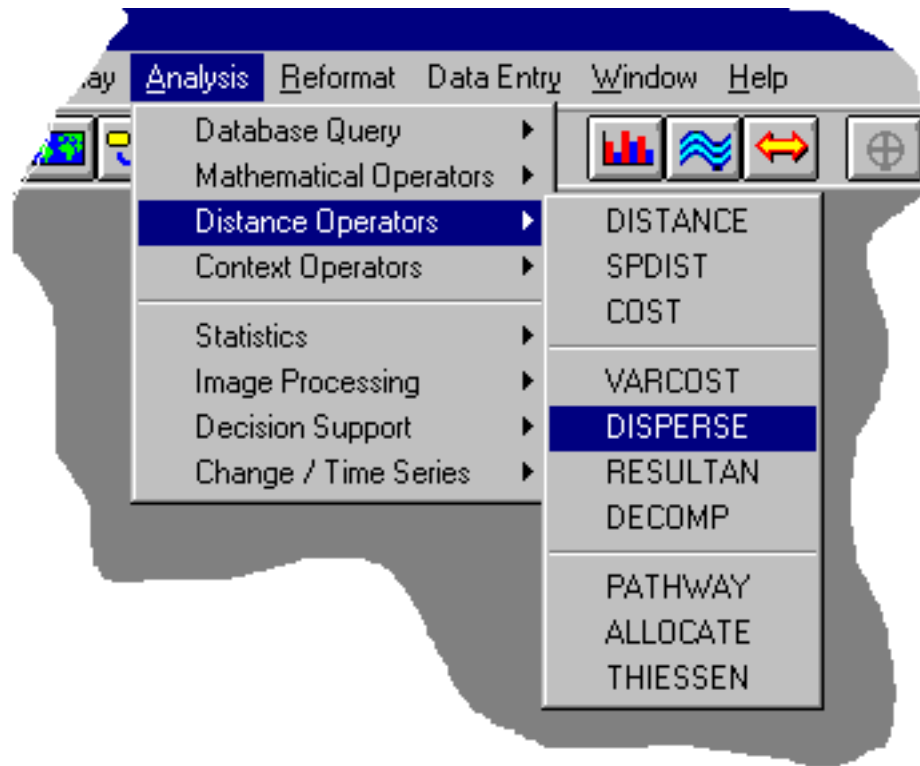
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GIS Analysis



You know the basics about the most important IDRISI filestructures, so let us take a closer look at the programs strength - the analysis capabilities.

IDRISI consists of several basic 'bricks', that allow you to build up your GIS-models:

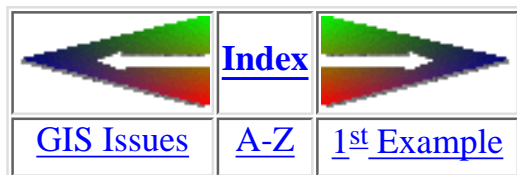


As the menuentries indicate, the modules are arranged thematically depending on what they are for. Several modules, eg. **HISTO** and **STRETCH** appear within 2 or 3 submenus, as their functionality fits for different tasks. That may seem strange and unusual but one can live with it. Especially those of you who know IDRISI from earlier DOS versions, won't have any problems to find the desired function. BTW, IDRISI implemented a little tool, Short Cut - it is found in the Environment menue - that gives experienced DOS IDRISI users a faster access in that you just type in the first letters of a module and the cursor will highlight it in a list, then press Enter, and ... here we go.

First I should tell you how things can be visualized in IDRISI.

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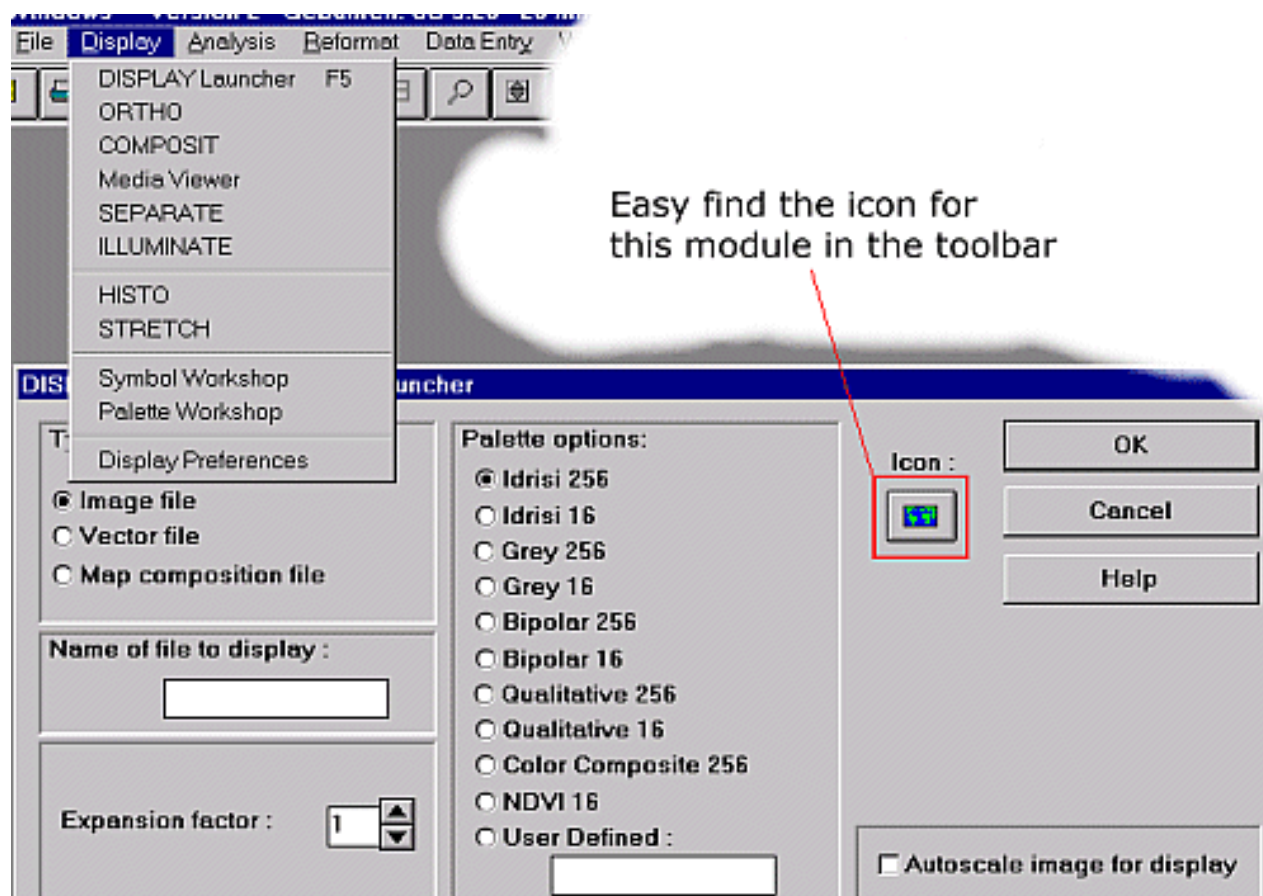
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Visualizing Data

DISPLAY Launcher

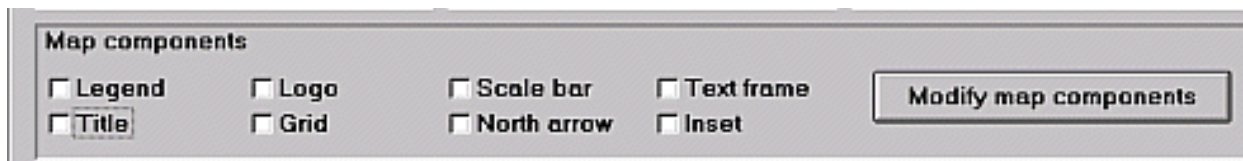
IDRISI is a raster-based program, so displaying images is essential for evaluating your raw data as well as intermediate products or final results by eye. Call the **DISPLAY Launcher** or simply press **F5**:



Decide which type to display - Image, Vector or Map composition file - and the dialog box presents you the appropriate fields. By default one gets into the image option. Now doubleclick (or rightbutton-click) the 'Name of file to display'-field. A Pick File list shows you all imagefile names in your working directory (remember [ENVIRON](#)) to select one.

The Expansion factor determines the size of your display window. IDRISI defaults to a value depending on the physical image size - if the raster is rather small, say 10 cols x 10 rows, you'll get an expansion factor of 64. If you like to compare many images visually, adjust that factor to your needs.

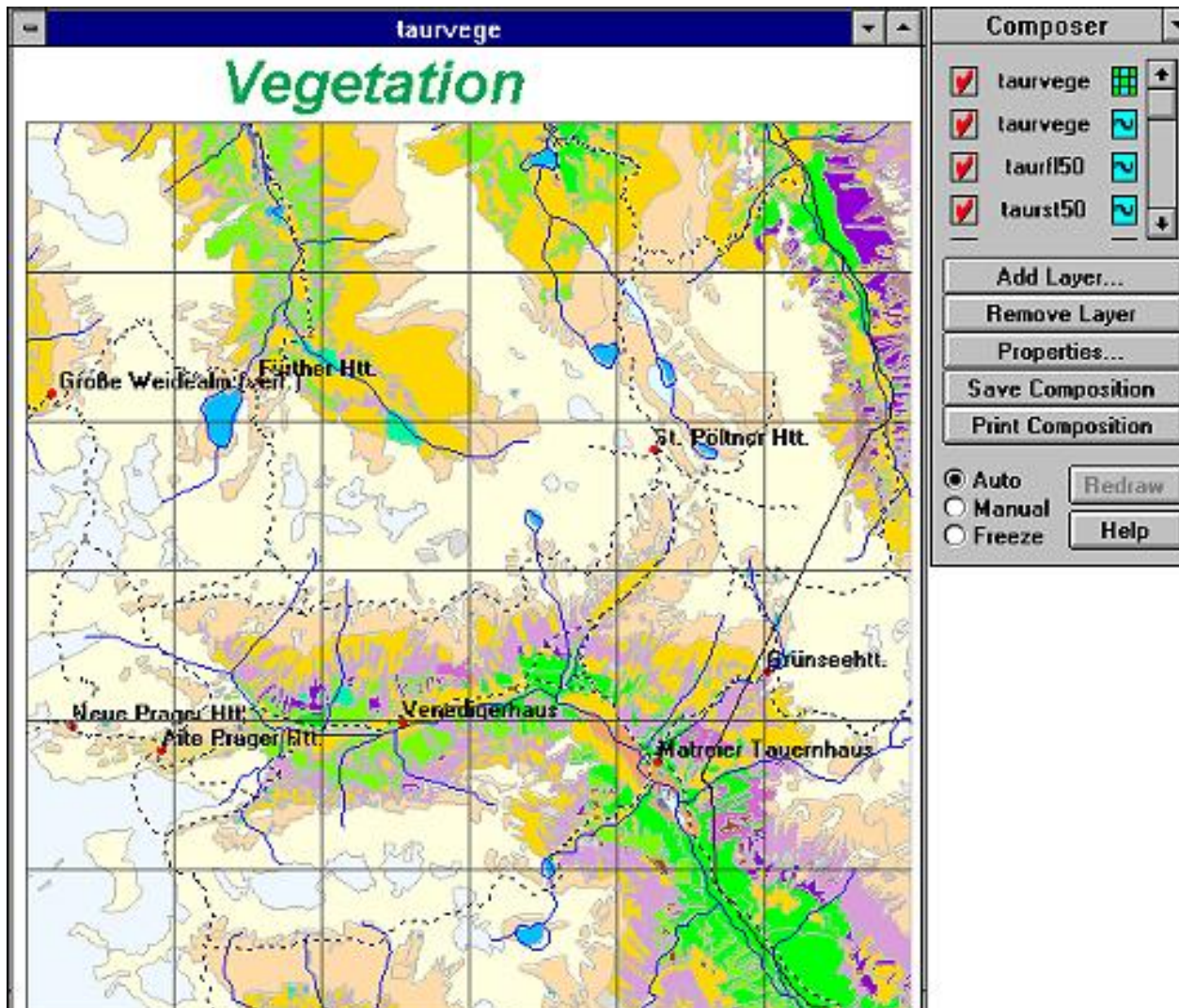
By electing a palette from the *Palette options* you tell IDRISI how to relate the values in the image to colors. Take one out of the already prepared or name your own palette file (visit the section about [Palette files](#) to learn more about structure, creating and handling). How IDRISI performs this relation, depends on the nature of the values: IDRISI provides you with up to



with floating point values have to be autoscaled. IDRISI checks for the minimum and maximum values, takes them as 0 resp. 255 and recalculates all the other values between as byte numbers. That's done automatically in the mentioned cases but you can force it with byte images too by clicking *Autoscale image for display*.

The option in the bottom part, *Map components*, allow you to add descriptive elements to your map. IDRISI lets you arrange that later too.

Using the image *taurvege* with a palette also named *taurvege*:



256 colors. For images with integer values ranging between 0 and 255 (byte range), IDRISI classes that value with the corresponding color code. Images holding values that extend the 0 to 255 range or those

Once you open a display, IDRISI opens a accompanying *Composer* dialogbox, that allows for adding/removing vector layers, modifying map components, saving and printing, thus preparing what IDRISI calls a Map Composition. Up to 16 layers can be stacked that way. One image is allowed per composition, for more use OVERLAY techniques instead. Several images side by side have to be concatenated first with CONCAT.

If you open a second display the name in the composer menu (eg. *taurvege*) changes to the active display window. Little icons right to the layer names tell you about the layer type. By drag and drop with that names in the composer you can alter the stack sequence. The square boxes left to the names indicate visibility. Checked means? Right - visible!

Checked means? Right - visible!

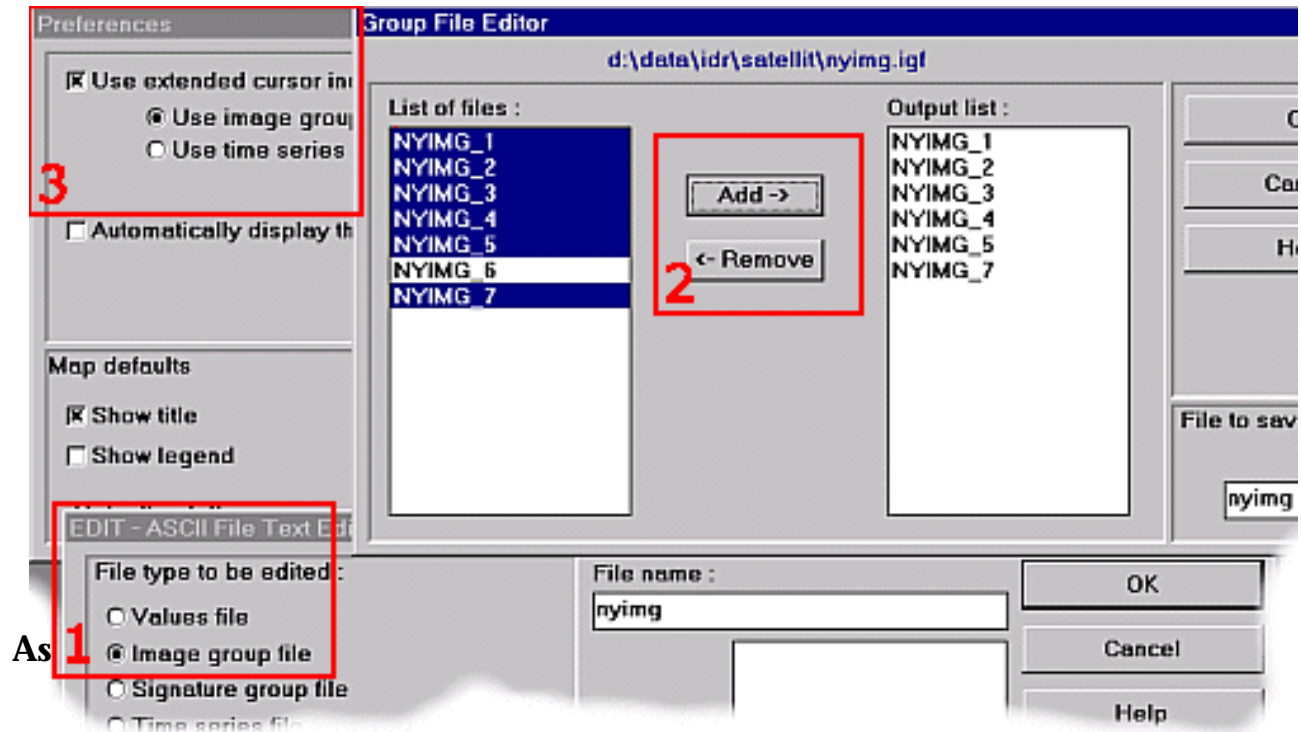
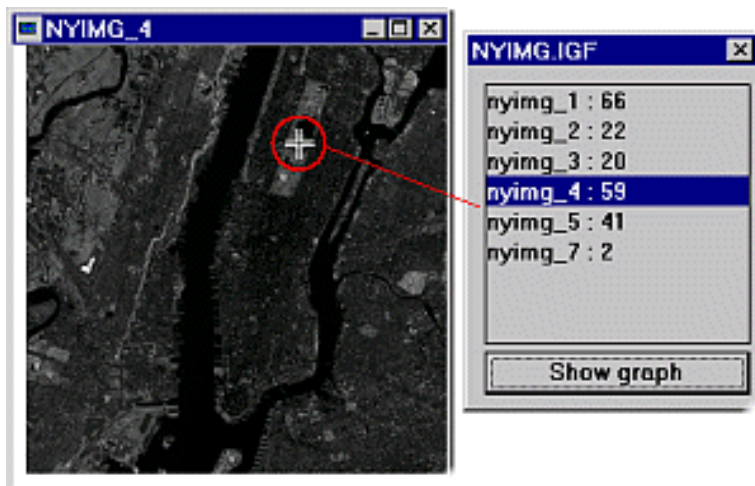
When working with bigger images (or slower CPU-speeds) it may be opportune to deactivate the *Auto Redraw* feature, because - well at least now at time of writing this text - display speed, especially with larger vector overlays isn't that heady.

The displayed image corresponds to a spatial database and with some simple tools you can query it interactively. If the cursor is moved over the image, column-/ row-number and the x- and y-coordinates are

Cursor inquiry mode, which must be activated from the toolbar . The cursor changes to a crosshair, and by clicking into the image IDRISI writes the cellvalues to the middle of the statusbar.

Enhanced DISPLAY Functions

Since IfW 2 you have more control and more functions when displaying images. A very useful utility is the *Extended cursor inquiry mode* (Display/Display Preferences), which allows to inquire several images at the same time. Take for example the visual analysis of a Landsat image, where you like to know the digital number (spectral reflectance value) for one specified pixel. So put (1) together a so-called *Image group file* from within the EDIT module. The *Group file editor* (2) is a comfortable tool to make this file. Simply choose those image files you would like to query. Save and tell IDRISI in the Display preferences (3) to load this newly created Image group file for the extended cursor inquiry.



As

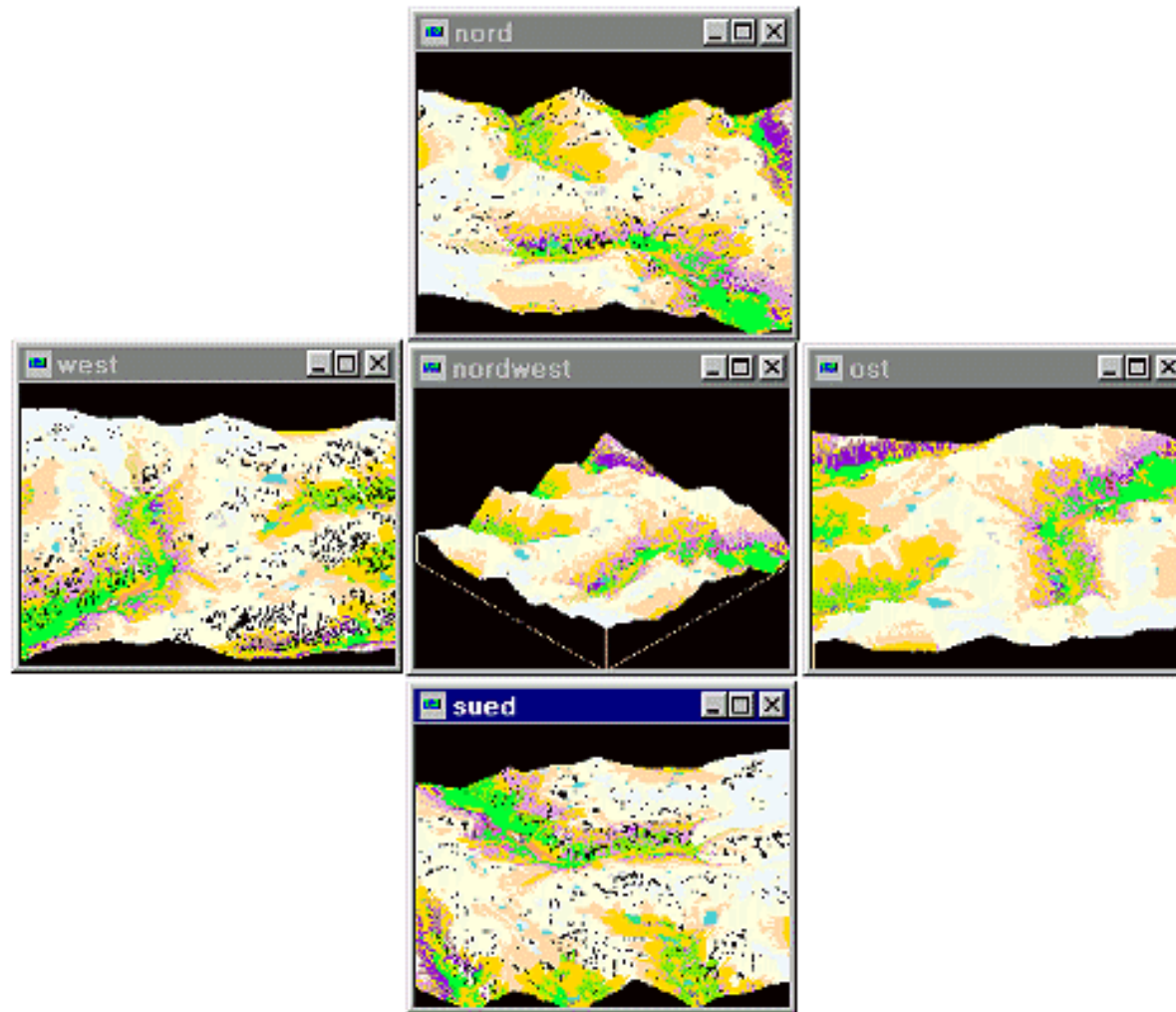
soon as you query a member of the activated image group file from the display, an additional information window pops up showing the values for the pixel under consideration in all the images you put in the group file before.

Another nice feature of DISPLAY is the *Interactive legend highlighting*: whenever you like to know the spatial distribution of all the pixels

belonging to one class (showing the same cellvalue resp. attribute ID) display the legend too, then press down the shift button and left-mouseclick on the legend entry box of the value you are interested in - all pixels with that cellvalue will turn into their complementary color and thus flash. If you do the same but right-mouseclick, you call up *Interactive legend editing*.

3D-Visualization with ORTHO

can be a valuable completion to 2-dimensional bird's-eye view. View direction and view angle can be adjusted between 0 - 90°. Together with the TRANSPOSE module (calculates rotated images) IDRISI can produce looks from/to nearly any direction. It allows for one byte image to be draped over the surface (normally but not compelling a DEM) and the choice of a palette:



VIEW and DUMP

VIEW

displays the cellvalues of raster files in a spreadsheet-like matrix and allows for exact cell-by-cell value identification

DUMP

is simply a binary Hex/ASCII file viewer to track your data down to byte level. It is not only useful in examining raster but all kind of data. DUMP can help checking out unknown data formats for import

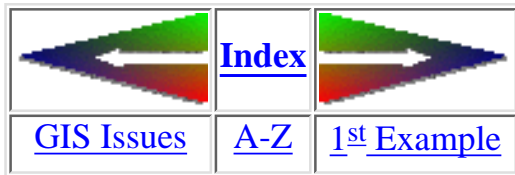
Other Display Functions

As you may have noticed from the first figure on this page, there are now (since IfW 2) more tools to visualize your raster data: Media Viewer, SEPARATE and ILLUMINATE.



The Media Viewer creates AVIs (Video for WINDOWS files) from a sequence of images (e. g., from a [Image group file](#)).

SEPARATE takes a input image + a [palette file](#) and separates the input files values into three images (red, green and blue) depending on the specified palette file.

ILLUMINATE may be used to merge panchromatic SPOT with multispectral LANDSAT TM images, also for the merging of hillshade images with spectral data. Idrisi help provides step-by-step instructions how to do this.



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1st Example

Let us start with a simple question:

given are a vegetation (raster) and a river (vectors) map.
What we want to find out: do certain plant associations cohere with proximity to rivers?

About the data:

the vegetation has been digitized from a analog copy. The original field data were superimposed on a 1:25000 map. The whole digital vegetation data exist in form of a Arc/Info® coverage. The import happened through Arc/Infos UNGENERATE format and IDRISI's **ARCIDRIS module**. As the latter produces vectors, a rasterizing process followed (resolution has been adjusted to 25 m). The river data originated from 1:50000 maps and were treated the same way as the vegetation information except the rasterizing. Both data are georeferenced to the same coordinates.

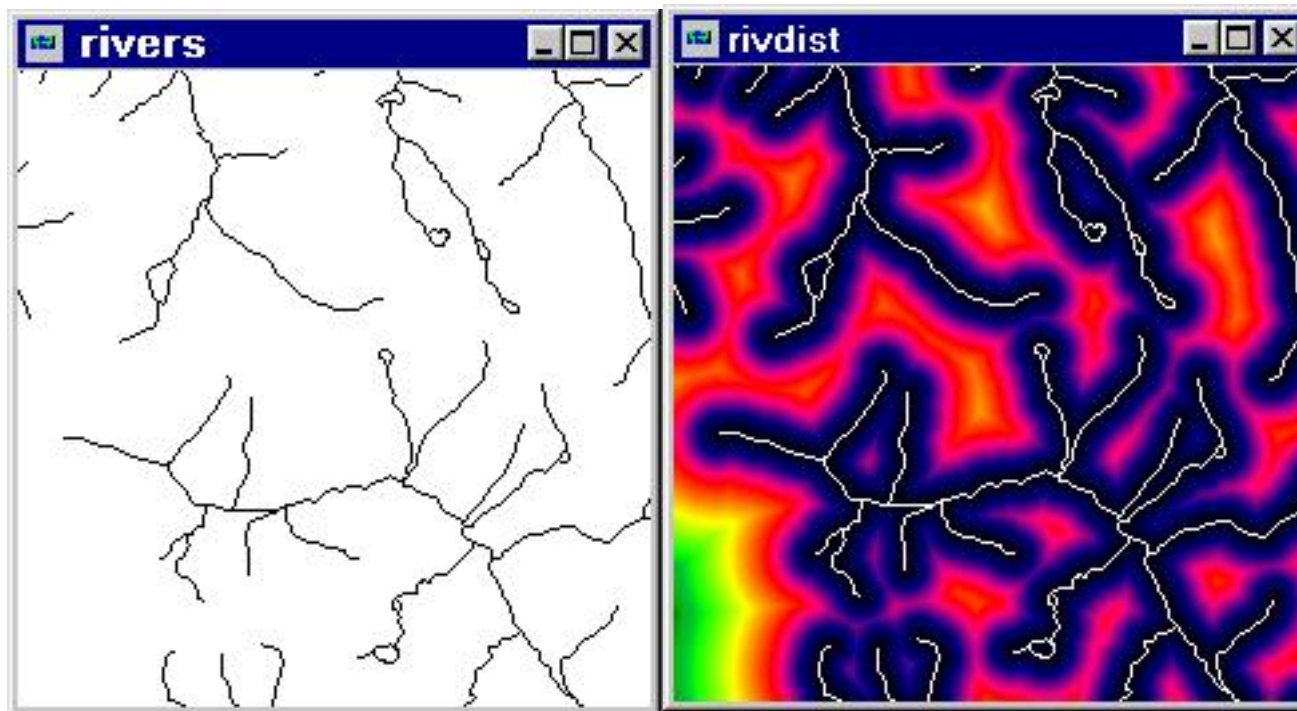
1. First we need to rasterize the river layer

in IDRISI this requires a two-step procedure: (1) INITIAL to create a new empty image for the data to be filled in during rasterize with (2) LINERAS. If desirable IDRISI allows for copying spatial parameters (rows, cols, min x, min y, ...) from an existing image.

2. Now have IDRISI calculate *buffer zones*

the DISTANCE operator looks for non-zero cellvalues, takes them as a target and calculates the distances to these cells. The resulting image now holds euclidian distance values given in reference units. Use SPDIST where spherical distortions should be avoided. Keep in mind, that DISTANCE calculates for a 'flat' surface - results do not take into account slopes hence do not correspond to 'real' distances, especially in steep mountainous areas!

The darker the color the closer we get to a water streamline. For a better orientation the vector layer rivers has been overlaid.



3. Regarding our problem, which areas will be of interest?

Consider the different data resolutions: vegetation on the basis of 1:25000, but rivers digitized from 1:50000 maps. The inspected region is part of the Alps, the rivers should better be delineated as brooks sometimes forming gorges with their own microclimate. For the sake of demonstration we will inspect the image for 100 resp. 300 m distance buffer zones around rivers.

By applying RECLASS to the output image of DISTANCE (rivdist) we extract a 100 m buffer zone around the rivers: distance values between 0 and 100 are set to 1, all others to 0. The output image (here named riv100) contains only 1 and 0, 'yes' and 'no', therefor call it a *boolean image*

The screenshot shows the 'RECLASS - Image Classification / Reclassification' dialog box. It has a blue title bar with a close button. The dialog is organized into several sections. On the top right are three buttons: 'OK', 'Cancel', and 'Help'. The 'Type of file to reclass' section has two radio buttons: 'Image' (selected) and 'Values file'. The 'Classification type' section has three radio buttons: 'User-defined reclass' (selected), 'Equal-interval reclass', and 'File mode'. The 'Input file' field contains 'rivdist' and the 'Output file' field contains 'riv100'. The 'Icon' field shows a small icon of a river. The 'Assign a new value of' field contains '1'. The 'To all values from' field contains '0' and the 'To just less than' field contains '100'. There is a double-headed arrow icon between these two fields with a '1' below it. A checkbox labeled 'Save as reclass file (.RCL)' is unchecked. The 'Title' field contains '100 m buffer zone around rivers'. The 'Value units' field contains 'classes'.

RECLASS - Image Classification / Reclassification

Type of file to reclass :
☒ Image
☐ Values file

Classification type :
☒ User-defined reclass
☐ Equal-interval reclass
☐ File mode

Input file : rivdist

Output file : riv100

Icon :

Assign a new value of : 1

To all values from : 0

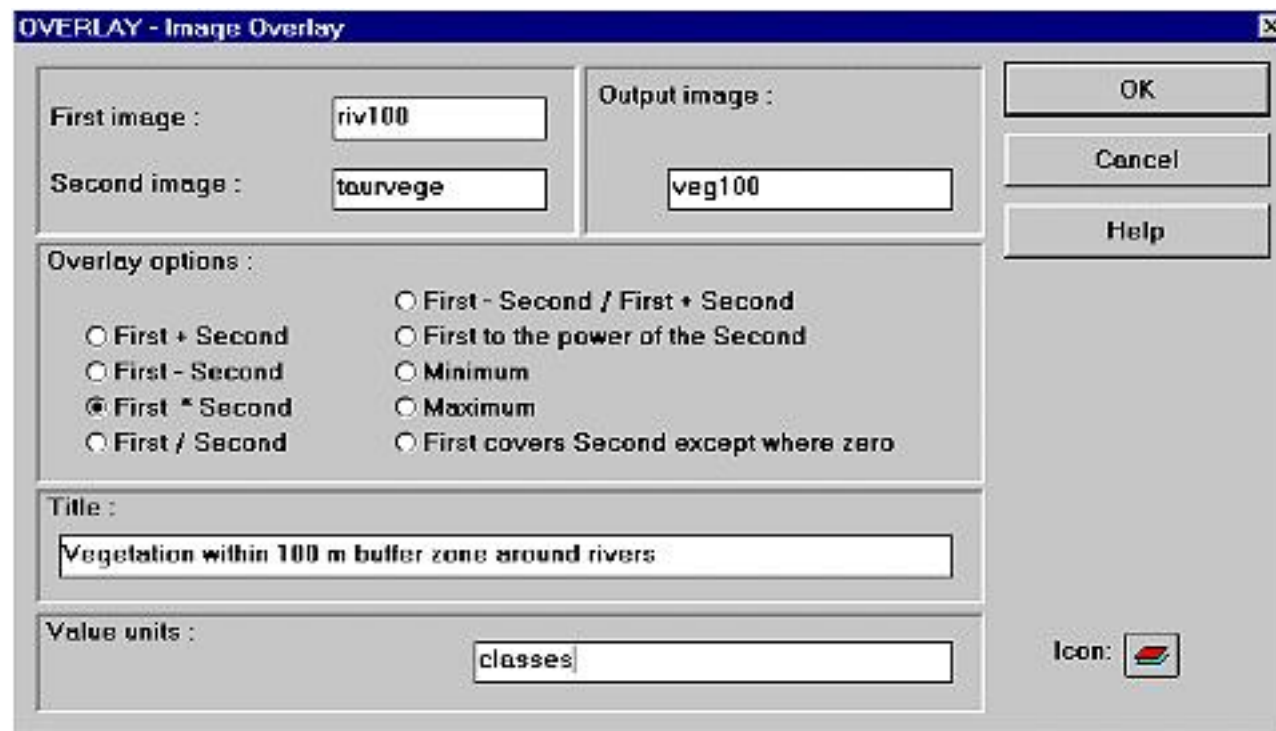
To just less than : 100

☐ Save as reclass file (.RCL) :

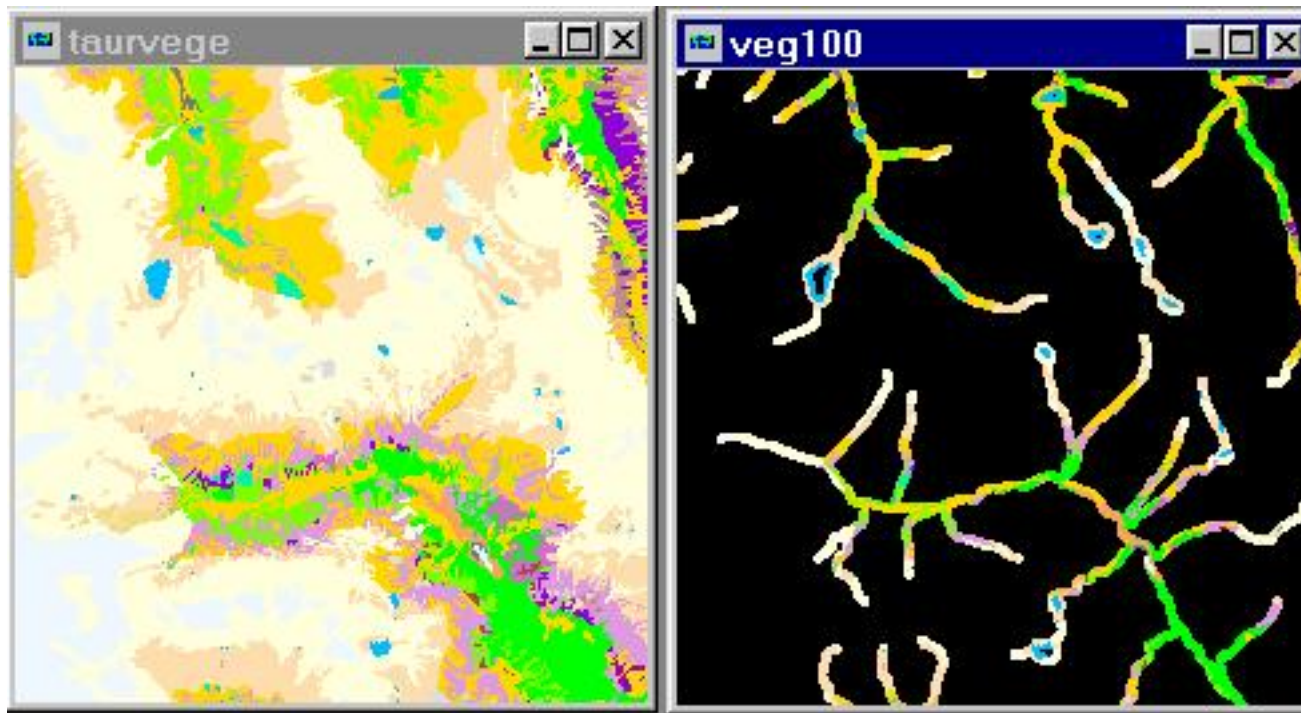
Title : 100 m buffer zone around rivers

Value units : classes

We go on with OVERLAY, a very useful and often employed module when it comes to combine two images through addition, subtraction, multiplication, rationing, etc. The module takes the values of the two input images and proceeds with them according to the *Overlay options* writing the results to the output image cells:



In that we *multiply* the vegetation with the boolean distance image, only those values (= vegetation classes) survive, that are multiplied with 1 - well, exactly these reside within our desired 100 m buffer zone. Black regions in the illustration below indicate areas outside the 100 m buffer.



4. Calculating the area

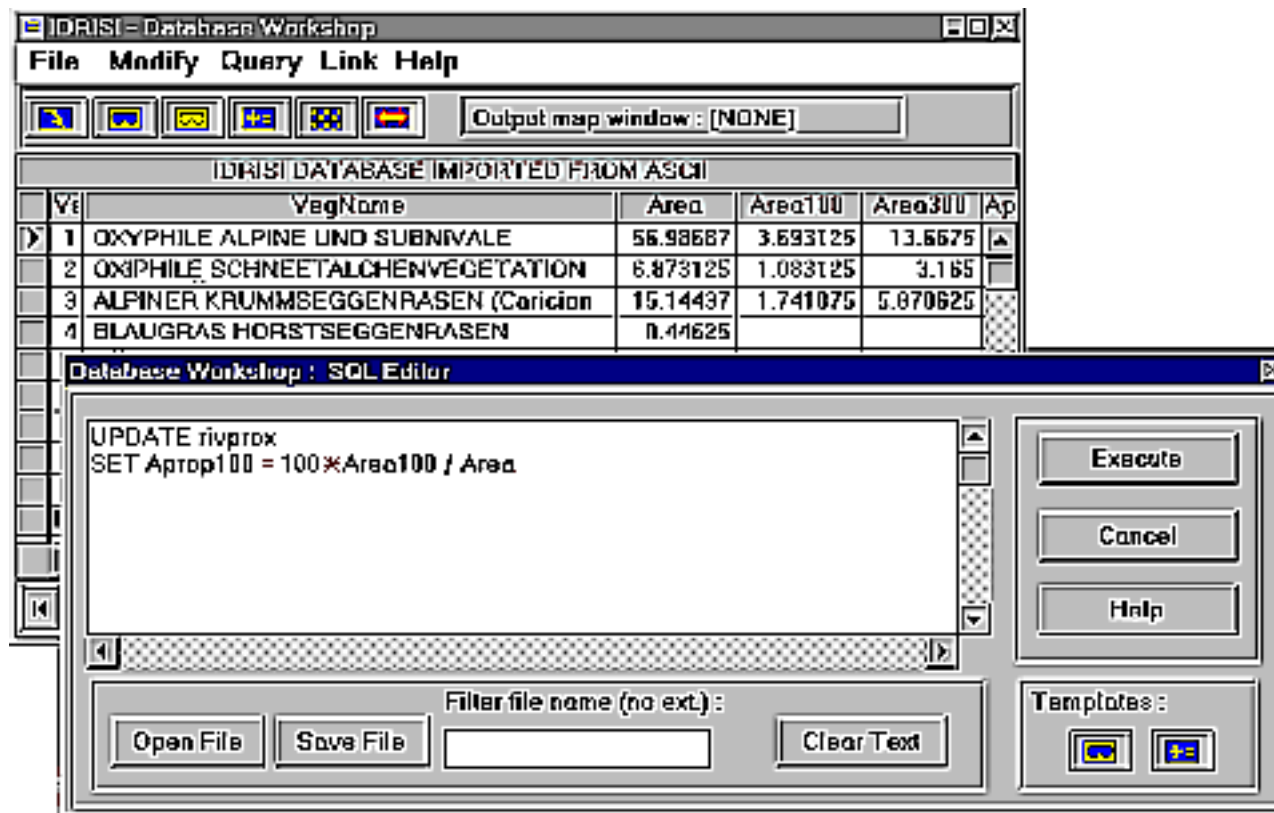
We need to stress the module AREA twice - (1) to know the overall area-size of each vegetation class (taurvege as input image for AREA) and (2) to get the areas in the buffer zone (veg100 as input). AREA offers three ways: create an image, where the cells of each vegetation class receive the summed area of that class, produce a values file or present the area for the classes as a table on the screen. In our case it seems appropriate to write out a values file. Further we must choose area measure units. I took km² (number of cells, m², acres, hectares, ... are among the choices).

Repeat the steps starting with RECLASS now with a buffer distance of 300 m.

5. Comparing with DATABASE WORKSHOP

The DATABASE WORKSHOP should be subject of an own exercise, so only the principal line is sketched here.

We ground the last step on three values files - that one for the areas of vegetation classes over the whole image, and the others showing the area sizes of the classes within the 100 resp. 300 m zone. Together with a values file of the class names a single database can be built up. The illustration below shows you, how additional database fields can be calculated from existing ones by standard SQL-statements (here the percentage of area within buffer zones related to overall area).





Very high percentages mean, that most of the area of that vegetation class resides within a 100 resp. 300 m distance buffer zone. Notice that water *does not* occupy 100 percent! This fact may well result from the data heterogeneity. Obviously the vegetation map contains a small lake, etc. that is not part of the rivers dataset.

Interpretation and ingenuity of the results in detail may be ceded to experts, but without knowing anything about the vegetation classes, we could make careful assumptions about which associations could be influenced by proximity to waters.

ID	Vegetation Class Name	Overall area	Area within 100 m zone [km ²]	Area within 300 m zone [km ²]	Percentage 100 m zone	Percentage 300 m zone
1	Androsacion alpinae	56.98687	3.693125	13.6675	6.480659	23.98359
2	Salicion herbaceae	6.873125	1.083125	3.165	15.75884	46.04892
3	Caricion curvulae	15.14437	1.741875	5.870625	11.5018	38.76439
4	Seslerio-Semperviretum	0.44625	0	0	0	0

5	Aveno-Nardetum	14.87438	1.904375	6.308125	12.80306	42.40934
6	Agrostio-Trifolio-Deschampsietum cespitosum	5.370625	1.90875	3.75	35.54056	69.82427
7	Agrostio-Trifolio-Deschampsion	2.3525	0.853125	1.9525	36.26461	82.99681
8	Polygono-Trisetion	0.51	0.324375	0.51	63.60294	100
9	Dactylo-Poion	0.023125	0.005625	0.023125	24.32433	100
10	Brachypodio-Koelerietum	0.021875	0	0.0075	0	34.28571
11	Loiseleurietum	3.27	0.49625	1.56875	15.17584	47.97401
12	Rhododendretum ferruginei	5.620625	0.94	2.718125	16.72412	48.35984
13	Erico-Rhododendretum hirsuti	0.00375	0	0	0	0
14	Junipero-Callunetum	0.721875	0.055	0.25	7.619048	34.63203
15	Pinetum mugli	1.406875	0.114375	0.39125	8.129721	27.80986
16	Alnetum viridis	5.616875	1.17625	3.28125	20.94136	58.41771
17	Cembretum	0.449375	0.026875	0.214375	5.980528	47.70515
18	Larici-Cembretum	1.659375	0.1075	0.585625	6.478343	35.2919
19	Vaccinio-Rhododendro-Laricetum	0.198125	0.020625	0.0625	10.4101	31.54574
20	Larici-Piceetum	4.884375	1.44125	3.6775	29.50736	75.29111
21	Piceetum subalpinum	0.00625	0	0.00625	0	100
22	Luzulo-Piceetum	2.3575	0.829375	1.846875	35.18027	78.3404
23	Alnetum incanae	0.160625	0.1	0.160625	62.25681	100
24	Salicetum eleagni	0.053125	0.025	0.053125	47.05882	100
25	Adenostyletalia	1.048125	0.1375	0.603125	13.11866	57.54323
26	Dryopteridetum	0.323125	0.071875	0.254375	22.24371	78.7234
27	Caricion fuscae	0.475625	0.28125	0.444375	59.13272	93.4297
28	very moist soils and fountain areas	0.301875	0.194375	0.301875	64.38924	100
29	Glaciers	11.6075	0.136875	0.723125	1.179194	6.229808
30	Waters	0.8275	0.6275	0.78625	75.83082	95.01511

31	Other regions (scree flora or cultivated areas)	0.404375	0.054375	0.08125	13.44668	20.09274
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How to work with Palettes and Symbol Files

- a recreative chapter?

● Palettes

You might have asked yourselves a lot of questions about colors and IDRISI:

- How does IDRISI match colors with cellvalues?
- What for does the software give us the choice between several already fixed palettes? (see that kind of torn [DISPLAY LAUNCHER figure](#) with the palette options in its middle part)
- Which palette should one use with which types of data?
- Why 16- versus 256-colors palettes?
- When do I need own palettes and how do I create them?

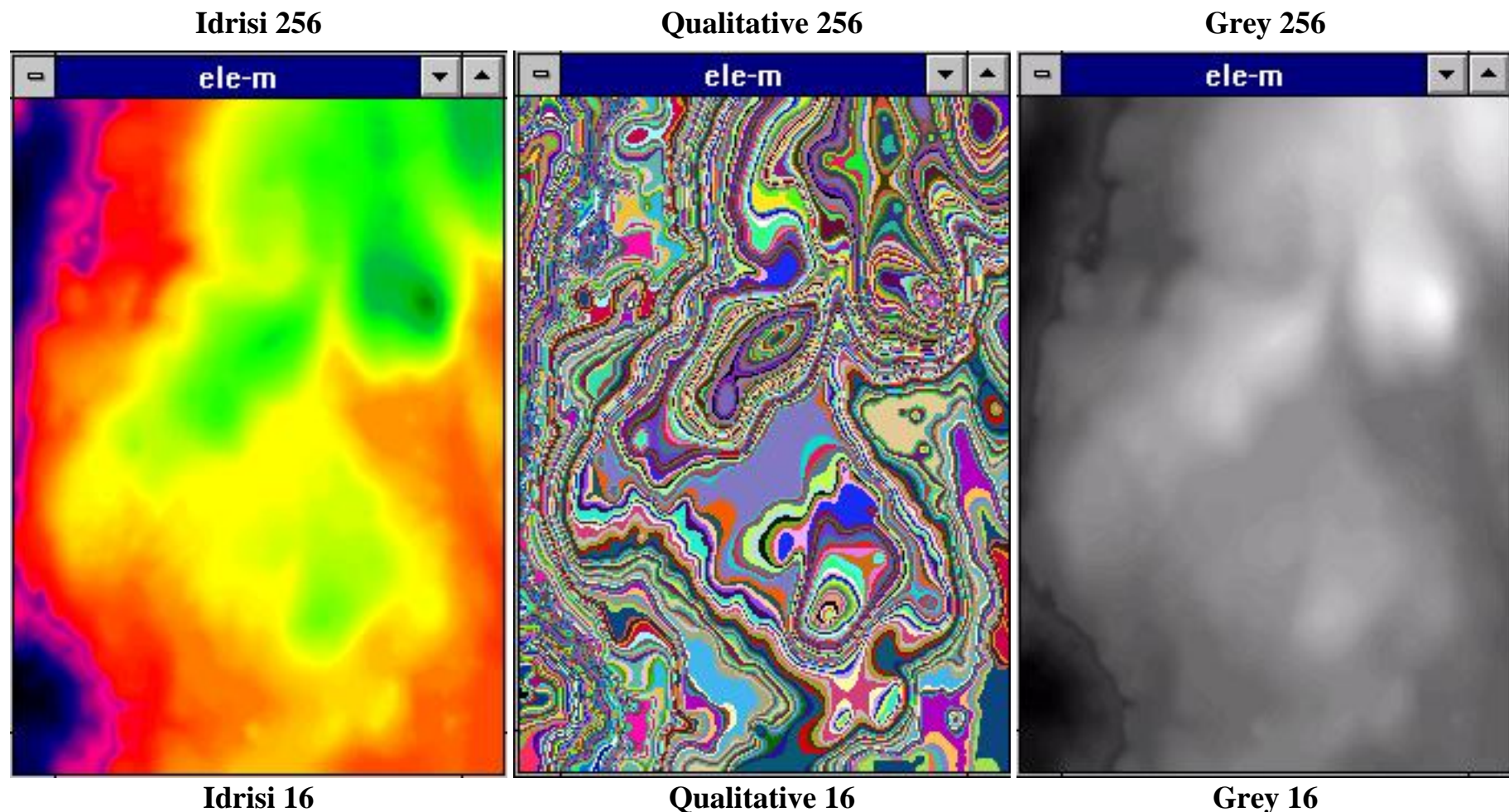
Let us unroll the whole one by one. **Matching the colors has to do a lot with that technical staff called '[data types](#)'. IDRISI builds colors upon the RGB-colorscheme (Red Green Blue) in the way that we have the image in one hand and a table of 256 color-indices in the other. These indices point to RGB-combinations, where each of that base colors ranges from 0 - 255. Imagine the number of possible combinations! $256 \times 256 \times 256 = 16777216$.**

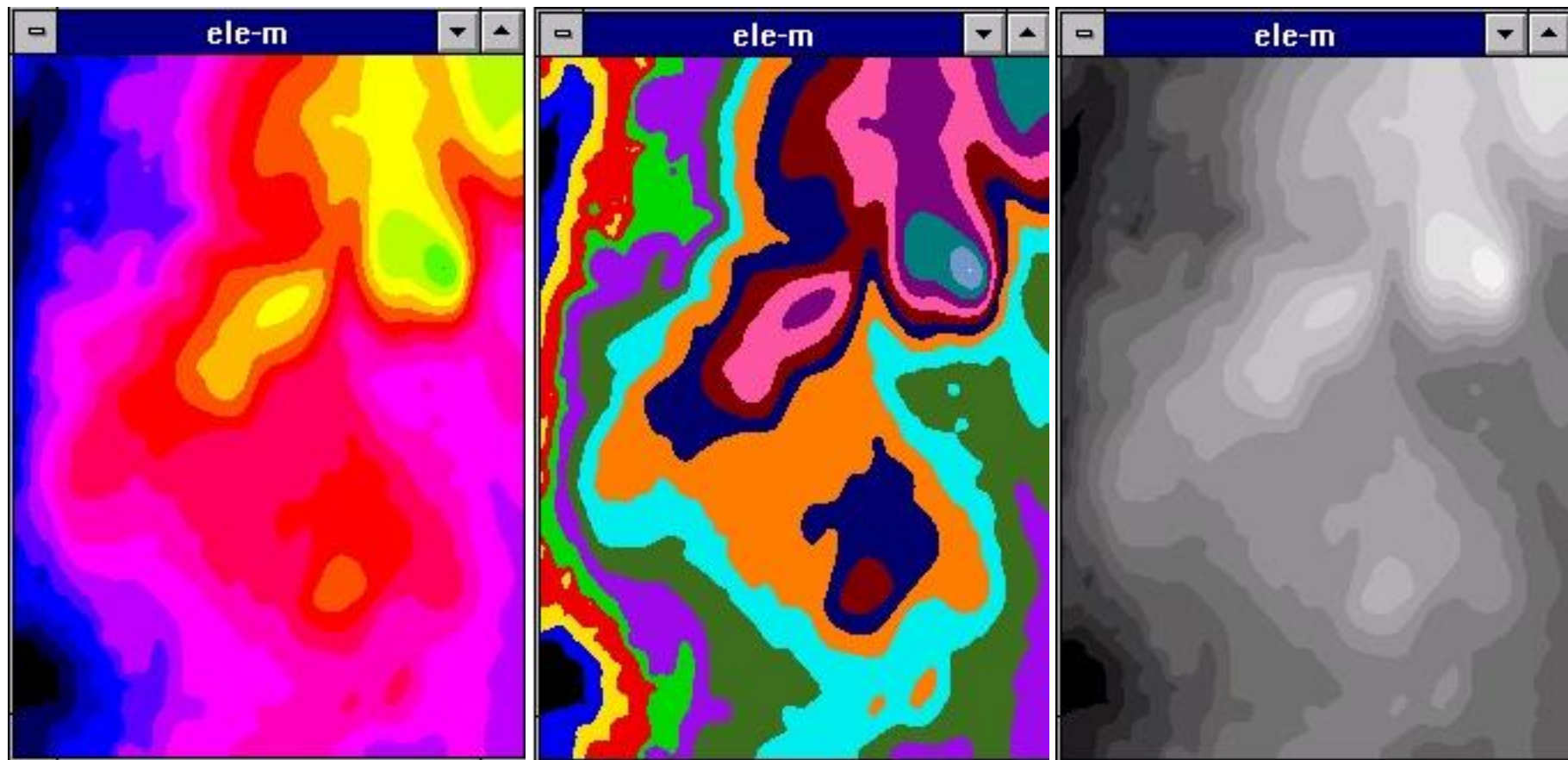
But remember that at this time IDRISI allows to use a 256 colors-subset out of the 16.7 millions. How that 256 colors will appear on your screen in turn depends on the graphics card that's in the computer you use (and - of course to a smaller amount - on your screens quality and settings). So-called '8-bit cards' (known also as the 'color depth') are capable to display 256 colors, as each of the 8 bits can be in 2 states - on or off, 1 or 0 - so 2^8 makes the magic 256. You should not run IDRISI for WINDOWS with a 4-bit color depth card (only 16 colors). Computer users often receive their systems 'fully set up', but now comes the moment of truth where you really should know about the resolution (how many pixels can be displayed on the screen) and the color depth. All modern graphics cards allow to be adjusted to a variety of different resolution/color depth-combinations under MS WINDOWS (3.x / 95 / NT / WIN-OS/2). The decision which to use, depends also upon the size of your monitor. Sorry to say, but serious working with graphical applications requires that basic knowledge about your hardware and its appropriate settings. Plug-and-Play? Hahaha!!

Now, on we go! IDRISI looks at the data type of the image file: if it is byte (integers from 0 to 255) the matching works perfect, as each cellvalue can be interpreted as a colorindex number, e.g. a cellvalue of 10 will receive the RGB-color of the color no. 10, 143 will show the color of color index no. 143 and so on (see also [Single Raster Analysis Tools I](#)).

Fine, but how does IDRISI with cellvalues such as -32? Or 45.789? Or 257? 54654.432? In the case of integers or reals IDRISI cannot perform that 1:1 matching of data values to color indices, so it takes the lowest and the highest value of the image and gives them the color no. 0 resp. 255. All the other values are autoscaled to fit in that range. This is indicated by automatically activating the autoscaling within the [DISPLAY LAUNCHER module](#) (again see the figure there to find that checkbox; with byte images we can force the IDRISI display system to do that autoscaling by clicking the checkbox to on).

Unpuzzling the next miracles: why those many different palettes and when to use which one? Take a glance at the following examples:





It is a DEM, a digital elevation model, where each cellvalue means a height at this location. How different it looks in each of the 6 palettes! Which one would you mostly prefer if the task was to roughly interpret the general height distribution?

the Idrisi 256 palette

looks rather beautiful (know that plasma clouds generating algorithms in programs for computing fractals?) ... but is maybe not the one to show us information at its best here

the Qualitative 256 palette

produces a really shrill output. These (the Qual256 and Qual16 palettes) have colors arranged in a manner that allows easy separation between nearby color indices. So a color is always followed by a completely different color in these types of palette tables. Use it for nominal data as an example.

the Grey 256 palette

again smooth clouds that may not be easy translated to a fine imagination

the Idrisi 16 and the Qualitative 16 palettes

do best demonstrate the two concepts behind: with the Idrisi 16 option the DEMs structures begin to crystallize, whereas the Qualitative 16 one does not really indicate a continuity.

the Grey 16 palette

makes most sense as the separation of 16 greys is more comfortable to the human eye than a differentiation between 256 nuances of greys or color shades. As we face IDRISI with real type height values, autoscaling is being activated. By using the Grey 16 (or Idrisi 16, Qualitative 16, or whatever palette with 16 colors), all our cellvalues are pressed in the range 0 to 16, what causes the images to show this stepped appearance.

If we want to demonstrate seamless transitions in our data, the usage of Idrisi 256 or Grey 256 (or maybe the 16 values variants depending on the number of classes in the data) would be reasonable. Examples are DEMs, sound ranging maps or maps showing the spread of pollution.

To show clearly distinct neighbouring areas holding discrete data, the Qualitative 256 or 16 palette options looks best (e.g. vegetation maps, geological formation maps).

Which palette option - the 256 or the 16 - to choose is a question of the number of different classes in your image. The palettes named and pictured above are just a subset of what's included in IDRISI. It knows two types of palette files:

1. *ASCII color tables*: these are the *.pal-files those of you IDRISI for DOS wizards know quite well. They are simply 4-columns tables, where the first column indicates the color index number and the 3 remaining columns the red / green / blue values. These range between 0 and 63, thus allowing for 64 levels (reasons are former graphical hardware limits).
2. *binary palette files*: you recognize them from their *.smp-extension. The various palette options, we were talking about are in fact nothing but single palette files that have been copied to your IDRISI for WINDOWS program directory. So don't kill anything from there! When you open a pick file list from the palette options field, IDRISI finds and displays those in the program- and those in the current data-directory.



When do I have to create my own palettes and how can IDRISI help?

In most of your projects you will have to alter the IDRISI palettes or create them new to fit your needs. The colors in the figure to the left for example show a new built palette file for a vegetation map. The digital colors should be somewhat similar to those used in the analog maps.

IDRISI for WINDOWS includes a valuable little program, called Palette Workshop. I will not explain its functions in detail but just the purpose of it in short. You call it from within the IDRISI menu but it has its own menubar. Simply load the palette to be altered or start creating your own new one. Color



entries may be changed very comfortably by moving RGB-sliders. The palette may be reversed as a whole. You can fix the allowable autoscaling range to a certain subset (the reverse function allways acts on these subset). The big Blend-button (litt'l bit down and right from the middle of the graphic) lets you interpolate the colors between a start and a end color. Of course your new

colorful creations can be saved (in program directory, what makes them permanently available or just in the actual project directory; as *.smp or as *.pal file).

(Mis)usage of colors would be a chapter for its own. They are a important part of your product and can direct or guide the viewer. Read more about in e. g. Mark MONMONIERs 'How to lie with maps' (Univ. of Chicago Press, Chicago 1991).

It should be noted here, that IDRISI has its own Palette conversion utility [PALIDRIS](#).

● Symbol Files

IDRISI uses symbol files to attach colors, shades, pattern-fills, textstyles, etc. to vector layers. In the chapter about [vector files](#) we learnt that IDRISI knows 4 vector object types - points, lines, polygons and texts. Each one of these has its exclusive symbol file type. These filetypes can be easily recognized by their extensions.

- *.sm0 point symbol files
- *.sm1 line -- "" --
- *.sm2 .. polygon -- "" --
- *.smt text -- "" --

As common with IDRISI, pick file lists for symbol file options always offer you the appropriate symbol type. Each type comes shipped with one default symbol file from the beginning.

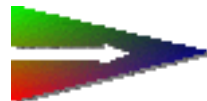
Equivalent to the Palette Workshop a Symbol Workshop allows you to change existing or create new ones. Again the functionality as described above for the Palette Workshop is included, but will be enhanced in future versions I believe.



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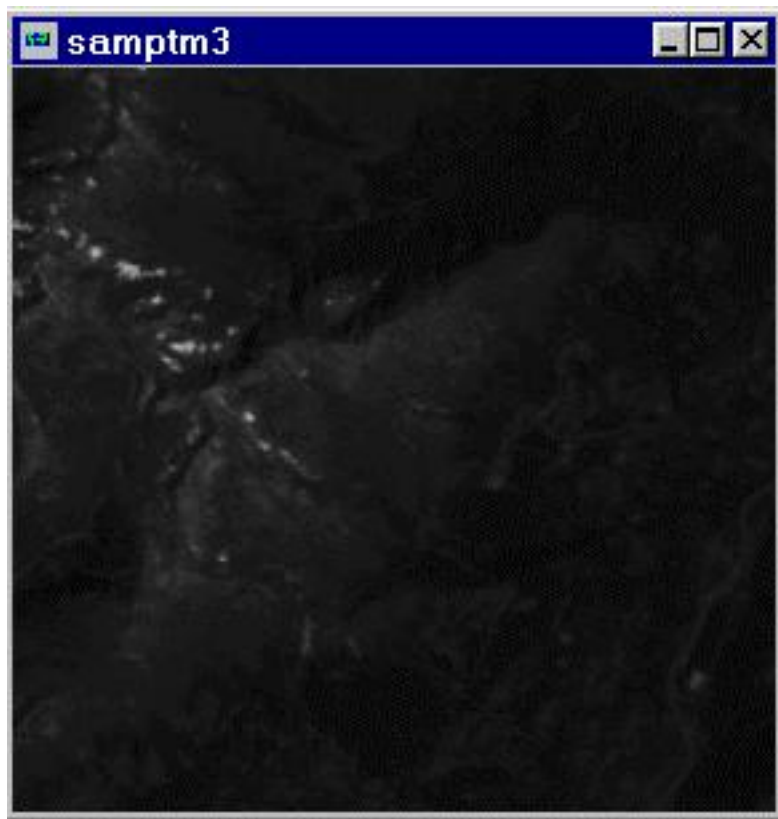
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Single Raster Analysis Tools I

We already learnt about **RECLASS**, **DISTANCE** and **AREA**. This chapter tells you about several other modules aiming at data exploration within a single image that go beyond plain visualizations.

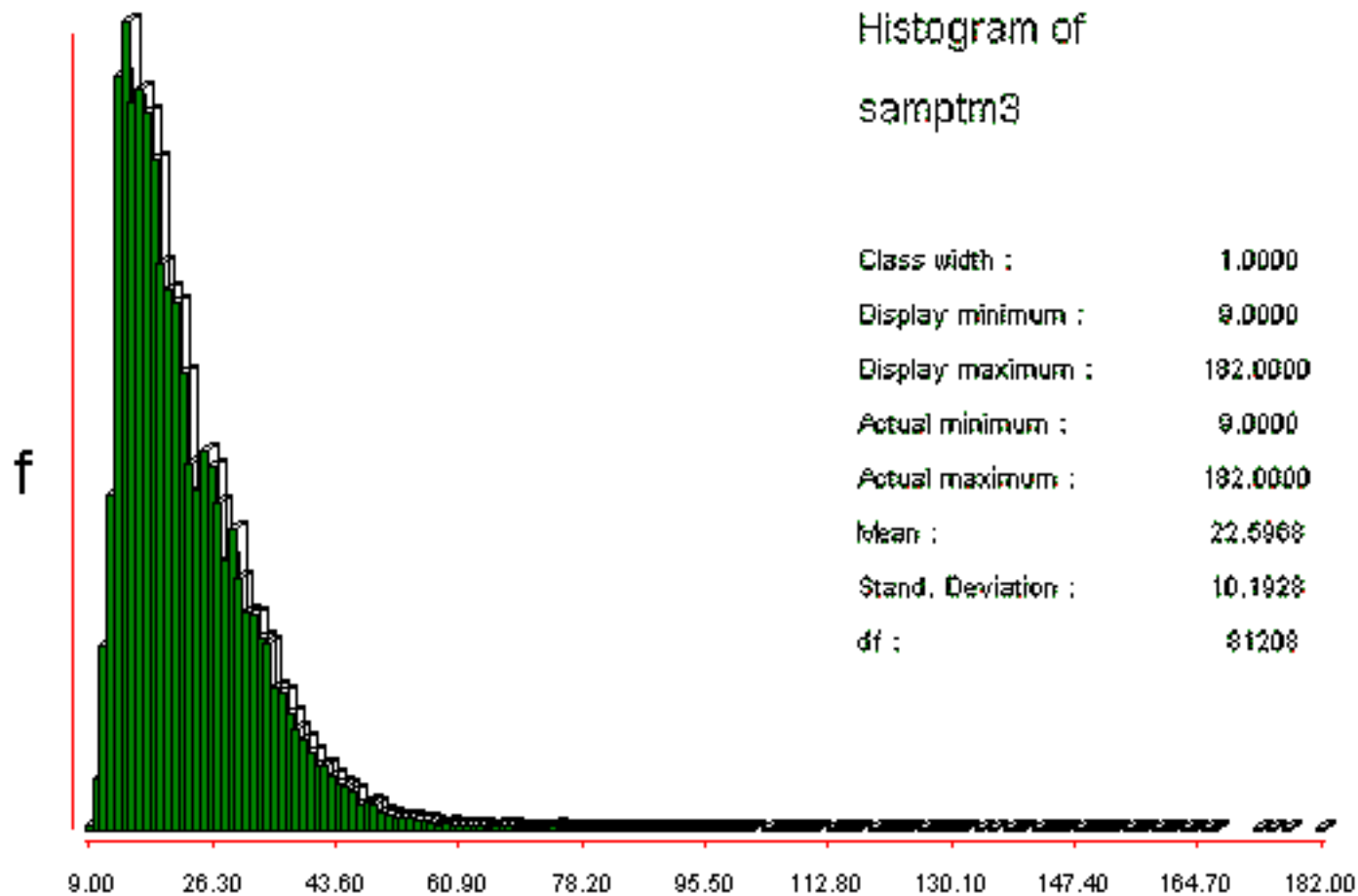
- **Basic descriptive statistics with HISTO**

When we display the image samptm3 with the Gray 256 palette, it will be disappointing for the first moment:



This image is a tiny clip from a Landsat TM 5 scene, band 3. To find out, if there's more to get from it, HISTO can provide us with helpful informations. HISTO asks for a input image - samptm3 - for which values it produces a frequency table resp. a frequency histogram. You may define the width or number of classes for the data range to be divided into, and you are free to set a new display minimum and/or maximum. If you prefer a numerical output instead of a graphic, the values are output to an editable window together with normal/cumulative frequency and proportion.

We go on with defaults (original HISTO-graphic has been altered for the purpose of display):



The x-axis shows the values ranging from chosen minimum to maximum (here: DN, digital numbers), whereas y-axis relates to the counts of same values. Considering the distribution of frequencies it becomes clear, why the image appears black: for the DISPLAY IDRISI took 0 (zero) as black and 255 as white, the values between are given gray colorcodes. But our image starts with 9 and ends up with 182, which is considerably lower than 255. As a simple solution the DISPLAY Launcher can be forced to perform automatic scaling - then it takes 9 as 0 (zero), 182 as 255 and rescales all other values.



Contented with this result?

OK, now take a look at the mean and the standard deviation, and consider the 'rat-tail' of cells with DN's above approx. 70. We can cut off all these values by applying [STRETCH](#) to samptm3 without losing too much information:

STRETCH - Contrast Stretch Utility

Stretch type :
☒ Linear
☐ Histogram Equalization
☐ Linear with Saturation

Percent to be saturated : 5.0

Input image : samptm3

Output image : samptm3s

☐ Leave out zero (as background value) from input image

Input image parameters :
☐ Specify lower bound other than minimum :
☒ Specify upper bound other than maximum : 70

Output image parameters :
Number of levels : 256
Lowest value to use for non-background areas (0 or 1) : 0
Highest value : 255

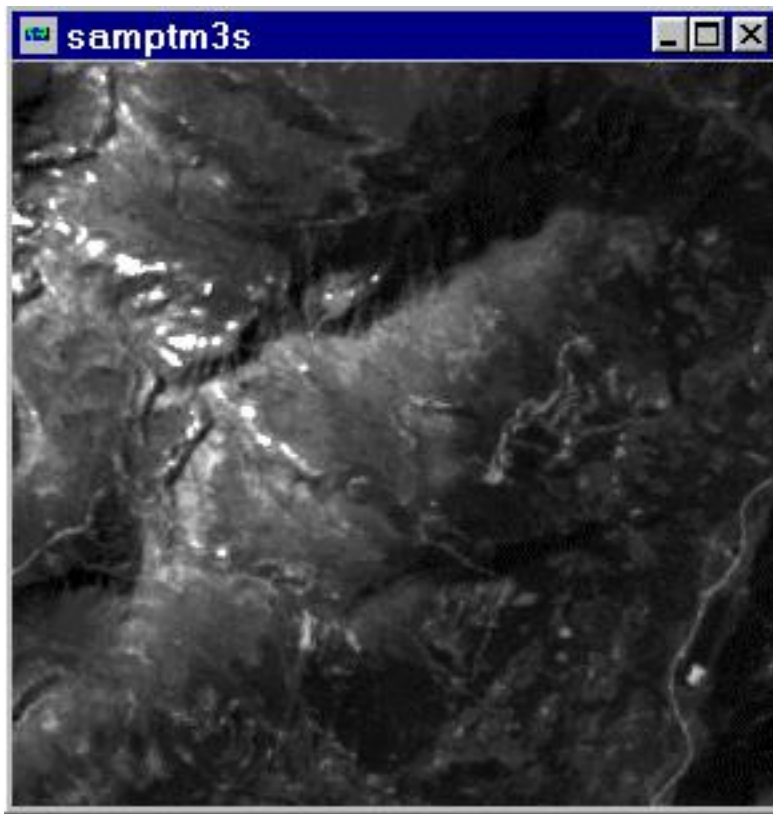
Title : Sample TM 3 stretched

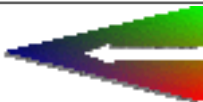
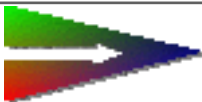
Value units :

OK
Cancel
Help



Icon :

We will return to STRETCH in detail [later on](#). Just as a short explanation: we told STRETCH to specify 70 as new maximum bound and 255 as highest value. Now 70 is equalized to 255, all higher values than 70 are set to 255 too. The stretched image shows a lot more structures now.



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Single Raster Analysis Tools VIII

- Me feels FUZZY more and more

You've all heard about fuzzy logic? It's a nice hot term, perhaps a bit outdated already. Meanwhile you might have met fuzzy logic cameras, camcorders and washing machines. "Fuzzy" also means something not being very clear, not being sharply defined.

Fuzzy logic! What a paradox, isn't it? "Logic" sounds much like a counterpart to fuzzy.

Maybe you have already found the FUZZY routine in the IDRISI software and played around with it. Did it help you solving your problems? Yes?? Well - stop reading now and go on with the next part.

Fuzzy denotes a thing or a status that cannot be defined very sharply. E. g., ask 100 persons, by what range of ages they would define a "young person" - you might receive answers starting from a newborn, others starting from 3 years, and so on. Maybe somebody would set the upper limit to 40. For sure you would get some overlapping range, where all agreed, e. g., humans at ages from 5 to 25.

Now, what should we take for true? Would you feel happy with a very deliberately statement such as: "young persons are human beings from the age of 0 up to 40"? Or should we better take the range of ages everybody agreed with - 5 to 25?

In either cases we do have a feeling, there's something wrong about. So what should we do?

Fuzzy logic can help us out, in that we do not set sharp, crisp bounds, where young persons immediately turn into medium or old ones. We put all the judgements into a group called "membershipset of young persons", those starting with 0 and the ones ending up with 40 years. But they all do have different strenghts of memberships, those within the all agreed range of 5 to 25 have a full membership, so let's give them a value of 1. Nobody extended the range beyond 40, so ages beyond 40 will receive a membership of 0 (sorry). That was easy, wasn't it? But now on to all the persons between these extremes - the perfect members, which are our overall accepted "young persons" and the guy at the age of 40? As you realized, we now do have two values, 0 and 1. Ha! Simply we give those between 25 and 40 also values between 1 and 0. We perform a remapping of the real ages to values within the range of [0, 1]. The way we do this is called the fuzzy membership function. You'll find 3 predefined (linear, sigmoidal and j-shaped) and a custom one in Idrisi.

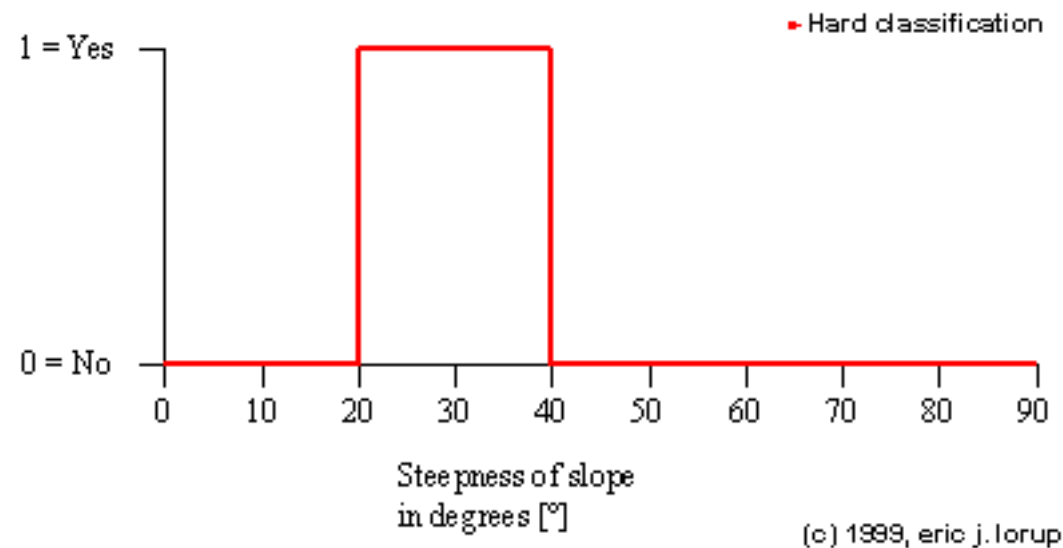
So what could we as GI(S)ers be interested in a thing like "fuzzy logic"? Can it help us? How?

Now substitute the variable "age" in the previous example by terms like "moderate distance", "steep slope", "low elevation", "high cadmium concentration", etc. These terms show the same fuzziness such as our question for young persons.

But what's worst about all that - even if you think, you found exactly the range for, e.g., a "steep slope" - try to imagine, what means "steepness" within a soil erosion analysis? What does it mean for an architect planning the best route for a new highway segment? What does it mean to someone, who enjoys extreme skiing? What does it mean ...

Fuzzy terms like the one listed before often have quite different meanings depending on their context! Fuzziness is fuzzy itself - urghh - horrible!

Now, how could we get around with all this? One way of course is simply introducing crisp thresholds. If necessary, a set of sharply classified ranges for each problem, where we need that: a steep slope in the context of a search for areas to serve extreme skiers could prefer slopes starting from 20° and ending at 40° (think, that's pretty steep for skiing, isn't it?). Our classification as a graph looks like this:



We are beaten by the non-satisfying fact, that - strictly following the hard classification - slopes with 19.9° or 35.1° do not belong to the steep slopes! Common sense tells us, that this cannot be the very end to this problem.



So, once again we sit down and define, what we believe as absolute thresholds for the definition of a steep slope in the context of skiing. This simple question turns out to become teasingly more and more: if we decide to even include non-extreme skiers, e. g., little children, our absolute minimum and maximum for the steepness expand to a wide range. So maybe we start at 5° as real lower threshold and go up to 60° to cover the most extreme ones among us (I know, there are some that rush down on even steeper slopes ...). These two values on the

opposite of their respective scale mark the degrees, below resp. above which we cannot speak of a "steep" slope. Let's take the range chosen before (20 - 40°) as our fully agreed range of steep slope values. Now a graph could look like one of the Fuzzy classification curves in the Flash animation below.



if you don't see any image, just an empty area, you need the [Macromedia Shockwave Flash Plugin](#) for your browser

for an alternative, see still images for the types of membership functions as GIFs (they will appear in one separate little browser window):

[Hard classification](#) | [Fuzzy linear](#) | [Fuzzy sigmoidal](#) | [Fuzzy j-shaped](#) | [Fuzzy user-defined](#)

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Map Pairs Analysis Tools I

Comparing images

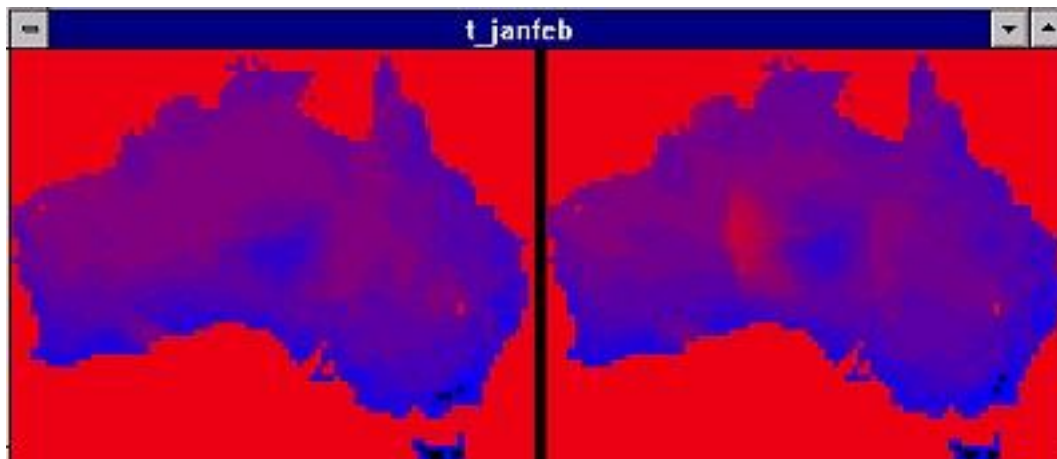
The main title indicates the start of a series of new chapters - how to cope with raster map pairs in IDRISI. It will only be possible to present a view spotlights. Several examples shall give you a feeling for what's possible in the IDRISI system and how it is done.

- Differencing

Question: given are two images showing the monthly mean temperatures (°C) for Australia in January and in February. What changes did occur?

The data have been windowed from global data sets in [GRASS](#)- format and transformed to Celsius-values.

- ***qualitative comparing:*** one way simply is to have both images visible on the screen. IDRISI for WINDOWS makes it easy to show up many images at the same time. With the [cursor inquiry mode](#) one would interactively query the two images. IDRISI also allows for a physical concatenation of two or more into one resulting image by CONCAT. See the resulting image:



[remark: Graphically resampling the cropped image made it appear blurred. Sorry] I have combined the two georeferenced temperature images into one. The blue color indicates colder, the red one warmer areas. Data exist only for land areas. The most conspicuous difference on the first sight may be this growing red area slightly west from the centre of Australia. But finding more details would strain our eyes and our patience.

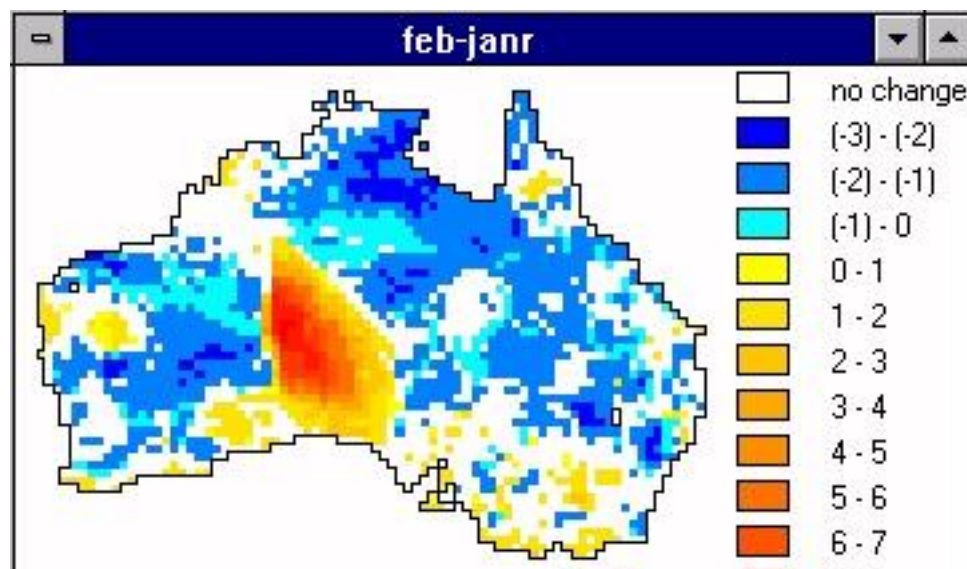
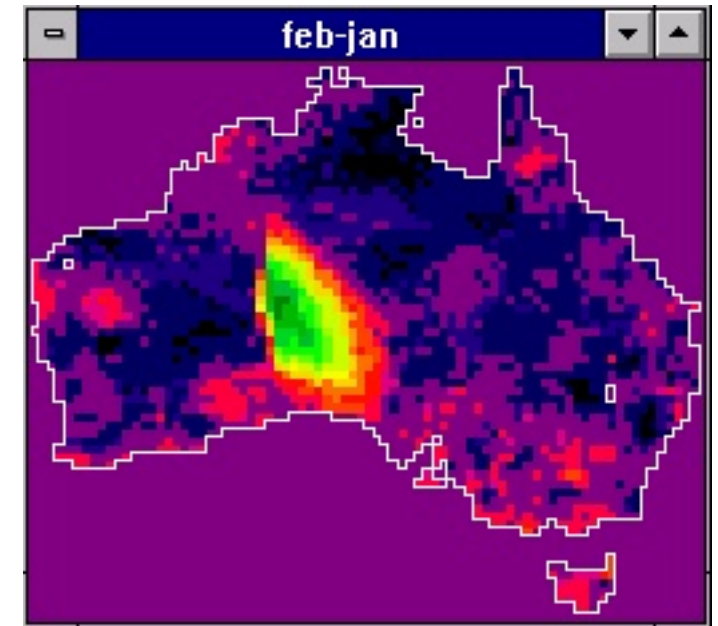
together tiled maps)

- *quantitative comparing*: as we are interested in areas of change, we should manage to isolated them. So think mathematically and just subtract one image from the other with OVERLAY (*LocalDifference*-operator in D. TOMLINs diction):

now every January cells value has been subtracted from the corresponding February cell value. Negative values mean lower temperature in February, positive values accordingly higher ones. No-change-areas are marked as zero and shown in dark violet. For better orientation I have added a coast line vector file. It has been generated by assigning 0 (zero) to all sea-values (background in our data) and 1 to all the others and subsequently vectorizing with the IDRISI-module POLYVEC.

I am not happy with this kind of representation. So if we are mainly interested in the direction of the temperature change, we should RECLASSify the image and create our own palette file.

(BTW, CONCAT is more useful in putting



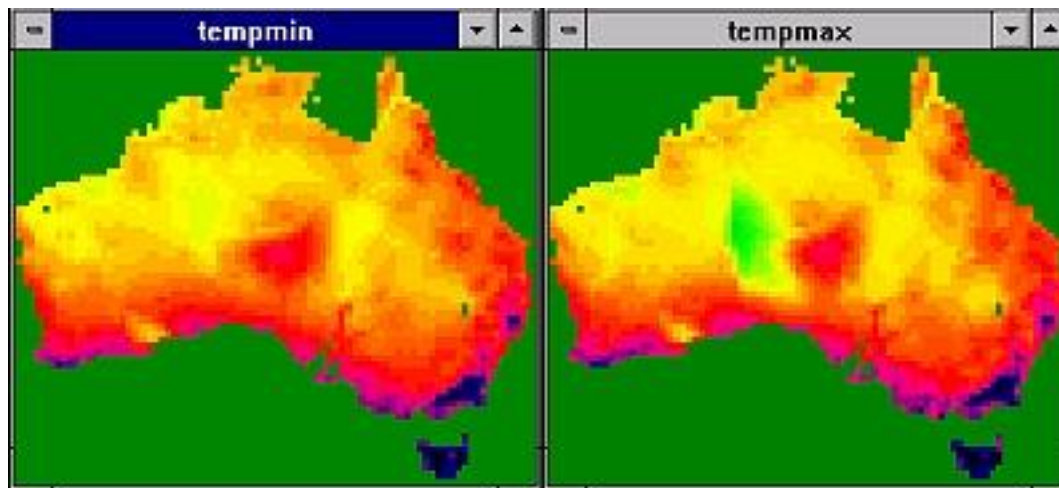
Blue color-tones point to areas of decreasing temperatures, the yellow to red shades clearly shape the increasing temperature regions.





● Minimum, Maximum



Question: show me the minimum / maximum temperature values for each cell in the time from January to February no matter which month is was!

Again OVERLAY has the solution to offer - the minimum and maximum overlay option. We feed OVERLAY with our two temperature images and receive an image with either the higher or the lower value (depending on the option we choose) from both.



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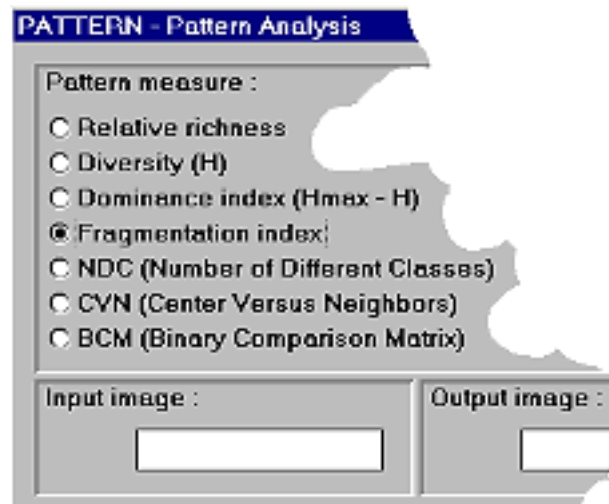
Single Raster Analysis Tools II

I would like to continue with two examples about how shape describing methods can be realized in IDRISI.

- Thinness Ratio - a simple shape factor with **AREA⁺⁺⁺**, **PERIM**, **SCALAR** and **OVERLAY**

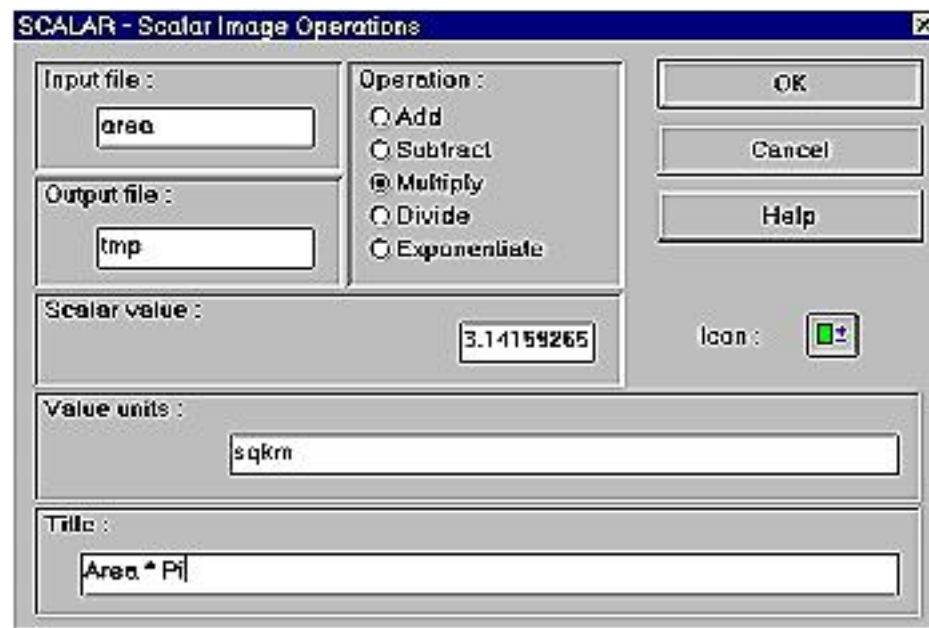
Many shape descriptors have been introduced for different purposes. E.g. to assist pattern recognition techniques in image processing, or make the approach to explain function and/or genesis by form (classification of certain geomorphological elements, ...).

If you are interested in pattern analysis, take a look at FRAGSTATS - a free software package available from ftp.orst.edu. It calculates more than 90 indicative parameters for quantifying landscape structure. BTW, IDRISI has implemented a module - PATTERN - which computes a handful of these parameters. They are well documented and referenced in the on-line help facility.



The thinness ratio is defined as $4 \pi \frac{A}{P^2}$, where A means the area and P the perimeter. By this formula we simply relate the area of a polygon to its perimeter. Again we will apply this method to the vegetation image (had no better dataset at hand :-)

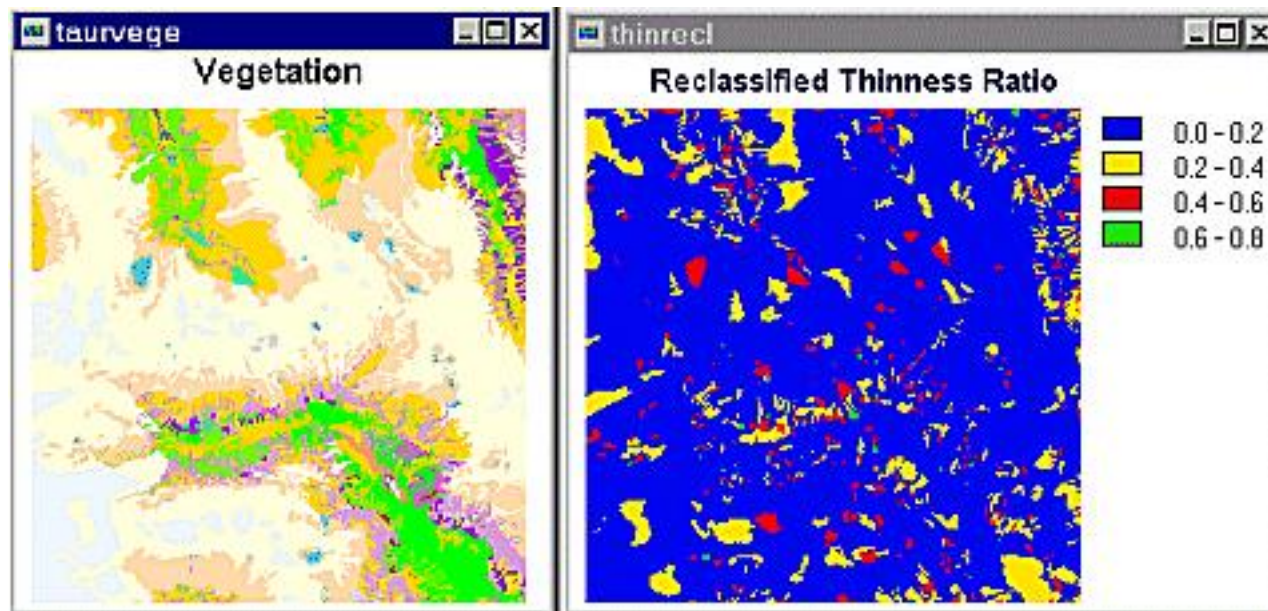
1. We need to isolate each single polygon first and attach to it a unique identifier. To achieve this, use GROUP. You have to name input and output images and check, whether to *Include diagonals* or not. GROUP assigns each disjunctive polygon a continuous unique id. It puts together polygons that have same values and neighbouring cells in the north, east, south or west direction (with checked *Include diagonals* additionally: NE, SE, SW and NW). In this example I decide to include diagonals, as a diagonal corridor makes 35.36 m, what's slightly above expected data resolution (ca. 25 m). The number of generated unique polygons is the maximum value of the GROUPed image (can be found through DESCRIBE or HISTO)
2. Now feed AREA and PERIMeter with the GROUPed images - polygons in the resulting image files contain their area resp. their perimeter give in units you chose.
3. To go on with the formula, take the AREA-image as input for SCALAR, a rather straightforward module to apply simple arithmetics to an image and multiply it subsequently by Pi and by 4 - all cellvalues are then treated with the same operation:



The PERIM output is raised to the power of 2 again with SCALAR.

4. We got two images now from one starting dataset - the scaled area and the raised perimeter. OVERLAY completes the action allowing us to divide the first by the last one.

To make the result clearer, I used a RECLASSification to 4 classes. The highest ratio is 0.785 for a single pixel. The blue color indicates a high grade of thinness whereas the tiny green spots show the opposite - compactness. The results strongly depend on scale and resolution. In a later part of the tutorial we will overlay the vegetation with the thinness ratio image to find out possible coincidences.

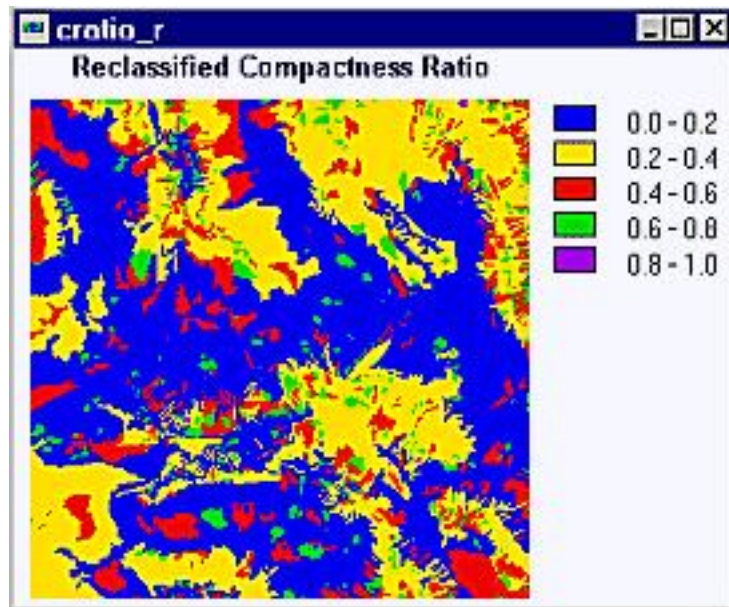


• Calculating the Compactness Ratio with CRATIO



In the Analysis/Statistics submenu you will find CRATIO which requires only input (the [GROUPed vegetation image](#)) and output image names, a click on the OK button and it calculates the Compactness Ratio, another shape describing factor. Its formula is quite

simple: $C = \sqrt{\frac{A_p}{A_c}}$, A_p means the area of the polygon and A_c the area of a circle having the same perimeter as that of the

polygon. The 'most compact polygon' (one pixel) has a theoretical compactness ratio of 0.886, so the reclassified images shows 5 classes. Higher values indicate more compact areas.



+++ for a very short [excursus on the 'Problem of True Area'](#)

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Image Processing III

Enhancement - Contrast stretching

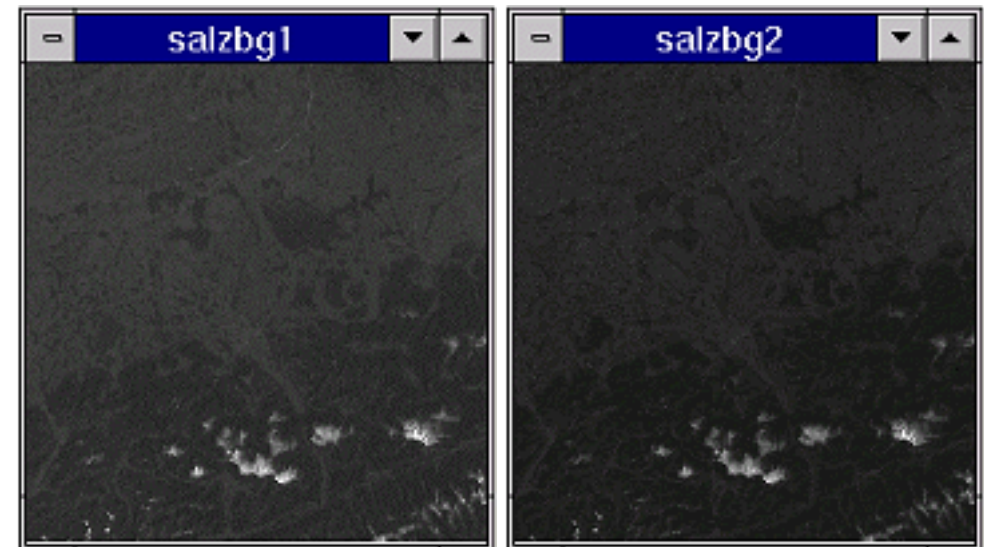
Now that we have the 4 spectral bands (see preceding chapter) as 4 separate IDRISI images, we should know more about their properties: they were derived from full sample [RESURS-O1 satellite data](#). The satellite's MSU-SK sensor scans over 5 **spectral ranges**. **4 of them are included here (the 5th is a thermal band with lower spatial resolution; comparable to band 6 of Landsat TM 5 data):**

- band 1 ... 0.5 - 0.6 μm
- band 2 ... 0.6 - 0.7 μm
- band 3 ... 0.7 - 0.8 μm
- band 4 ... 0.8 - 1.1 μm

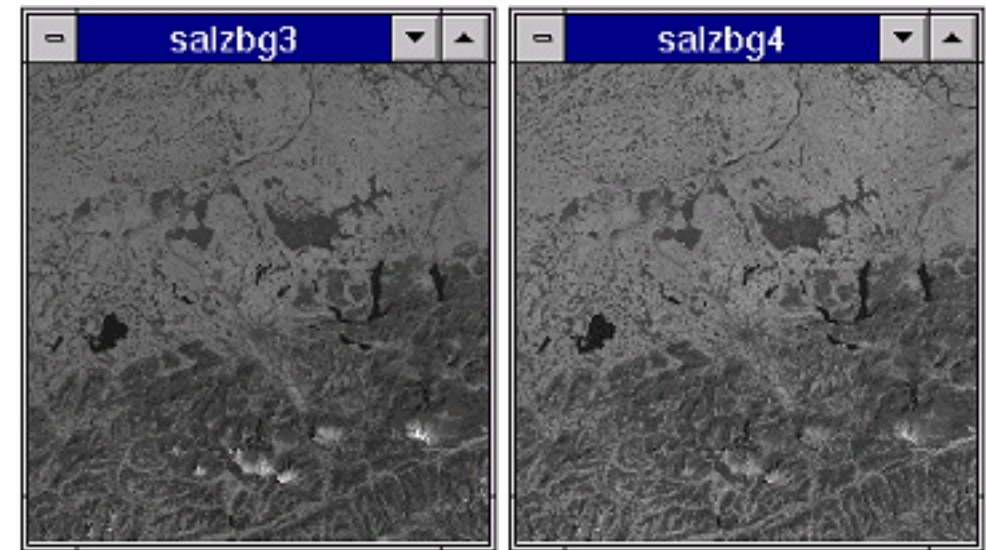
All of them have a **spatial resolution of 160 m**. That means, **one pixel represents the mean spectral reflectance value for an area of 25600 m²**.

The windows show a subset from the imported sample data created with the [WINDOW](#)-utility. A little bit below the images center lies the town of Salzburg

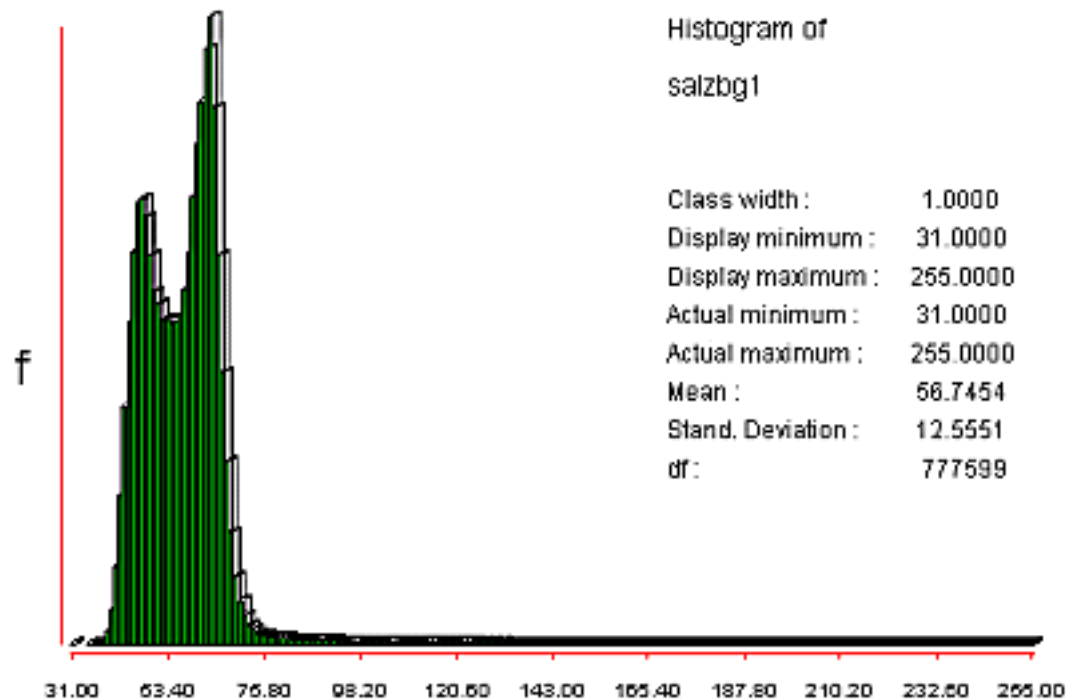
Remotely sensed multispectral data show a portait of earth's surface expressed as spectral reflectance values. So the appearance of different landcover types depends on their spectral properties - e.g., an object



absorbing most of the incident radiation will show up as dark to black. Differentiation of objects is based upon the fact of different absorption resp. reflectance properties of objects within the various spectral bands measured by the satellites scanner.

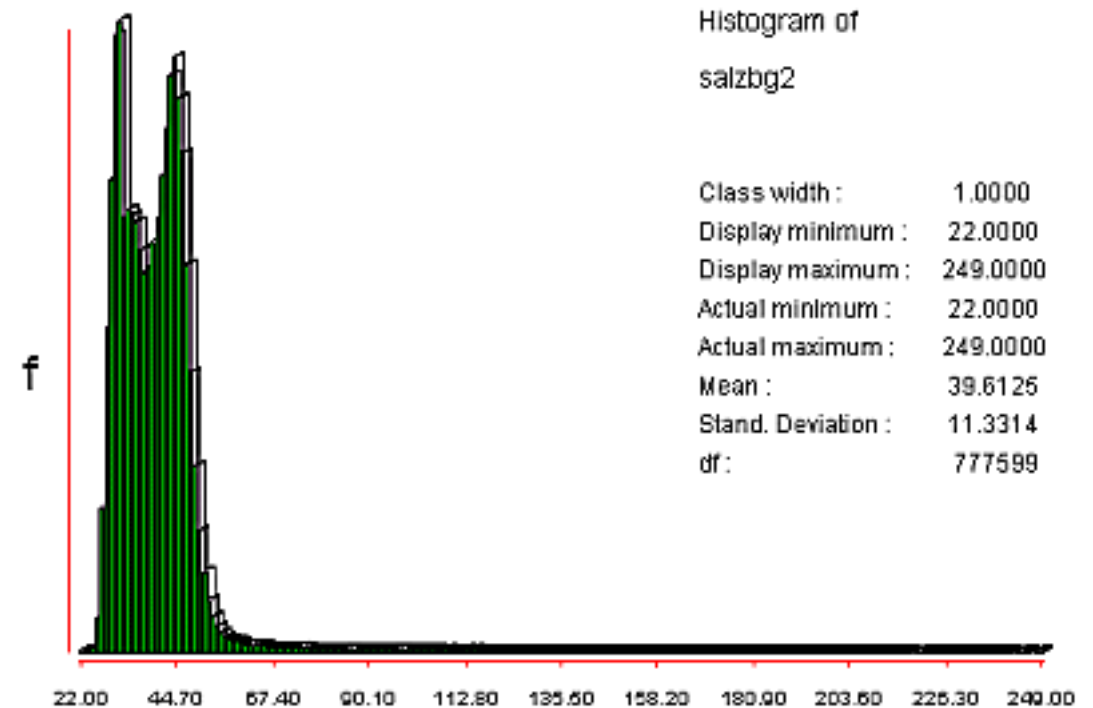


It is now common practice to achieve a visual impression of the data before going deeper. Look at the upper row (band 1 & 2) in the figure above. There's not much contrast and the [HISTO](#)grams clearly show why:

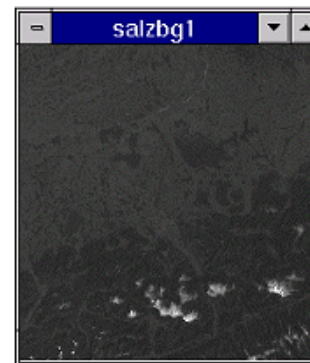


Note the very strong positive skewness in the distribution of the digital numbers. The 'rat-tail' of values between ca. 80 and 255 belongs to the highly reflecting ice and snow regions in the southern part of the image. For the color display of byte images (such as this ones) IDRISI matches the cell values with their corresponding color codes (also see the chapter on [palettes](#)). In our example most values concentrate in the range 31 - ca. 80.

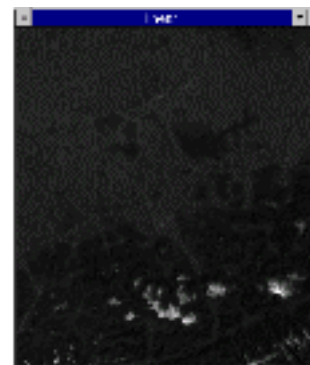
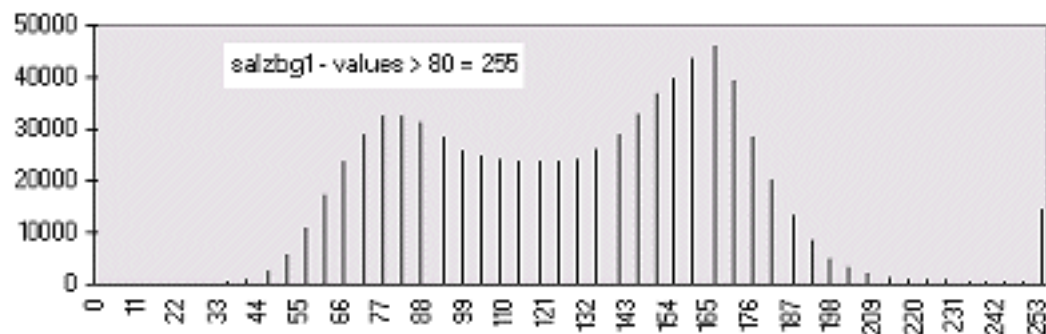
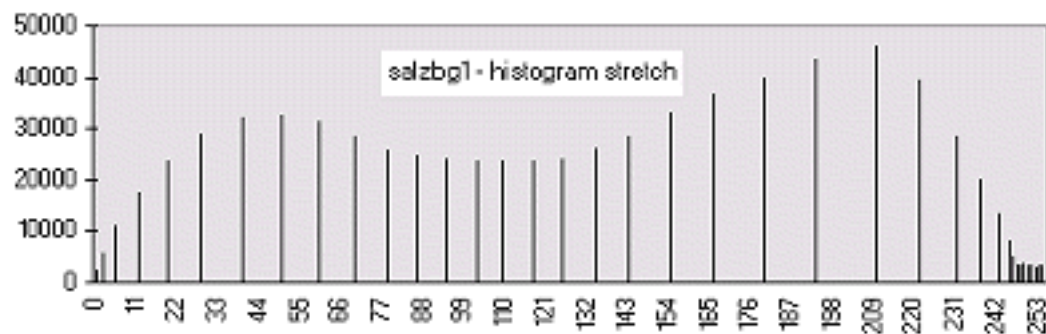
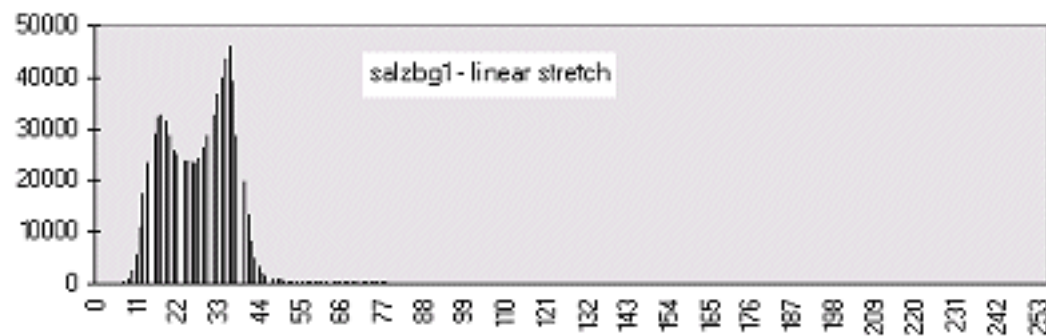
The technique of contrast **STRETCH**ing allows us to gain some more contrasted visual representations. In general we force to rearrange the distribution of the values in our image.



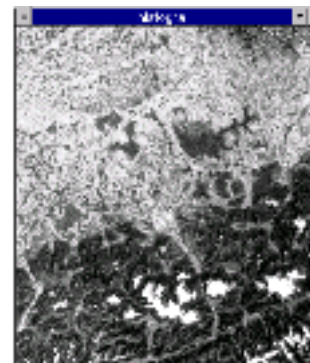
The following table demonstrates the effects of the different contrast stretching methods available in IDRISI. Even the small pics should show the differences:



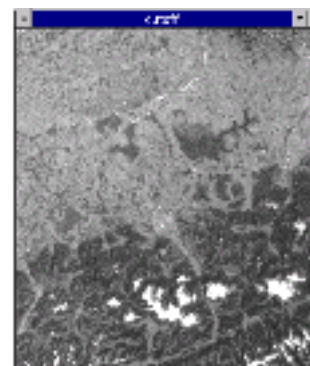
This is the same histogram as in the first histogram figure above, only aspect ratio and scaling are slightly different. The low frequent numbers greater than 80 are not visible in this diagram.



The linear stretching takes the actual minimum/maximum of 31/255 and rescales them to numbers between 0 and 255. In our case this has the opposite effect of what's desired - the image even gets darker! If I'd taken the third option for stretching in IDRISI - linear with saturation points - the results would have been quite fine.





An improvement on the linear is the **histogram-equalization approach** - more display codes are assigned to more frequently occurring digital numbers. Notice the dramatically improved contrast!



If we are mainly interested in enhancing the darker part of the image only, we may choose a new number to be our maximum value. For this example I told IDRISI 80 to be the new maximum for rescaling. Lower values have undergone a linear stretch. All raw data values greater than 80 were forced to become 255 in the output. We **cut off** them.

We already went through [FILTERing](#) in more detail, so check back there, if you are not familiar with that kind of methods. They may be useful to enhance certain details, e.g., directional surface features.

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Single Raster Analysis Tools VII

- AUTOCORR - Some notes on spatial autocorrelation

Autocorrelation is better known from the fields of time series analysis. It denotes a method to study similarity/dissimilarity of the same variables between corresponding intervals. Those intervals (*lags*) **may be of temporal or spatial nature**.

Who whispered: 'Boy, another formula! Another index number describing whatsoever! Who cares?!'.

That's exactly the point: everyone should care, who uses statistics which are based on an assumption of independence! A lot of spatial related test methods may be rather doubtful, as autocorrelation could lead to heavy biased results!

To give an practical example: when fitting models to spatial data (regression models, trend surfaces), the residuals must not be spatially autocorrelated. Autocorrelation would indicate 'leakiness' of our model, some minor patterns or variations it did not catch. We then should work it over again.

IDRISI's [AUTOCORR](#) function is prepared to compute a *spatial* autocorrelation index known as *MORAN's I*:

$MORAN's\ I = n \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (y_i - \mu)(y_j - \mu)}{\left(\sum_{i=1}^n (y_i - \mu)^2 \right) \left(\sum_{i \neq j} w_{ij} \right)}$	n	number of values to be taken into account (cells in our case)
	w	spatial weights: 1 in the directions up/down/left/right, 0.70711 (square root of 2) as weight for the diagonal neighbouring cells
	$y_{i/j}$	value at location i resp. j (simply number the cells by sequence)
	μ	mean of values y

This algorithm is implemented in IDRISI such that we are faced with two choices:

- *Rook's case* - **think of the chess game and how you're allowed to move the rook basically! In the same manner we look at each**

cells upper, lower, left and right adjacent cells to calculate the index

- *King's case* - **additionally to Rook's case we add the diagonal neighbours too**

To be complete: IDRISI also allows for masking the image to limit our area of interest. All cells, where the mask-image shows non-zero values are included in the calculation (provided that both images have matching spatial dimensions).

There is no specific rule about the choice of the weights in general (s. BAILEY & GATRELL 1995*). Dealing with regular datasets (as is the case in an image without a mask) makes weighting much more feasible than with irregular spaced observations.

AUTOCORR computes MORAN's I for the *first lag* only, that means it scans through the whole image and looks at each cell and its immediate neighbours. Exactly this possible dependency on spatial neighbourhood is what we are interested in. So we would like to compute not only for the 1st lag but also for the 2nd, 3rd and so on. We have to be a bit tricky: to get MORAN's I for the 2nd lag, we first remove every 2nd pixel from our image by using [CONTRACT](#) and then running AUTOCORR. Attention: this trick does not correctly compute the subsequent lags, as CONTRACT thins or aggregates cells, what means loss resp. bias in original data!

MORAN's I in most cases range between -1 and +1, where +1 means absolute and 0 none spatial autocorrelation. A negative index could indicate some kind of regular pattern. Additionally AUTOCORR outputs several measurements to test for significance of MORAN's I. If no autocorrelation is present, the expected value of I is $-1/(n-1)$. The outputs below are simply too small numbers for the display.

The datasets used to show the IDRISI output are choosen only because of their nearly perfect autocorrelation/non-autocorrelation.

Here are the results for a sample DEM image from the Harvard Forest dataset:

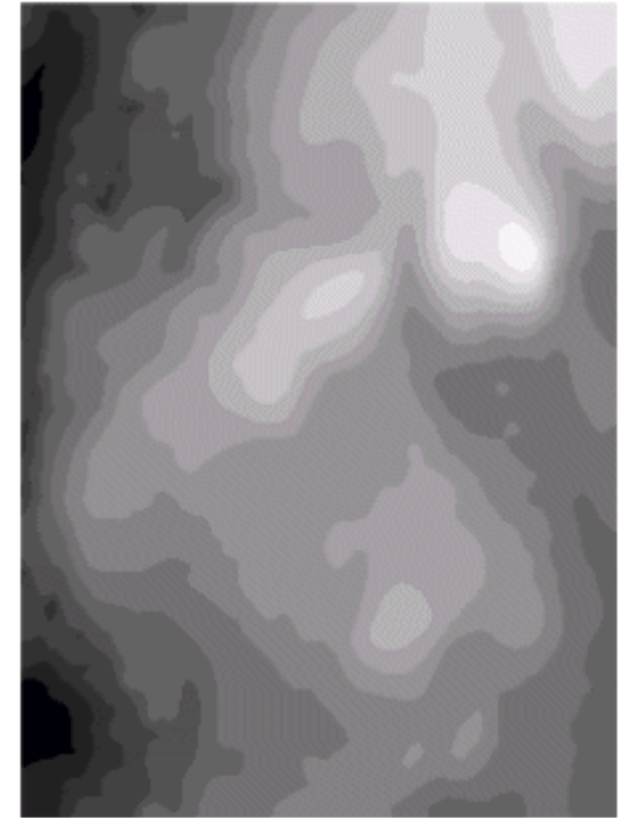
Image :ele-m

Case :Rook's Case

Number of cells included	=	67710
Mean of cells included	=	351.9728
Standard Deviation (sigma) of cell values	=	0.0996

The 3rd number above is in fact the 'Standard Error of Mean' not the Std. dev.

Spatial Autocorrelation (Moran's I)	=	0.9955
Expected value of I if not autocorrelated	=	-0.0000
Variance of I (normality assumption)	=	0.0000
Variance of I (randomization assumption)	=	0.0000
z test stat (normality assumption)	=	365.6350
z test stat (randomization assumption)	=	365.6348

Elevation (m)

To make the difference clear, I have computed MORAN's I for an image created by [RANDOM](#), another IDRISI tool. Distribution of values in that image is random:

Random distribution

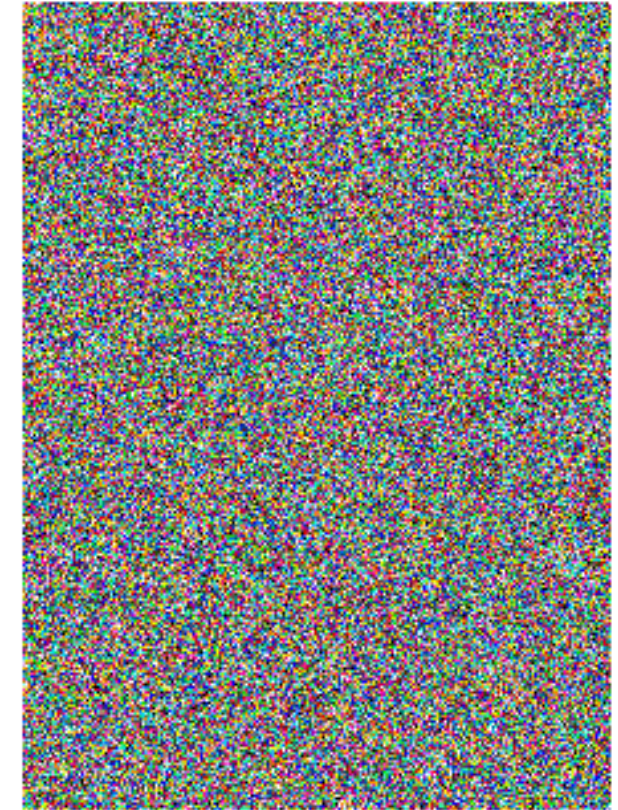
Image :random

Case :Rook's Case

Number of cells included	=	67710
Mean of cells included	=	50.0225
Standard Deviation (sigma) of cell values	=	0.1121

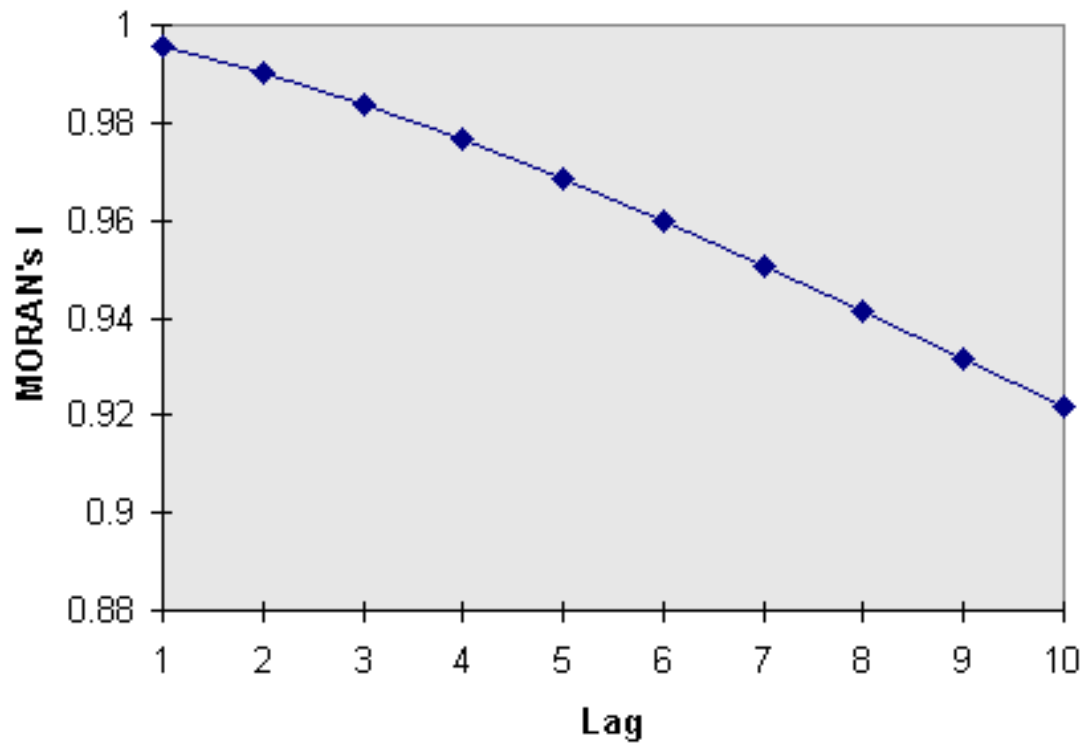
The 3rd number above is in fact the 'Standard Error of Mean' not the Std. dev.

Spatial Autocorrelation (Moran's I)	=	-0.0029
Expected value of I if not autocorrelated	=	-0.0000
Variance of I (normality assumption)	=	0.0000
Variance of I (randomization assumption)	=	0.0000
z test stat (normality assumption)	=	-1.0472
z test stat (randomization assumption)	=	-1.0472



The following diagram shows the coherence between distance (lag) and MORAN's I (*MORAN-Correlogram*). Values have been taken from the Harvard Forest DEM and MORAN's I computed from subsequently CONTRACTed DEMs:

MORAN's I - Autocorrelation



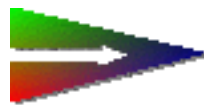
* Trevor C. BAILEY & Anthony C. GATRELL, 1995: Interactive Spatial Data Analysis. Longman, Essex.



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Crosstabulation

Crossing tables? Never heard! Now what's that for?? The following description of the functionality of the **CROSSTAB module in IDRISI** is the continuation of the last chapter about comparing. We use it solely for image comparison.

For those of you being unfamiliar with the crosstabulation-concept, I shall start with a basic introduction:

imagine two maps (raster images) which tell us about the landusage of a certain district for two consecutive years. As a basis for future planings we need to learn about the changes that occurred in that district. Did forests change? Did they grow or has their area decreased? What classes do we meet this year where urban areas have been the last year? etc.

We could successfully answer to those questions by differencing with **OVERLAY**, doing **RECLASSifications** again and again ... but **CROSSTAB** kills more than two birds with one stone!

Look at our two landuse images(yes, they are simple, I know). The cellvalues are equivalent to landusage classes.

LANDUSE 95		LANDUSE 96
1 1 2 4 4	these matrices shall indicate	1 2 2 2 4
1 2 2 4 4	two images with 4 different classes	1 3 2 2 2
1 3 2 4 2	---	3 3 3 2 2
3 3 3 2 2	feed them both	3 3 3 3 2
	into the CROSSTAB-module	

Summary information from Crosstab analysis

Cross-tabulation of LANDUSE 95 (columns) against LANDUSE 96 (rows)

LANDUSE 95						
LANDUSE 96		1	2	3	4	Total
	1	2	0	0	0	2
	2	1	4	0	4	9
	3	1	3	4	0	8
	4	0	0	0	1	1
	Total	4	7	4	5	20

The table explained above is the same that IDRISI outputs with Output type option 2 and 3 (see figure of dialogbox to the right). You see four options - the wider the choice the greater the trouble? Well, option 1 outputs an crossclassification image. Nothing to get into a sweat. Such an image recodes the cells equivalent to the crosstable-combinations. We skirt option 4 a bit later.

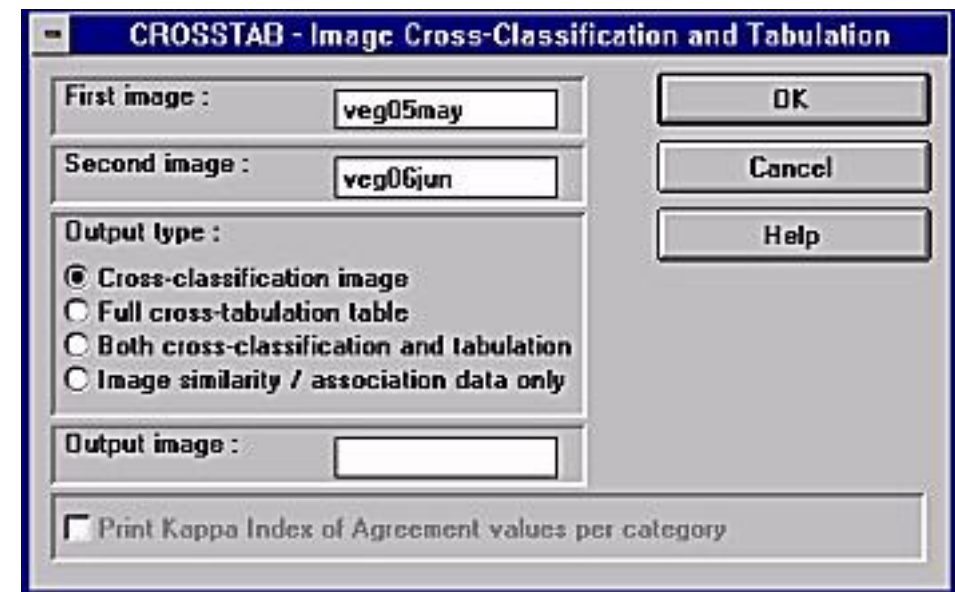
As the saying is: one pic' tells you more than a thousand words, so let's have a look at the crossclassification image from our simple landuse images outlined before (here I called them use95 and use96, they are the same as landuse 95 resp. landuse 96):



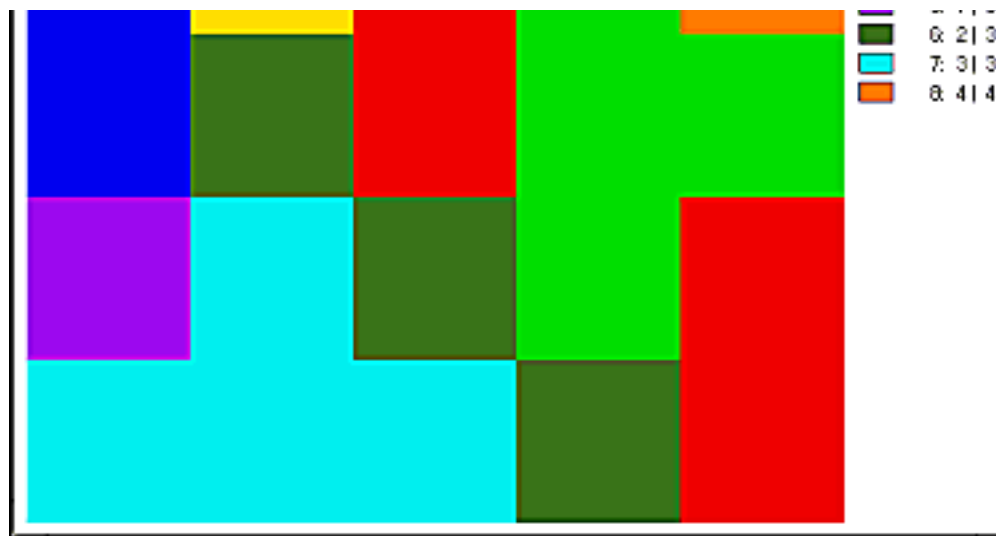
The bold italic style numbers in the second row are the classes from our 1995 image, those in the second column from the 1996 image. For the output table CROSSTAB simply counts and sorts combinations! Read the table like this:

'there are 4 cells in 1996 with class 2 that had the same class in 1995' or 'there are 4 cells in 1996 with class 3 that had the same class in 1995, but there is 1 cell with class 3 that had been class 1 and 3 cells that had been class 2 before'. You could also say: '4 cells with class 4 in 1995 shifted to class 2 in 1996, only 1 cell stayed same'.

The Totals tell the overall number per class and image. We had for example the double area (= cells) of class 1 in 1995. The red-colored diagonal-values are occurrences of classes that didn't change.



If you compare the image with the crosstable, its meaning will become clear. How many yellow areas (cells) do you see? Right! Only one. What does the legend (CROSSTAB produces legend and title automatically) say about the yellow? It has value 2 and stands for all cells that had class 1 in use95 but class 2 in use96.



Now try to identicate all the other combinations until the glorious aha-experience hits you.

Cross-Classification images give us a good idea of chances that happened during the time and also - at least roughly - about their directions. So this is a rather useful tool.

But wait, there's more, there is more! IDRISI's CROSSTAB computes the KAPPA Index of Agreement (KIA) for us if we check the box. It is also known as KHAT or KAPPA Coefficient of Agreement. This statistical measure was introduced by the psychologist COHEN in 1960 and adapted for accuracy assessment in the remote sensing fields by CONGALTON & MEAD (1983)*

KIA is a means to test two images, if their differences are due to 'chance' or 'real (dis)agreement'. It is often used to check for accuracy of classified satellite images versus some 'real' ground-truth data. IDRISI computes an overall as well as per-category indices.

How are these coefficients being calculated? Here's the bundle of formulas:

$$\kappa = \frac{\text{observed accuracy} - \text{chance agreement}}{1 - \text{chance agreement}}$$

Overall KAPPA**

$$\kappa = \frac{N \sum_{i=1}^r x_{ii} - \sum_{i=1}^r (x_{i+} * x_{+i})}{N^2 - \sum_{i=1}^r (x_{i+} * x_{+i})}$$

r ... number of row in crossclassification table

x_{ii} ... number of combinations along the diagonal

x_{i+} ... total observations in row i

x_{+i} ... total observations in column i

N ... total number of cells (the number in the lower right corner of our table, 20)

Computationally IDRISI acts as follows to get the overall Kappa:

observed accuracy = proportion of agreeing units = p_0 =

$$(2 + 4 + 4 + 1) / 20 = 0.55$$

chance agreement = proportion of units for expected chance agreement = p_c =

$$(2 * 4 / 20 * 20) + (9 * 7 / 20 * 20) + (8 * 4 / 20 * 20) + (1 * 5 / 20 * 20) = 0.27$$

KAPPA Index of Agreement = KIA = $(p_0 - p_c) / (1 - p_c) =$

$$(0.55 - 0.27) / (1 - 0.27) = 0.383561644$$

For the per-category-KAPPA IDRISI follows the algorithm introduced to remote sensing by ROSENFELD & FITZPATRICK-LINS (1986)^{*}:**

$K_i = \frac{p_{ii} - p_{i+}p_{+i}}{p_{i+} - p_{i+}p_{+i}}$	p_{ii} ... proportion of units agreeing in row i / column i p_{i+} ... proportion of units for expected chance agreement in row i p_{+i} ... proportion of units for expected chance agreement in column i
---	--

Again an calculation example should blow away mists! The KIA for class 2 and use96 as reference image:

$$p_{ii} = (4 / 20) = 0.2$$

$$p_{i+} = (9 / 20) = 0.45$$

$$p_{+i} = (7 / 20) = 0.35$$

$$KIA = (0.2 - 0.45 * 0.35) / (0.45 - 0.45 * 0.35) = 0.145299145$$

The KAPPA ranges from 0 to 1. 0 means total agreement from chance, 1 perfect 'true' agreement. A value of let's say 0.145 could be thought of '14 percent better agreement than just by chance'.



I promised to touch option 4, so to complete that: IDRISI outputs similarity coefficients Chi Square (plus the degrees of freedom), CRAMER's V and the overall KAPPA. Check one of the popular statistics textbooks, if you are unfamiliar with these.

^{***} Russell G. CONGALTON & Roy A. MEAD, 1983: A Quantitative Method to Test for Consistency and Correctness in Photointerpretation. - Photogrammetric



Engineering and Remote Sensing 49,1: 69 - 74

**** Thomas M. LILLESAND & Ralph W. KIEFER, 1994^{3rd}: Remote Sensing and Image Interpretation. John Wiley & Sons, New York.**

***** George H. ROSENFELD & Katherine FITZPATRICK-LINS, 1986: A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. - Photogrammetric Engineering and Remote Sensing 52,2: 223 - 227**

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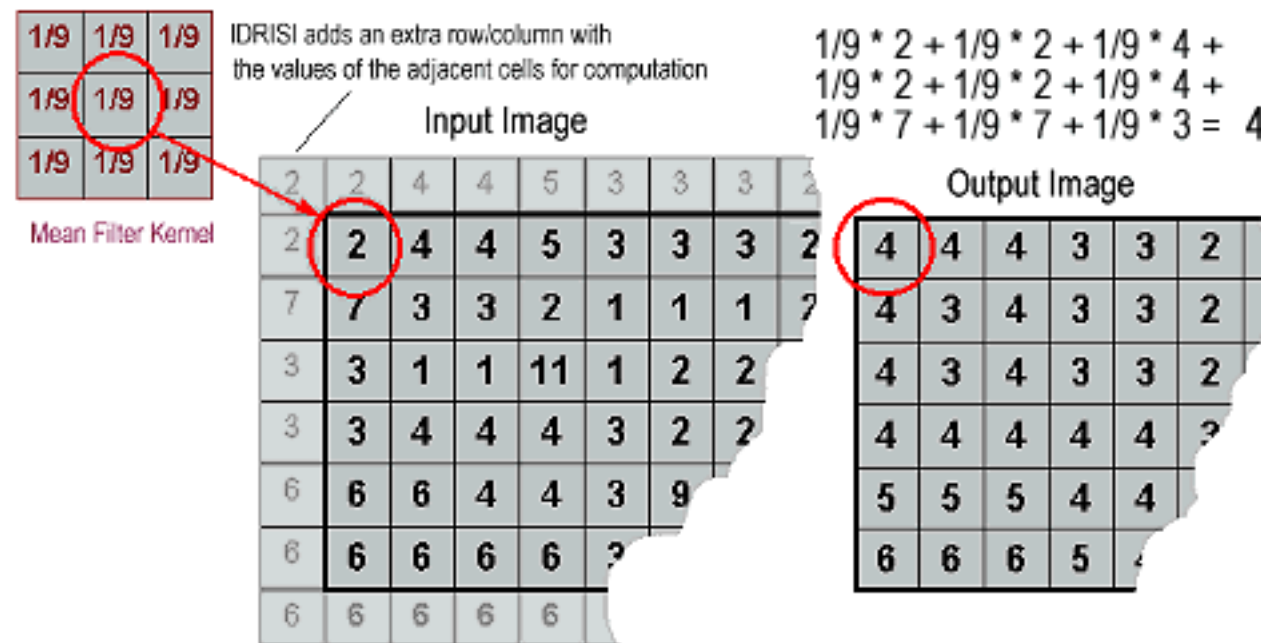
Single Raster Analysis Tools III

● Using **FILTER**

FILTER appears in the Analysis/Context and in the Analysis/Image Processing menus. It can be applied to a variety of different tasks. You may find the names *convolution*, *roving window* or *filtering* too for its functions. Within the concept of *Cartographic Modeling*, established by D. TOMLIN*, the module refers to the family of *Focal Operators*.

In the focal operators context pay attention to the NDC-option (= number of different classes) within [PATTERN](#) as it relates to FocalVariety. More focal functions - all those from PATTERN too - can be found in the function TEXTURE.

FILTER accepts an input image and computes the output image cells as a function of their neighbourhood. In IDRISI, neighbourhood is defined by a 3x3 cells kernel (window) focusing on the center cell. To get an idea of how that works, imagine this kernel 'roving' over the input raster cell by cell. Now the focus pixel and its 8 neighbours are multiplied by the values stored in the kernel, then summed up and the result is written to the corresponding pixel in the output image:



FILTER provides several ready-made filter kernel functions (the numbers relate to a simple 3x3 filter kernel size):

- **Mean (= low pass):** 1/9 1/9 1/9 1/9 1/9 1/9 1/9 1/9 1/9 (= FocalMean), allows for 3x3, 5x5 and 7x7 kernels
- **Gaussian,** allows for 5x5 and 7x7 kernels
- **Median,** allows for 3x3 and 5x5 kernels
- **Adaptive Box,** allows for 3x3, 5x5 and 7x7 kernels
- **Mode (= FocalMajority),** allows for 3x3, 5x5 and 7x7 kernels
- **Laplacian Edge Enhancement:** -1/9 -1/9 -1/9 -1/9 +17/9 -1/9 -1/9 -1/9 -1/9, allows for 3x3, 5x5 and 7x7 kernels
- **High Pass:** -1/9 -1/9 -1/9 -1/9 +8/9 -1/9 -1/9 -1/9 -1/9, 3x3
- **Sobel Edge Detector,** 3x3

In IfW 2 the user may define own filters of various sizes (but restricted to a rectangular shape). The Filter editor provides a user-friendly interface for the creation of these filters. Filter definitions can be saved too.

1. Smoothing - low pass filters

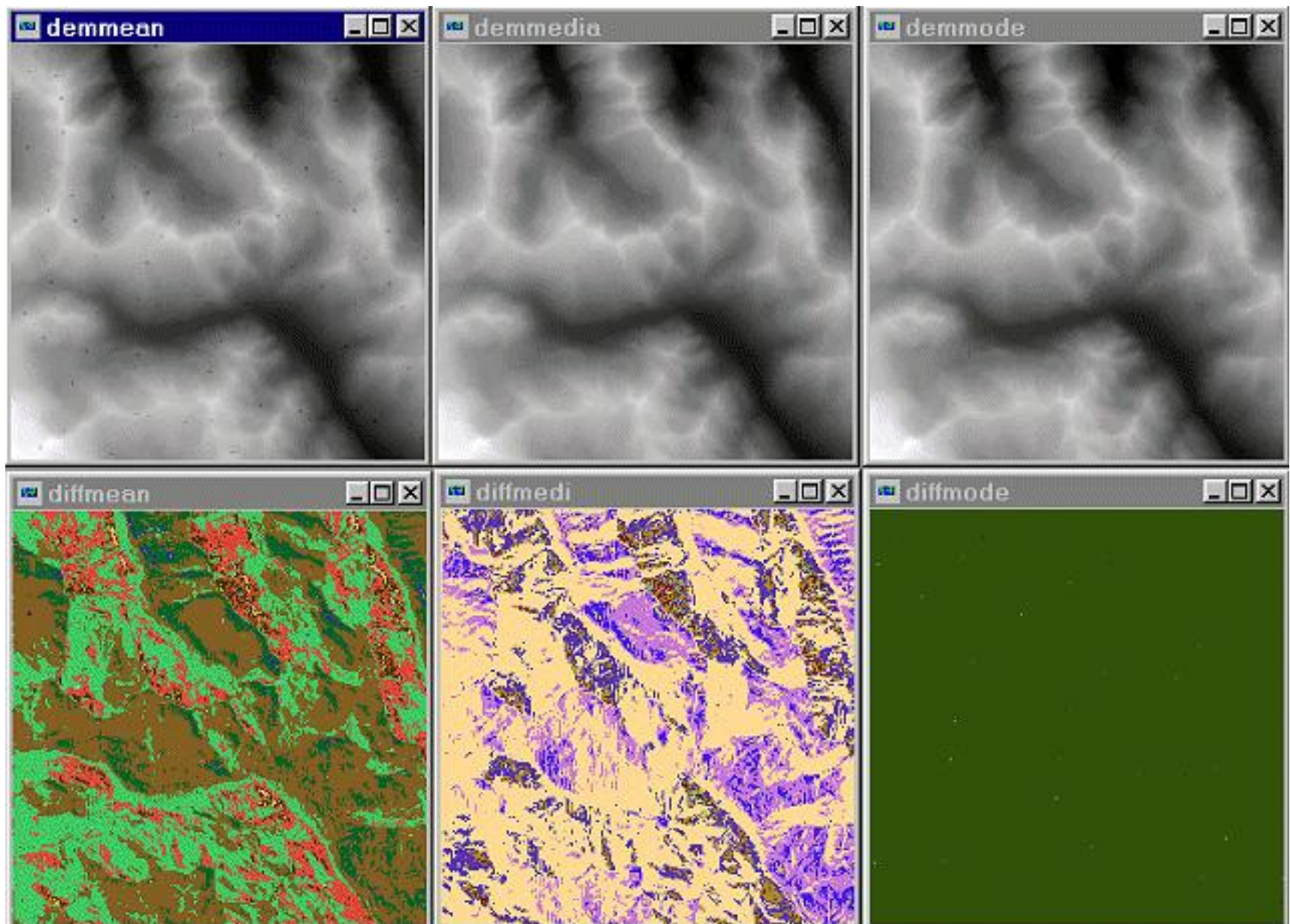
You may have to deal with images, that are 'noisy' for one or another reason - more often you will be concerned with that during image processing, e.g. generalizing raw classifications. But there will be cases in GIS, where it is appropriate to apply a low pass filter, achieving somewhat 'smoothed' results. Interpolated DEMs are a common example. The choice of filter type

strongly depends on the nature of your data

Let us treat a DEM with FILTER. It shows undesired artifacts generated through the joining of two DEMs from different sources. There are random pixels with a value of 0 (zero) scattered all over the DEM. How could we remove them? There is more than just one way.

- a mean filter would certainly not yield to satisfying results, as the range within the 3x3 kernel around the erroneous pixels is much too high. Use mean filters e.g. to *smooth* DEMs.
- the median filter is said to remove noise from images properly - examine the graphic representation of the difference images too.
- a mode filter seems to be the best choice for our problem.

The graphic below shows a mean, median and mode filtered noisy DEM (hope you will recognize the tiny dots). diffmean, diffmedi and diffmode are difference images (noisy DEM minus filtered outputs - done with OVERLAY) to check, what has been filtered out. diffmode contains of the noise pixels itself:



2. Adaptive Box - non brute force smoothing

As stated above smoothing is applied to images with 'noisy' appearance, but what if noise is not distributed homogeneously over the image? A DEM might show a few erroneous pixels like shooting holes in some part of the image. So it is not your intention to smooth the whole image and thus loose information unnecessarily.

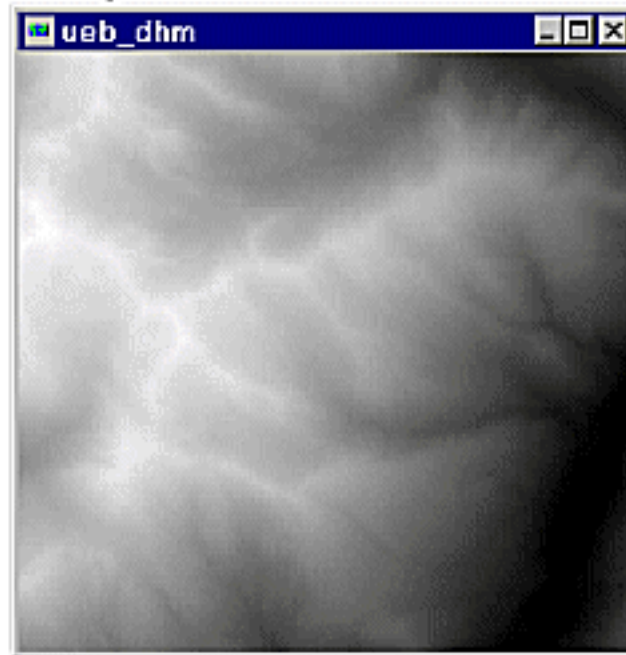
In such a case the *Adaptive Box filter* would be a good choice: you give two threshold values - one for the local standard deviation (computed from the values within the 3x3, 5x5 or 7x7 roving kernel window) and one as the acceptable difference between the focussed cell and the mean of the neighbours. Furthermore you decide about the action to take for the case of both standard deviation and difference thresholds being exceeded (replacing such pixels by zero or by local average). All other pixels are left original. By that only highly variant values will be matched.

3. Edge enhancing, edge detecting - high pass filters

Distinguish between FILTER kernels, that enhance and those that detect and 'extract' areas of sudden change. The former have roving window values that sum up to 1, so in case of 9 similar values in a raster there will occur no change in the output. If at least one value differs from the others, this 'contrast' gets *enhanced*.

Edge detect filters (high pass) sum up to 0 (zero), so cells surrounded by neighbours with the same values are set to 0 (zero):

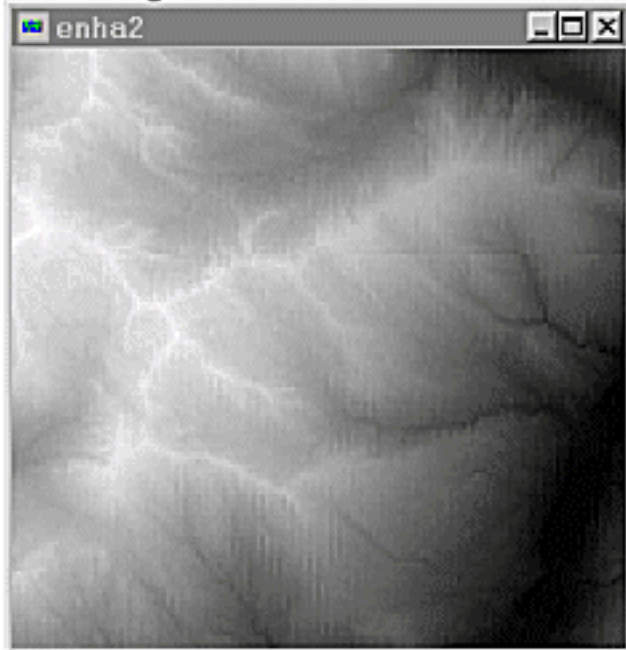
original DEM



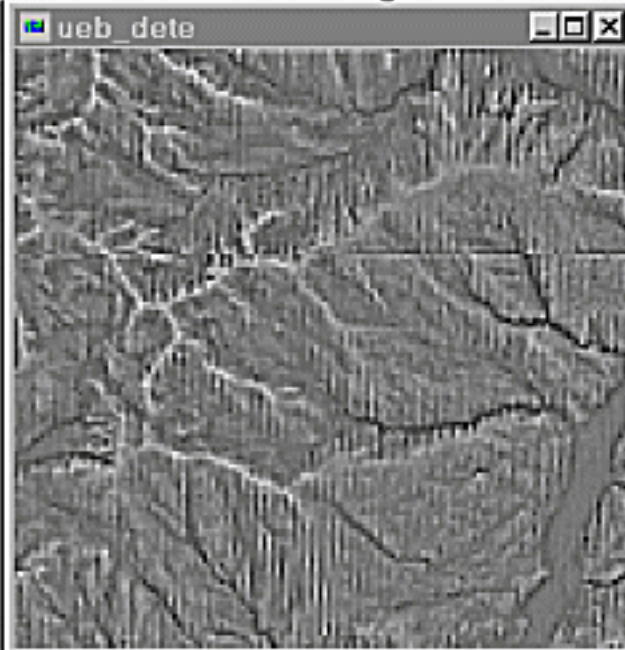
edge enhanced DEM



2x edge enhanced DEM



DEM treated with edge detect filter



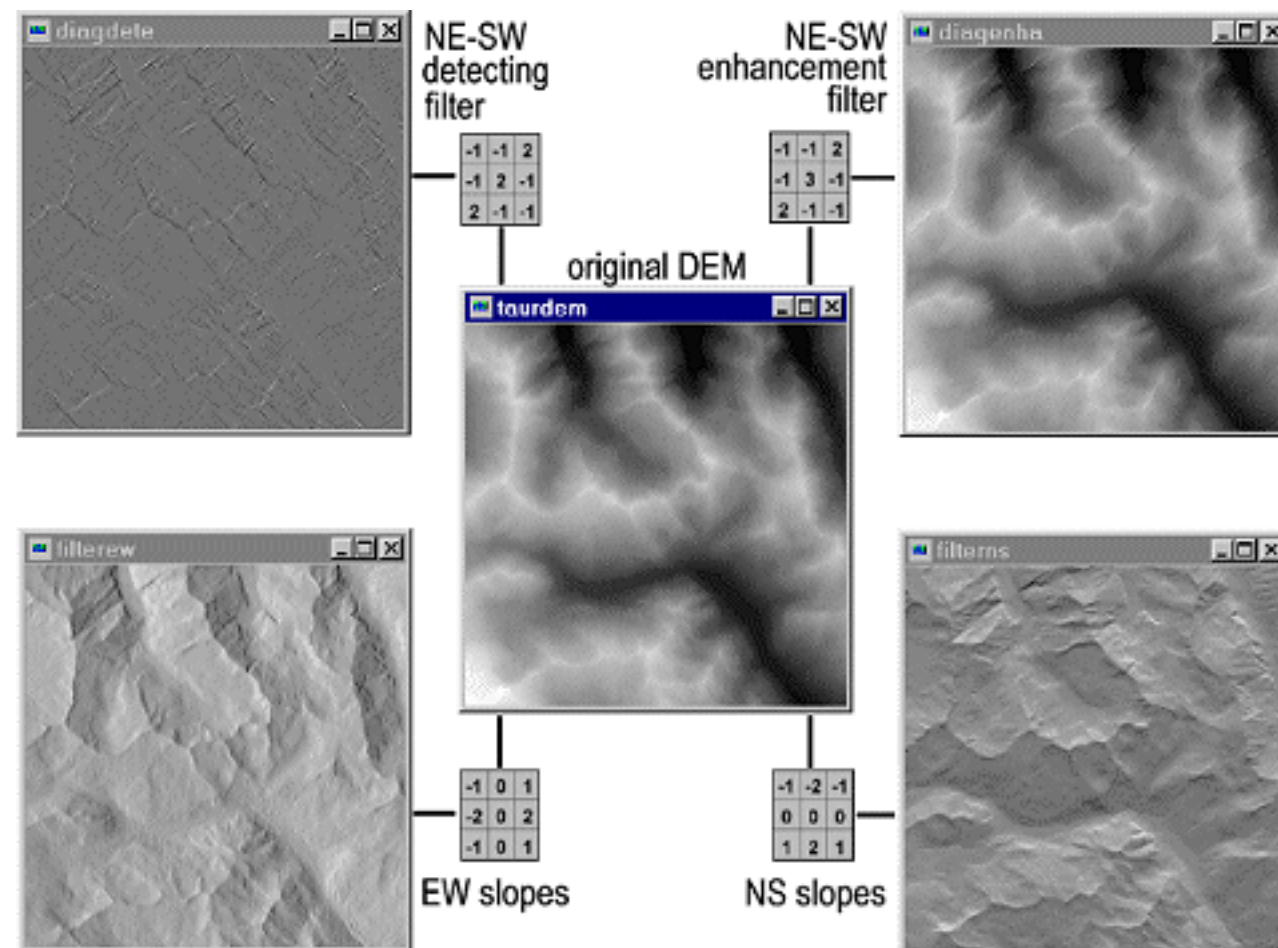
Especially the high pass filter detects some irregularities in the DEM, that did not appear in the original. The DEM has been pieced together from different sources and we just found a seam!

The module TEXTURE (since IfW 2) has the ability to do Edge analysis by applying 3x3 directional filter kernels to the input image. It will output up to 8 images (N, NE, E, SE, S, SW, W and NW).



4. Directional filters

The optional user definable 3x3 kernel may be used to create directional filters. Depending on overall kernel sum, they may enhance or detect directional structures in the filtered images. A few examples shall elucidate that principle:


The NE-SW detecting filter enlightens (= high values) NE-SW ridges (streamlines, ...), black appearances (= low and negative values) indicate the diametrical diagonals.



C. Dana TOMLIN, 1990: Geographic Information Systems and Cartographic Modeling. Prentice-Hall, Englewood Cliffs

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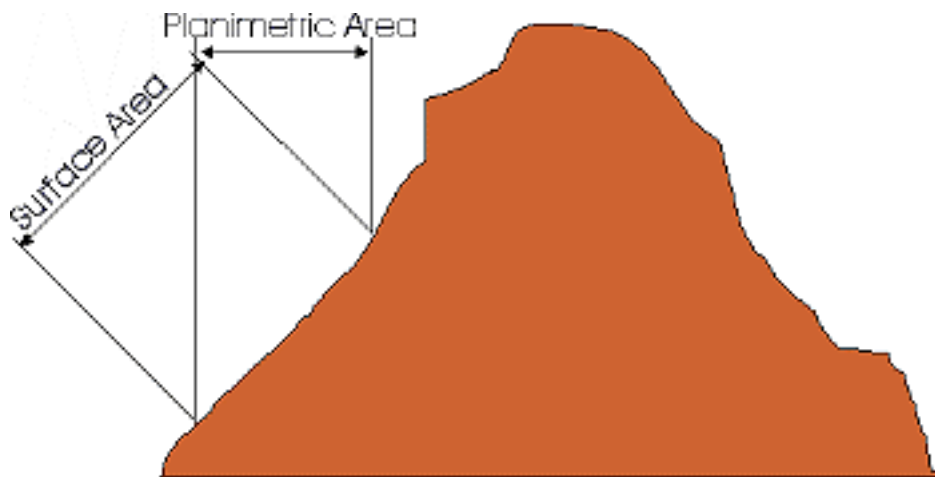
a small sidebar:

The Problem of 'True' Area

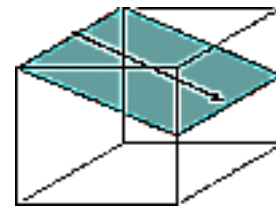
We were talking about AREA, we used it together with PERIM to achieve some form describing index. As with all spatial data we should be aware of some errors, of certain inaccuracies attached to our input as well as to our output results. So a thorough knowledge about the fundamental concepts how software does its calculations is desired.

How does AREA work? Rather simple, in that it counts all the cells with same attribute value in an image and computes area as this number times cellwidth times cellheight (in reference units). One single cell is **assumed to be plane**. **If our region of interest is situated in nearly flat landscape, that may be a minor problem. But the steeper our surface the more there will be a considerable difference between the 'Planimetric' and the 'Surface' area.**

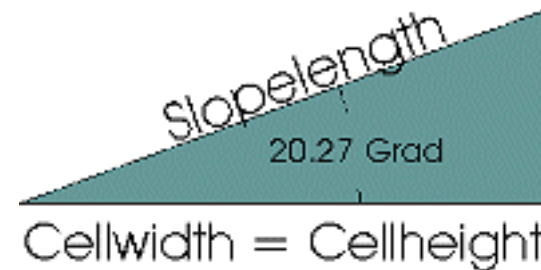
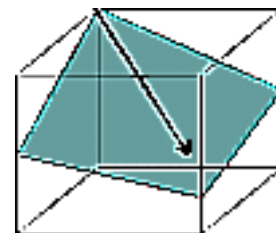
Surface vs. Planimetric Area



Cardinal vs. Diagonal Direction




Cardinal Direction



Diagonal Direction

As is clearly seen, the surface area will always be larger. WEIH (1994)* presented a method, how to cope with that, at least approximative: we can distinguish between 'Cardinal' and 'Diagonal' direction for each of the single cells. *Cardinal* means exposed to N, S, E or W, *Diagonal* denotes to cells with expositions other than N, S, E, W. A simple trigonometric function helps us to compute the slopelength of one pixel, which in turn may be used for the area calculation. Anybody interested in how to implement that in IDRISI, please contact the author of these webpages.

Robert C. WEIH, Jr., 1994: The effect of slope on area calculations in a geographic information system. - In: International Symposium on the Spatial Accuracy of Natural Resource Data Bases. p. 132 - 140

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Image Processing II

Import of data

Raw data (which may denote already preprocessed data you retrieve from a provider of satellite data) are often organized in the so-called BIL-format (= **Band Interleaved by Line**), a common way to store multispectral data. Here's an example for a 4-bands data file:

```
110 115 138 215 ... line 1 of spectral band 1
72 85 97 105 ..... line 1 of spectral band 2
218 172 160 35 .... line 1 of spectral band 3
156 134 129 92 .... line 1 of spectral band 4
111 115 142 210 ... line 2 of spectral band 1
69 83 96 104 ..... line 2 of spectral band 2
.....
```

In real the digital numbers (a measure for the spectral reflectance) are stored in a long sequence. So you must feed the [BILIDRIS](#)-routine with some knowledge about the nature of your raw data to be imported. That should not be a problem, as these data are delivered together with a header file, which might be directly included in the BIL-data or could be shipped as separate text file.

Have a taste of what that looks like from the following real sample file ([© SSC Satellitbild, 1996](#)), where the informations of immediate interest in the process of importing through BILIDRIS are colored red:

Parameter	Description	Example
IDENTIFIER	Unique name of standard product	SK950709N50E015
DATE	Acquisition date, year/month/day	950709
TIME	Acquisition start time (UTC), hour/minute	0905
CENTER_LAT	Scene Centre Latitude, degrees minutes	50 15
CENTER_LON	Scene Centre Longitude, degrees minutes	15 53
NW_LAT	North-West Corner Latitude, degrees minutes	53 27
NW_LON	North-West Corner Longitude, degrees minutes	12 9
NE_LAT	North-East Corner Latitude, degrees minutes	52 8
NE_LON	North-East Corner Longitude, degrees minutes	21 24
SW_LAT	South-West Corner Latitude, degrees minutes	48 7
SW_LON	South-West Corner Longitude, degrees minutes	10 48
SE_LAT	South-East Corner Latitude, degrees minutes	46 57
SE_LON	South-East Corner Longitude, degrees minutes	19 8
PROD_BANDS	Image bands in the product (1-4 digits)	1234
DEVICE	Instrument device number	SK1
TRANSMISSION	Direct data dump or tape-recorder playback	DIRECT
MISSION	Resurs-O1 mission	3
STATION	Ground station where data is received	Kiruna
IMGFILE	Name of the file with image data	AL191021.bil
NCOLS	Number of columns in the image file	4000
NROWS	Number of lines in the image file	3750
NBANDS	Number of bands in the image file	4
LAYOUT	Organisation of bands in the image file	BIL

The latitude, longitude coordinates must be expressed as decimal degrees. The SW_LON / NW_LON form the MinX / MaxX, the SE_LAT / NW_LAT the MinY / MaxY reference points. Reference system is 'latlong', reference units are 'Degrees'.

Results of the BILIDRIS-routine are 4 images, each of them 15 MB in size, representing 4 different spectral bands.

Besides the BILIDRIS import IDRISI has yet some more tools to get satellite data in:



- the import/export utilities

[BIPIDRIS](#) to import Band Interleaved by Pixel files

[ERDIDRIS](#) to convert to and from [ERDAS](#) *.gis and *.lan files (also mention the Palette conversion [PALIDRIS](#))

- a binary file viewer

[DUMP](#) (or [here](#))

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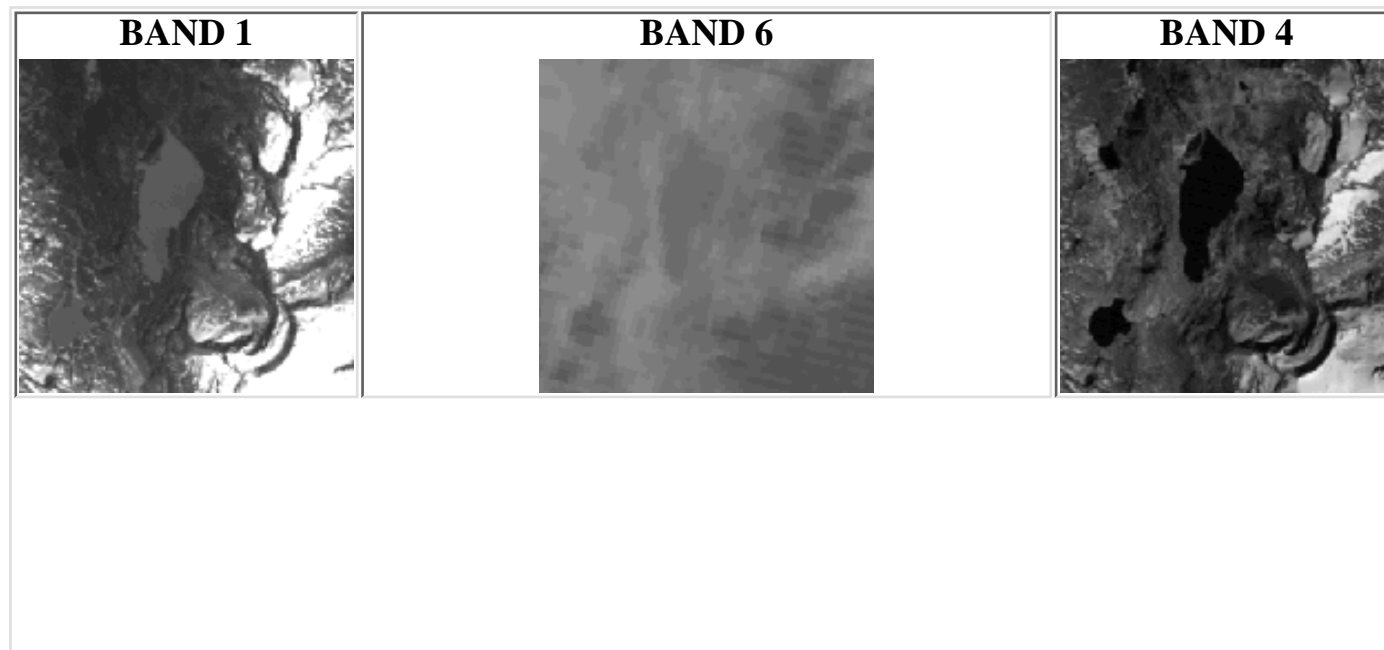
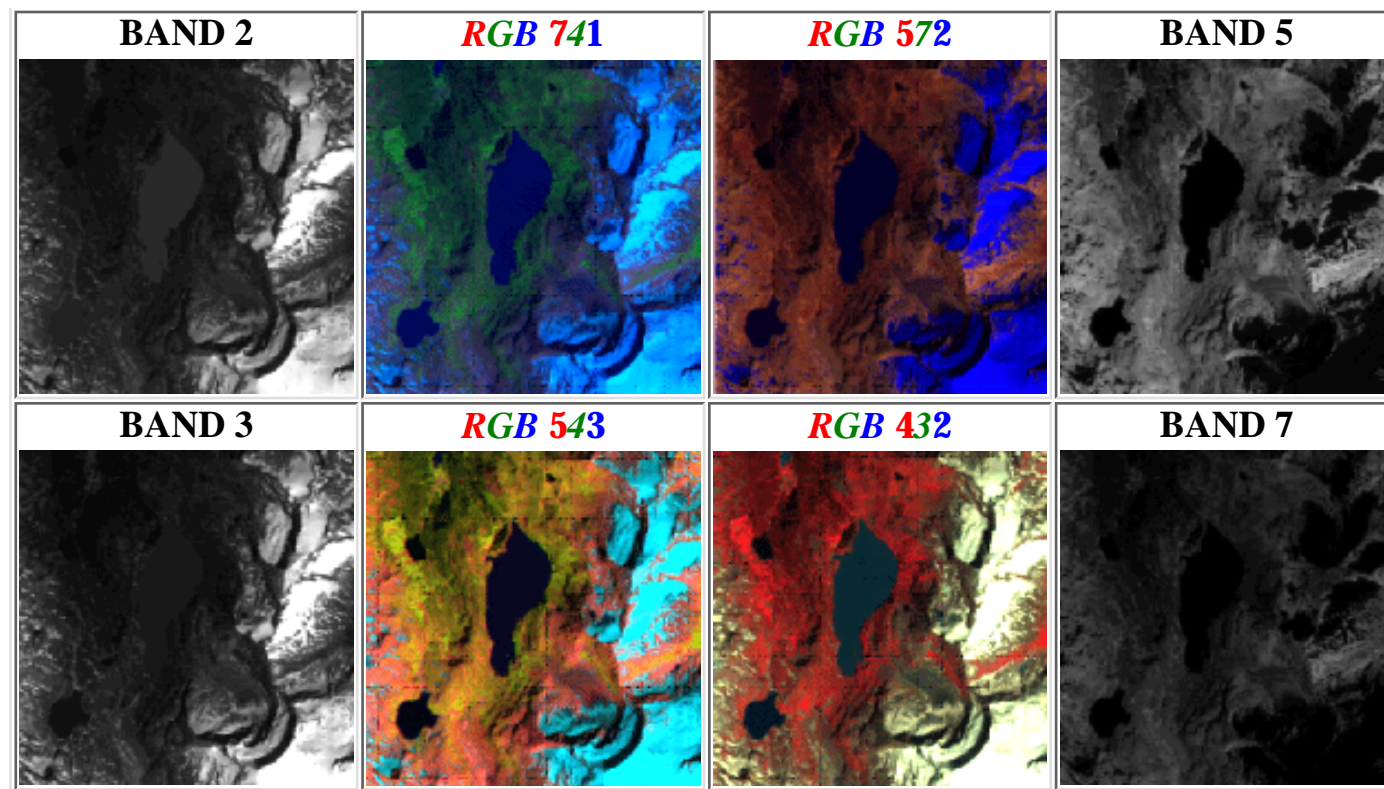
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Image Processing IV

Visualizational aspects

Assume we have enhanced our raw data. With the actual IDRISI for WINDOWS version it is unfortunately not possible to display 'real' [RGB](#)-composites. That would mean to interpret the digital numbers from three spectral bands as RGB-color codes. Thus we turn spectral properties into a visually interpretable picture: objects with very high reflectance values, e.g., in band 3 only, will appear red if the red portions are taken from this band. In consequence this allows for the display of normal, false color and arbitrary color composites. Depending on what's to classify, you'll choose the most optimal combination. A few examples from a Landsat TM 5 subscene showing the region around the [Alpinforschungszentrum Rudolfshütte](#). There are 7 single bands and 4 different combinations (the spatial resolution of 120 m for band 6 - compared to 30 m for all others - makes it appear blurred):





In the center of the images you notice a lake, two others are to the W resp. SW. Glaciers start in the eastern part. Spruce forests dominate the slowly declining surface in the northern part. Alpine meadow types surround the lakes. See how different these landcover types appear in the four sample combinations!

creating **COMPOSIT RGB-images**

Producing these color composites with IDRISI is a bit 'static' - it requires to compute three images (= bands) together into one. It does so by first rescaling (stretching) the digital numbers in each of the three single bands to 6 levels (0 - 5). An index is then calculated:

$$index = blue + (green * 6) + (red * 36)$$

A pixel with the highest possible reflection (255) in all three images would compute to 215 in the color composite output image. The stretching to 6 levels means information loss! Future version of IDRISI are likely to provide real truecolor image display.

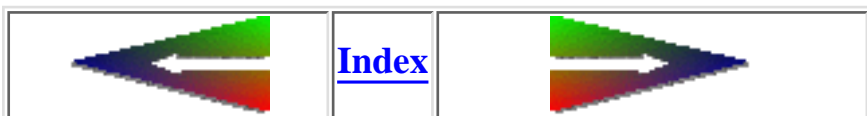




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Single Raster Analysis Tools VI

- Interpolation methods in IDRISI - a coarse overview

This chapter would honestly require to go far back, as *interpolation* is a rather delicate field in GIS. The interpolation methods in IDRISI and their depth of implementation are confined to the very basics at the moment. Enough to demonstrate principles though.

Now what is interpolation all about? These are geostatistical ways to estimate information for locations without such, by founding on known surrounding values. Easy to understand the concept, if you imagine height points for some area which you gathered in the field using modern GPS (Global Positioning System). By interpolating between the known height spots you try to build a continuous surface, a DEM. Or you already have some analog maps showing the elevation isolines - again you could rely on known values (in that case: the height lines) to interpolate the unknown elevation between them.

Getting *some* results is quite easy - indeed a matter of doing a few clicks! Our computer works hard and the outputs often look very reasonable at the first glance.

-- But: what did we really get? how reliable are the values compared to reality??

What may sound as a simple task has more but one trap! To achieve good results one has to be very careful in choosing the 'right' interpolation method and in interpreting the outputs. Those of you interested in underlying algorithms, read David F. WATSON: 'Contouring: A Guide to the Analysis and Display of Spatial Data' (Pergamon Press, Oxford 1992) or Edward H. ISAACS & R. Mohan SRIVASTAVA 'Applied Geostatistics' (Oxford Univ. Press, Oxford 1989) among several others.

- TREND

First, TREND isn't a method to calculate unknown values for specific locations - it is what its name states: it shows larger scale *trends, patterns* within our data. Statistical basis is the solving of polynomial equations, where IDRISI gives you the choice of 3 orders:

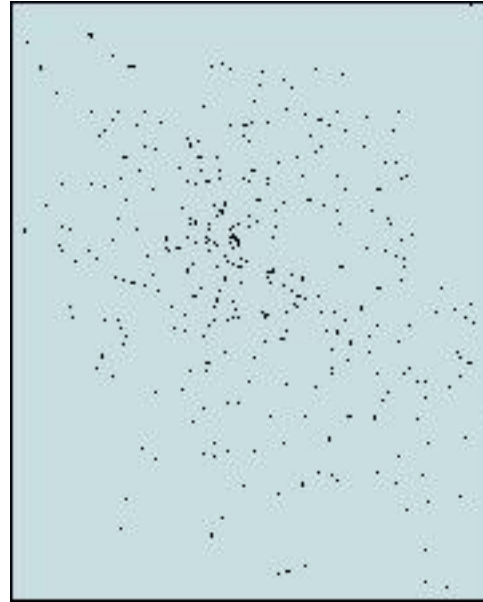
- *linear*: $z(x,y) = b_0 + b_1x + b_2y$

- *quadratic*: $z(x,y) = b_0 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2$

- *cubic*: $z(x,y) = b_0 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2 + b_6x^3 + b_7x^2y + b_8xy^2 + b_9y^3$

x, y are the coordinates, z is the attribute value (must be of interval scale at least).

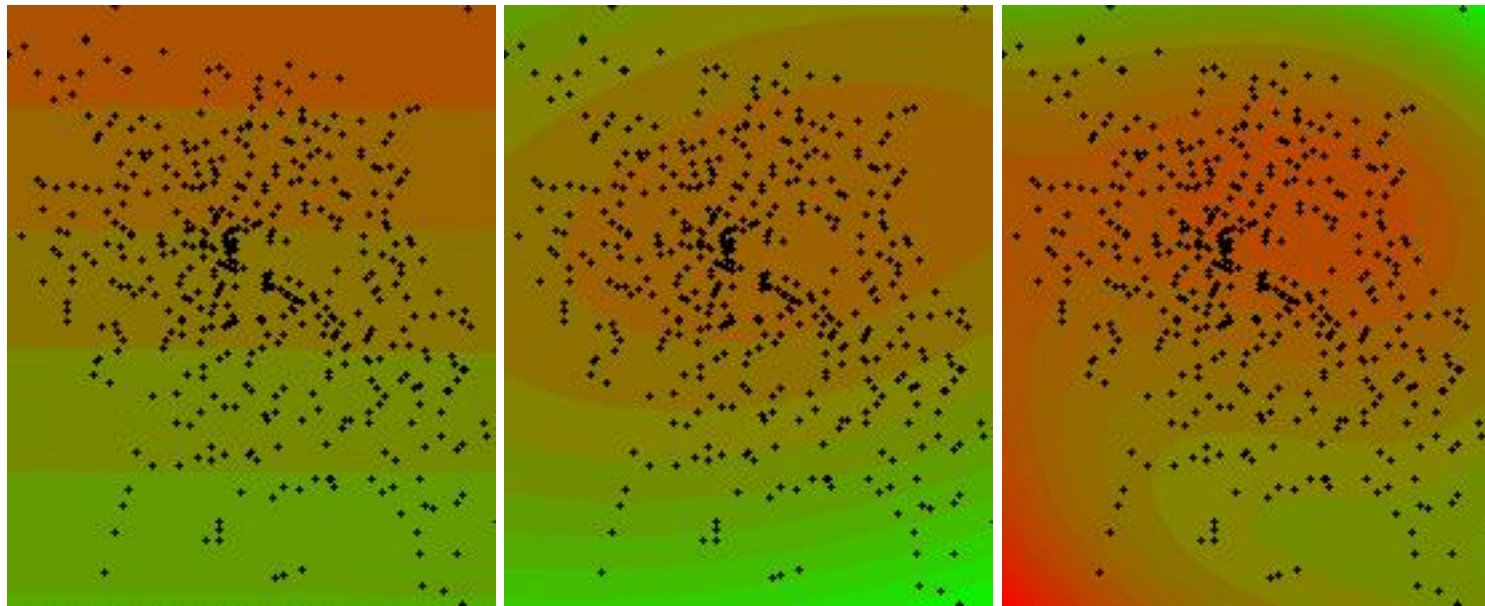
To give an example (very simplified): following you see a map of 453 point locations in the City of Salzburg with the attribute: number of different lichen species at this point (lichens are those strange plant organisms made up from some kind of symbiotic living-together fungus with algae :-); rather valuable bioindicators!). For the ease of demonstration we make the assumption, that habitat quality is positively correlated with the number of different lichen species per location (data from collection in 1982, ZIEGELBERGER & TÜRK, Salzburg Univ., Dept. of Plantphysiology)



Now let us compute the trend-images:

linear, quadratic, cubic

(red = less species / green = more species per sample location)



IDRISI finishes the TREND-calculation by presenting you some statistics (Goodness of fit, F ratio, degrees of freedom, ...) that can be compared between different trend orders to proof for the significance. *Goodness of fit* tells about the 'amount of variation explained' through the 'fit'. It is computed by examining the residuals:

$$R^2 = 1 - \frac{\sum_{i=1}^n (Z_i - \hat{Z}_i)^2}{\sum_{i=1}^n (Z_i - \bar{Z}_i)^2}$$

Z_i ... observed values
 \hat{Z}_i ... model-predicted values
 \bar{Z}_i ... mean of observed values

The above images show a very general pattern of the lichen distribution. Note the increasing complexity from the simple linear (left) to the cubic (right) surface. The quadratic (middle) and the cubic trend images seem to indicate a center of lower species counts in the northern half of the City of Salzburg, which very coarse reflects the situation in reality. But if you focus on the lower left corner of the right result you will notice a zone of apparently lower species counts. It is evident, that there are very few measure points around, so *extrapolation* will occur, which makes this results very doubtful.

○ INTERCON

With the help of this module you may derive DEMs from contour lines. INTERCON requires the contours to be an image, so the whole procedure starts with (1) converting the vector sources into a raster (see [1st Example, topic 1](#) for the rasterizing steps). Pay attention to the initial value given to the empty image in INITIAL. It should not be any height value (e.g., do not use 1, if there will be heights of 1 in your DEM). (2) The INTERCON routine asks you for the heights of the four edges. You will maybe have to estimate them. IDRISI then constructs several profiles: a boundary profile from the four edges and any height contour that intersects with the border, a horizontal profile across the rows, a vertical one across the columns and two diagonal (upper left to lower right, upper right to lower left). While making the profile, the program records the slopes for the locations between known height contours and finally assigns the height computed from the maximum slope profile. (3) To get rid of minor inconsistencies, apply a [mean filter](#) to the INTERCON-result (at least once) to smooth the DEM.

○ INTERPOL

Whereas TREND performs a global interpolation, INTERPOL does a local one. It offers two methods: *Inverse Distance Weighting (IDW)* and *Potential Surface Calculation*. The latter is being refined currently, so I will not make remarks on it.

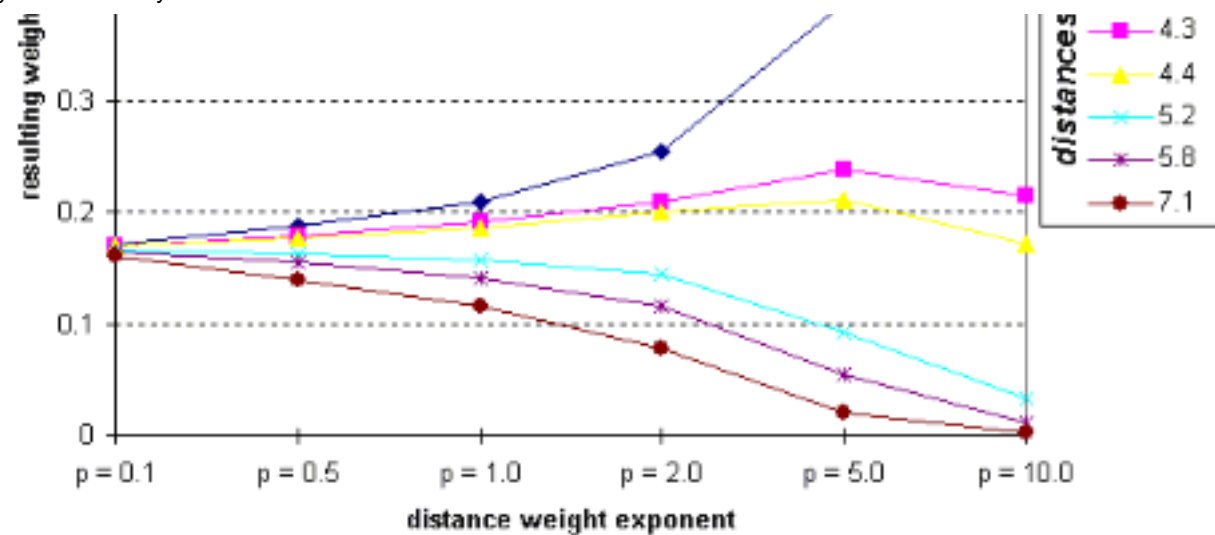
IDW: look at the formula and the line chart below - we calculate estimates of unknown values dependent on neighbouring known values. The distance acts as weight and its exponent allows further adjustment of that weight: the higher the distance exponent, the higher the influence of the nearest known feature value:

$$\hat{z} = \frac{\sum_{i=1}^n \frac{1}{d_i^p} z_i}{\sum_{i=1}^n \frac{1}{d_i^p}}$$

\hat{z} ... interpolated z-value
 d ... distance from known point i
 z ... z-value of known point i
 p ... distance weight exponent
 n ... number of points to be included in search (in IDRISI: six-on-average or all)
 i ... number of known value points to be taken into account



These are just six random chosen sample distance values. They indicate the distance from the point to be estimated to the next six known value points in ascending order (the weights have been standardized). Note how the weights of the different



distances diverge with higher exponents.

The dialog box of INTERPOL:

The dialog box 'INTERPOL - Surface Interpolation' contains the following options and fields:

- ☒ Interpolate digital elevation model
- ☐ Calculate potential surface
- Input vector file : []
- Output image : []
- Distance weight exponent : 2.0
- ☒ Use vector point ID's as heights
- ☐ Use a values file for heights :
- ☒ Use a six-point search radius.
- Data type : integer [v]
- Columns : []
- File type : binary [v]
- Rows : []
- Value units : []
- Title : []
- Buttons: OK, Cancel, Help
- Coordinates: Minimum X: [], Maximum X: [], Minimum Y: [], Maximum Y: []

The decision, which parameter combination to use isn't always easy. Look the results over very critical. Here's an excerpt from the IDRISI for WINDOWS Help on the INTERPOL function:

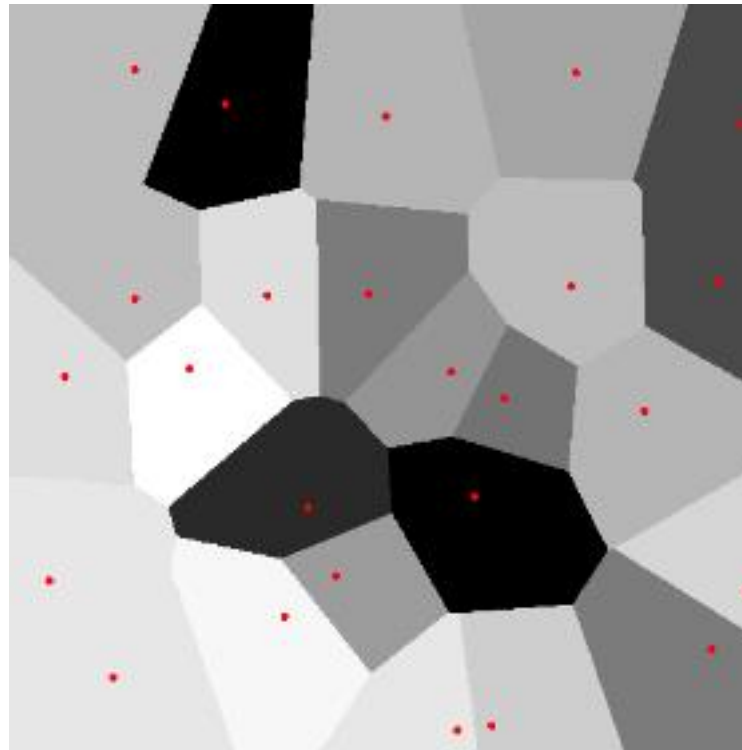
Do not assume that because a computer has done the interpolation that it has any strong claim to accuracy. There are many interpolation procedures, appropriate for different surface characteristics, and this is only one. The weighted-average technique used produces quite smooth surfaces with maxima and minima occurring at the locations of control points. As one moves away from these control



the local average height, where local is determined by the search radius.

○ THIESSEN



Another way in the point-to-area methods is provided through THIESSEN. This function requires vector points or images with single non-zero cells as points to perform what is generally known as *Voronoi Tessellation* - the generation of Thiessen Polygons: each point, resp. cell in the output image is allocated to the nearest known point.

See an example:



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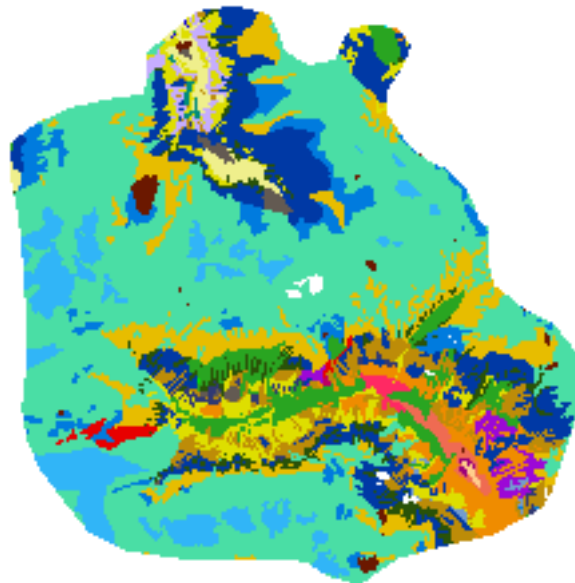
Boolean Operations

In this part of the tutorial you will meet some techniques you are already acquainted with from our [1st example](#) - methods to query information across different layers and pre-conditions.

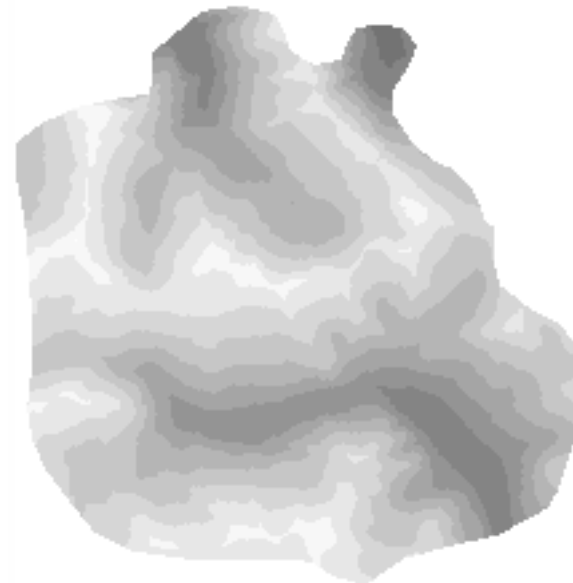
1. AND-Operation

From a vegetation map (TAURVEGE) and a digital elevation model (TAURDEM) show me all areas with vegetation class 6 in the height range from 1700 to 1800 m a.s.l. (don't be confused about the irregular shaped region)

TAURVEGE



TAURDEM



that means, we are interested in those areas that show class 6 and are found between 1700 - 1800 m. So how should we proceed?

- . **RECLASSify TAURVEGE to a boolean image, one that consists of one's for our areas of interest (in this example all patches with class 6) and zero's in all other areas. I will use the function ASSIGN instead. ASSIGN requires us to create a values file, through which we tell the rule for reclassification. So call EDIT / Values file and name the new file CLASS6, let it be integer and write just one line:**

6 1

ASSIGN asks for the feature definition file - that's the one to be recoded - TAURVEGE, a values file - CLASS6 and an output name - again CLASS6. Don't be afraid about overwriting: the values file has an extension different from the image ones:

CLASS6



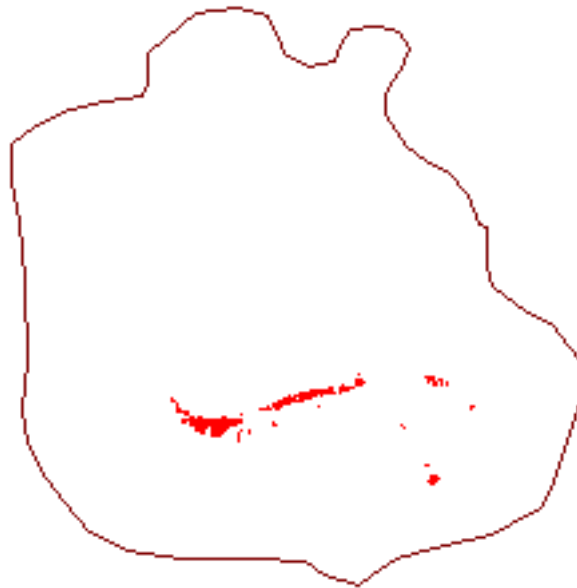
- b. We stress RECLASS to extract the 1700 - 1800 m heights band from our DEM:**

DEM1718



c. with **OVERLAY** we multiply **CLASS6** by **DEM1718** to **RESULT**, so only locations (cells) with a value of 1 in both images will survive:

RESULT





The same result could be achieved by the minimum function in OVERLAY ([TOMLIN](#): *LocalProduct*).



2. OR-Operation

From a vegetation map (TAURVEGE) and a digital elevation model (TAURDEM) show me all areas with vegetation class 6 in the height range from 1700 to 1800 m a.s.l. or areas with class 16 in the same height distribution

- **we do not need to repeat all the steps from example 1 in that chapter, so a short note will be enough: through the same operations as in 1 we can prepare a result2 image whose areas lie in the 1700 - 1800 range plus showing vegetation class 16. To fulfill the *or*-rule, we simply use the and- or the maximum-option in OVERLAY to combine result and result2. That's all folks!**

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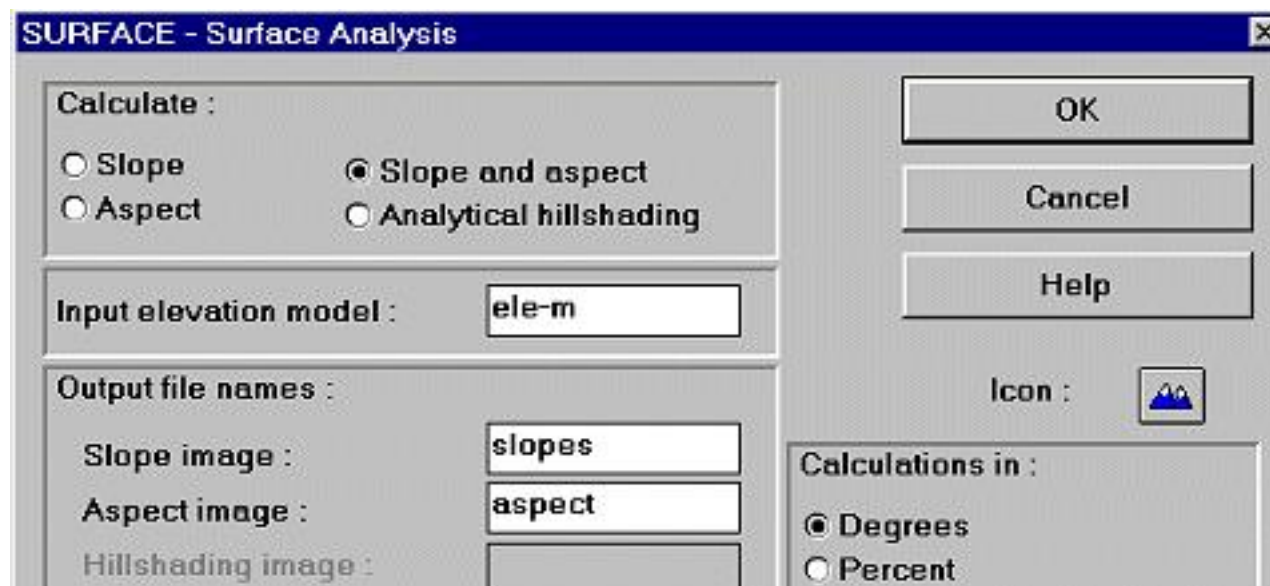
Single Raster Analysis Tools IV

- Computing Slope and Aspect with **SURFACE**

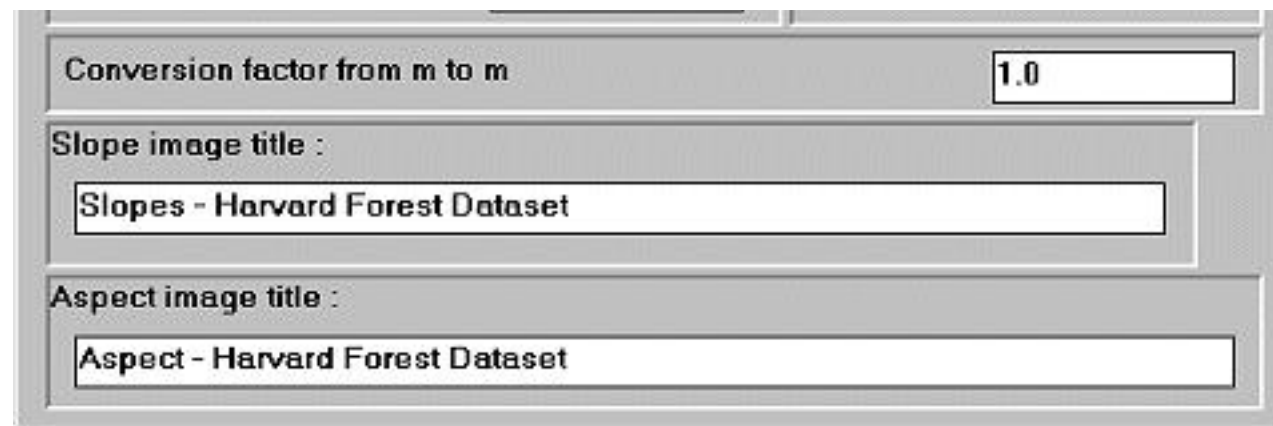
The **SURFACE** module can derive three surficial characteristics:

- *Slope*
- *Aspect*
- *Analytical Hillshading* (= **shaded relief**)

To be correct: the last one is not really a surficial characteristic, but a kind of synthetical shading of a DEM for illustration purposes only.



In terms of IDRISI the values in a slope image reflect the maximum slope around each pixel among four directions - N, W, E, S. Only these 4 neighbours are taken into account. Be critical of what you get 'at your fingertips', calculations of slope aren't that clear-cut they may seem to be (background reading e.g. BERRY 1993, p. 147ff. *). Be prepared to receive considerably - in terms of reliability - different results throughout GIS software products treating one and the same dataset. Disturbing, isn't it?



Conversion factor from m to m: 1.0

Slope image title :
Slopes - Harvard Forest Dataset

Aspect image title :
Aspect - Harvard Forest Dataset

Slopes may either be expressed as decimal degrees (0 - 90°) -

$$Slope[^\circ] = \arctan\left(\frac{\partial z}{\partial x}\right) \text{ - or percent}$$

(45° equals to 100%, whereas 90° slopes approach to infinity) -

$$Slope[\%] = 100 * \left(\frac{\partial z}{\partial x}\right) \text{ - in the}$$

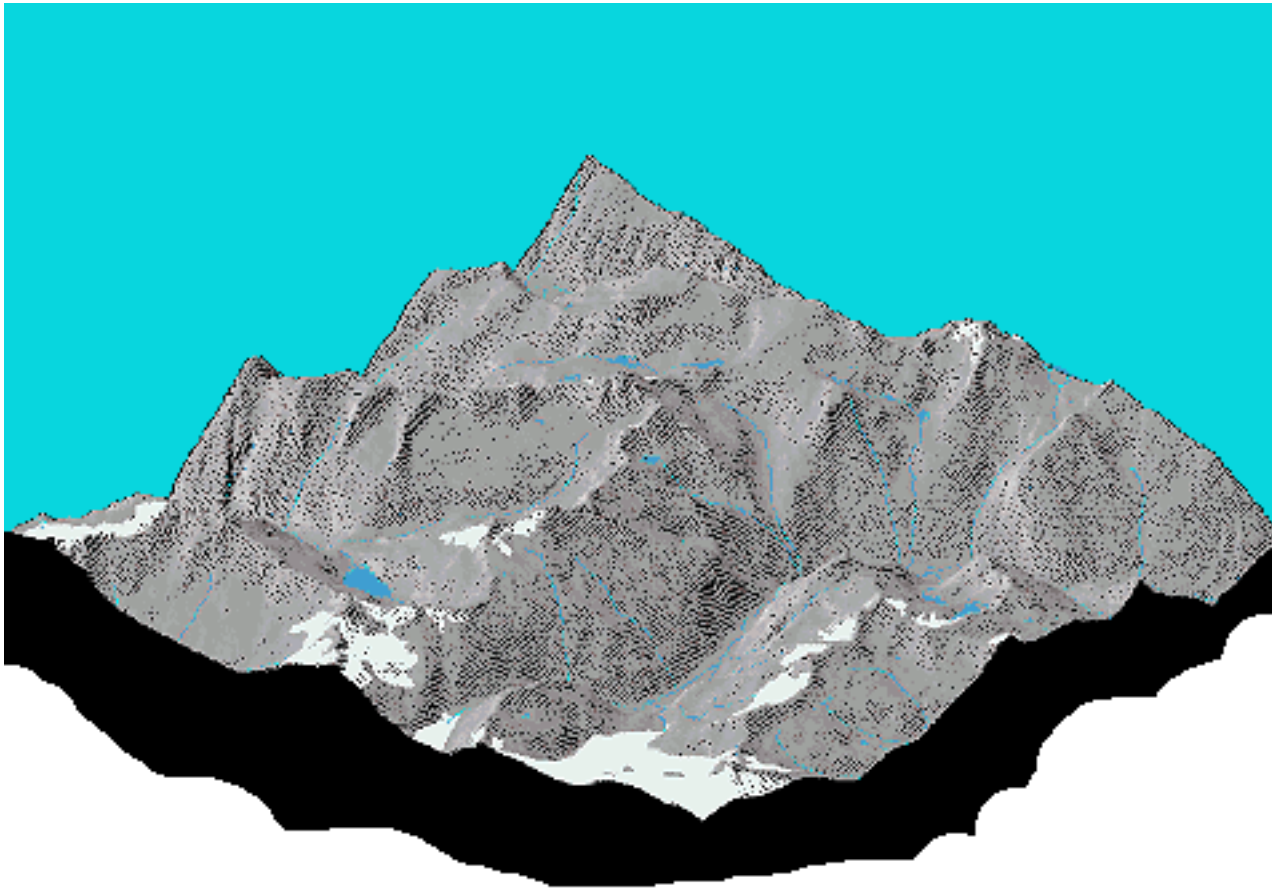
SURFACE module. Slope images may be used to derive constraint areas, e.g.

for planning factories, roads, ... they are part of predicting soilerosions, or danger of avalanches and so on. Keep in mind that slope computing is by no means strictly restricted to DEM datasets.



Let us now proceed to the aspect images. IDRISI's SURFACE module calculates them as 'the direction in which the maximum slope faces'. The values are decimal degrees of type real that range between 0° and 360° (N). The direction is clockwise (90° means east, 180° south, ...). Values of -1 are assigned to completely flat areas (where slopes are 0).

Last but not least we may simulate the state of illumination for a DEM at given sun azimuth (260 - 290°) resp. elevation angle (0 - 90°). As with the [ORTHO](#)-module before we could apply TRANSPOS to the DEM, rotate it, run the analytical hillshading and rotate the resulting image back to the origin, thus simulating light sources from any direction. The algorithmic basis of the analytical hillshading is a simple combination of trigonometrical calculations with slope, aspect and the zenith angle. Hillshade images are intended only for visualizations (e.g. enhancing textural and directional elements). Values range from 0 to 1 so a STRETCHing to 0 - 255 may be expedient. Notice, that cast shadow is *not* taken into account!

The following graphic is the 3D-representation of a hillshade draped over the raw DEM. Rivers, lakes and glaciers have been added subsequently in a previous step. The blue sky was a little bit tricky but has been realized completely with IDRISI:



Joseph K. BERRY, 1993: Beyond Mapping: concepts, algorithms, and issues in GIS. GIS World Books, Fort Collins

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Image Processing I

Contents

In this new series of chapters to follow, I will try to give a very coarse introduction to *Image Processing as done with IDRISI*. Often users aren't aware of the fact, that IDRISI provides a complete 'starter-kit' to perform classical image processing. The next pages shall roughly guide you through some techniques and methods in that fields.



What you will not find here, is the theory behind (as much as necessary only :), so help yourself with one of the excellent [textbooks](#) about image interpretation and remote sensing. Also refer to the online [Remote Sensing Tutorial](#) at Goddard Space Flight Center, NASA ([European users try our local mirror](#)).

The term *image processing* is used here mainly in the context of satellite classification and related aspects.

We will touch several items, starting with an example, how to [\(1\)](#) import satellite data. After that, a closer look on [\(2\)](#) enhancement functions (such as [STRETCH](#)ing, [FILTER](#)ing, using [HISTO](#)grams) follows. Closely related [\(3\)](#) visualization aspects (e.g., band combinations, [COMPOSIT](#) images and [removing redundancies](#)) will be covered then. [\(4\)](#) Classification methods presented here will comprise unsupervised ([CLUSTER](#)) and supervised techniques (defining training areas, creating, comparing and editing spectral signatures: [MAKESIG](#), [EDTSIG](#), [SIGCOMP](#), [PIPED](#), [MINDIST](#), [MAXLIKE](#)). [\(5\)](#) Accuracy checking should conclude the whole ([ERRMAT](#)).

among several fine books:

1. Thomas M. LILLESAND & Ralph W. KIEFER, 1994^{3rd} ed.: Remote Sensing and Image Interpretation. John Wiley & Sons, New York
Eric C. BARRETT & Leonard F. CURTIS, 1992^{3rd} ed.: Introduction to Environmental Remote Sensing. Chapman & Hall, London

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Image Processing IV (cont.)

Concentrating on essentials

The techniques brought up here fit in more functional categories, so do not strictly rely upon this outline. More thorough discussions of the following topics would require lots more space, so I strongly recommend reading [\(geo\)statistical textbooks](#) (also check the recently published [sample exercise](#) from the [Remote Sensing Core Curriculum](#) about Principal Components Analysis).

Data reduction - [PCA](#) (Principal Components Analysis)

Link back to the previous page and take a look at the 7 spectral bands from the Landsat TM data. You may notice more or less strong correspondence in the data - these are redundancies, 'digital ballast' not always necessary to carry along with the data. With the statistical method of *principal components analysis* we 'extract the essentials' by producing so-called 'principal component images' and statistical information output in IDRISI:

Table: *PCA tabular output in IDRISI*
7 spectral bands were feed into the PCA-function to produce 7 components

VAR/COVAR	taurtm1	taurtm2	taurtm3	taurtm4	taurtm5	taurtm6	taurtm7
taurtm1	3087.33	2070.67	2530.54	974.94	-517.63	-449.01	-34.25
taurtm2	2070.67	1546.11	1842.13	844.92	-359.73	-300.25	-54.99
taurtm3	2530.54	1842.13	2218.84	960.56	-411.23	-362.97	-38.62
taurtm4	974.94	844.92	960.56	1063.28	106.61	-16.30	-22.00
taurtm5	-517.63	-359.73	-411.23	106.61	1021.40	288.10	482.89

this is the **variance**/co-variance matrix between all cellvalues in each band combination

taurtm6	-449.01	-300.25	-362.97	-16.30	288.10	157.74	97.38
taurtm7	-34.25	-54.99	-38.62	-22.00	482.89	97.38	290.16

COR-MATRX	taurtm1	taurtm2	taurtm3	taurtm4	taurtm5	taurtm6	taurtm7
taurtm1	1.000000	0.947761	0.966847	0.538101	-0.291492	-0.643424	-0.036191
taurtm2	0.947761	1.000000	0.994571	0.658977	-0.286261	-0.607986	-0.082100
taurtm3	0.966847	0.994571	1.000000	0.625371	-0.273162	-0.613545	-0.048126
taurtm4	0.538101	0.658977	0.625371	1.000000	0.102303	-0.039810	-0.039612
taurtm5	-0.291492	-0.286261	-0.273162	0.102303	1.000000	0.717772	0.887027
taurtm6	-0.643424	-0.607986	-0.613545	-0.039810	0.717772	1.000000	0.455205
taurtm7	-0.036191	-0.082100	-0.048126	-0.039612	0.887027	0.455205	1.000000

this correlation matrix contains the **PEARSON product-moment correlation coefficients (range: -1 to +1)**

COMPONENT	C1	C2	C3	C4	C5	C6	C7
%var.	77.51	14.42	6.45	1.08	0.37	0.10	0.06
eigenval.	7274.64	1353.37	605.34	101.62	34.36	9.61	5.92

these numbers show, **how much variance is being explained by the components. Note that 98.38% of the overall variance is explained through the first three components!**

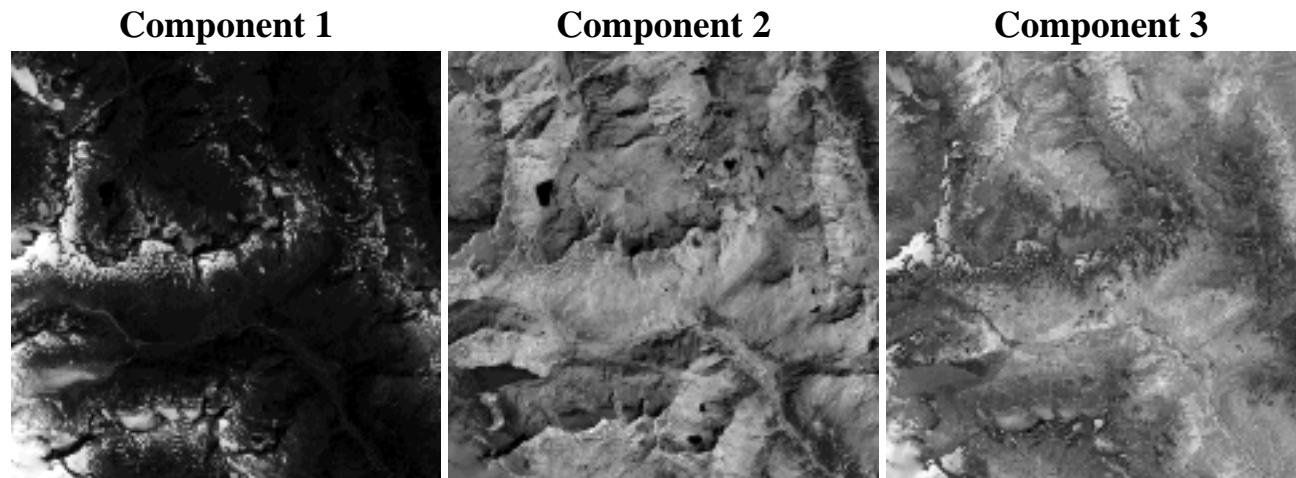
eigvec.1	0.637395	-0.024205	-0.332783	-0.664908	0.078396	-0.128519	-0.132783
eigvec.2	0.453689	0.032000	0.011831	0.568448	0.035183	0.001237	-0.684566
eigvec.3	0.551395	0.026079	-0.050350	0.419740	0.048126	-0.022627	0.716756
eigvec.4	0.250048	0.409488	0.816091	-0.233731	-0.101826	0.196958	0.000000
eigvec.5	-0.111267	0.798522	-0.256041	0.062861	-0.203832	-0.488801	0.000000
eigvec.6	-0.092584	0.210568	0.060913	0.000970	0.968702	-0.070669	0.000000
eigvec.7	-0.019534	0.384777	-0.388984	0.000205	0.000000	0.836813	0.000000

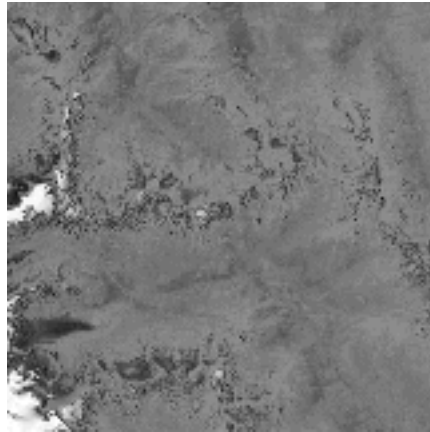
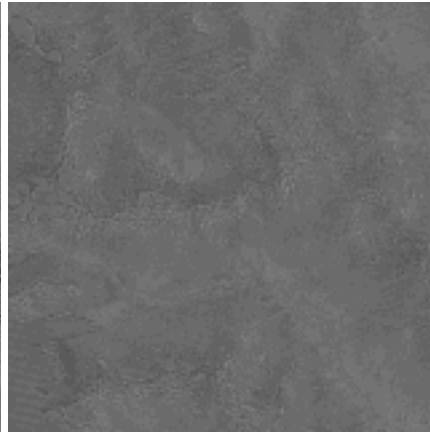
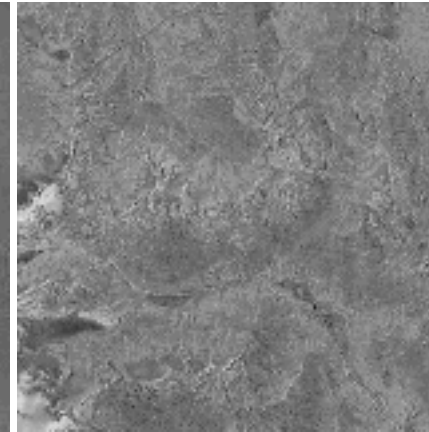
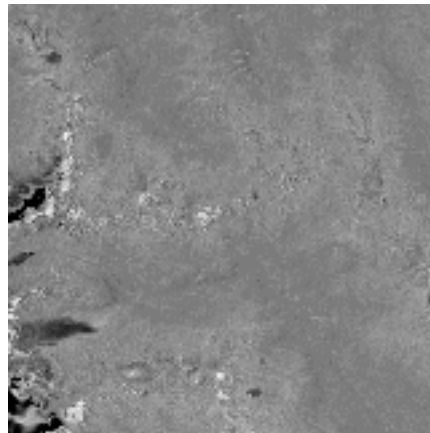
Summary of eigenvectors per eigenvalue

LOADING	C1	C2	C3	C4	C5	C6	C7
taurtm1	0.978414	-0.016026	-0.147356	-0.120630	0.008270	-0.007172	-0.005814
taurtm2	0.984110	0.029939	0.007403	0.145732	0.005245	0.000098	-0.042358
taurtm3	0.998401	0.020367	-0.026299	0.089826	0.005989	-0.001489	0.037021
taurtm4	0.654042	0.461983	0.615764	-0.072257	-0.018305	0.018729	0.000000
taurtm5	-0.296944	0.919171	-0.197110	0.019828	-0.037385	-0.047423	0.000000
taurtm6	-0.628746	0.616786	0.119328	0.000778	0.452112	-0.017447	0.000000
taurtm7	-0.097810	0.830999	-0.561843	0.000121	0.000000	0.152325	0.000000

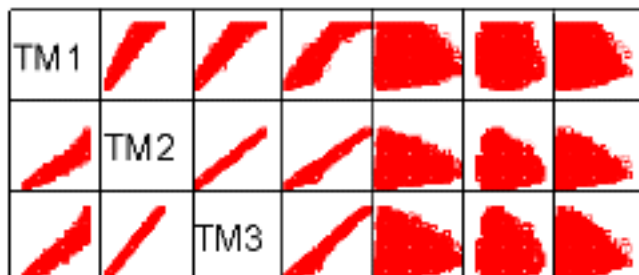
the loadings are coefficients of the eigenvectors linear equation; they aid in analysing the **relative importance of a band within a principal component (range: -1 to +1)**

If you are not familiar with techies like 'eigenvalue', 'eigenvector', ... I recommend again diving deeper with [statistical textbooks](#). To give you an expression of how that component images look like - find here 7 images from a subscene of the Hohe Tauern region (around the Matreier Tauernhaus):



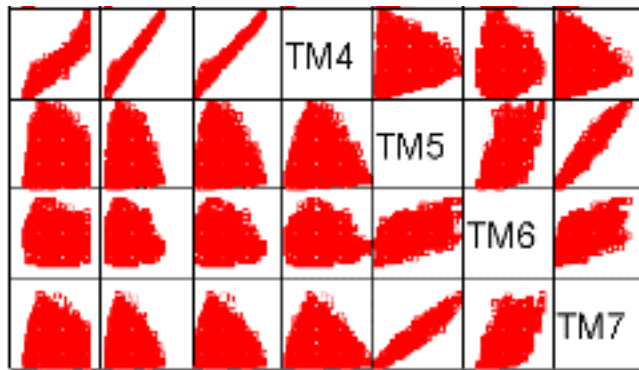
Component 4**Component 5****Component 6****Component 7**

Such images might be simply used for enhancement, data reduction or even later on in the classification process (be careful in using them in the latter). Helpful not only for interpreting the results of the PCA are additional XY-scatterplots of one band versus another. In the IDRISI for DOS version you could create simple scatterplots with the routine [SCATTER](#). The following scatterplot matrix has been prepared with the help of [SPSS 7.0](#):



e.g., 'TM 1' means thematic mapper band 1;

compare these plots against the correlation matrix part of the IDRISI output. Clearly visible are strong positive linear correlations between bands 2 + 3, 2 + 4, 3 + 4.





among my personal favorites:

John C. DAVIS, 1986^{2nd} ed.: Statistics and Data Analysis in Geology. John Wiley & Sons. New York

A. R. H. SWAN & M. SANDILANDS, 1995: Introduction to Geological Data Analysis. Blackwell Science, Oxford

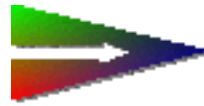
Trevor C. BAILEY & Anthony C. GATRELL, 1995: Interactive Spatial Data Analysis. Longman, Essex.

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Single Raster Analysis Tools V

● QUADRAT and CENTER - 2 modules for point pattern analysis

Epidemiological, geological, ecological ... questions sometimes require a means of describing point distribution patterns. In the Analysis/Statistics submenu of IDRISI you will find 2 modules, that may give you some assistance - QUADRAT and CENTER. They assume the cellvalues of the input image as equivalents to the count of points (occurrences) that fall within that cells (additionally it can be a weighting factor for each cell in CENTER).

In both modules IDRISI results with statistical summary informations written out to a textedit window

- **CENTER can be used e.g. to show the shifting in population density over time by repeating the calculation for time series images.**

results of CENTER

- | | |
|---|---|
| 1. Image analyzed : popden | name of analyzed file |
| 2. Mean center falls in col 250 /
row 395 | the col/row position of the <i>weighted mean center</i> |
| 3. Standard radius in cell widths
is 36716 | analogue to standard deviation in univariate distributions; tells expresses the dispersion of points
about the mean center |
| 4. X coordinate of the mean
center in M : 253899.688721 | same as col in 2., but ref. units |
| 5. Y coordinate of the mean
center in M : -679978.179932 | same as row in 2., but ref. units |
| Standard radius on the ground | |
| 6. expressed in M :
183577680.000000 | same as cells in 3., but ref. units |

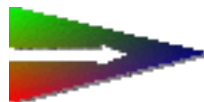
Coefficient of Relative

7. Dispersion (%) :

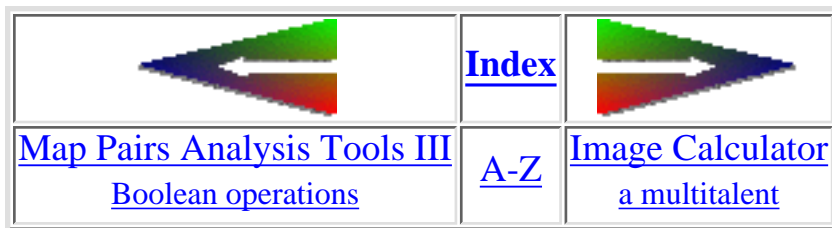
14268.986511 (= CRD)

$$CRD = \frac{std.radius}{radius\ of\ circle\ with\ same\ area\ as\ that\ of\ study\ region} * 100$$

- **QUADRAT** computes mean, variance, variance/mean ratio, t-test result, significance level and an estimation of the "ideal" quadrat size, as the results of the variance/mean ratio can be biased by that size. Ratios around 1.0 indicate a random point pattern, ratios < 1.0 suggest distributed patterns and ratios > 1.0 clustered ones. But the analyst has to pay attention to possible autocorrelative effects ([AUTOCORR](#)) that may lead to distortions in the results. QUADRAT allows the declaration of a mask image (1's where cells should be computed, 0's where should not = BOOL image).


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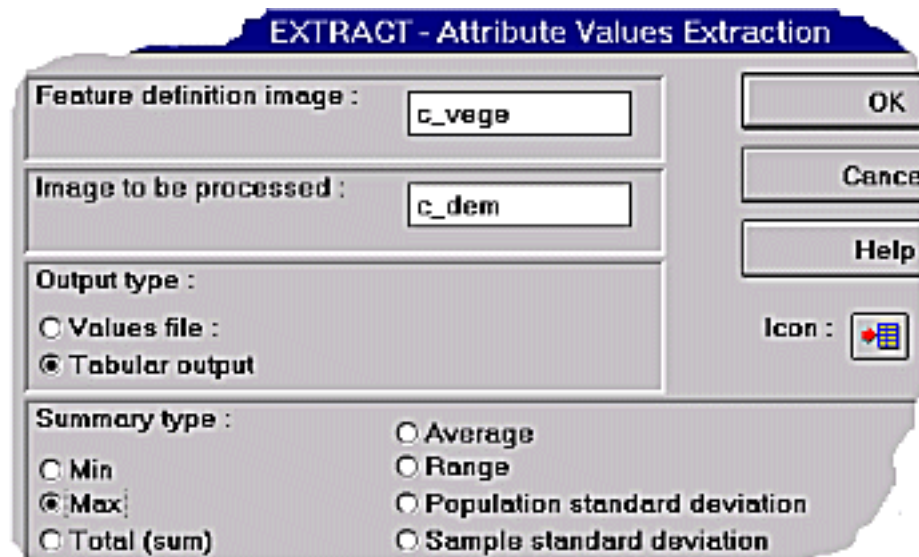
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Zonal Operators

Let our interest now focus on maybe distinct zones: what is the maximum height throughout all the areas of vegetation class 16? What is its mean height? Or even more expressive - its range?

EXTRACT helps you in finding a solution to that spatially complex questions:



During several lessons I often found it a bit difficult for students to grasp what 'zones' are, when they first heard about it. No magic around, so - de-mystifying - *zones* are nothing but 'a set of data pertaining to one of the variations' in an image ([TOMLIN](#), p. 10). So all the pixels with value 16 in our image together define the zone for value 16.

Areas belonging to a zone may vary in shape, they may be scattered all over our image or just be represented by one patch. Important is: the 'zone' embraces all those patches and areas in our image as a whole for the calculations.

What's the maximum summary type doing? It looks for the least value throughout every zone. How does IDRISI get to know about zones? By entering a 'Feature definition image' (look at dialogbox). Where do the

values (for the maximum values search) come from? They are stored in the image we type in 'Image to be processed' (dialogbox). As a result IDRISI faces us with a table or a values file with the summary-listing for the maximum-values for each zone.

So remember the sample images from the preceding chapter about the boolean operations. Now let us pick up such a 'zone' from the TAURVEGE dataset, e.g. vegetation class 16 and try to answer the question in the first paragraph of this page. For convenience the resulting tables from 4 subsequent EXTRACT-sessions have been put together:

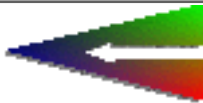
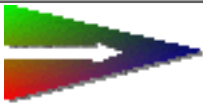
Maximum values extracted from c_dem based on c_vege		Range extracted from c_dem based on c_vege		Average values extracted from c_dem based on c_vege		Pop. SD extracted from c_dem based on c_vege population standard deviation	
Category	maximum		range		average		standard deviation

0	0.000000		0.000000		0.000000		0.000000
1	3005.000000		1456.000000		2504.381592		210.497955
2	2768.000000		986.000000		2369.511963		155.876114
3	2752.000000		1163.000000		2314.930420		146.568085
4	2585.000000		648.000000		2305.068604		163.373474
5	2563.000000		1187.000000		2076.591797		232.300858
6	2371.000000		1054.000000		1831.569946		271.871185
7	2306.000000		872.000000		1776.380005		245.223694
8	1597.000000		104.000000		1512.675293		13.514922
9	1326.000000		6.000000		1323.000000		2.449490
10	2053.000000		251.000000		1926.371460		71.104385
11	2483.000000		1038.000000		2124.806885		135.756699
12	2316.000000		802.000000		1952.322754		166.755127
13	2107.000000		76.000000		2067.333252		23.584364
14	2288.000000		776.000000		1850.957520		182.762695
16	2217.000000		881.000000		1832.449463		147.938126
18	2210.000000		485.000000		1946.748413		84.431808
19	2151.000000		513.000000		1893.650879		109.676735
20	2146.000000		774.000000		1683.381470		128.012512
22	1782.000000		259.000000		1622.614868		57.986622
23	1493.000000		59.000000		1466.476196		17.589550
24	1539.000000		40.000000		1506.329468		7.656429
25	2064.000000		605.000000		1736.760986		123.231606
26	1781.000000		223.000000		1653.132080		42.241016
27	2248.000000		790.000000		1928.270752		136.568451
28	1512.000000		18.000000		1500.677734		2.839514
29	2955.000000		825.000000		2595.644043		176.245438

30	2744.000000	1286.000000	2214.259521	275.286438
31	2827.000000	1049.000000	2448.753174	325.876984

From the results above we could say: vegetation class 16 climbs up to a height of 2217 m a.s.l.

But: perhaps the images we compared do not match exactly, perhaps there has been some error of the field team, perhaps ...

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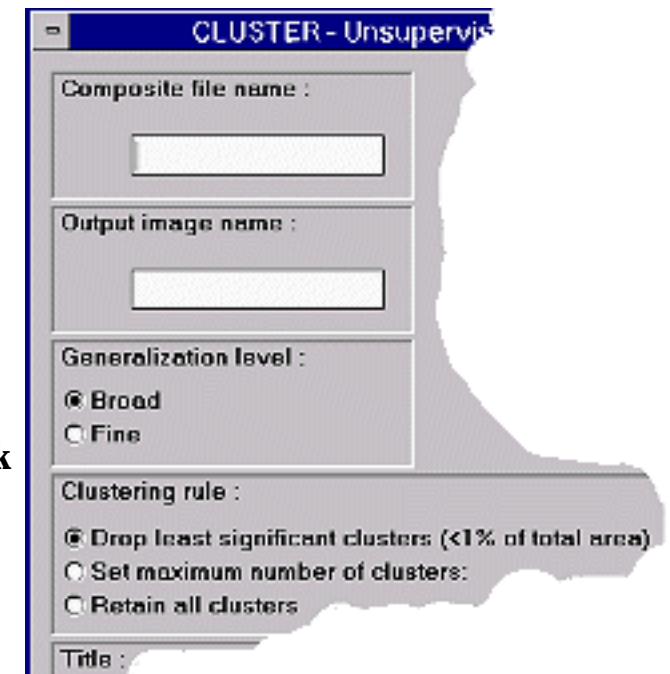
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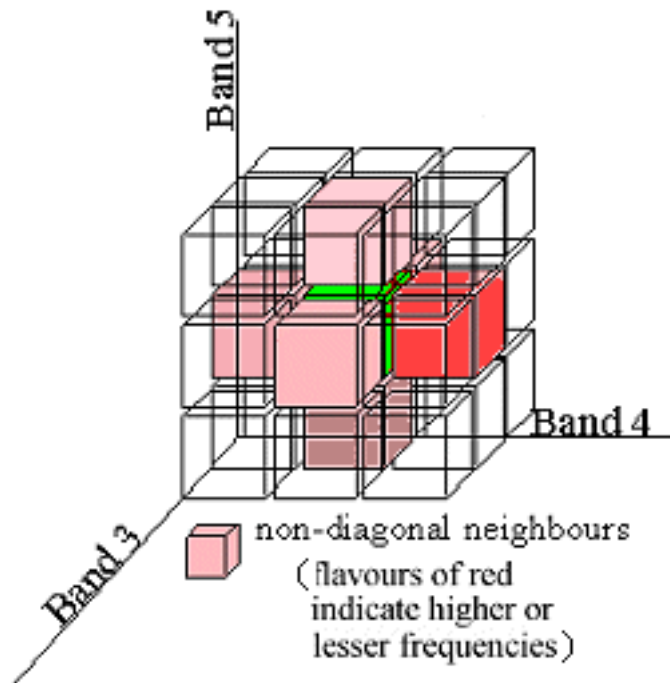
Image Processing V

Image classification

- Unsupervised method with [CLUSTER](#)

Think of a case, that you do not know much about the real landcover classes in your satellite image (e.g., very out-of-the-way areas). A method to get more information from your data is what's known as **unsupervised classification**. **By that we mean a whole family of techniques, from which IDRISI uses one, called 'histogram peak technique'.** For details read the IDRISI help files. The method relies on [RGB-images](#) created with [COMPOSIT](#): the spectral information from 3 different bands has been converted to a index number in the range 0 - 215. CLUSTER computes same way back and internally produces 3-dimensional histograms for the 3 bands used.





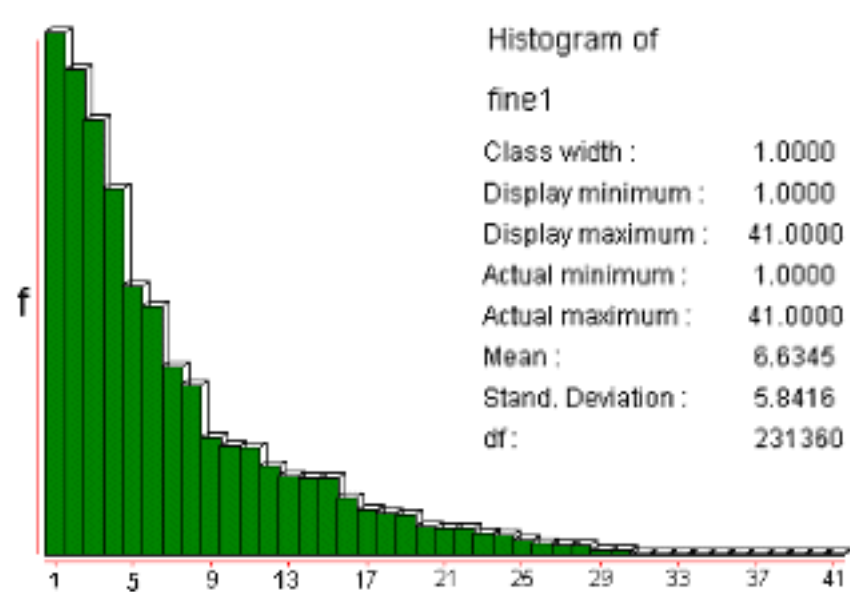
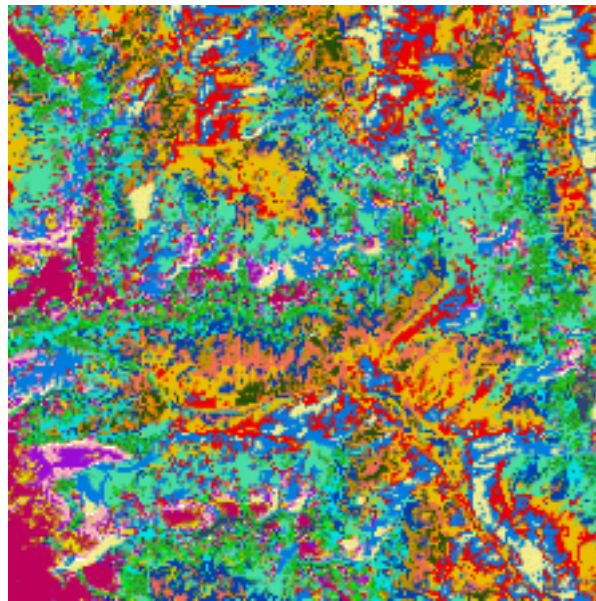
Classes are identified as histogram 'peaks' (spoken 3-dimensional: centres of high frequency). Membership to a class is defined by the neighbourhood to such a 'peak'. In the case of **broad generalization a class is defined by having a frequency higher than all of its non-diagonal neighbours. The fine generalization type allows for one non-diagonal neighbour with a higher frequency.**

You will also recognize three different clustering rules. What combination of parameters should we choose now? To a high degree image processing and interpreting is a matter of experience, trial and error. The same holds true here.

One approved way is to select fine generalization plus retaining all clusters to get an idea of the number of clusters to expect. Use histogram to explore the frequencies and their distribution.

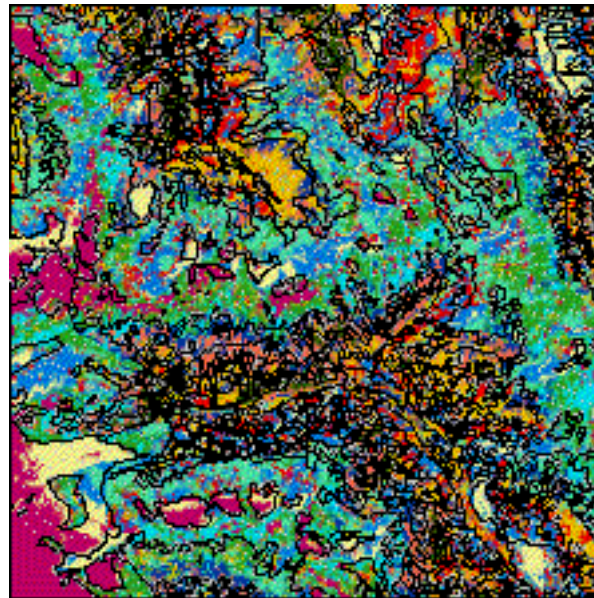
fine generalization - retain all clusters

histogram for image to the left

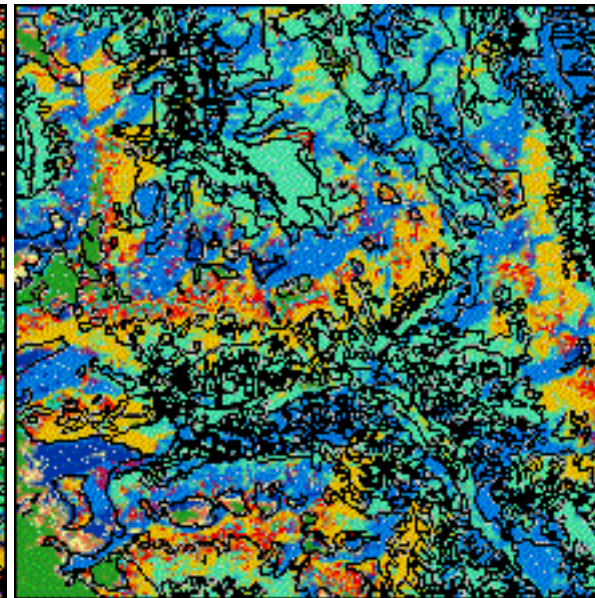


41 classes are of course not realistic for a Landsat TM 5 classification in a mountainous environment like the one in question. Search for significant breaks in the histogram, e.g., after 4, 6, 8 (11, 15, ...). Use CLUSTER with same input as before but set maximum cluster numbers to some break value, e.g., 11. Below are two examples from such an explorative attempt (both overlaid by vegetation boundary from analog map):



fine generalization
set maximum number of clusters to 11



broad generalization
set maximum number of clusters to 11



Some regions show resonable match others don't. The final task that's up to you is to interpret classes, related them to real world objects and land cover types.

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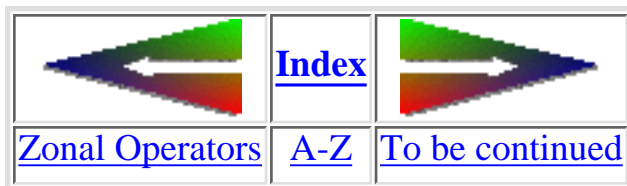


Image Calculator - a multitalent

Well, you now got to know several tools for the analysis of map pairs (where I do not strictly want to stress this as a systematic nomenclature of spatial analysis functions!). Now I won't show you anything really new - disappointed?

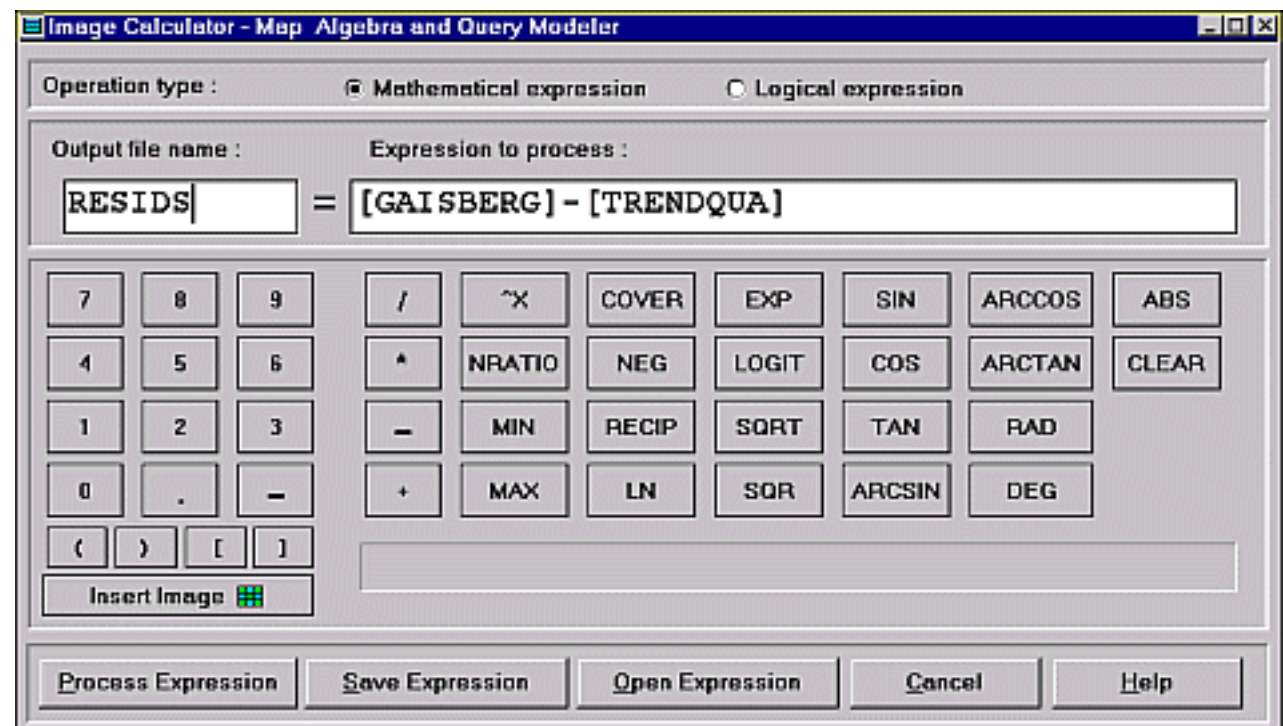
No, wait! It is going to be a lean back case. Many of the analytical steps we took in the previous chapters can be performed with the help of a nice tool implemented since IfW 2 - the **Image Calculator**. **Helps to compute expressions, that otherwise would require many single calls to several modules.**

Designed as a regular calculator you may compute with your images using all the operators and functionality otherwise found in OVERLAY, TRANSFOR, SCALAR and RECLASS. No wonder, as the tool calls these modules in the background.

Following below a few examples of expressions, as you might be using them and to give you an idea of what and how thing can be input here.

A common error is to forget the brackets enclosing the image names and a mismatch in the number of opening vs. closing brackets.

Save expressions especially if they grow very long and complex. The files created have the extension *.EXP and can be modified or created with any plain-text editor.



The samples (the left-side name symbolizes the Output file name) reflect some of the capabilities using mathematical expressions (for the logical part see later on):

1. What's the minimum of the seven input images (IMAGE1 to IMAGE7)?

$$\text{OUTPUT} = \text{MIN}([\text{IMAGE1}], \text{MIN}([\text{IMAGE2}], \text{MIN}([\text{IMAGE3}], \text{MIN}([\text{IMAGE4}], \text{MIN}([\text{IMAGE5}], \text{MIN}([\text{IMAGE6}], [\text{IMAGE7}]])]))))$$

Notice the nesting of the MIN function - computation starts from the innermost MIN pair.

2. If you use trigonometric functions, angle values have to be converted to radians. This too can be easier by nesting the commands needed:

$$\text{OUTPUT} = \text{RAD}(\text{COS}([\text{IMAGE1}])) * \text{RAD}(\text{SIN}([\text{IMAGE2}]))$$

3. Simple computations would take quite a long time doing it with the functions. 7 calls to OVERLAY and 9 to SCALAR would be necessary in the following case:

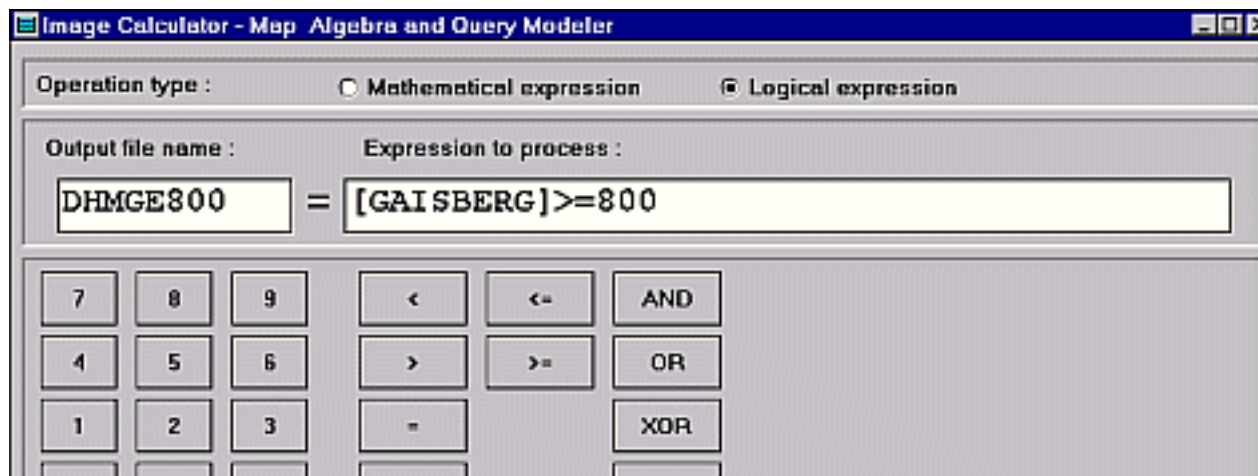
$$\text{OUTPUT} = ((([\text{IMAGE1}] * 1.34 - [\text{IMAGE2}] * 3.45) / ([\text{IMAGE1}] * 5.34 + [\text{IMAGE2}] * 7.21)) * (([\text{IMAGE3}] * 1.24 - [\text{IMAGE4}] * 6.5) / ([\text{IMAGE3}] * 8.7 + [\text{IMAGE4}] * 2.5))) + 25.13$$

Pay attention to the parentheses, they determine the sequence of the calculations. As you realize, some functions accept the mixing of numbers and images as input.

4. If you really like, you may only use numbers with several of the functions, which turns the Image calculator into a normal calculator:

$$\text{SQR}(4) + \text{SQR}(4)$$

returns? Exactly 32.00000



Now after these mathematical expression examples have a look at the possibilities of the logical expressions part of the Image Calculator.

They may deserve as substitute for the [RECLASS](#) function partially.

The expression as shown in the figure to the left outputs from the input DEM a boolean image, where all pixels with original heights equal to or above 800 meters receive a 1, whereas all the others become 0.



As before, again some examples should demonstrate how to use the logical part of the Image Calculator:

1. We are interested not only in the areas equal to or above 800 meters but also those below 1000 meters:

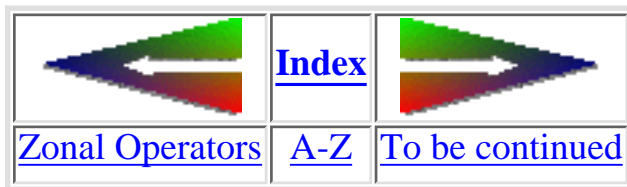
OUTPUT = ([GAISBERG]>=800) AND
([GAISBERG]<1000)

2. Assign all pixels a value of 1 where IMAGE1 is greater than IMAGE2:

OUTPUT = [IMAGE1] > [IMAGE2]

3. Perform more complex queries:

OUTPUT = ([IMAGE1]>[IMAGE2]) AND ([IMAGE3]>100) OR ([IMAGE2] >= [IMAGE3]) NOT ([IMAGE1] < 150)



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