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CREALP

CENTRE DE RECHERCHE SUR L'ENVIRONNEMENT ALPIN

User's Guide

Matterocking 2.0



Written by:

Michel Jaboyedoff

Quanterra

Ch. de la Tour-Grise 28

1007 Lausanne

Switzerland

Tel. 079 752 35 15

E-mail: support@quanterra.org

Table of Contents

1. Introduction	2
Installation	2
File format	3
The GRD files	3
The ASC files	4
2. The windows and their use	5
3. What does Matterocking?	7
How the DTM is used	7
Characterization of discontinuities	8
Computation of slope and slope aspect	9
Potential sliding zones	9
Average number of discontinuities counted in each topographic facet	9
Average number of wedges counted in each topographic facet	10
Average number of sectors	11
Number of discontinuities based on apparent spacing	12
Probabilities	13
Altitude difference.	13
4. The menus	14
Common File menu	14
Common Utility menu	15
File to treat window menu	15
File exports	15
Treatments default value option	16
Treatments	17
Alternate menu for edit numerical data window	18
Image view of file	19
The extract window	20
The merge function	21
Report Window	21
References	22
Index	23

Chapter

1

1. Introduction

The program MATTEROKING 2.0 is designed to estimate the average number of discontinuities on digitized topographic relief. This software is used for potential rock slope instabilities detection.

Theory will not be developed in detail here, it can be found elsewhere in articles (Jaboyedoff et al., 1996; Rouiller et al., 1997; Jaboyedoff et al., 1999, Baillifard et al., 2001).

Using digital elevation model (DTM), the program **Matterocking** permits to compare structural data with topographic surface orientation in order to estimate the average number of discontinuities intersecting a topographic relief. Locations where rock-instabilities can occur by discontinuities or wedges that allow sliding can be spotted. Different functions are implemented such as estimates of potential sliding areas, surface number, and linear number of discontinuities within cell of the DTM.

Matterocking is designed to calculate and not to generate graphic outputs. Nevertheless, some visualization utilities exist to have a quick view of the results. The file format are chosen in order to be used in to standard visualization program: Surfer Golden software© and ArcView ESRI©.

Installation

The program available on the WEB (www.crealp.ch) was compiled under Windows 98, in order to avoid problems of installation.

To install, click on install program, the installation will update or not the requested Microsoft system files for running Visual Basic 6.0 applications, and add the requested DLL and OCX.

File format

The input and output files are rectangular (only surfer files) or squared grid text files. Two file formats are proposed:

- The grid format (*.GRD), which is the standard ASCII file format of Surfer 6.0.
- The grid format (*.ASC), which corresponds to the ArcView 3.x ASCII file import format.

A third file is proposed for export with coordinates, which can be read from excel. The no data value of both files type can be changed. The separator for the grid files can be either “;” or tabulators or spaces.

Two examples of DTM files are distributed with the program TOPOSW.ASC and TOPOSW.GRD.

The GRD files

The ASCII Surfer file format contains an alphanumeric header DSAA in the first line. The second line contains the number of columns (Nx), and the number of lines (Ny). Note that the order of the rows of the file is inversed compared to the screen display (Fig. 1.1).

The next three lines must contain X ,Y and Z limits (Xmin Xmax, Ymin Ymax, Zmin Zmax) respectively. The Grid mesh size can be different in x or y direction. The following lines are Ny rows of Nx data; the rows can be also cut in-between data values.

The default value is the standard Surfer 6 default value 1.70141e+038. Separators can be tabulators, spaces, comas, and semicolons. Note that surfer format does not open a file with number of rows and columns containing a period (reel number value).

DSAA				DSAA			
Nx	Ny			3	3		
Xmin	Xmax			0	1500		
Ymin	Ymax			1000	2500		
Zmin	Zmax			136	1850		
Value(1,1)	Value(1,2)	...		200	500	136	
Value(2,1)	Value(2,2)	...		510	1525	1850	
...		315	528	1243	

Figure 1.1 Description of the 3.GRD file format with an example of a 3 × 3 grid file (header in bold).

The ASC files

<code>ncols</code>	<code>Nx</code>		<code>Ncols</code>	<code>3</code>	
<code>nrows</code>	<code>Ny</code>		<code>nrows</code>	<code>3</code>	
<code>xllcorner</code>	<code>Xmin - Delta/2</code>		<code>xllcorner</code>	<code>-375</code>	
<code>yllcorner</code>	<code>Ymin - Delta/2</code>		<code>yllcorner</code>	<code>625</code>	
<code>cellsize</code>	<code>Delta</code>		<code>cellsize</code>	<code>750</code>	
<code>NODATA_value</code>	<code>Dodat</code>		<code>NODATA_value</code>	<code>-9999</code>	
<code>Value(Nx,1)</code>	<code>Value(Nx,2)</code>	<code>...</code>	<code>315</code>	<code>528</code>	<code>1243</code>
<code>Value(Nx-1,1)</code>	<code>Value(Nx-1,2)</code>	<code>...</code>	<code>510</code>	<code>1525</code>	<code>1850</code>
<code>...</code>	<code>...</code>	<code>...</code>	<code>200</code>	<code>500</code>	<code>136</code>

Figure 1.2 Description of the 3.ASC file format with an example of a 3 × 3 grid file (header in bold). Same file as in figure 1.1, observe the inverse position of rows.

The ASCII ArcView grid file is slightly different from the Surfer one, it is necessarily a squared grid. The headers must be displayed in lines with identifier indicating each header value (`ncols`, `nrows`, `xllcorner`, `yllcorner`, `cellsize`, `NODATA_value`). As in Surfer file the number of columns *ncols* (`Nx`) and rows *nrows* (`Ny`) must be specified. The grid position is described by the lower left corner x-y coordinates `xllcorner` and `yllcorner` and the cell size `cellsize` (`Delta`). *Note that the lower corner of the ASC file does not correspond to the lower corner of the GRD files, because the first one uses a point as a pixel and the second uses point as mesh. Thus the ASC lower corner is shifted by a half-cell size down and left.* The no data value `NODATA_value` is optional (`Nodat`), if it is not indicated, the default value `-9999` is used by the program.

*The program **Matteroking** reads ASC file only if each header is on its own line.*

Chapter

2

2. The windows and their use

General functionalities of the program are described in this chapter.

The program **Matterocking** displays 5 types of windows, each one has a specific functionality. Most of the menus are similar, except for the window of treatments (Fig. 2.1).

The grid files can be either treated, saved in other formats, edited numerically, viewed graphically; part of them can be extracted. The history of actions, which have led to file saving is stored in a file REPORT.TXT.

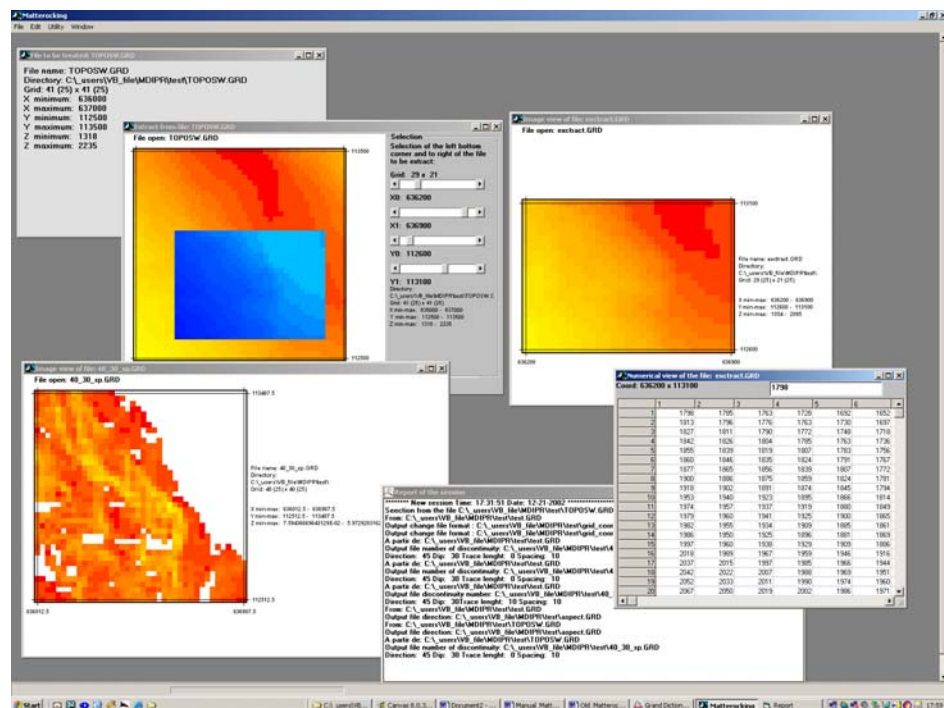


Figure 2.1 Main window of the program, containing the five types of windows.

The windows for treatment load data from file for the numerical treatment performed by **Matterocking**, and allows also to export file in other formats. It

displays the characteristics of the grid. The specific menus of this window are the treatment and exports.

The files can be edited and saved after modification in the numerical grid display. The files can be viewed in a graphic display, which indicates also the characteristics of the grids. A similar window permits to extract graphically or not a part of grid file.

A report window contains all the actions that have led to a new file. This window cannot be closed.

3. What does Matterocking?

The methods used in the program Matterocking are simply described in this chapter.

How the DTM is used

DTM are 3D grid points of elevation values z that are distant by Dx in x direction and Dy in y direction (Dx and Dy are necessarily equal for ASC files). A cell is limited by four points, corresponding to a facet of topography, defined by the three x - y - z coordinates for each point. It can be approximated by a plane (Fig 3.1). The lines joining the middle of the opposite side of the topographic cell define this plane.

Matterocking used mostly the orientation of the facets to calculate the number of discontinuity by cells.

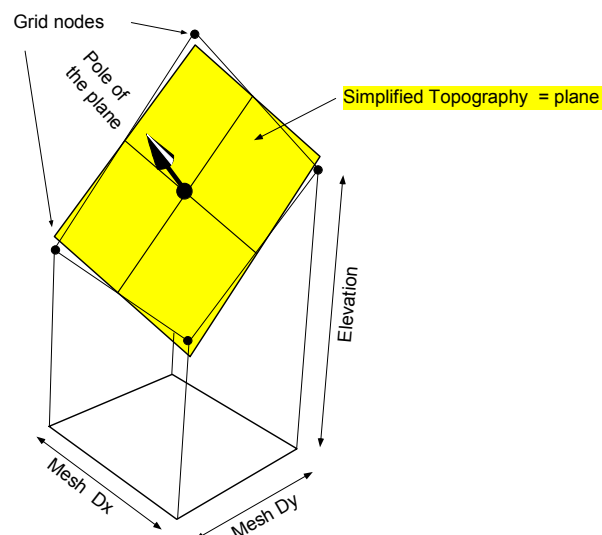


Figure 3.1 In yellow the approximation of a facet of DTM cell using a plane.

The estimation of the orientation that is the perpendicular to the topographic cell is estimated in the center of four points and leads to a shift of the output grid origin from $X \rightarrow (X + Dx/2)$ and $Y \rightarrow (Y + Dy/2)$. This procedure has the advantage of less smoothing slopes than the standard GIS methods, which usually use a rectangle which contains point distant by $2 Dx$ and $2 Dy$ to estimate orientation of the topography.

During computation the cells that contain one or more default value, is not taken into account because the orientation cannot be computed. The grid is blanked for such cells.

Characterization of discontinuities

Here the discontinuities are considered as planar structures with average isotropic dimensions. This means that they can be simulated on average as discs (Fig. 3.2 a).

Matterocking compares the average geometrical characteristics of the discontinuities with DTM, thus average orientation (direction/dip), average spacing (L), average trace length (T) have to be defined (Fig. 3.2 b). T can be assumed as the average section of a disc with a plane of constant orientation.

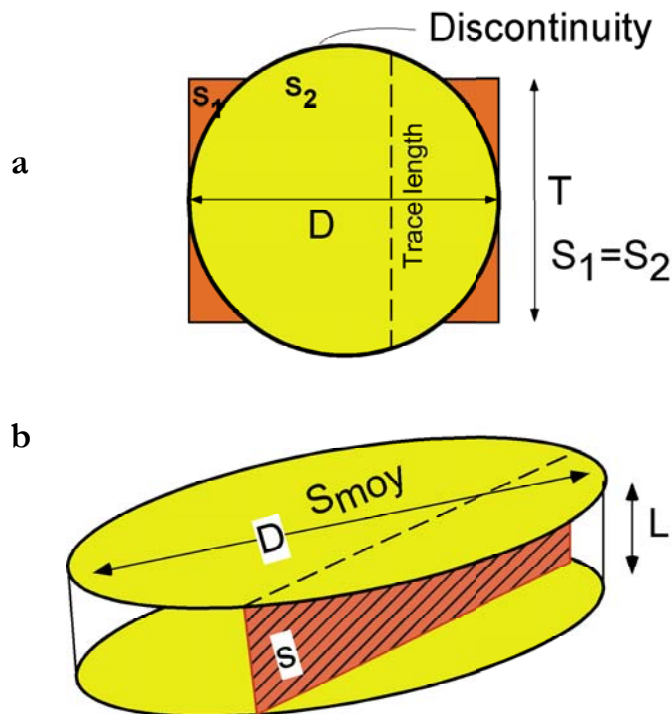


Figure 3.2 a) Illustration of the signification of the average trace length T compared to the diameter D of a disc. **b)** T is the average section of the disc. The section of a discontinuity is represented by $s = L \times T$

Computation of slope and slope aspect

Using the perpendicular of the topographic facet, the *slope aspect* (azimuth) is easily obtained, computing its direction in the plan x-y assuming that the normal to the plane rising towards the sky (and not under the topography). The values range from 0° to 360°.

The *slope* is simply the angle between the perpendicular to the plane with the vertical, it ranges from 0° to 90°.

Potential sliding zones

To create rock instability by sliding, a discontinuity set must have a dip less steep than the topographic surface. The computation is simply to calculate that the steepest slope of the discontinuity set makes with the perpendicular to the topographic facet a smaller angle than 90° (Fig. 3.3).

This test is performed for the entire grid leading to zones of potential sliding of value 1 and -1 for the not sliding points (the solution with -1 was chosen instead of no data value, because no variation occurs and thus Surfer can not contour unique value and no data value).

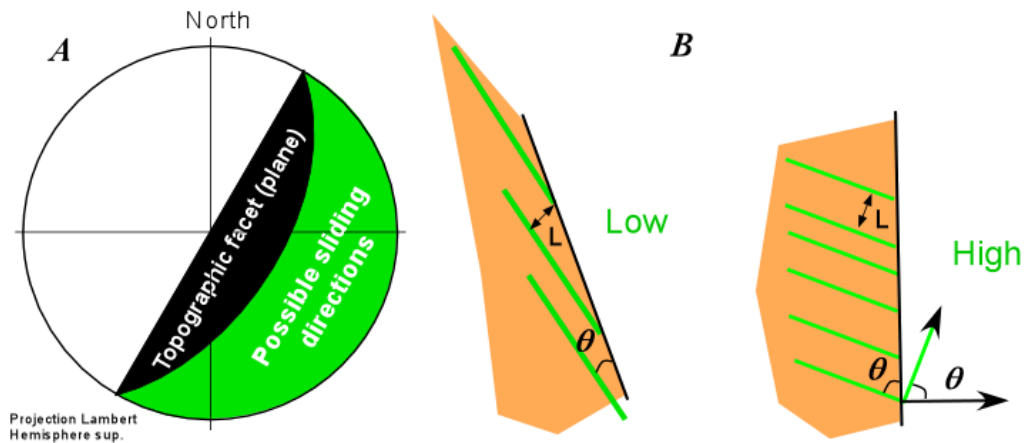


Figure 3.3 (A) Example of stereonet of the possible direction of sliding (in green), taking into account the topographic orientation (in black). (B) Illustration of the potential sliding zone in section, the apparent density depends on the angle θ between topography and discontinuity.

Average number of discontinuities counted in each topographic facet

Assuming a topographic surface S perpendicular to a discontinuity set, the average number of discontinuities counted within the surface S is $n_s = S / (L \times T)$, assuming that $(L \times T)$ is the section a discontinuity. Now if the angle between discontinuities and topographic facet is different from 90°, then the number of discontinuities is

smaller because the apparent section is greater than $(L \times T)$, the apparent spacing L_{app} increasing to $L/\sin \theta$, where θ is the angle between the perpendiculars to the discontinuity and the topographic surface (Fig. 3.4).

This calculation is independent from the direction of dipping of the discontinuity.

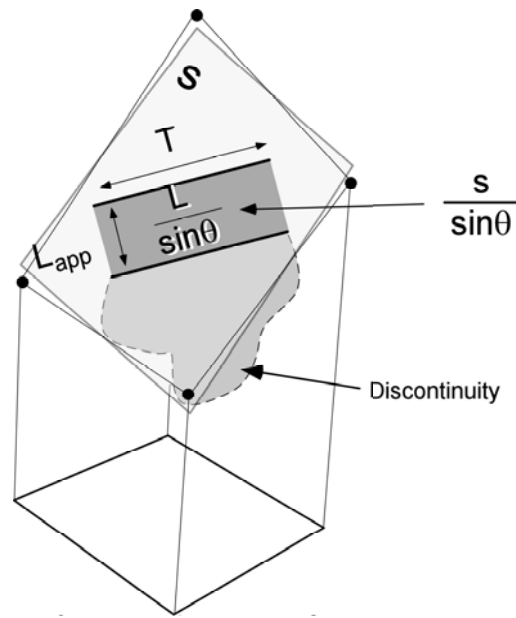


Figure 3.4 Illustration of the average section of a discontinuity cutting a topographic facet. θ is the angle the perpendicular to the discontinuity and the topographic facet (see Fig 3.3). Here the discontinuity orientation does not allow siding.

Average number of wedges counted in each topographic facet

Wedges are defined by two discontinuity sets. Assuming a continuous network of infinite discontinuities for the two sets spaced respectively by L_1 and L_2 , it draws on a surface perpendicular to the discontinuity sets a network made of parallelepipeds. The parallelepipeds are considered as the section of the wedges. The number of wedges in a surface S is given by $n_w = S / (L_1 \times L_2 / \sin \alpha)$, where α is the angle between the two sets.

This value is increased if the line of intersection of the two sets is not perpendicular to the surface of topography (Fig 3.5 and 3.6). If β is the angle between the discontinuity intersection line and the pole of the surface of topography, the number of apparent wedges is given by: $n_w^{app} = S \times \cos \beta / (L_1 \times L_2 / \sin \alpha)$.

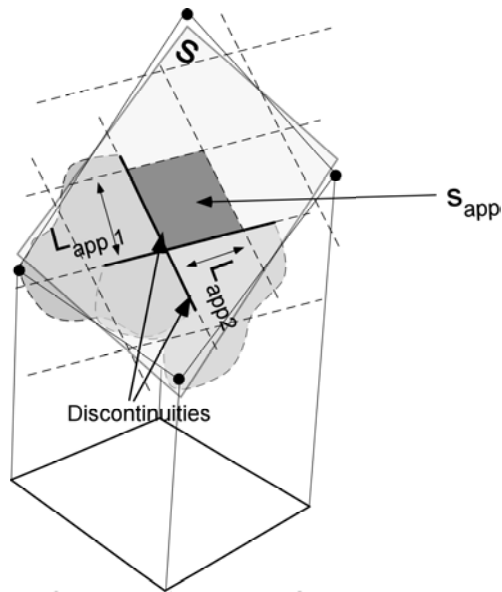


Figure 3.5 Illustration of on topographic facet of the meaning of a wedges section. Here the wedge orientation does not allow siding, S_{app} corresponds to the apparent surface of the wedge on the facet of surface s .

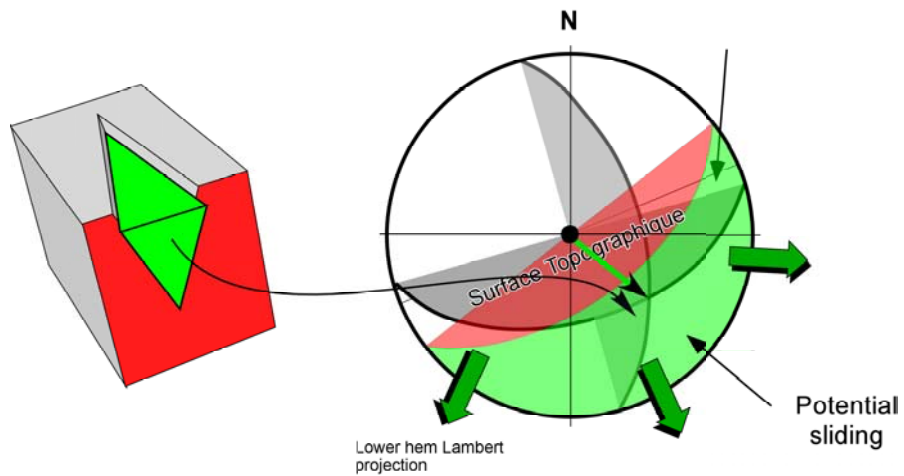


Figure 3.6 Stereonet corresponding to a wedge sliding.

Average number of sectors

The previous methods present a difference; the number of discontinuities is independent of the steepest slope of the discontinuities, thus it does not give any information about the direction of potential sliding compared to the topographic surface. On the contrary wedge is sensitive to the direction of sliding. The less wedges occur, the less probable is an instability.

The same principle can be used assuming that the greatest slope of a discontinuity set is equivalent to the direction of the wedge and $L \times T$ equivalent to the section of the wedge, leading to sectors of discontinuity potentially involved in sliding. T can be changed to a smaller value than the trace length (Fig. 3.7). T can be chosen as rock instability expected dimension. The scale is relative.

This procedure permits to obtain an image of the potential volume involved in sliding.

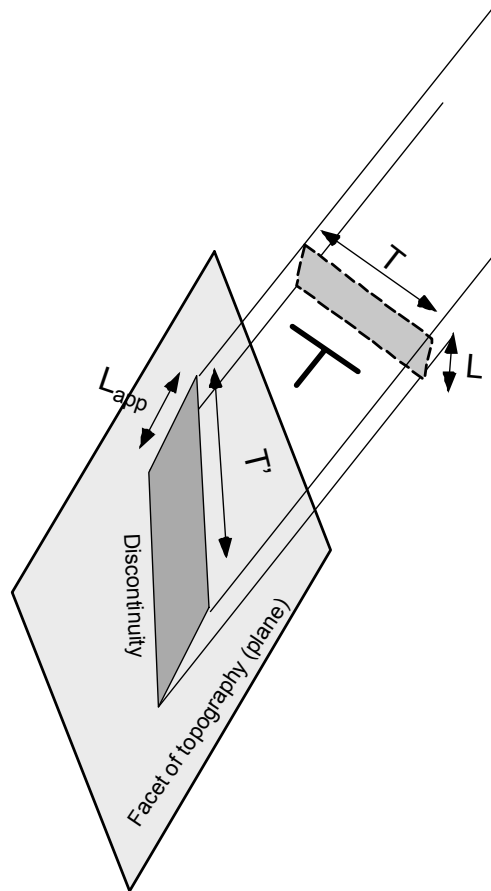


Figure 3.7 Using the section of a discontinuity perpendicular to the discontinuity greater slope, it can be a projection on the topographic facet, leading to the section of the apparent section of the discontinuity.

Number of discontinuities based on apparent spacing

The traces of discontinuity sets are parallel on a planar topographic facet. The apparent spacing is perpendicular to the two traces. The mean number of discontinuities can be calculated along this direction. On a facet of topography the

maximum length l of a line parallel to the apparent spacing can be estimated. The number of discontinuities that can be found on average is given by l/L_{app} (Fig. 3.8).

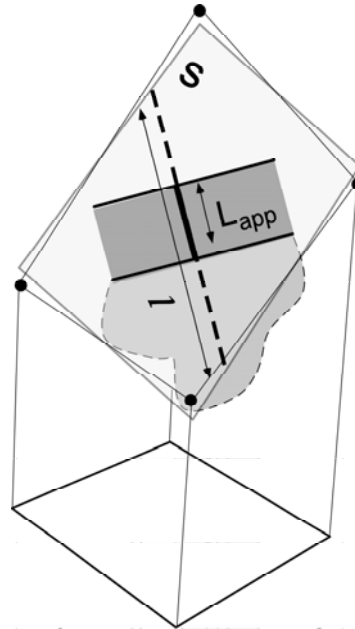


Figure 3.8 l corresponds to the longer length of facet parallel to the apparent spacing L_{app} .

Probabilities

Assuming random distribution of discontinuity position, it is possible to calculate the probability P to find at least one discontinuity within a distance or a surface. This probability is simply given by $P = 1 - e^{-N}$, where N is the mean number of discontinuities found within a distance or a surface.

This method can be applied by counting on several cells the number of discontinuity (surface). The application to each cell is not necessarily appropriate because the size of discontinuity can lead to trivial results.

It makes sense to estimate probability of finding a discontinuity within a cell using spacing.

Altitude difference.

Within a cell of the DTM, the maximum height of a slope can be computed by using the maximum difference between two extreme points of the cells. This corresponds to a rough estimate of cliff height.

Chapter

4

4. The menus

Common File menu

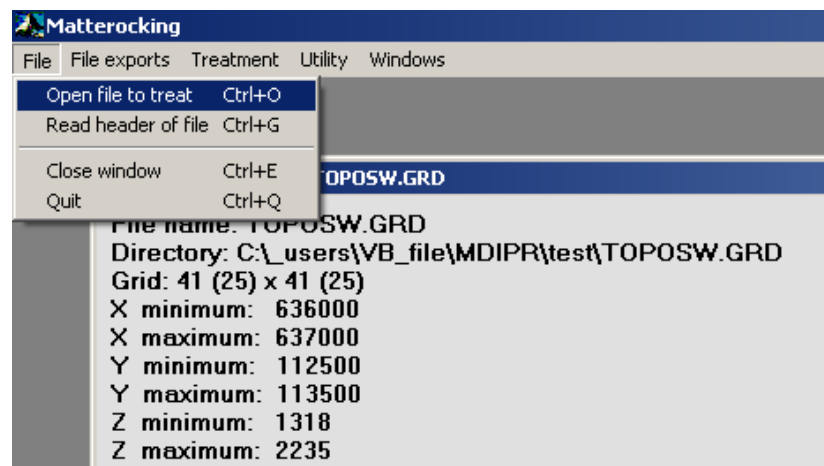


Figure 4.1 Menu file and window of file treatment.

Open file to treat opens and loads in memory a file to treat and activate the menu that allows the treatments. The windows opened display the characteristics of the file (Fig. 4.1).

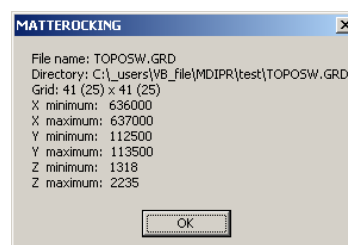


Figure 4.2 View file header window.

Read header of file permits to read only the header of file, it gives the specification of a file (Fig. 4.2). Note that for ASC, no minimum and maximum values are displayed because they do not appear in the header.

Close window closes the active window and **Quit** terminates the program **Matterocking**.

Common Utility menu

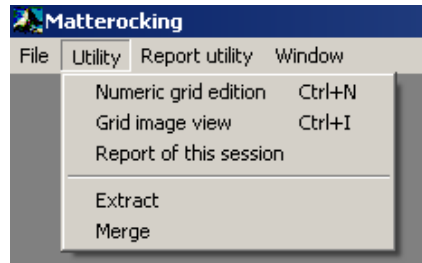


Figure 4.3 Common menu Utility.

This menu contains five different functionalities, which leads to the opening of new windows or allowing the transformation of files.

The ***Numeric grid edition grid*** menu opens a file in a grid format in a new window, containing the grid value.

The ***Grid image view*** menu opens a file and displays in a two colors gradient image within a fixed size in a new window.

The ***View actions of this session*** menu maximizes the report window.

The ***Extract*** menu opens a window that allows extracting a part of a grid file.

The ***Merge*** menu permits to merge grids that are contiguous.

File to treat window menu

The file loaded can be exported or treated several times.

File exports

The menu ***Above a threshold value*** proposes to save a new grid file that contains value above a threshold or cut off value chosen by the user and below which the grid data value is set to the current default value of the file (Fig. 4.4).

The menu ***In an another format*** gives simply the possibility to save the current file in the same or another format.

The menu ***Save as numeric grid with coordinates***, saves the current file in a file containing line and column headers that indicate coordinates.

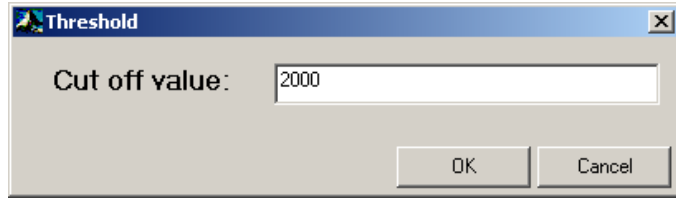


Figure 4.4 Input form for the threshold value.

Treatments default value option

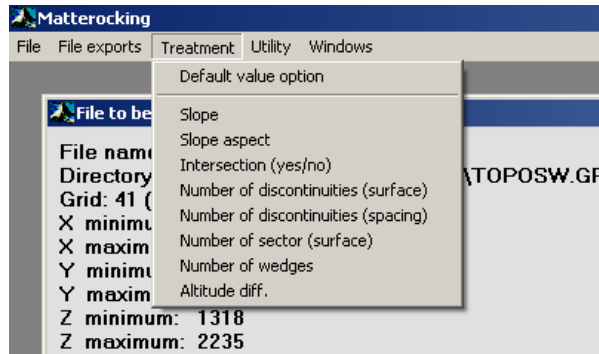


Figure 4.5 Different treatment menus.

The treatment is the heart of the software (Fig. 4.5). It permits to compare topography and discontinuities geometrical characteristics.

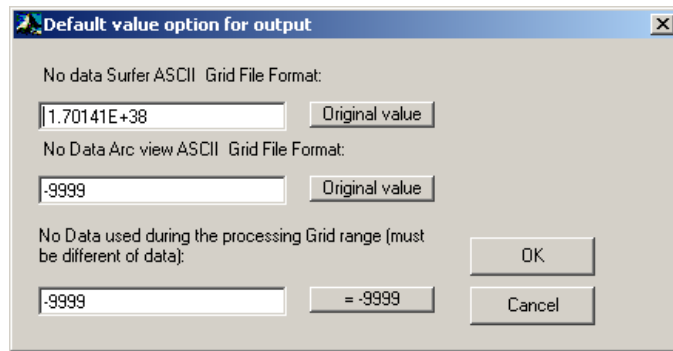


Figure 4.6 Form input for the different default values.

The *Default value option menu* set the default values i.e. no data value (see file format paragraph) of the different file format (Fig. 4.6). Changes are stored in a file *d_val.bin* in the application directory. Note that the changes are effective for all new opened files and for all next session up to the next changes. This file is automatically created if it does not exist. The original default value can be automatically introduced.

Treatments

All menus of treatments display a dialog box for saving the results. Depending on the treatment a dialog box asks for the geometrical characteristics of the discontinuity set.

The first treatment simply saves a file of *Slope* and *Slope aspect* (azimuth) calculated from the active DTM file.

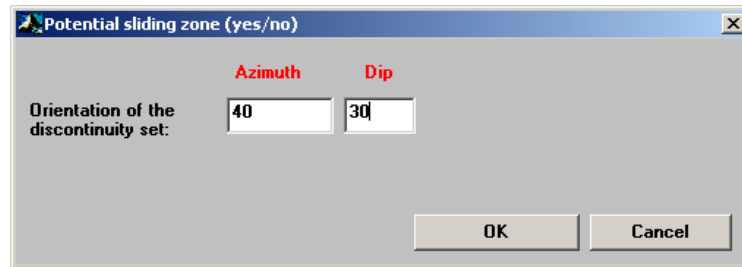


Figure 4.7 Dialog input box for the orientation value of the discontinuity set.

Potential sliding (yes/no) menu asks for an orientation of a discontinuity set. It creates a file containing the 1 and -1 corresponding respectively to the zones where the discontinuity can produce rockslides or not (Fig. 4.7).

Number of discontinuities (surface) menu creates a file that contains the average number of discontinuities per unit cells of the DTM, based on average surface of discontinuities. The azimuth, the dip, the average spacing and the trace length of the discontinuity set must be inputted (Fig. 4.8). The computation can be performed on the entire surface if the check box is checked or computed only within the surface in which potential sliding exists.

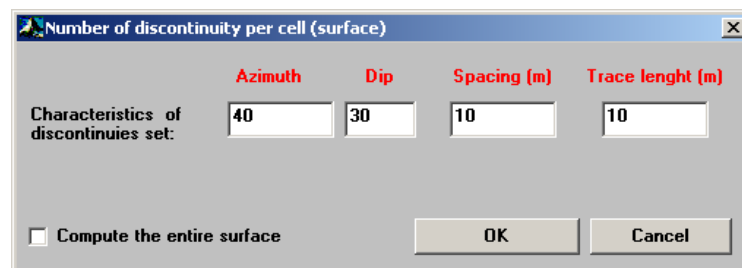


Figure 4.8 Dialog input box for the computation or number of discontinuity per unit cell based on surface count. The check box permits to compute this value on the entire surface of the DTM.

Number of discontinuities (spacing) menu creates a file that contains the average number of discontinuities per unit cell or the probability to find at least one discontinuity within the cell, this last option is set by checking the probability option. The azimuth, the dip and the trace length of the discontinuity set must be inputted (Fig. 4.9). Those values can also be computed either on the entire surface or in the potential sliding zone (default).

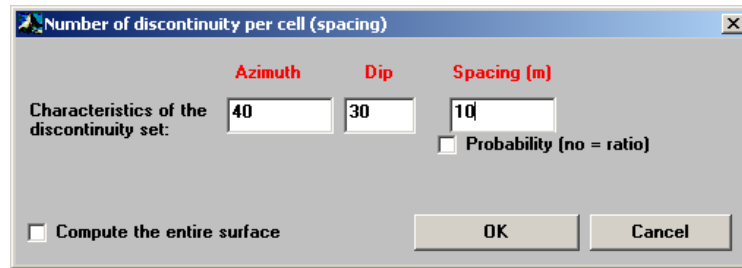


Figure 4.9 Dialog input box for the computation or number of discontinuities per unit cell based on spacing count. The check box permits to compute this value on the entire surface of the DTM, if probability is checked the probability to find at least one discontinuity per unit cells is computed, the results range from 0 to 1.

Number of sectors (surface) menu creates a file that contains the average number of discontinuity in the direction of its steepest slope per unit cells of the DTM, based on average surface of section of the discontinuity set. Inputs are identical to **Number of discontinuities (surface)** (Fig. 4.8).

Number of wedges menu creates a file that contains the average number of wedges per unit cells of the DTM. The azimuths, the dips and the trace lengths of the two discontinuity sets must be inputted (Fig. 4.10). This value can be obtained on the entire surface by checking Compute on the entire surface.

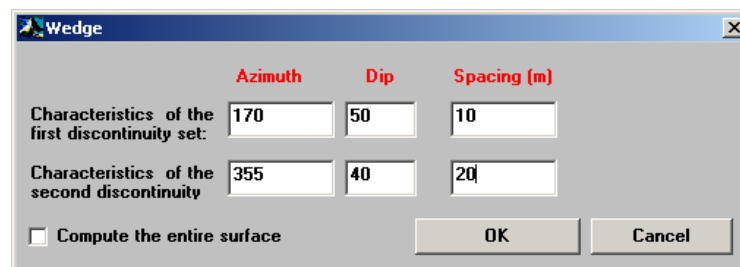


Figure 4.10 Dialog input box for the computation or number of wedges per unit cell based on surface count. The check box permits to compute this value on the entire surface of the DTM. Orientation and spacing must be specified for the two sets of discontinuities.

The menu **Altitude diff.** simply creates a file of the greatest difference of altitude within a cell, computed for the limiting points.

Alternate menu for edit numerical data window

The numerical data are displayed in a grid, which can be modified and saved. The coordinates of each grid point are displayed on upper left corner of the window. The headers of the grid correspond to the column number and the row number as it appears on a map.

The **Edit** menu permits to **Copy** (Ctrl + C) the current selection and paste it to the clipboard with tabulator separator, which is compatible with Excel.

In the menu file **Save** saves the current file with the current modifications. The menu **Save as** permits to save the current state of the file as a new file in the one of the two available formats (Fig. 4.11). As in the File to treat window the menu **Save as numeric grid with coordinates** save the current file in a file containing line and column headers that indicate coordinates.

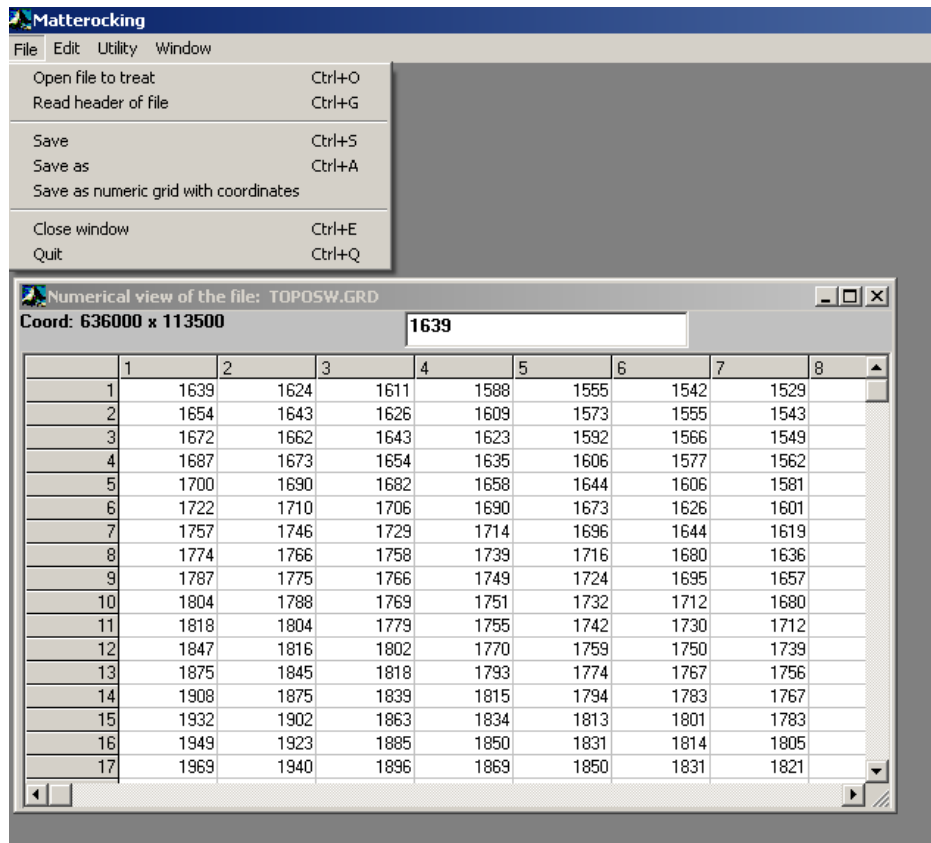
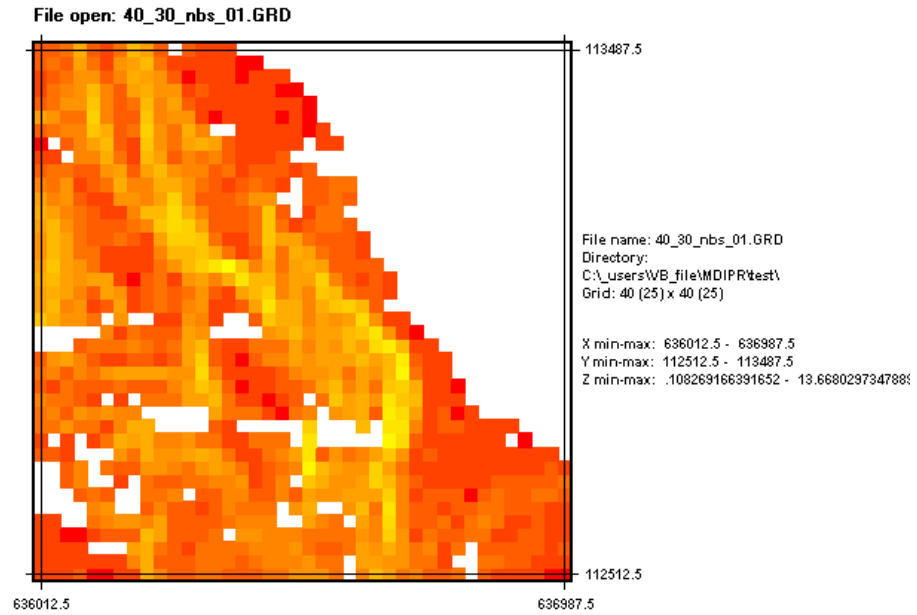


Figure 4.11 Grid file edit window. The coordinates are displayed in the upper left corner; the input box is located on the top of the numerical view. The file menu with its three options of file saving is also dropped down.

Image view of file

The display of a file as image, by **Grid image view** displays in a two colors gradient image from red to yellow. Three supplementary menus are added. First in the **File** menu a **Print low quality** menu is added, which performed a screen dump of the active window. The **Edit** menu permits to **Copy file header** and its location and performs also screen **Copy** of the image (Fig. 4.11).



Directory: C:_users\VB_file\MDIPR\test\40_30_nbs_01.GRD
 Grid: 40 (25) x 40 (25)
 X min-max: 636012.5 - 636987.5
 Y min-max: 112512.5 - 113487.5
 Z min-max: .108269166391652 - 13.6680297347889

Figure 4.11 Grid file image view copied from the Matterocking. The copy of the header is displayed below.

The extract window

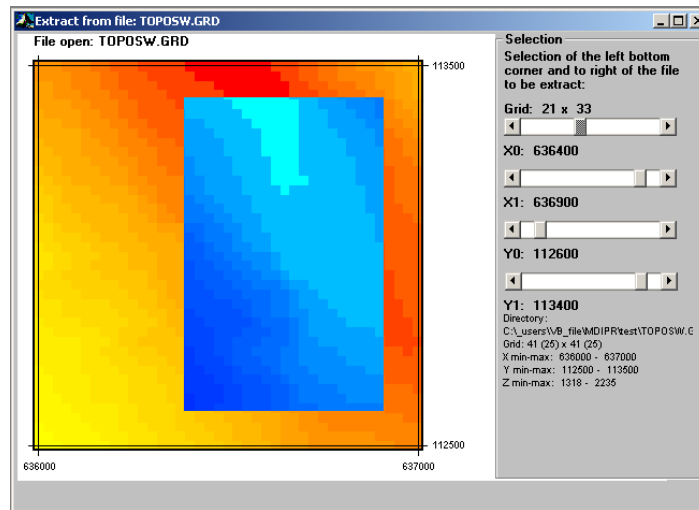


Figure 4.12 Extract form file window with the graphic display. The blue area corresponds to the selected area. The coordinates are automatically updated while moving scroll bars.

This window is similar to the image view of file with a supplementary menu **Save selection** which allows to save the selection made by a graphic utility and scrolls bars (Fig. 4.12). Before opening the window the program asks if the user wants to see data or if selection is performed without display of data (for big files).

The merge function

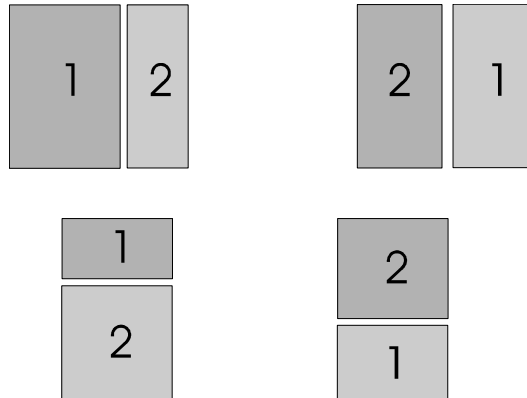


Figure 4.13 Illustration of the different possibility for merging files 1 and 2.

This menu asks for two files that have to be merged. The files have to be contiguous exactly; it means that the adjacent columns must have the same number of rows, and being distant from a D_x exactly. The same remark can be made for the contiguous rows; they must contain the same number of columns and must be distant from D_y exactly (Fig 4.13).

Report Window

The Report of the session window is always opened; it is impossible to close it (Fig. 4.14). The file menu associated with report replaces the close function with *Maximize* and *Minimize the report window*.

The *Report utility* menu gives the possibility to *Emptied* or *View the entire file report* in an independent text window to visualize and *Save* the total of the report file.

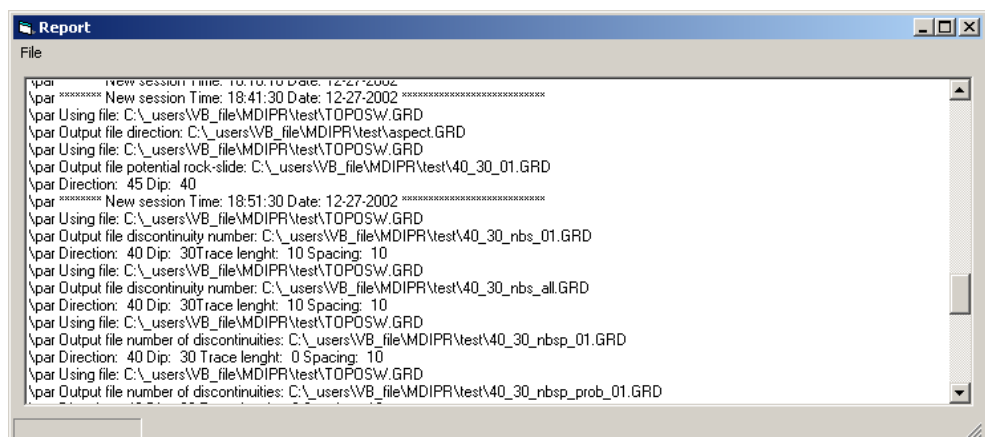


Figure 4.14 Edit window of the complete report file. The sessions are indicated and the parameters used for computation of each outputted file are also indicated.

References

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Index

- Above a threshold value, 15*
- Alternate menu for edit numerical data window, 18*
- Altitude diff., 18*
- Altitude difference, 13*
- ASC, 3, 4, 7, 14*
- Average number of discontinuities counted in each topographic facet, 9*
- Average number of sectors, 11*
- Average number of wedges counted in each topographic facet, 10*
- Cellsize, 4*
- Characterization of discontinuities, 8*
- Common File menu, 14*
- Common Utility menu, 15*
- Computation of slope and slope aspect, 9*
- Copy, 18, 19*
- Copy file header, 19*
- DSAA, 3*
- DTM, 2, 7, 8, 13, 17, 18*
- Dx, 7, 8, 21*
- Edit, 18, 19, 21*
- Emptied, 21*
- Extract, 15, 20*
- File exports, 15*
- File format, 3*
- File to treat window menu, 15*
- GRD, 3, 4, 20*
- Grid image view, 15, 19*
- How the DTM is used, 7*
- Image view of file, 19*
- In an another format, 15*
- Installation, 2*
- Matterocking, i, 2, 5, 7, 8, 15, 20*
- Merge, 15*
- Minimize the report window, 21*
- Ncols, 4*
- NODATA_value, 4*
- Nrows, 4*
- Number of discontinuities (spacing), 17*
- Number of discontinuities (surface), 17, 18*
- Number of discontinuities based on apparent spacing, 12*
- Number of sectors (surface), 18*
- Numeric grid edition grid, 15*
- Nx, 3, 4*
- Ny, 3, 4*
- Potential sliding (yes/no), 17*
- Potential sliding zones, 9*
- Probabilities, 13*
- Read header of file, 14*
- Report utility, 21*
- Report Window, 21*
- Save as numeric grid with coordinates, 15, 19*
- Save as numeric grid with coordinates Print low quality, 15, 19*
- Save selection, 20*
- slope, 2, 9, 11, 12, 13, 18*
- slope aspect, 9*
- The ASC files, 4*
- The extract window, 20*
- The GRD files, 3*
- Treatments, 16, 17*
- Treatments default value option, 16*
- View actions of this session, 15*
- View the entire file report, 21*
- Xllcorner, 4*
- Xmax, 3*
- Xmin, 3, 4*
- Ymax, 3*
- Ymin, 3, 4*
- Zmax, 3*

