QUANTERRA

INTERNATIONAL INDEPENDENT CENTER OF CLIMATE CHANGE IMPACT ON NATURAL RISK

ANALYSIS IN MOUNTAINOUS AREA

User's Guide

CONEFALL

Designed for Windows 98

Version 1.0

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CONEFALL 1.0

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Home

Table of Contents

Chapter

1

1. Introduction

The program CONEFALL is designed to estimate roughly the potential rock falls prone area.

T heory will not be developed in detail here, it can be found in many different articles (Evans and Hungr, 1993, Toppe, 1984). The basics are described in an article: *CONEFALL: CONEFALL: a program for the quick preliminary estimation of the rock-fall potential of propagation zones* (Jaboyedoff and Labiouse, submitted).

The principle of the program is rather simple. A block can propagate if the slope is sufficiently steep. Physically consider that if the slope is steeper than a limit φ_p, then the block accelerates. If it is lower, it decelerates. Using the previous assumption, a block can propagate from its source to the point of intersection of the topography with line starting from the source point making an angle φ_p with horizontal. The space where a block can propagate from a grid point is located within a cone of slope φ_p with a summit placed at the source point (Fig. 1.1). This procedure is applied to all source points.

The source points can either be considered as the entire cliffs, the border of the cliff or its bottom. Using simple consideration it can be shown that the mean velocity of blocks is given a function of the difference in altitude Δh between the cone and the topography. Δh is proportional to the kinetic energy that may be acquired by the block during the fall.

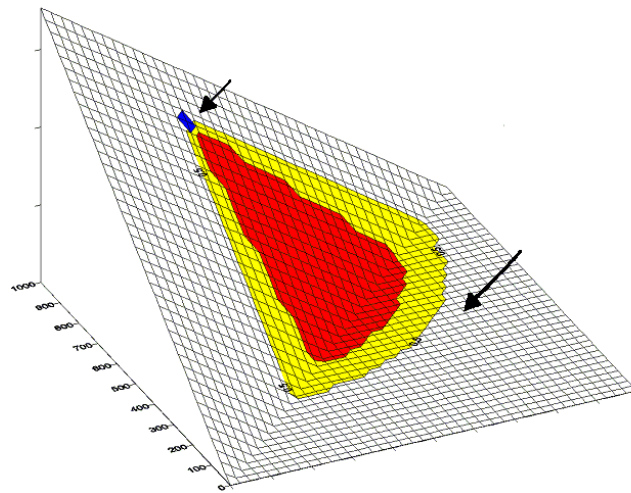Note that CONEFALL can be used to roughly define the potential propagation zone for a landslide.

Figure 1.1 *Illustration of the potential propagation area of the blue pixel, using a cone slope of 35° and 40°.*

Installation

The program can be found at the address www.quanterra.org. Compilation was performed under Windows 98, to obtain a multi-platform compatibility.

The installation is done by clicking the install program, the Microsoft system files needed for running Visual Basic 6.0 applications are updated or not, and the requested DLL and OCX are added.

File format

The used input and output files are grid text files. Two file formats are proposed:

> ➢ The standard grid file ASCII file format of Surfer 6.0 (*.GRD), which can be rectangular.

> ➢ The ArcView 3.x import grid ASCII grid format (*.ASC), which accepts only squared grid.

The standard default values are recognized for the DTM file and for the format Arcview it can be set by no data value. **Note that the –1 value is considered as no data value.** The separator for the grid files can be either ";" or tabulators or spaces.

Two examples of grid files are given with the install program: a DTM.GRD and source file associated SOURCE.GRD.

The GRD files

The ASCII Surfer grid file format is defined as follows:

```
DSAA
Nx     Ny
Xmin   Xmax
Ymin   Ymax
Zmin   Zmax
Value(1,1)  Value(1,2)   …
Value(2,1)  Value(2,2)   …
…           …            …
```

The first five lines are necessarily on 5 lines. DSAA is the header of surfer ASCII file format. Nx is the number of columns, and Ny the number of lines. Xmin Xmax, Ymin Ymax, Zmin Zmax are the minimum and maximum X ,Y and Z limits. The following lines can contain Nx × Ny data values. Remember that for Surfer files the order of the rows of the file is inversed compared to the screen display.

The ASC files

The ASCII ArcView grid file format is defined as follows:

```
ncols          Nx
nrows          Ny
xllcorner      Xmin - Delta/2
yllcorner      Ymin - Delta/2
cellsize       Delta
NODATA_value   Dodat
Value(Nx,1)       Value(Nx,2)        …
Value(Nx-1,1)     Value(Nx-1,2)      …
…             …                 …
```

The ASCII ArcView grid is a squared grid. The headers are arranged in lines (this is mandatory) and indicate the grid characteristics. *ncols* (Nx) and *nrows* (Ny) are the number of columns and rows of the grid. *xllcorner* and *yllcorner* are the coordinates of the left bottom corner and *cellsize* (Delta) is the cell size.

The lower corner of the ASC files uses a point as a pixel and the GRD files use point as mesh. As a consequence the ASC lower corner is shifted by a half-cell size down and left. The no data value NODATA_value is optional (Nodat), but is set automatically to –1 by CONEFALL.

Project file

The program CONEFALL is based on DTM grid file and source grid file pixel area. The results are stored also in a grid file. Because several options are available, project file *.PRC are used to trace the options chosen to generate the output file, and the DTM and source file used.

The project file contains a command line, the three grid file names and options describing the method used (0-3) and the result type (average or mean values), the

cone characteristics and values: slope angle, aperture angle of the cone, the block mass, the speed factor.

The separator used between command and the option value is a tabulator. An example is given below:

```
Comment:                Crétaux case study - EPFL - LMR
DTM_filename:           C:\Directory_file\DTM.GRD
Source_point_file_name: C:\Directory_file\SOURCE_POINT.GRD
Output_file:            C:\Directory_file\PROPAGATION.GRD
Method:                 3
Angle_option:           0
Use_all_values:         1
Cone_angle:             35.0
Mean_bloc_mass:         3200.0
Speed_factor:           0.9
Value_method:           1
```

A project can be directly created in a text editor using the appropriate headers.

Windows

CONEFALL displays a main window, which contains all the specification of a project. A window can be used to display graphically grid files. An option permitting to erase points graphically in grid file is identical to the previous one but a save menu is added.

2. Basics

The program CONEFALL theory is simply presented, the details can be found in Evans and Hungr (1993) and in Jaboyedoff and Labiouse (submitted.).

The principle of the cone method is to define a maximum run-out distance for block propagation using the source point. The angle with horizontal of the line joining the stop point and the source point does not exceed a limiting angle φ_p ranging from 27-38°, depending on the way of defining source points.
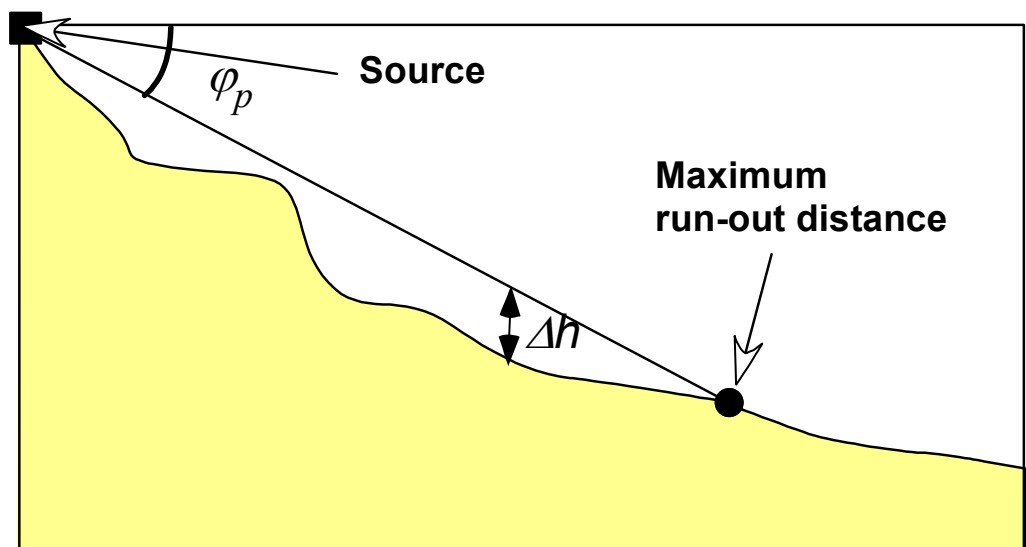

Figure 2.1 : *Relationship between φ_p and the maximum run-out distance.*

The previous assumption leads in 3D to a potential propagation zone corresponding to a cone for a single source pixel. Several pixels will lead to a surface corresponding to the envelope of the cones (maximum value of all cones at one point of the propagation zone) of all contributing source points or the mean value of their altitude. Using this surface and the topographic altitude estimations of kinetic energies or of velocities can be estimated. If the slope axis is well defined

the cone can be limited on both sides, because the block cannot propagate laterally beyond a certain angle with the steepest slope.

It can be shown that at one point (x) of the propagation zone, the difference in altitude between the cone and the topographic surface Δh is proportional to the kinetic energy or the velocity v squared (Fig. 3.1):

$$\Delta h = \frac{v^2(x)}{2g} \qquad (2.1)$$

Where g is the gravity acceleration. Assuming a mass m_a a ratio between rotational energy and total kinetic energy, translation velocities v_{trans} can be estimated. Putting $f_v^2 = (E_{trans}lation/E_{kinetic\ tot})$ using 2.1 leads to:

$$v_{trans}(x) = f_v\sqrt{2g\Delta h} \quad (2.2)$$

3. Options and Menus

The option of a CONEFALL' project is completely set within the main windows. Functionalities are available from menus.

Opening, creating and closing projects

The project text file (*.PRC) that contains all the options can be saved and loaded using the file menu or the tool bar.
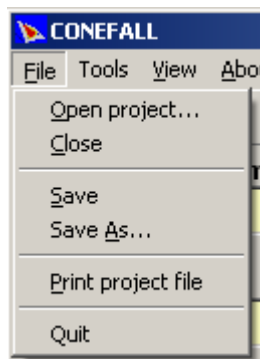

Figure 3.1: *File menu.*

The *File* menu permits to **Open a project**, to blank the options and file fields using Close (Fig. 3.1). **Save** menu saves the current project and **Save As** saves the current project under another file name.

Print project file simply prints the current project file.

To create a project, all options and file names must be set. A line of comments following the header "Comment:" can be entered in the project but it is not mandatory.
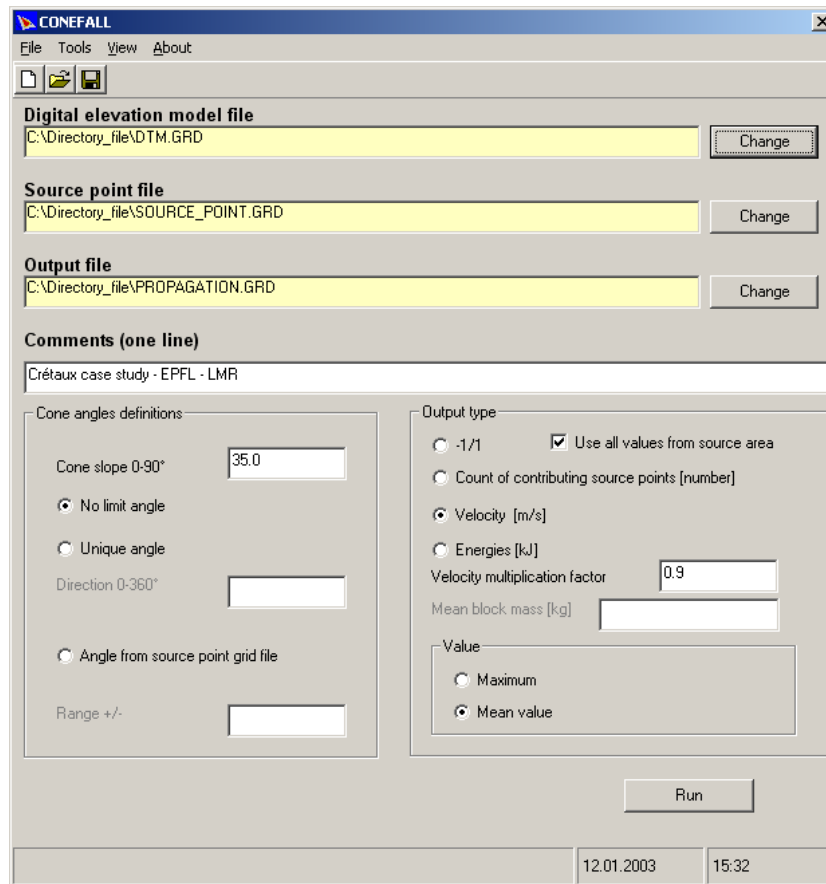
Figure 3.2: *Main widow of CONEFALL.*

Files

Using the three **Change** buttons the Digital elevation model file, the source points file and the output file are set. The DTM file must contain altitude that must be positive (Fig. 3.2).

In the present version of CONEFALL the source point and the DTM files must have exactly the limits and number of points.

Output file is either an integer or a float values grid file depending on the type of treatment. The no data value is equal to –1.

In the project file the three file headers are:

```
DTM_filename:
Source_point_file_name:
Output_file:
```

The source points file

The source points define the points generating rock-fall; they can be set at 1. The points that are not sources must be set to the value –1. But a preferential direction of falling can be set, then the source points are coded by an integer being 0° and < 360°. This option is useful only if lateral limits are for the cone (Fig. 3.3).

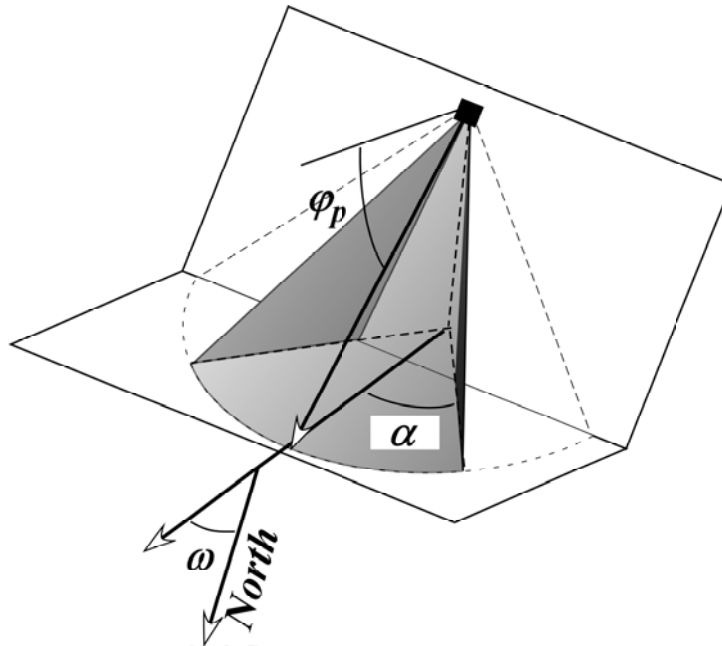**Figure 3.3 :** *definition of the cone slope angle φ_p, the cone direction ω and of the cone and the range $\pm\alpha$ of aperture.*

The Tools menu
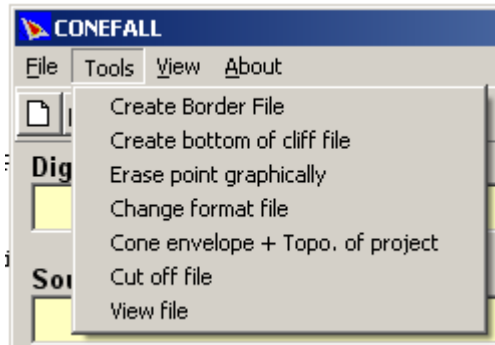
Figure 3.4: *Tools menu.*

This menu permits to modify source files, visualized grid file, visualize surface of cone and extract file above a threshold (Fig. 3.4).

The **Create border file** menu transform a source grid file in a file that contains only the border of the sources zones (Fig. 3.6).

Create bottom of cliff file allows to search the border of the source areas located at the bottom of those zones. The sequence first asks to open the DTM file and second the corresponding source file. The program proceeds and asks a file name to save the results. The complicated geometry of sources area creates artifacts. In this case it is necessary to manually correct the results (Figs. 3.5 and 3.6). This can be done using **Erase point graphically**, which graphically edit the pixels of a source file in a new window, using the mouse the incorrect pixels can be deleted. Once erasing of the erroneous points is finished, the file can be saved. Note that grid files containing values ranging from 0-360 in addition to default value and –1, are accepted by this function and 0-360 values are values are preserved by this
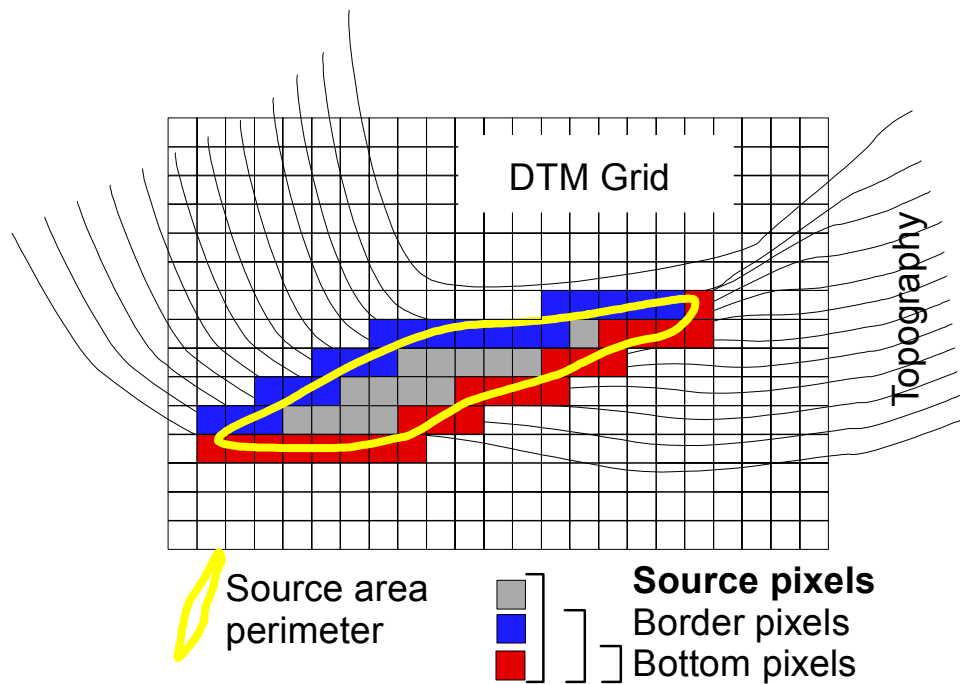
operation.

Figure 3.5: *Illustration of the different types of pixels.*

The **Change format file** gives the possibility to switch from *.GRD and *.ASC and conversely, the no data value is replaced by –1.

The **Cone envelope + Topo. of project** allows to export the current project topography with the cone envelope that replaces the topography within the potential propagation zones. This can be useful to visualize the potential debris fan.

Cut off file saves a file replacing the values the value below a threshold value.

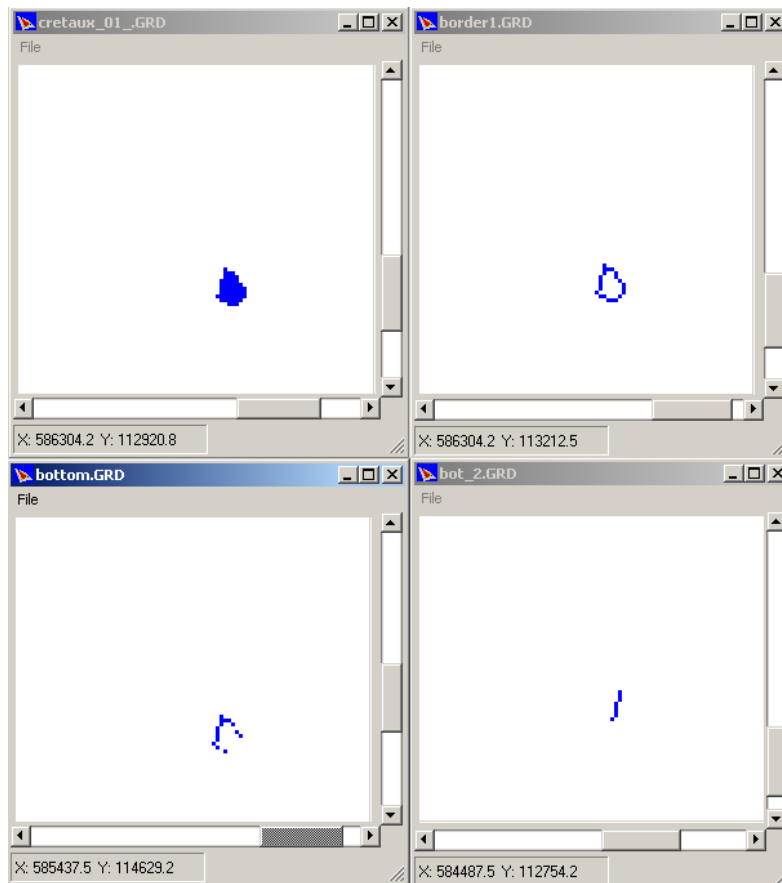The **View file** menu leads open a window displaying a file in a bi-color gradient.

Figure 3.6: *Graphic Window for erasing points displaying in blue (upper left) complete source area, (upper right) file obtained after* **Create border file,** *(lower left) after* **Create bottom of cliff file** *function and in lower right window the result after manual erasing.*

Cone angles definitions

This box contains the geometrical specifications of the cone used to estimate the area of propagation (Fig. 3.2). First the **Cone slope 0-90°** φ_p must be set usually within the range 27° - 37° .

Normally no direction of propagation is used, in this case **No limit angle** is checked. In particular case the propagation has to be limited laterally. Then *Direction 0-360°* (azimuth) ω and the **Aperture range** $\pm\alpha$ of the propagation are set (Fig 3.3).

If the ω is unique for the entire source point grid file, **Unique angle** must be checked. If ω is dependent on the location, **Angle from source point grid file** must be checked, and the source point file must contain the ω for each source point. Note that $\pm\alpha$ must be set in both case and it is unique for the all file. α limits laterally using a direction and a tolerance ($\pm$ a range).

In the project file the headers are for φ_p, ω and α respectively: "`Cone_angle:`", "`Range_direction:`" and "`Direction_angle:`". The options are indicated

by `Angle_option:"`. For **No limit the angle** is set to 0, 1 for **Unique angle** and 2 for **Angle from source point grid file**.

Output type

The outputs are either simply the propagation zone or estimates of average or maximum values of velocities or energies. Depending on the choice of the mean block rock mass m_b or velocity factor f_v must be set.

In order to increase the speed of computation only the border of the source file area are used (Figs. 3.5 and 3.6). But when looking at average value it is better to use the **Use all values from source area** checked, in order to obtain the potential contribution of all pixel sources.

The option **–1/1** permits to simply obtain a grid of the potential propagation area. The output grid file contains two values 1 for the propagation area and –1 for the void zones.

The **Count of contributing source points [number] permits** to obtain a rough image of the rock-fall transit density. In this case is better to use the **Use all values from source area** checked.

The **Velocity [m/s]** option is based on the estimation of formula 2.1 and 2.2, the Velocity multiplication factor f_v must be set to 1, if total kinetic energy is estimated or lower if empirical corrections are used. For the translation velocity estimation f_v =0.9 is suitable.

Energies [kJ] leads to the estimate of kinetic energy **E** taking into account f_v and the **Mean block mass [kg]** (m_a) using $E = m_a f_v^2 2g\Delta h$.

If **Value option** permits to chose if the results are **Maximum** or **Mean values**.

The file headers of the project file are "`Mean_bloc_mass:`" for m_a value, and "`Speed_factor:`" for f_v. "`Value_method:`" is used to specify the option of results 0 for **maximum** and 1 for **mean value** and "`Use_all_values:`" is the header is set to 0 or 1 indicating to use only the bordering pixels or all the source for the computation respectively. The method is indicated by "`Method:`" using 0 for **–1/1** option, 1 for **Count…,** 2 for **Velocity** and 3 for **Energy**.

Synthetic example

Using a synthetic topography defined by a half sphere, some of the options of the program are demonstrated. At a certain altitude a discontinuous fictive cliffs are defined. They contain directions of propagation with a range of 20°. Most of the orientations are set near the steep slope of topography, some, as the results display are different. The computation was performed using the counting option. The file project contains the following lines:

```
Method:              1
Angle_option:        2
Use_all_values:      1
Cone_angle:          33.0
Range_direction:     20.0
```
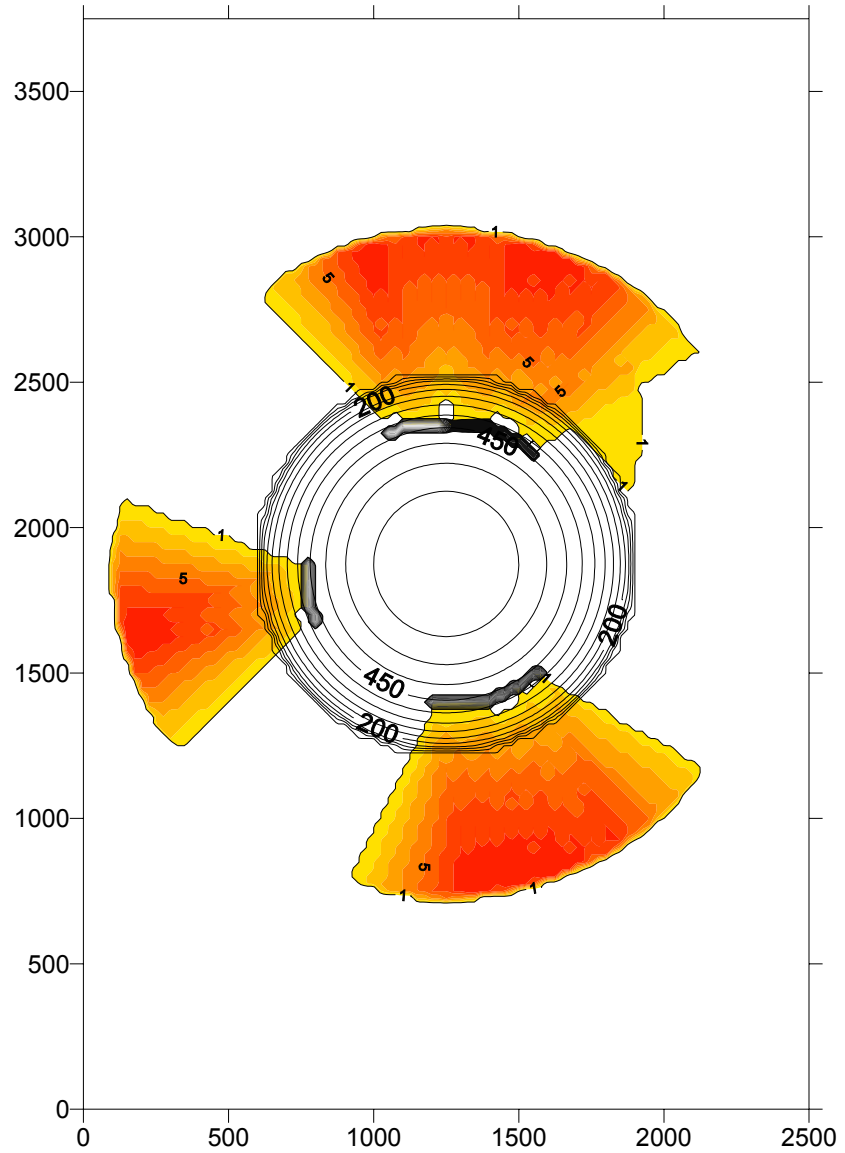

Figure 3.7 : *Example displayed in Surfer program. In grayed the source pixel with black =0° and white for 360° (note that the contouring introduce artifacts). The contours indicate the number of contribution cones (yellow-red gradient).*

References

Evans, S., Hungr, O., 1993. The assessment of rockfall hazard at the base of talus slopes. Canadian Geotechnical Journal, 30, 620-636.

Jaboyedoff, M. and Labiouse, V. submitted. CONEFALL: a program for the quick preliminary estimation of the rock-fall potential of propagation zones. Computer & Geosciences.

Toppe, R. 1987. Terrain models: a tool for natural hazard mapping. In: Avalanche formation, movement and effects. Edited by B. Salm &H. Gubler. International Association of Hydrological Sciences. Wallingford, UK. Publication 162, pp. 629-638.

Index