

# Skew Estimation Tutorial

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## 1. Introduction

The main goal of this tutorial is to give a basic description of the SARscape velocity Skew Estimation tool to obtain risk classification maps.

This tool computed the velocity risk map of files generated by PS or SBAS processes in raster, vectorial or geodatabase formats. The input must be vertical decomposed. It is intended to detect areas where an important velocity differential is present which may indicate future collapses.

To achieve this purpose an indicator named "β" is retrieved with the following formula:

$$\beta = \frac{\Delta d_{vi}}{l}$$

With:

$\Delta d_{vi}$  = the differential settlement [mm]

$l$  = the moving window radius [m]

This value β is then used to classify the points based on the following values:

$$\text{Class 1 (Low risk)} = \beta < \frac{1}{3000}$$

$$\text{Class 2 (medium risk)} = \frac{1}{3000} < \beta < \frac{1}{1500}$$

$$\text{Class 3 (Hish risk)} = \frac{1}{1500} < \beta < \frac{1}{500}$$

$$\text{Class 4 (Very High risk)} = \frac{1}{500} < \beta$$

As it is easy to see the value of β highly depends on the size of the moving window, Increasing the radius not only has an impact on computing time and memory usage but also risks smoothing the result too much losing precision. Conversely, choosing a window too small introduces a lot of noise.

Generally speaking choosing a bigger size will result in more low risk points while decreasing it will result in more high and very high risk ones.

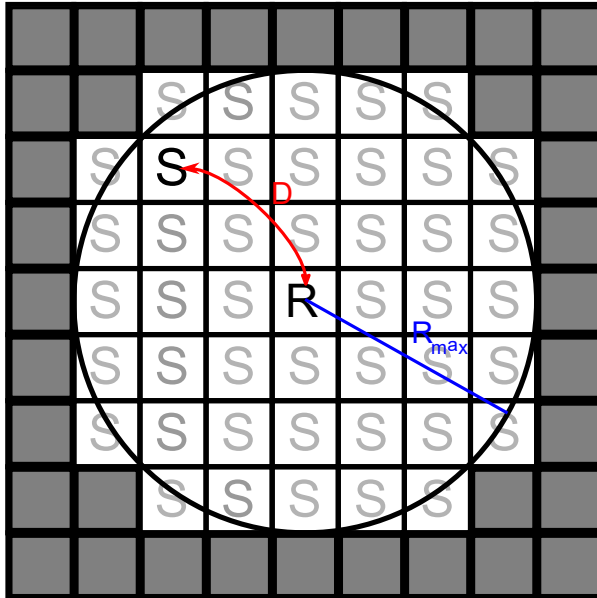


Figure 1 The length of the moving window radius must be selected based on the resolution of the image and the sparsity of the points.

## 2. Training Data sets description

The exercise on this tutorial will be based on a single PS dataset in vectorial format on the Cadia Hill Gold Mine located in New South Wales, Australia.

This scene is particularly indicated because we know where and when a collapse occurred, furthermore close points present a very high mean velocity difference. Hence, it is far easier to obtain a meaningful result that will illustrate all the different classes of risk.

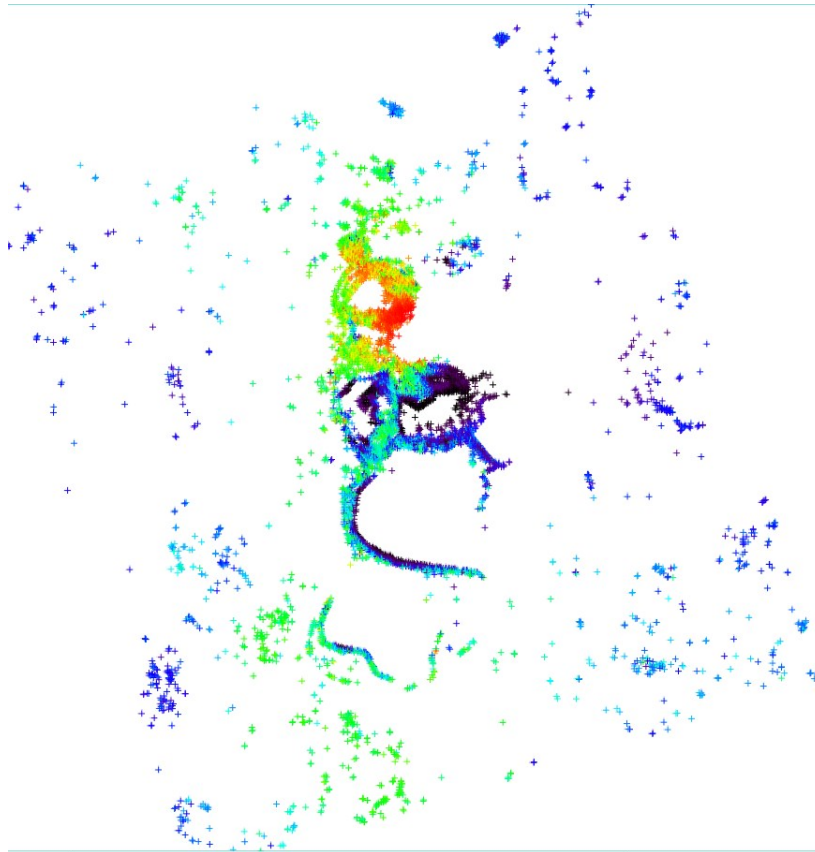


Figure 2 PS mean velocities in vector format

This results were generated using 80 images from 2015/03/01 to 2018/02/25 and the data is geocoded and decomposed (vertical).

### 3. Skew Estimation

The example of this section of the tutorial will be performed with vectorial, the raster and geodatabase version is left as exercise to the student.

The scope of this section is to analyse and understand how to read the Skew Estimation resulting data in addition to explore its limitations. To open the Skew Estimation panel go to *Interferometric Stacking/Post Processing Tools/Skew Estimation*.

#### **Input File List**

Select the *Cadia\_45D\_PS\_75\_0.shp* file (in general, more than one shp file can be selected but they will all be merged in a single one in the output). In case the input is a raster file then the file without extension has to be selected. If instead the input file is a geodatabase the ".gdb" file should be selected from the ".gdb" folder

## Principal Parameters

### *Gradient radius (m)*

The radius of the moving window used to compute the gradient, a bigger window will result in a general lowering of classes while a smaller one will introduce more noise and show more high risk classes.

### *Gradient class low threshold*

The threshold for the Low risk class, default  $0.00033 = \frac{1}{3000}$

### *Gradient class medium threshold*

The threshold for the Medium risk class, default  $0.00066 = \frac{1}{1500}$

### *Gradient class high threshold*

The threshold for the High risk class, default  $0.002 = \frac{1}{500}$

### *Shape x field name*

The name of the shape field containing the x values.

### *Shape y field name*

The name of the shape field containing the y values.

### *Shape z field name*

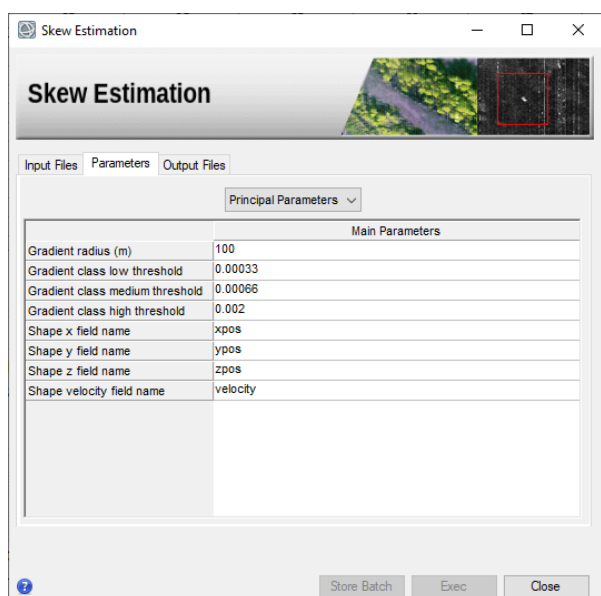
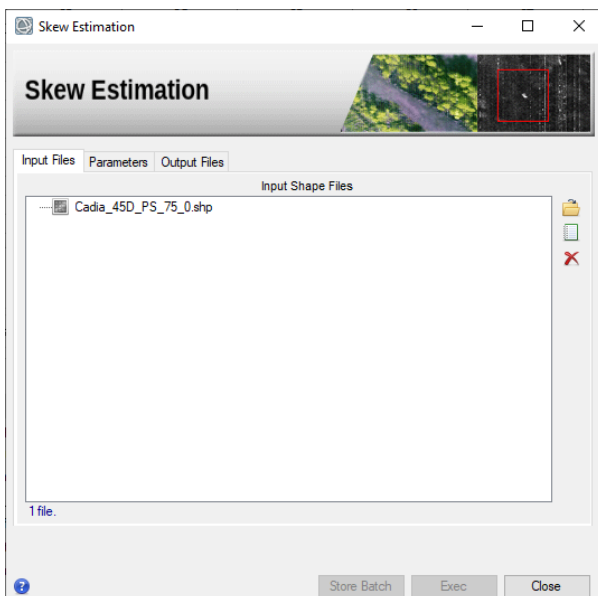
The name of the shape field containing the z values.

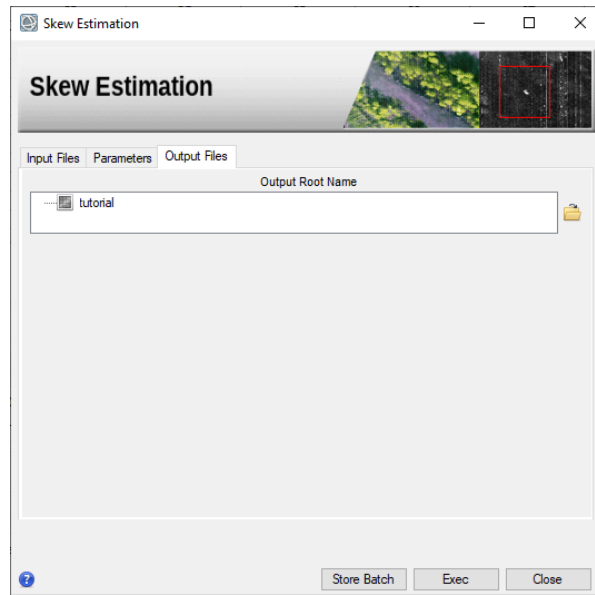
### *Shape velocity field name*

The name of the shape field containing the mean velocity values.

## Output Root Name

*Name that the output file will have*





## 4. Results

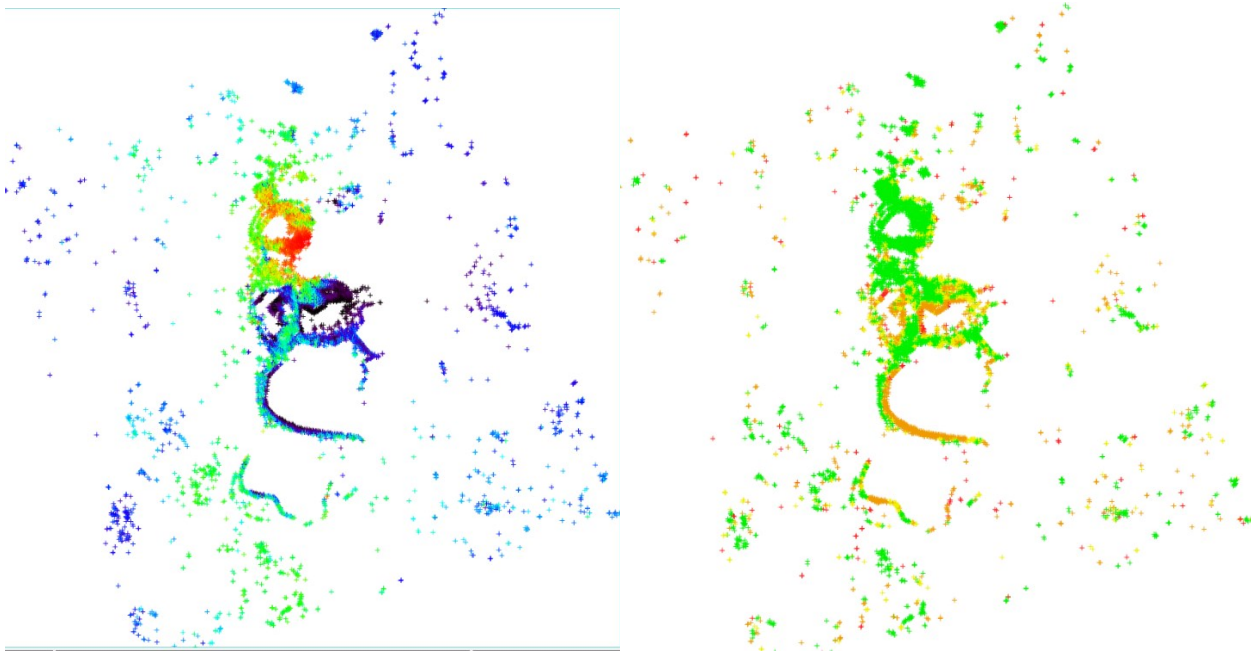


Figure 3 Comparison of the original data and the result, colored by class with window size of 100m

From this result we can clearly see that the vast majority of High and Very High risk classes are concentrated in correspondence with sudden changes of velocity in a small distance.

It is also interesting to notice how gradual or single point changes are smoothed out using this window size, this is particularly noticeable in the upper part of the image.

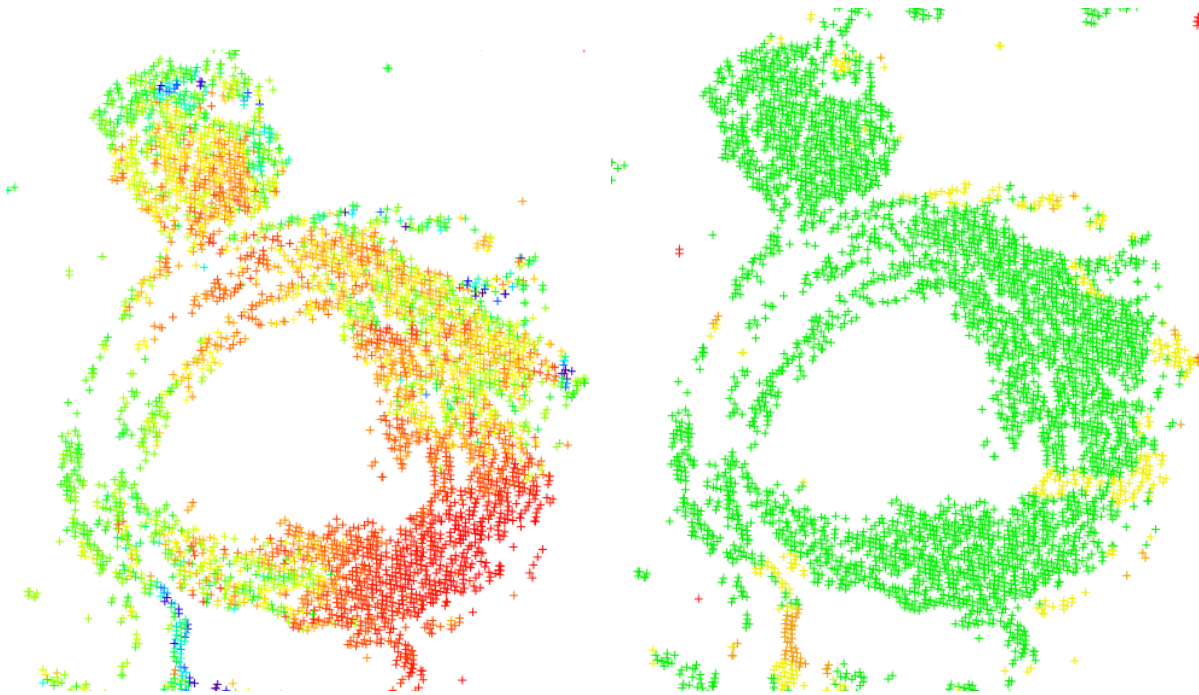
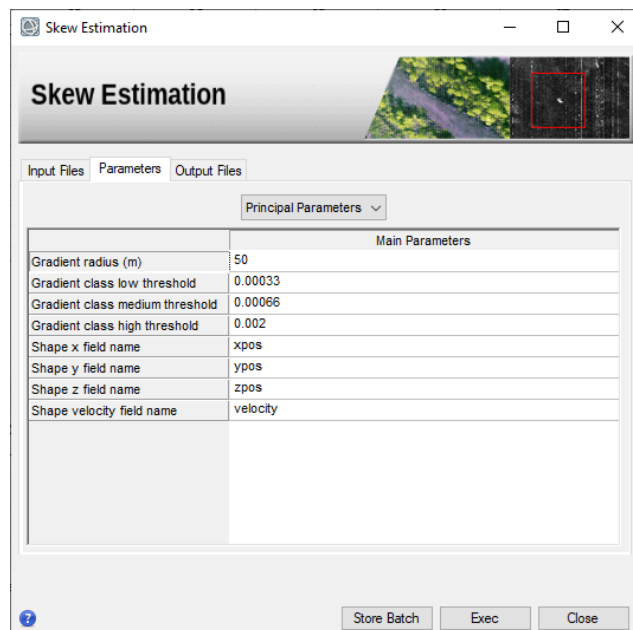


Figure 4 particular of the upper side of Cadia Mine

As a comparison we can see the difference with the same processing done using a window size of 50m





With this smaller window it is clearly visible how now there are more classes of higher risk, it is also interesting to note how now gradual of single point changes are detected much better.

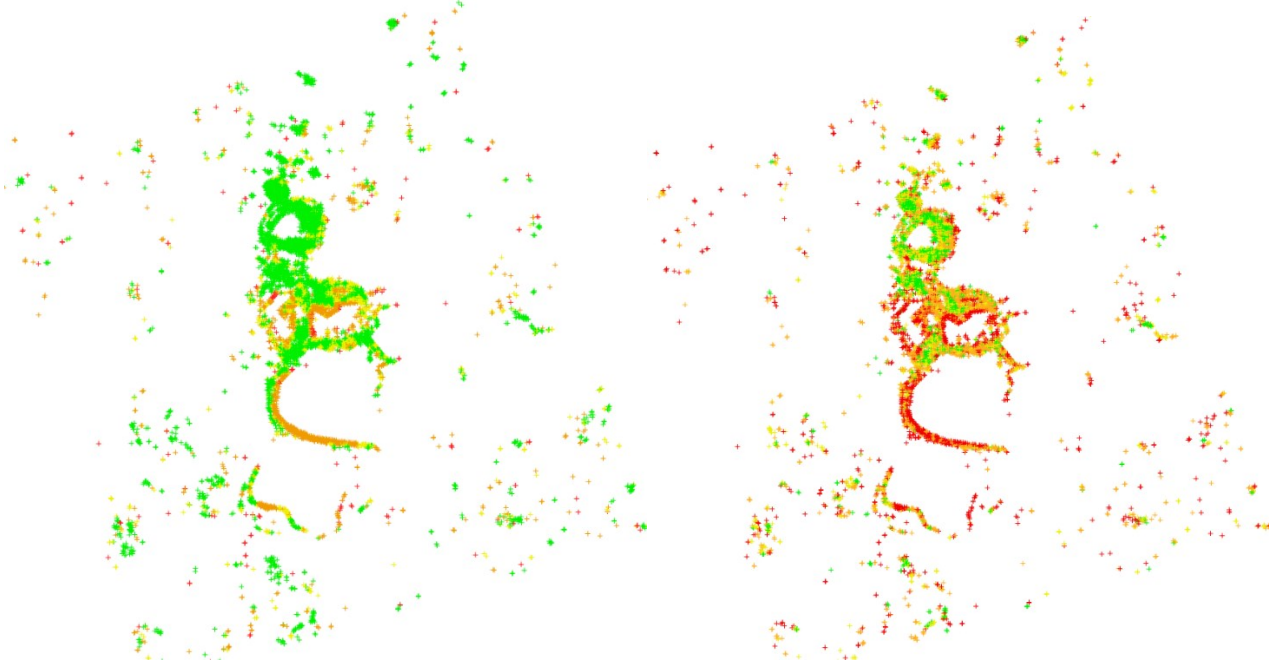


Figure 5 Comparison between the classes at 100m and 50m window radius results

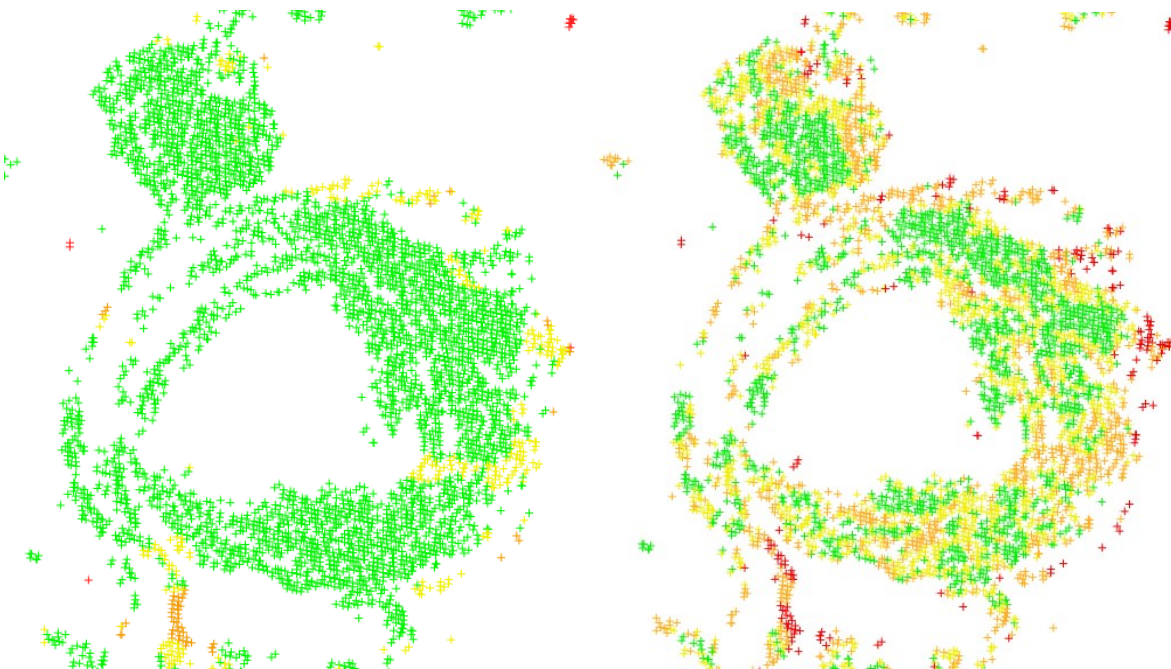


Figure 6 Comparison between 100m and 50m window radius on the upper part of the image

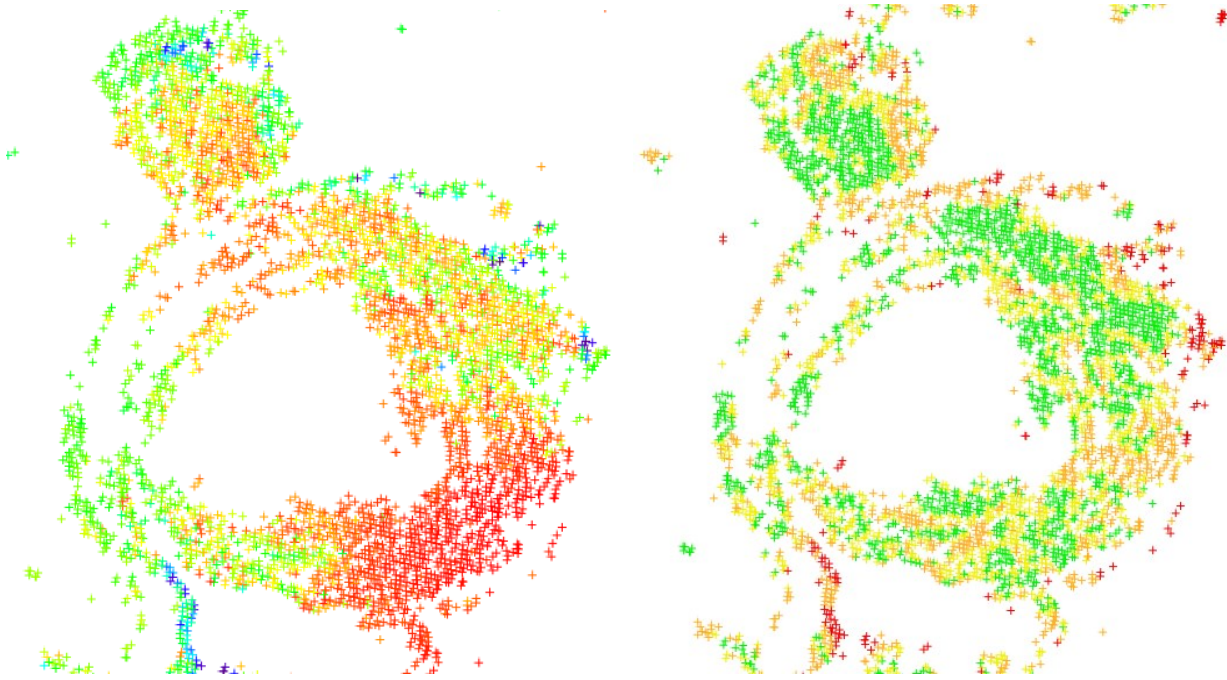


Figure 7 Comparison between the original image and the 50m window size in the upper part

## 5. Interpreting the Results

As we said before the classes indicate the risk of collapse, to understand in which direction this collapse is most likely to occur we can check the "angle\_degr" field in the output.

To better understand how this fields can be interpreted let's focus now on the lower side of the image, where we know a collapse occurred on 2018/03/09 (outside our images interval).

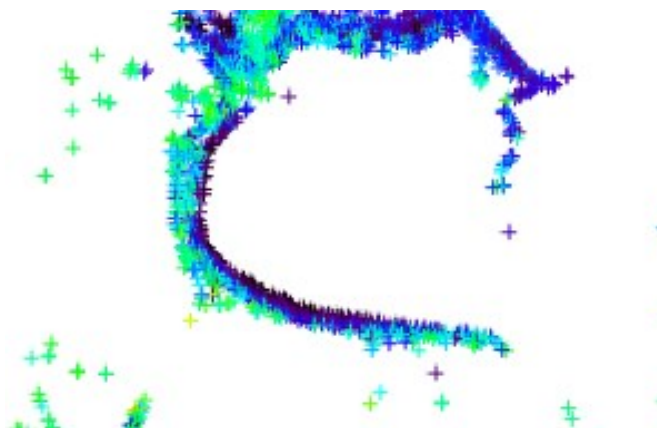


Figure 8 Lower side of the image with the mine basin

Switching again to our 100m and 50m results we can see that this area shows a High and Very High risk of collapse respectively.

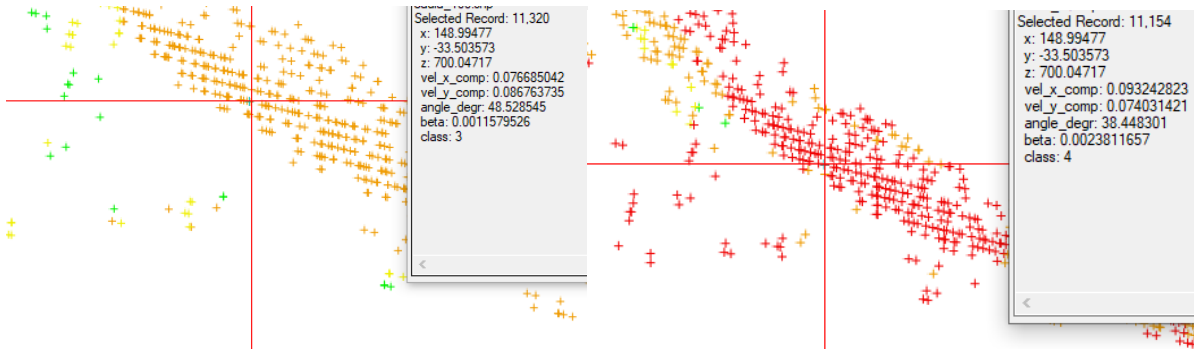
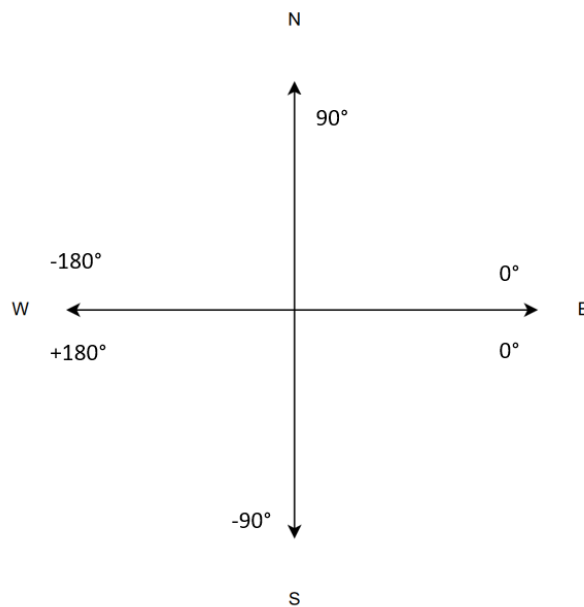


Figure 9 comparison of the collapse in 100m and 50m respectively

We can see that the angles in similar points (the number of records may change with the window size so it's difficult to detect the exact same one in both results) is around 40 to 50 degrees.

The angles can be interpreted using the following schema:



From this we can see that the most likely direction of a collapse is indicatively S/W, we can confirm this by checking this area with Optical Satellite images as confirmation.

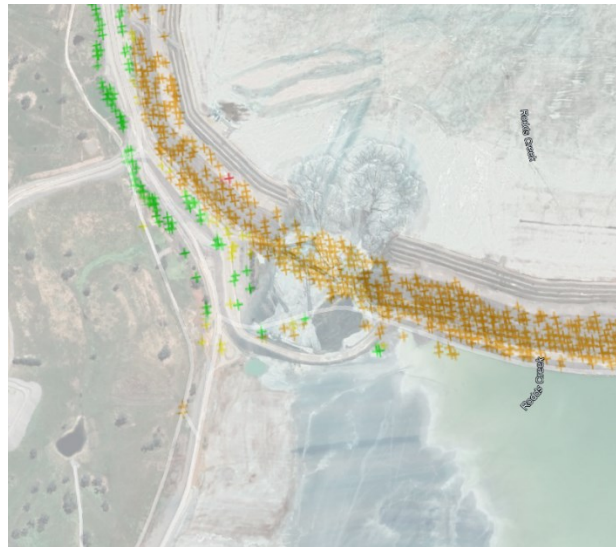


Figure 10 Lower area overlapped with an optical image of the collapse

## 6. Limitations

This process has some intrinsic limitations that may render it more or less useful depending on the area and dataset.

- It is unable to detect small or gradual changes in velocity without using a very small window but doing so introduces a lot of noise that makes the result unreliable.
- Points at the border of the image are not reliable because only neighbours on a single side are present.
- Sparse points have a disproportionate impact on their surrounding's result, in this case a raster input is preferable but this translates to a longer processing time.
- A regular grid of points is not well suited for this process, this is because the plane fitting the velocities is necessarily bound to the grid. For this reason a PS input is highly recommended.
- The smaller the chosen window size and the more points are going to be removed from the output, this is because there is a hard minimum of 3 points that need to be present to compute  $\beta$ .