

**Earth Surface Dynamics**  
**Editor-in-Chief**  
**Dr. Niels Hovius**

Date: April 14, 2021

**Earth Surface Dynamics Manuscript esurf-2020-94**

**“Locating rock slope failures along highways and understanding their physical processes using seismic signals”**

Dear Dr. Niels Hovius and Dr. Claire Masteller,

Thanks for handling our manuscript. We hereby submit the revised version of our manuscript for your further consideration. We would like to thank referees for the valuable suggestions for all figures, which we have all taken into account in our revision and change the figure style to colorblind friendly. In the revised manuscript, all of our changes are by tracking. A point-by-point response to all the comments can be found below “Responses to Reviewer’s Comments”.

Thank you for your time and consideration, we hope very much that our revisions are satisfactory to you.

Yours sincerely,

Jui-Ming Chang, on behalf of all authors

## Responses to Reviewer's Comments

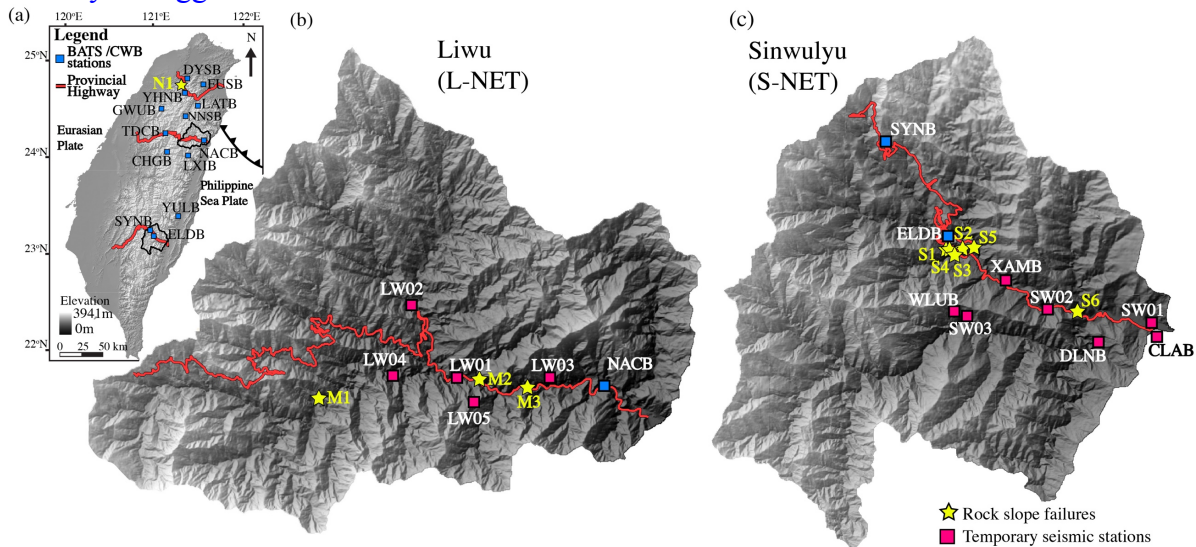
**Note:** Reviewer's comments are all quoted in their entirety and are in *Italics*, while authors' responses are in blue.

### Reviewer 1#

I recognize that much of this information is included in the captions, but these are very lengthy, and thus, to ensure that this information is not lost, I am recommending modifications of the figures themselves for clarity and inclusion of clear labels and legends in the figures, as there are many details and annotations that readers may miss otherwise. I am also suggesting modifications to the figure color schemes to improve accessibility (particularly to make figures red-green colorblind friendly).

Figure 1. Text in figure is very difficult to see, particularly in the legend. Please increase text sizes for legibility. Please modify red/green color scheme to be colorblind friendly.

Modify as suggestion. Please see the new version below.



**Figure 1.** Research area and distribution of seismic stations and ten rock slope failures (RSFs, yellow star). (a) Topographic map of Taiwan shows three provincial highways (red lines) and BATS/CWB stations (blue square). (b) Liwu catchment, the east flank of the central provincial highway, and the temporary seismic network (L-NET, pink square). (c) Sinwulyu catchment, the east flank of the southern provincial highway, and the temporary seismic network (S-NET, pink square). The data of Digital Elevation Model (DEM) of Taiwan and two catchments are from Government Open Data Platform, Taiwan.

Figure 2. It is currently unclear where the flow-chart/decision tree begins. Please revise for clarity. Please modify red/green color scheme to be colorblind friendly. Modify as suggestion. Please see the new version below.

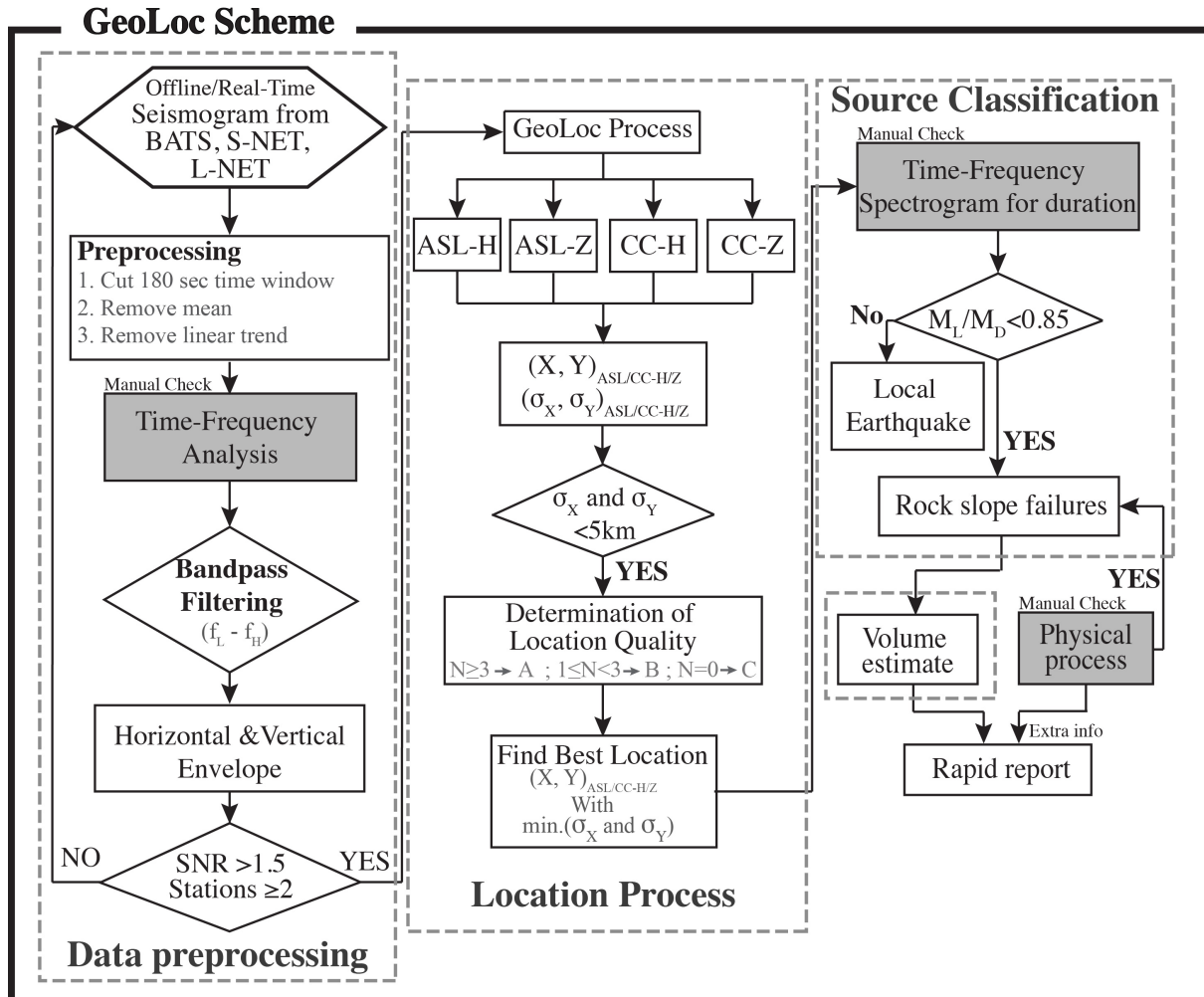
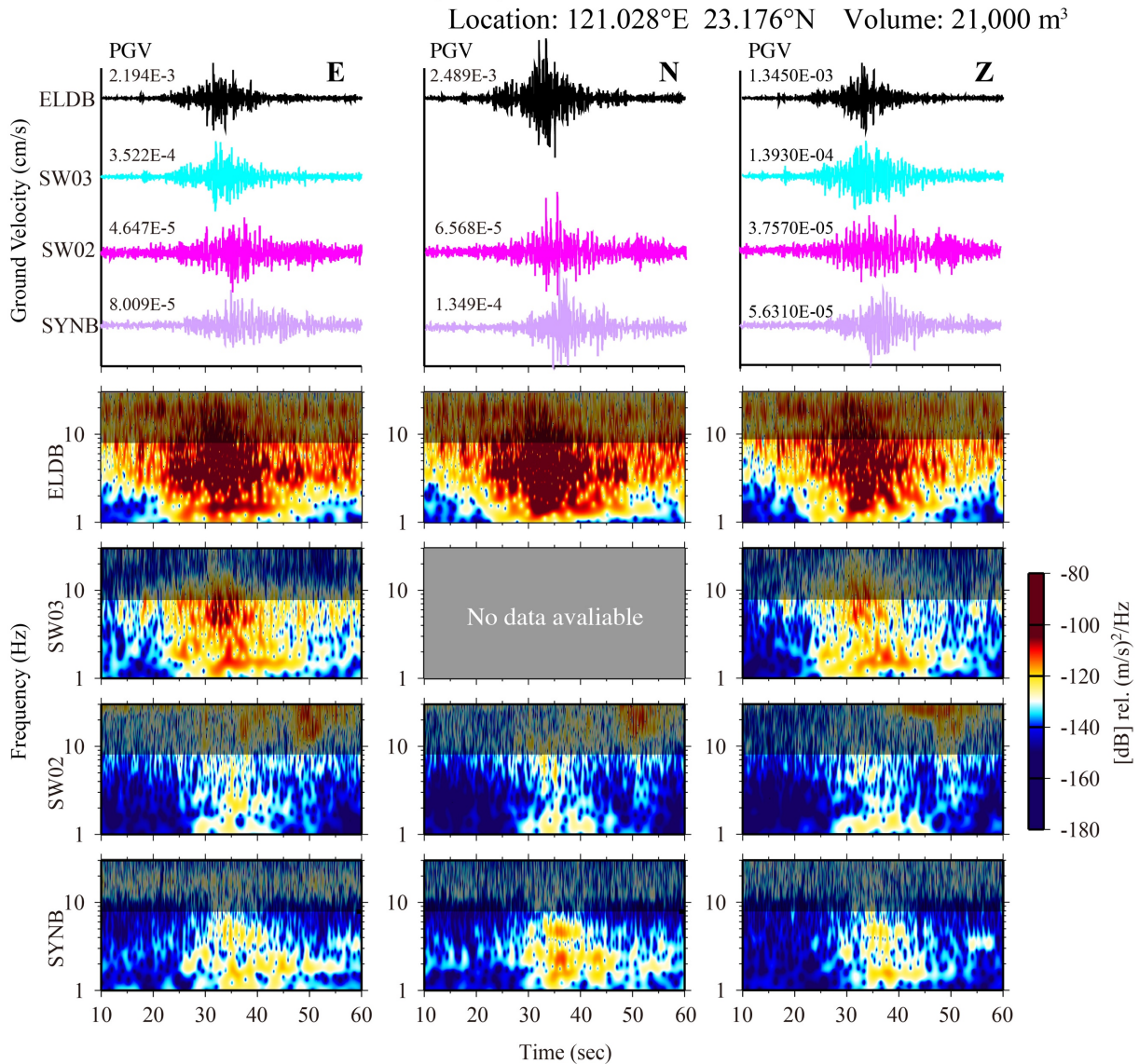


Figure 2. Flowchart of the GeoLoc scheme, including data preprocessing, location process, source classification, and volume estimate. All steps are automatic, except the steps with grey background which involved manual check in this research.  $f_L$  and  $f_H$  are the lower and upper band of the bandpass filtering.  $(X, Y)_{ASL/CC-H/Z}$  is the best location form the ASL or CC with horizontal or vertical components.  $(\sigma_X, \sigma_Y)_{ASL/CC-H/Z}$  are those location uncertainties based on the relative fitness over 0.95.  $N$  is the number of results from methods with components (total:  $N=4$ ) whose location error less than 5 km threshold. The result with minimum location error defines the best location.

Figure 3. The numbers next to each of the ground velocity waveforms are unclear. Please modify the figure or caption to clarify what these represent. Green dashed line is very hard to see. Please modify the color for clarity. Also please add this line to an in-figure legend for added legibility in the figure.

[Modify as suggestion. Please see the new version below.](#)

**S4** 4th October 2016 07:03:10 (UTC)



**Figure 3.** Recorded waveform and spectrogram of Event S4. The value next to the waveform is the peak ground velocity (PGV) for each signal. The bright area of the spectrogram is the range of the bandpass filter (1-8Hz,  $f_L$  to  $f_H$ ), which should cover the signals of all stations recorded during the event.

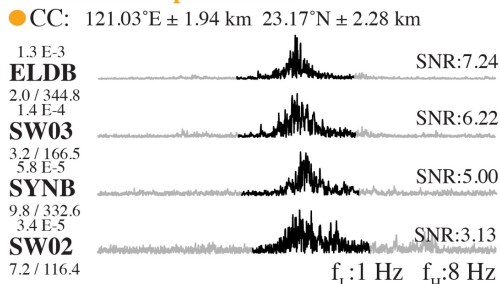
Figure 4. Text sizes, particularly in location maps, are very small and difficult to see. Please enlarge. Please modify red/green color scheme to be colorblind friendly. There are two references to black lines in the figure caption, corresponding to the wave forms and to the location maps - please visually differentiate between these and include these in a figure legend. The red outlines are also not clear, please add these to an in-figure legend in addition to their reference in the caption itself. The "relative misfit" label is very hard to see being inset into the color bar, please move this below the colorbar to increase legibility.

Modify as suggestion. Please see the new version below.

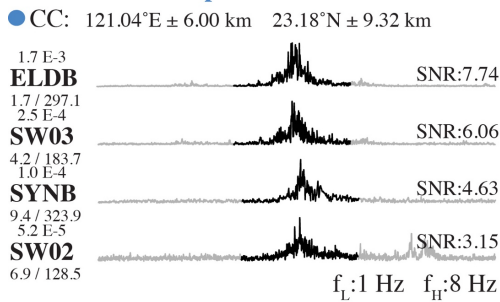
S4: 4-October-2016 07:02:10 (UTC)

**Location Quality Level: A**

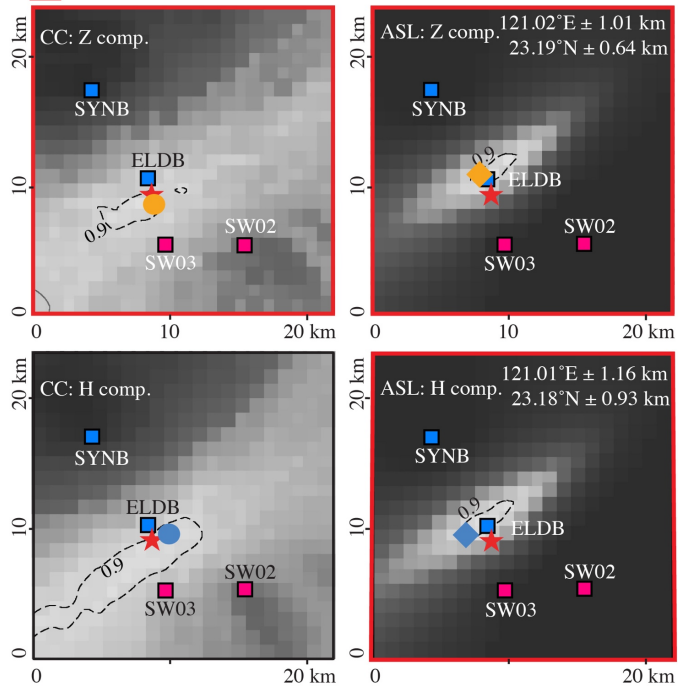
**Vertical Envelope Function**



**Horizontal Envelope Function**



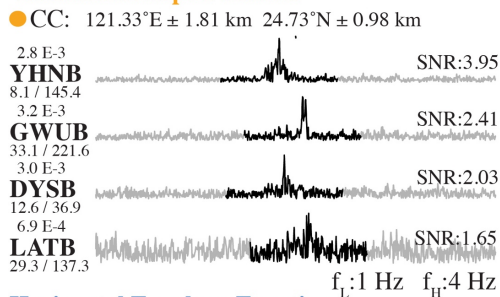
★ True Location ■ BATS/CWB stations ■ Temporary seismic stations  
 □ Results satisfying the threshold of location uncertainty



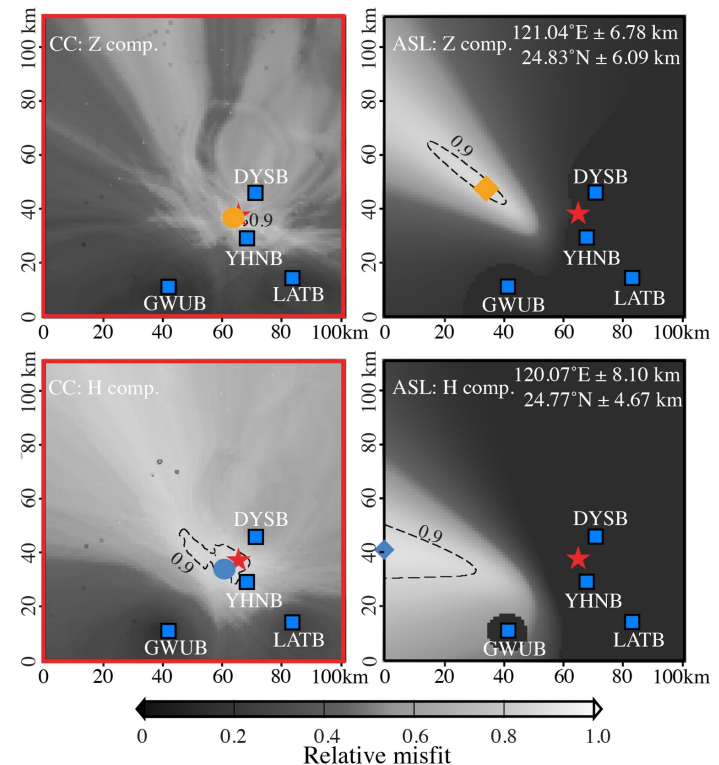
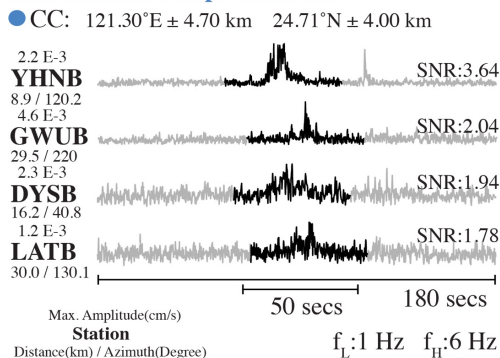
N1: 18-July-2019 01:07:10 (UTC)

**Location Quality Level: B**

**Vertical Envelope Function**



**Horizontal Envelope Function**

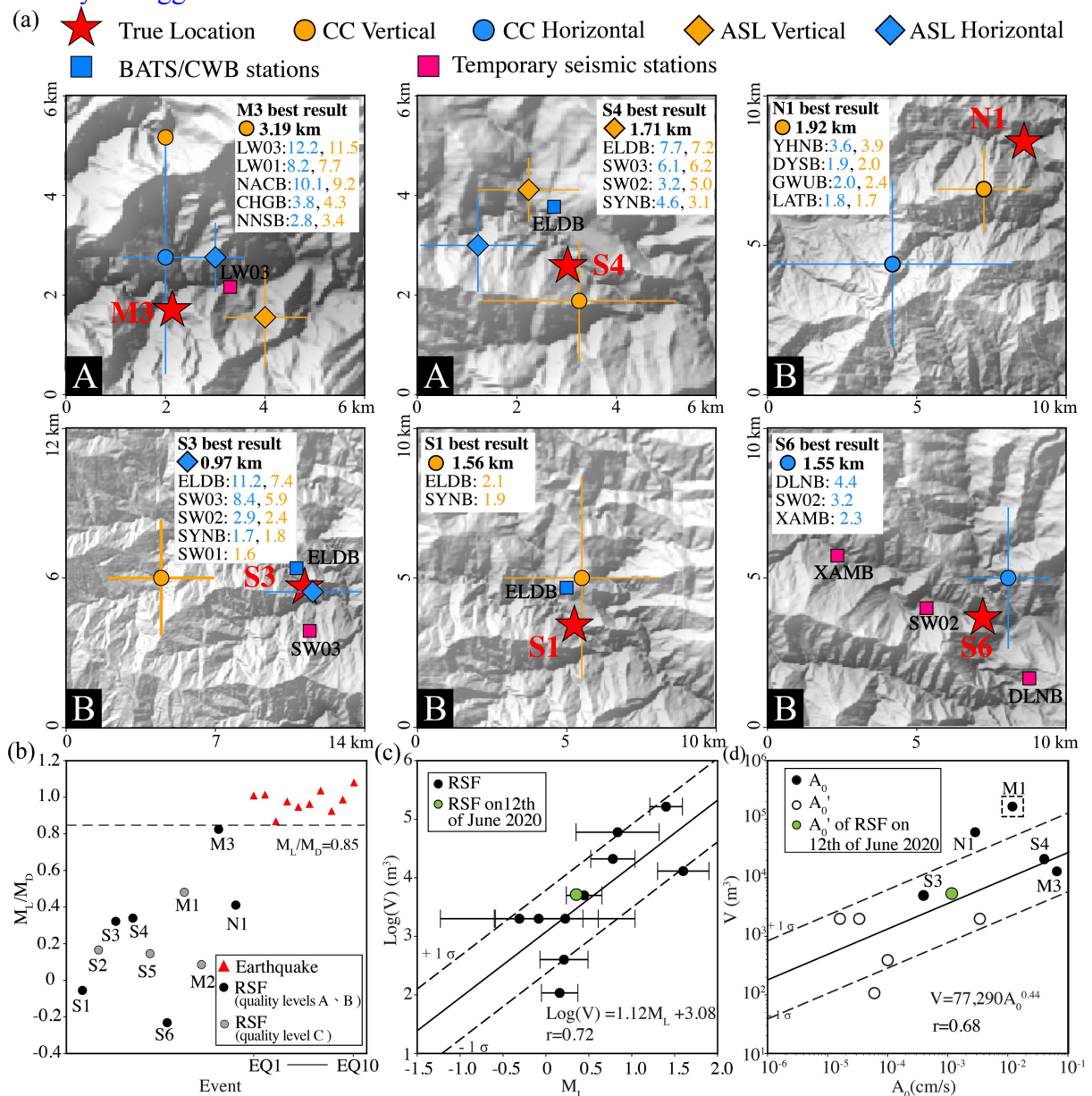


Max. Amplitude(cm/s) Station Distance(km) / Azimuth(Degree)

**Figure 4.** The result of CC and ASL in Events S4 and N1. The left panel is the horizontal and vertical envelope function of the detected stations of the Events S4 and N1. The black lines with 50-second signals are used in the CC. The right panel is the result of the CC and ALS with a horizontal and vertical component. The circle and diamond symbols present the best result of the CC and ASL, respectively. The black dashed lines are the contour of a relative misfit with 0.9. The uncertainty of the location is estimated based on the standard deviation of longitude and latitude for the source grid points with the relative misfit higher than 0.95.

Figure 5. Include green squares of seismic stations in the legend. Please add black outlines to the red stars and green squares for legibility. Please modify red/green color scheme to be colorblind friendly. What is x-axis on 5b? Please clarify. Magenta points and open circles in C and D should be defined in the legend in the figure. Grey points should also be defined in the legend in Panel B.

Modify as suggestion. Please see the new version below.

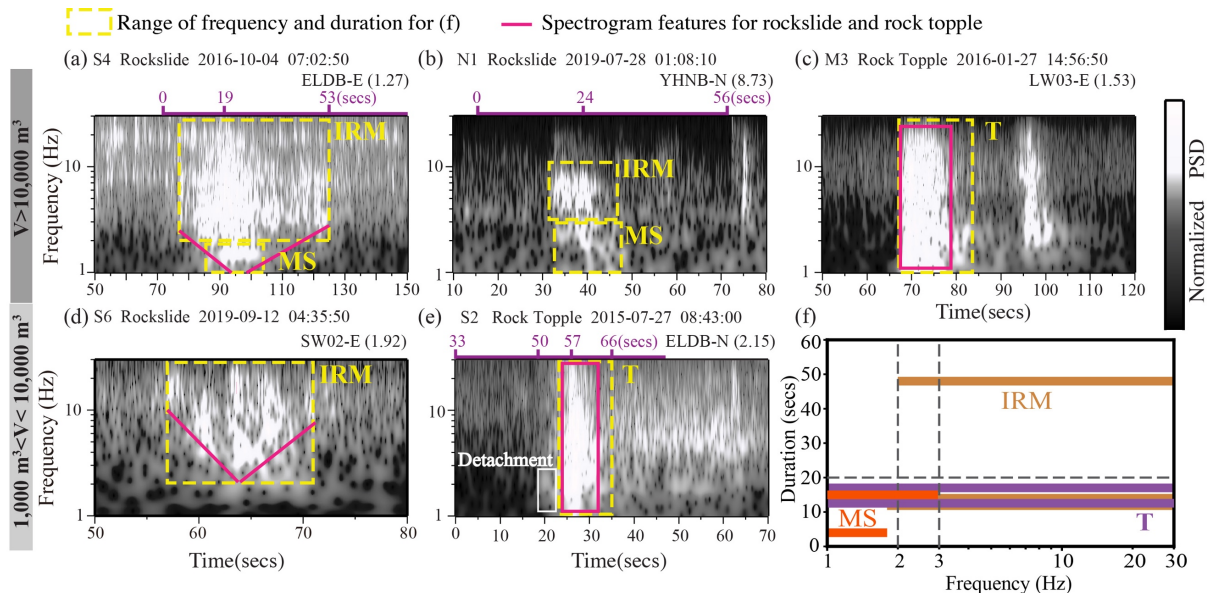


**Figure 5.** Results of the location process by the GeoLoc scheme,  $M_L/M_D$  of the RSFs and earthquakes, scaling of seismic parameters, and source volumes. (a) Results of location quality levels A and B from GeoLoc and their location uncertainties. The number beside the

station name shown in the upper right corner is the SNR value for the horizontal (blue) and vertical (orange) envelopes. The symbol in the white box is the best result of location, and the value beside the symbol indicates the location error. (b)  $M_L/M_D$  of RSFs and earthquakes. A horizontal dashed line indicates a threshold of  $M_L/M_D$  of 0.85 used in this study. The relationships of (c) the event volume ( $V$ ) and  $M_L$ , and (d) the event volume ( $V$ ) and  $A_0$ . The black circles show the  $A_0$  extracted from the best location result. The open circles are the peak ground velocity ( $A_0'$ ), extracted from the nearest stations. Event M1 is excluded in regression analysis due to its high location error. The data of Digital Elevation Model (DEM) of Taiwan is from Government Open Data Platform, Taiwan.

Figure 6. The reasons for the purple and orange backgrounds in this figure are not clear, as are many of the annotations on these figures. Please modify the figure caption to make these clear or remove the orange/purple backgrounds. The purple lines associated with the videos are very hard to see, please make these thicker. The inclusion of panel E is not very clear in the current presentation of the data. A figure legend defining these annotations thing the figure would help readers digest the figure.

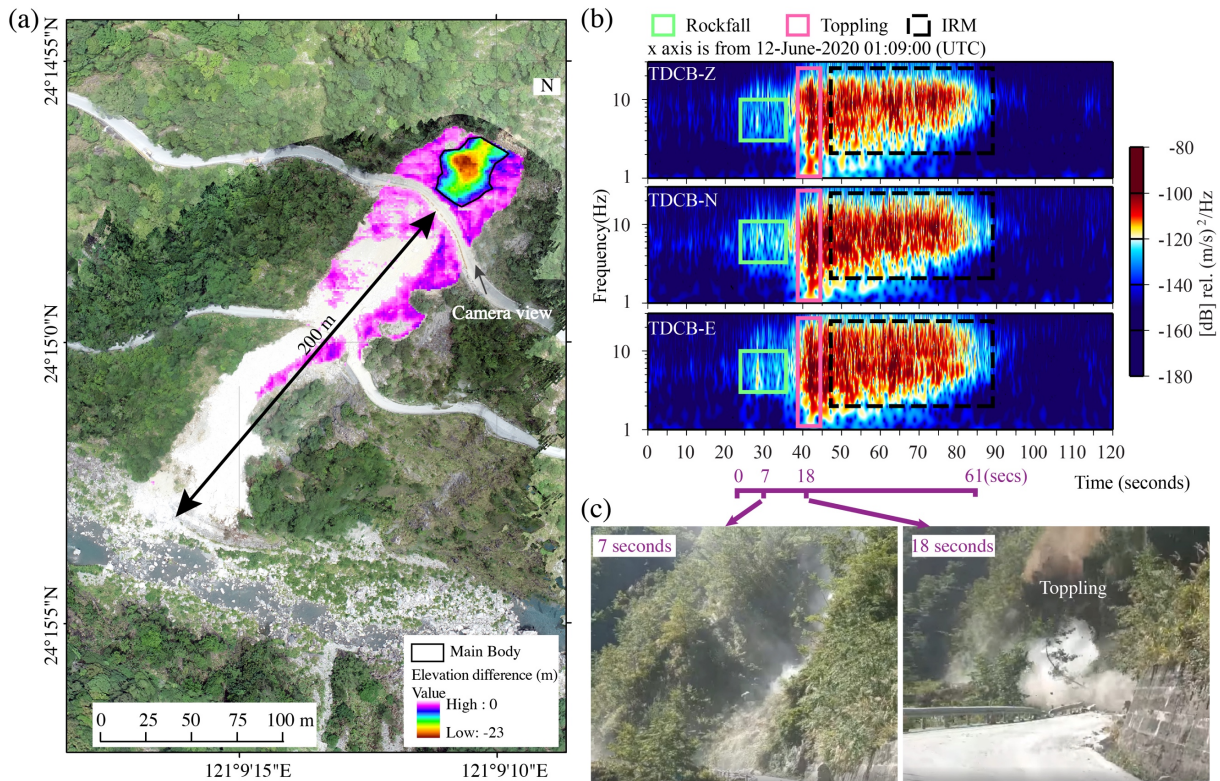
Modify as suggestion. Please see the new version below.



**Figure 6.** Spectrogram of five events and classification of physical processes by spectrogram features, frequency, and duration. The rows are separated for the different scales of failure volumes. (a-e) Spectrograms of different events. The top left corner is the event number, the physical process and the starting time of the x-axis. The top right corner is the station name with the component and the epicentral distance (km). The purple bars above (a), (b), and (e) are the durations (secs) of the video with the time points (Table S2). (f) Sliding and toppling processes are distinguished by the frequency and event duration.

Figure 7. A) It is hard to tell from the image if the lidar differences are confined the the main body or the whole failure. Outlining the area where the elevation differences are plotted

would be helpful. B) Text annotations are difficult to see. Please modify for legibility. White with black line annotations are really hard to see. Please modify these for legibility. A figure legend defining these annotations thing the figure would help readers digest the figure. C) Modify as suggestion. Please see the new version below.



**Figure 7.** The field photo, spectrograms, and time-lapse photos form the video of recent RSF on the 12<sup>th</sup> of June 2020. (a) Field photo of the event. The gradient color is the elevation difference between DEM originating from Lidar in 2012 and, the digital surface model(DSM) derived from drone survey after the event. The main body is considered the elevation difference larger than 3m. (b)The spectrograms of three components. The upper left corner of the spectrograms is the station name with the components. The purple axis below spectrograms indicates the time points from the video. (c) Time-lapse photos from the video corresponding to the physical process of rockfall (Left panel) and toppling (Right panel). The seconds shown in the top-left corner indicate a time tag in the video.

Much of the text in the figure captions can be streamlined by including legends or annotations in the figures themselves. I would recommend modifying the figures towards streamlining delivery of this information to readers.

Modify as suggestion.