Geog 357 Project Report: Mount Meager Glacier Retreat

Introduction

The Mount Meager Massif is a group of glacier-clad stratovolcanoes in the Garibaldi volcanic belt that formed as a result of subduction zone volcanism. Subduction zone volcanism occurs when two plates converge (Pacific and Juan de Fuca subducting below the North American Plate). The crustal portion of the subducting plate contains a high amount of surface water and water contained in hydrated minerals. As the plate descends and encounters greater temperatures and pressures, the water is released into the mantle wedge above (Borealis 2021). Water lowers the melting temperature of the mantle and causes it to melt. The magma produced by this process rises up to create a belt of volcanoes parallel to the trench. Landslides and rockfalls have become more common in the Mount Meager area as a result of the melting snow and ice. Melting glaciers change the water flow system and destabilize the area (removal of the protective layer, volcanic rock weaker due to rapid formation). Exposed fumaroles, vents where volcanic gases are emitted, indicate that retreating glaciers could also contribute to the possibility of another eruption. The objective of this project is to utilize satellite imagery and post processing techniques to identify and map glacier change over ~30 years in the Mount Meager volcanic complex.

Data Sources

The United States Geological Survey Earth Explorer was used to download Landsat 5 TM and Landsat 8 OLI satellite imagery. The first image was dated 20 September 1990 (Figure 1), and the second image was taken on 20 September 2022 (Figure 2). Both images were cloud free in the study area. Catalyst PCI was used for data processing and analysis.

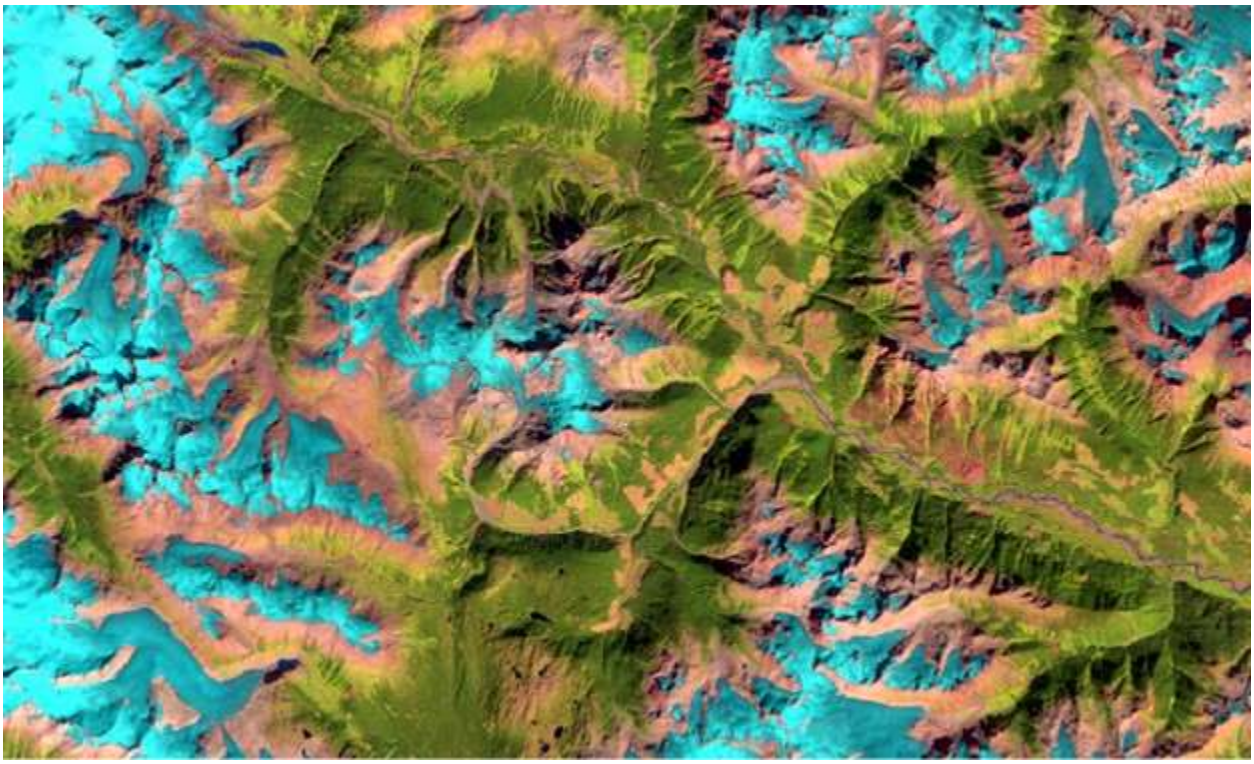


Figure 1. Landsat 5 TM image of the Mount Meager volcanic complex and surrounding area on September 20, 1990. Displayed in the mid infrared, near infrared, and red bands.

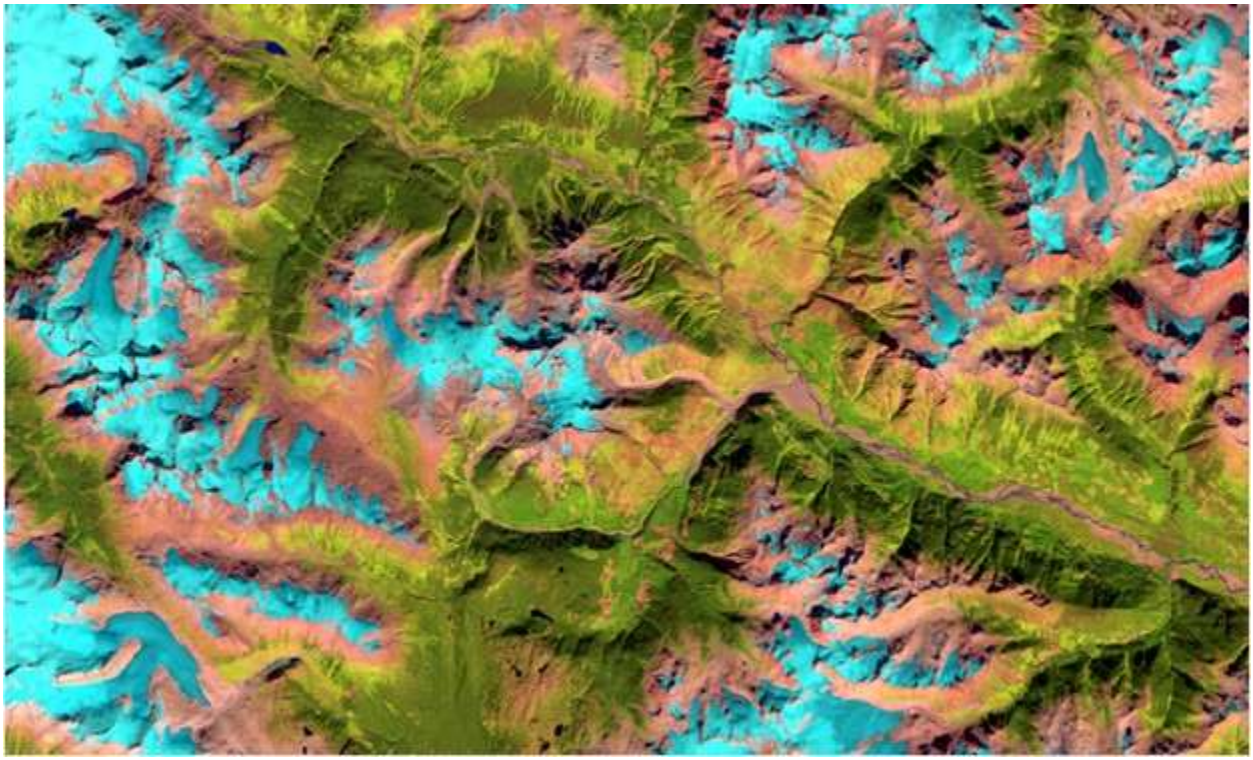


Figure 2. Landsat 8 OLI image of the Mount Meager volcanic complex and surrounding area on September 20, 2022. Displayed in the mid infrared, near infrared, and red bands.

Methods

The steps below were used for the Landsat 8 2022 data. A similar process was used for the Landsat 5 1990 image.

1 Use the raster calculator to create NDSI: (Green - SWIR)/ (Green + SWIR)

2 Use the raster calculator to create a red/ SWIR ratio (4/6)

3 Query digital numbers to find threshold value to identify snow and ice (1.8)

4 EASI modelling script using ratio >1.8 and near IR >8000 for silty water in the Lillooet River

5 Use the EXPOLRAS algorithm to extract, sieve, and vectorize glacier features (55 pixels)

6 Bring shapefiles into ArcGIS, overlay onto high resolution band 8, manually digitize and edit polygons to correct for shadows above Meager Peak

7 Create Meager volcanic complex boundary and clip

8 Smooth using SMMCMASTER back in Catalyst

9 Repeat the process for the 1990 image and determine total areas of each polygon in the attribute manager

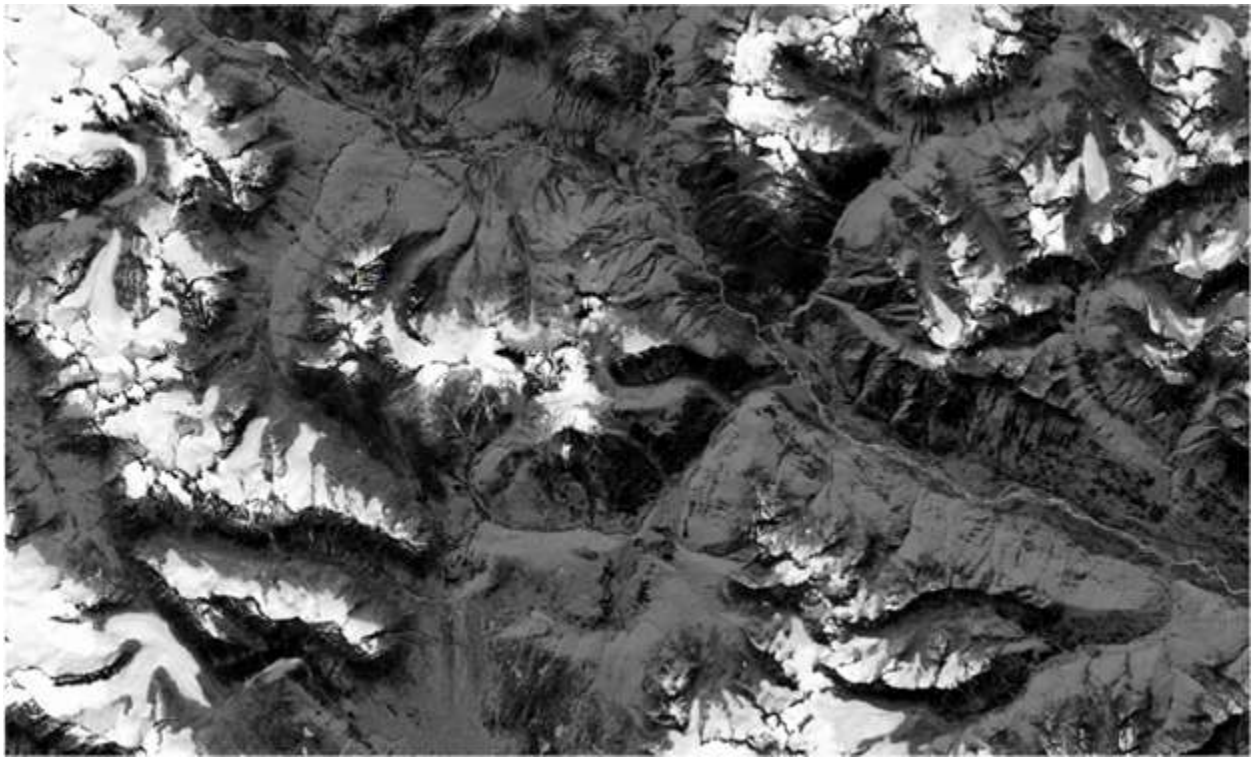


Figure 3. Normalised difference snow index of the Mount Meager area in 2022.

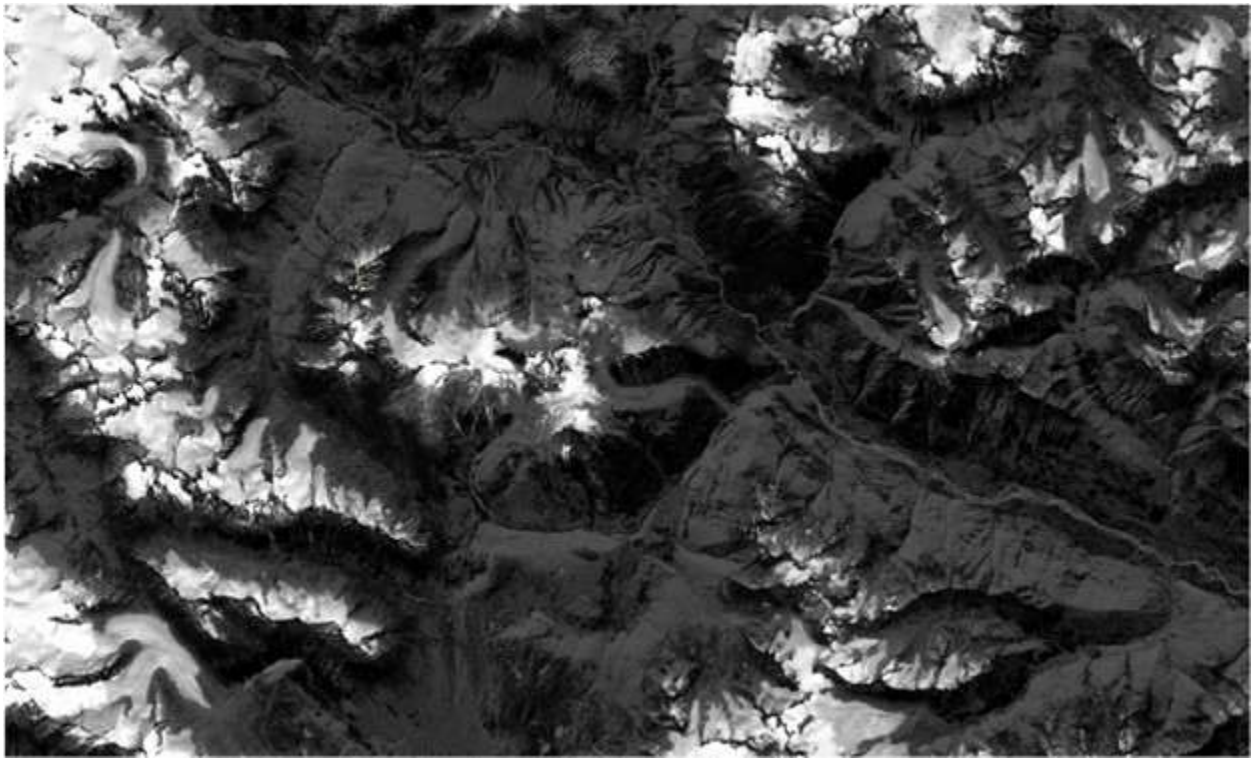


Figure 4. Red/ SWIR ratio of the Mount Meager area in 2022.

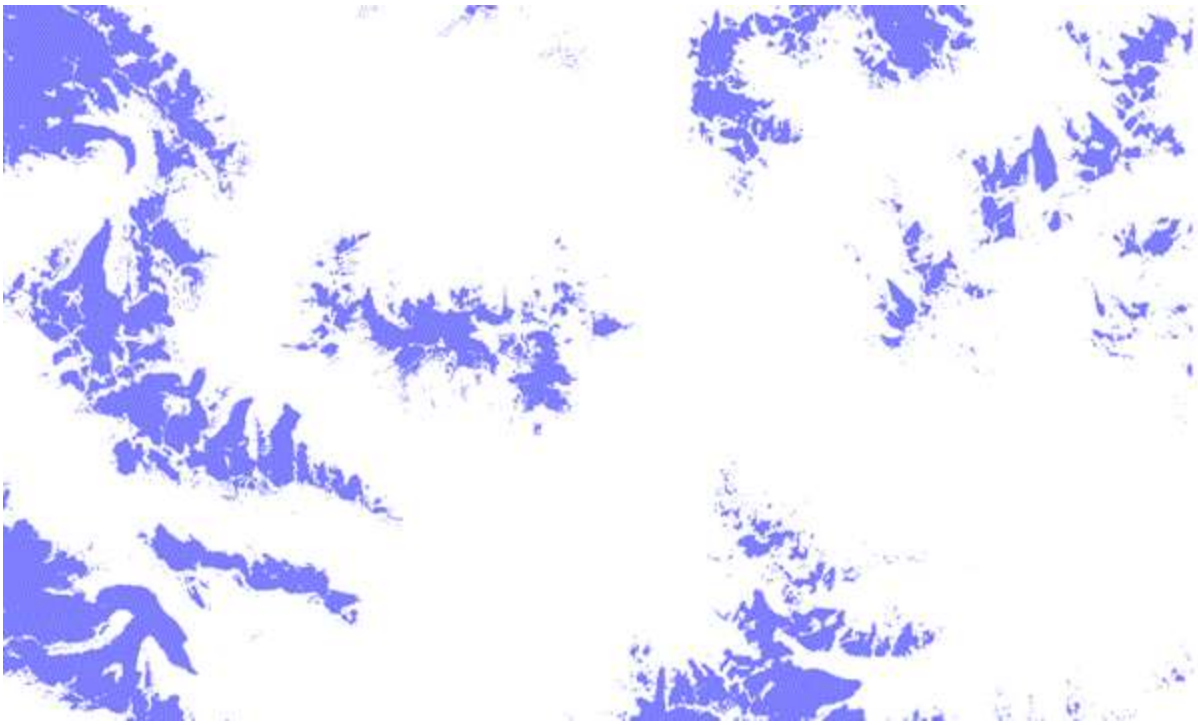


Figure 5. EASI modelling result showing extracted glaciers in the Mount Meager area in 2022.

Figure 6. Smoothed glaciers vector zoomed in on the Mount Meager volcanic complex in 2022.

Analysis

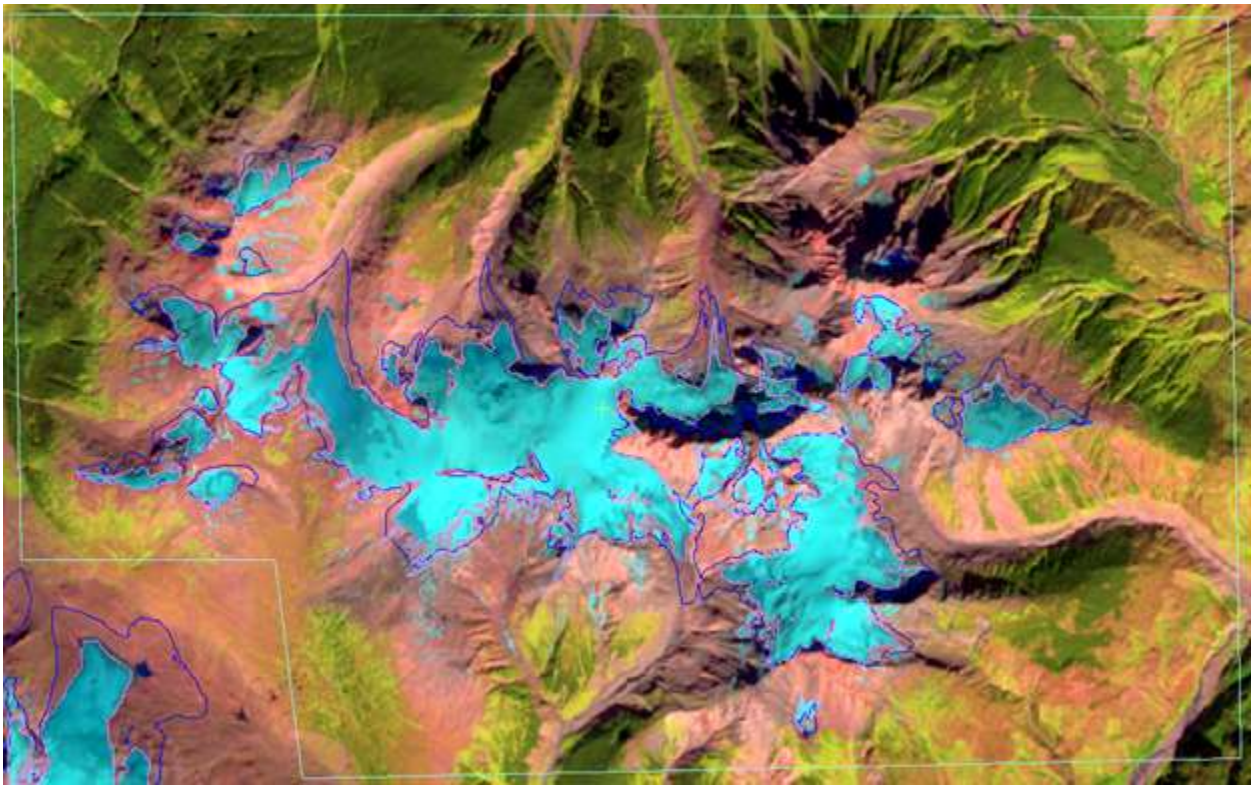
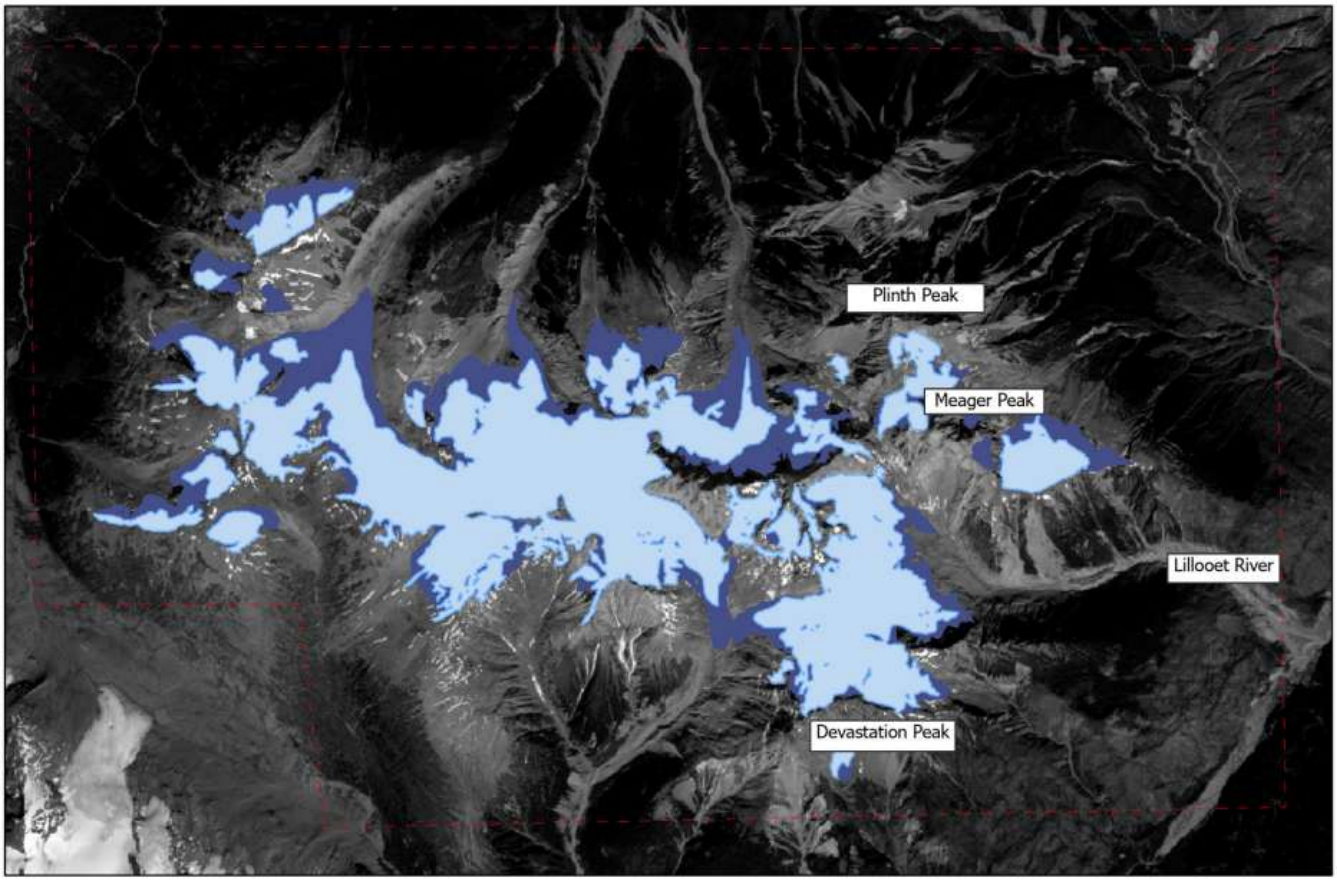


Figure 7. The 1990 (dark blue) and 2022 (light pink) glacier extent vectors on top of the Landsat 8 OLI image of the Mount Meager volcanic complex in 2022.

The total area covered by glaciers in 1990 was estimated to be 31.5 square kilometers while the total area in 2022 was approximately 22.2 square kilometers. Figure 7 shows a clear loss on the west side of the complex and a significant decrease on Meager Peak itself. Plinth Peak (north of Meager Peak) also shows considerable glacier loss. ArcGIS was used to create a map of the Mount Meager volcanic complex using the high resolution Landsat 8 OLI band 8 as a basemap. The glacier shapefiles were added to display the extent of the glacier retreat between 1990 and 2022. The basemap is effective in showing the glacier runout tracks below Meager Peak. Landslides become more frequent as glaciers continue to melt. For example, in 2010 a large landslide event (49 million cubic meters) took place and temporarily blocked Meager Creek.



Project Limitations

1 Time of year: I initially selected satellite images from July which had too much seasonal snow cover. I then attempted to look for something in August or early September but all I could find with no clouds was late September. This gave me more shadows to deal with but minimal seasonal snow cover.

2 Manual digitizing: There may be some errors as I had to manually adjust my polygons in Arc before calculating the total areas to correct for shadows. I may have missed some glaciers as the band 8 tiff was too dark in some places.

3 Missed spots: There are some white spots in the band 8 basemap that may be missed glacier cover. These could also be areas of snow?

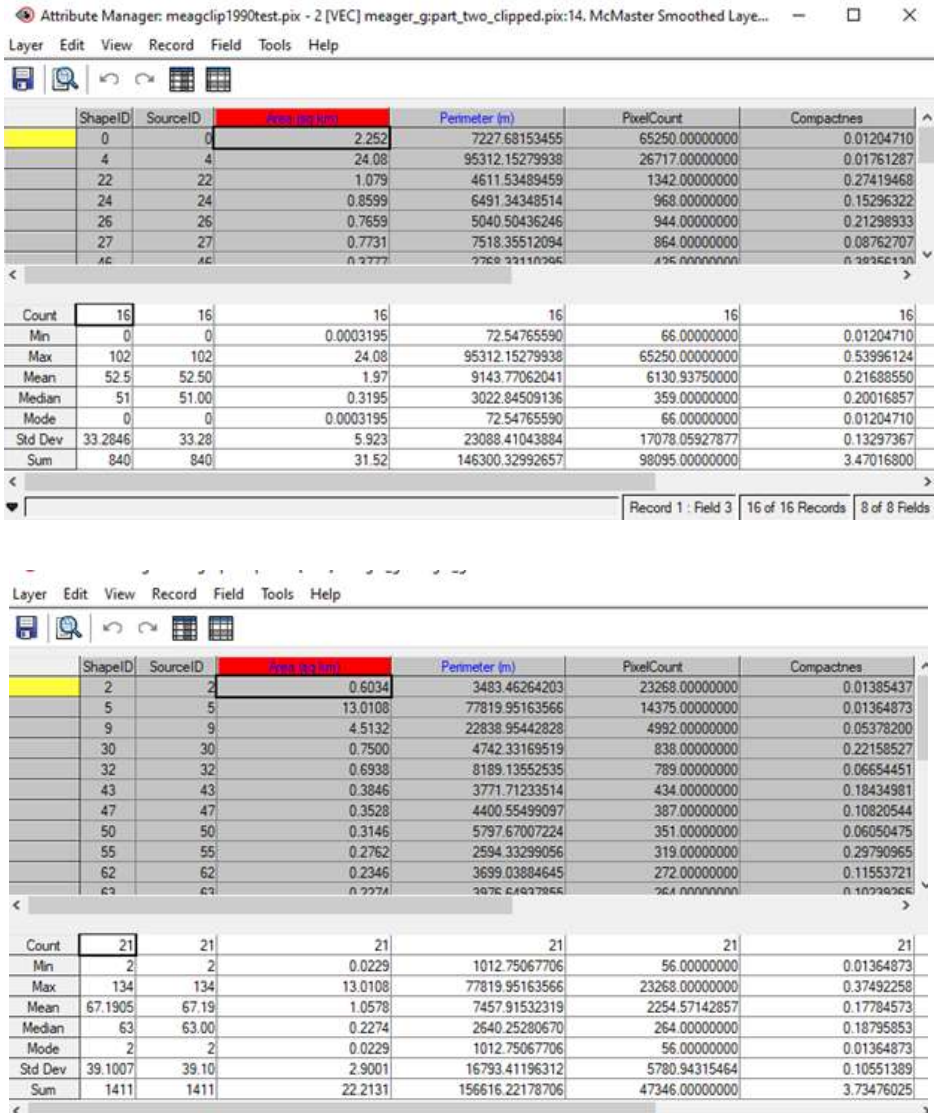


Figure 8: Screenshots of the attribute manager showing total area of glacier cover in square kilometers. Top is glacier cover in 1990 and bottom is glacier cover in 2022.

Reference

Borealis, S. (2021, April 25). Living in the shadow of a volcano: B.C.'s mount meager shows signs of stirring. scienceborealis.ca Blog. Retrieved December 1, 2022, from https://blog.scienceborealis.ca/living-in-the-shadow-of-a-volcano-b-c-s-mount-meager-shows-signs-of-stirring/