# Mountain Legacy Project

## Guidebook

Prepared by: Julie Fortin

September 2015

# Table of Contents

# Introduction to the Mountain Legacy Project

The Mountain Legacy Project (MLP) is among the largest repeat photography projects in the world. It holds the largest collection of systematic historic mountain photographs, with over 120,000 images taken between 1861 and 1958. This collection exists thanks to surveys conducted by the Dominion Land Survey (and subsequent departmental iterations) and the Geological Survey of Canada when making the first topographic maps of Western Canada.

The project itself aims to understand how the landscape has changed in Canadian mountain ecosystems over the past 150 years. To accomplish this, it uses repeat photography: members return to the locations of the historic images and recapture them in the present day. As of 2016, over 7000 repeat photographs have been taken by MLP members since 1998. The resulting studies, comparing past and present landscape, are remarkably interdisciplinary. They incorporate field work, archival science and data management, computational analysis, ecology, anthropology, history, geography and traditional knowledge to answer questions in the natural and social sciences.

The MLP was originally based out of the University of Alberta (1998-2001), then known as the "Bridgland Repeat Photography Project" after the prolific surveyor, Morrison Parsons Bridgland. It was then moved to the University of Victoria where it was rebranded as the "Rocky Mountain Repeat Photography Project" (2002-2005) to recognize an expansion of historical survey interests along the spine of the Rockies. In 2006, given archival research that showed a vast collection of historical survey images across mountainous Western Canada (Alberta, British Columbia and the Yukon), it expanded to its present designation, the "Mountain Legacy Project".

The MLP involves partners and participants in academia, government, non-governmental organizations and the general public. The majority of the work is based out of the Visualization Lab in the School of Environmental Studies at the University of Victoria. Any external party interested in using the MLP dataset for research or public education purposes is encouraged to do so by contacting the project director. Possible applications include studying land use history, resource management or ecological restoration practices, or assessing phenomena such as glacier retreat, tree line regression, forest fire patterns and succession, changes to surface hydrology and to wildlife habitat, human activity, floods, avalanches and much more.

# The historical photographs

### A brief history of photography

The precursor to the modern camera can be traced back to ancient times with the concept of “camera obscura”. It consisted of a dark room with a pinhole in a wall allowing light through to form an image on the opposite wall. In the 17th century, it was found that inserting a lens into the pinhole improved image quality. In those times, the image was not permanent; it still had to be reproduced by artists.

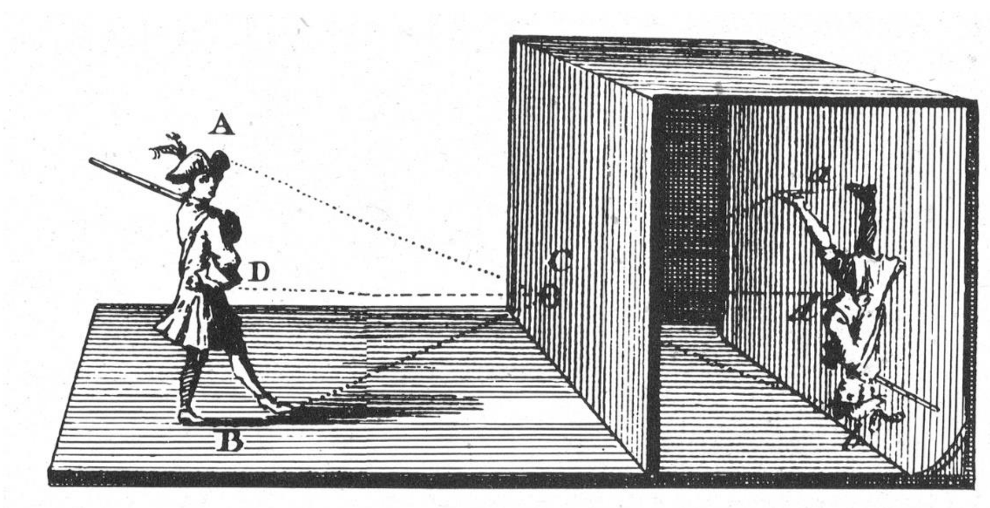


**Fig 1.** A camera obscura: a pinhole in a wall allows light to pass through, generating an (inverted) image on the opposing wall.

The discovery of photosensitive chemicals around the year 1800 paved the way for pictures to be captured permanently by photochemical reactions. Various iterations of chemicals on different kinds of sheets were invented throughout the subsequent decades, such as silver chloride on paper, silver iodide and mercury on silver-plated copper, collodion on glass (wet plate), and gelatin and silver bromide on glass (dry plate). These eventually were phased out in favour of film. More recently, digital technology is slowly rendering tangible sheets obsolete in the photographic process, as images can be stored permanently without prints.

## Historical surveys

In the mid to late 1800s, when camera technology started becoming accessible and portable, cartographers began using it for topographic mapping. The advent of these phototopographic survey methods coincided with the need to document the Canadian mountain west. Thus, Canadian surveyors broadly employed these techniques to map the Rockies (and beyond), which resulted in some of the broadest systematic photographic surveys in the world.

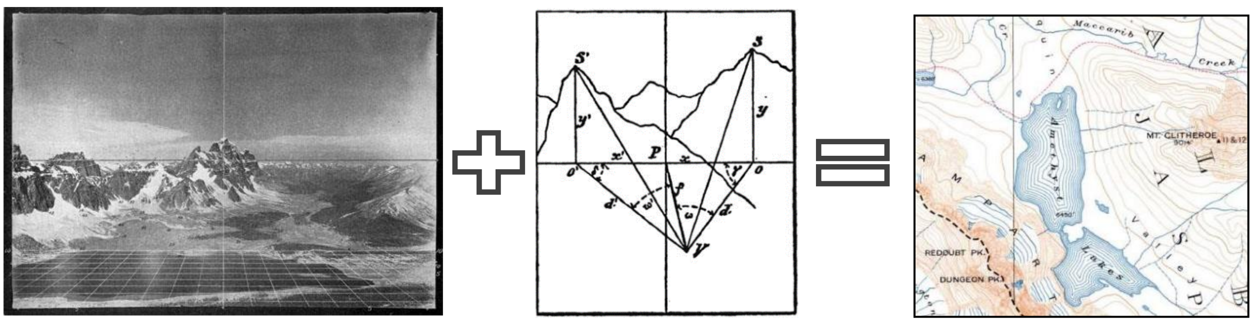


**Fig 2.** An illustration of the phototopographic map making process.

The cameras used by the Canadian surveyors in the late 1800s and early 1900s were "large-format"; they produced large negatives that magnify well and from which a surprising amount of detail can be extracted. Typically, the negatives were formed on 4x6" glass plates with high quality emulsions. The size they opted for, rather than 8x10" glass plates (which would have magnified even better), was probably a trade-off between image quality and size/weight of equipment. Indeed, the ensemble of camera, tripod and other accessories could weigh above 9 kg.

Given the heavy equipment needed, surveyors would typically travel with large crews of ideally seven men: the surveyor, his assistant, the cook, two expert packers (assuming they were using horses), and two other men to help carry camera equipment and camping gear. We know from field notes and from the amount of snow visible in the photographs that they would go out in the summer months (although the exact dates of the historic photos are rarely available). In a single summer season, one lead surveyor and his team could complete dozens of stations. And often, there were several surveyors working in different areas during the same year, each completing surveys for distinct purposes. For example, in 1915, Morrison Parsons Bridgland was surveying Jasper National Park while Arthur Oliver Wheeler worked on the Interprovincial Boundary Survey near Waterton Lakes.

During these historical surveys, they would hike up to the peaks of mountains, set up their camera on a tripod, make sure it was level, and take pictures of other mountains. They would prioritize places that offer the best view of the surrounding landscape, as often they would rotate the camera on the tripod to form a closed circle view of the horizon. Sometimes, this required taking photos from more than one location at a given station. For their topographic purposes, they would ensure they had good triangulation of each peak from at least two other peaks at optimal angles. At some stations, they built a large cairn to mark the location from which they took the photographs in case of future revisits.

**Fig 3.** 2016 field crew members Sandra (orange) and Julie (blue) next to a large cairn built by Howard Frederick John Lambart and his crew in 1927 (station 35).

Following this field work, negatives were brought to Ottawa where an enlargement camera was used on the photographs to produce prints of 10 x 14 inches. These were then used in the topographic map-making process.

In a nutshell: historical surveys occurred between 1861 and 1958 in the summer months; they were expeditions involving large crews, led by men employed by various departments of the Canadian or provincial governments; they used heavy but high-quality camera equipment to capture photographs of mountain peaks and sometimes left a marker making the station location easily identifiable in the future.

### Archival collections

Once these surveys were completed and the topographic maps were drawn, what happened to the glass plate negatives of the photographs? For the most part, they were thrown into boxes and stored in archival facilities, not to be thought of again for decades… until a few persistent MLP researchers began poking around the archives in the 1990s.

These researchers found a significant number of glass plate negatives in boxes labeled "maps" (technically, the photographs were considered by-products of the topographic map-making process). These boxes had actually been marked for destruction, but somehow – thankfully! – slipped through the cracks. MLP members and archivists saw the immense potential in maintaining these artifacts, and they have been kept at the Library and Archives Canada/Bibliotheque et Archive Canada (LAC/BAC) preservation facilities ever since.

Other parts of the historical collections are housed in public and private collections, such as the BC Archives, the Royal BC Museum, the Whyte Museum of the Canadian Rockies and the University of Alberta Library.

## Preservation and digitization

### Storage

The Mountain Legacy Project's collection of over 120,000 historical images contains invaluable information. Thankfully, glass plates, which were the standard method for capturing photographs a century ago, are exceptionally durable and have kept the images in mint condition for decades. As such, most images are of great quality, although occasionally there are cracks, leaks or discolorations that complicate analysis.

These collections require tremendous work on behalf of archivists to maintain. The artifacts must be preserved in ideal temperature and humidity conditions and must be protected in case of emergencies such as electrical outage, flood or fire. Furthermore, they must be adequately labeled and sorted to make for efficient retrieval when needed.

## Scanning

The next steps with these archival collections is to render them usable in a digital format. To date, LAC/BAC has digitized several hundred historical photographs using an ultra high resolution scanner: the Epsom 10000. This ensures optimal image quality such that minimal information is lost in the process. With this step, the collections are immortalized both on physical plates and on hard drives. These ultra high resolution scans of historical images are used exclusively for analysis, as rapid appraisal photos (described below) are not of sufficient quality.

Any photograph in the MLP's collection which has an e-copy number associated with it has been scanned in ultra high resolution. The e-copy number is the file name given to the file by LAC/BAC upon scanning.

## Rapid appraisal

Unfortunately, at approximately $35/plate, scanning is a relatively expensive method of digitizing the historical images. Thus, another part of the MLP's work consists of taking "rapid appraisals" of the glass plates – i.e. taking pictures of the plates using medium format cameras. This allows the MLP to figure out where historical surveyors went, and helps prioritize the order in which repeats should be taken. These rapid appraisal pictures are what is used in the field to line up the camera when taking repeat photographs.


**Fig 4.** Set-up for rapid appraisal process featuring Rob Watt at LAC/BAC in February 2017.

The process of taking rapid appraisals is demonstrated by Mary Sanseverino in the video found at facebook.com/ mountainlegacyproject/videos/1291829200912766/. In sum:

1. MLP researchers visit the Gatineau Preservation Centre of LAC/BAC
2. Archivists bring boxes from the storage facilities to a working room

3. MLP researchers set up their cameras on tripods above light tables in such a way that they are facing the surface of the light table
4. Wearing gloves (to prevent oil contamination of the emulsion), MLP researchers remove the glass plate negatives from the sleeves in which they are kept
5. They place the negatives one at a time, emulsion-side-up, on the light table
6. They take a photograph using a remote shutter to avoid camera shake
7. They record the information associate with that negative (usually written down on the sleeve which contained the negative – e.g. surveyor name, year)
8. They repeat this for all the glass plates in the box, and for as many surveys as they have time for in the duration of their visit

# Field work

**Pre-field preparation**

Ideally, as much preparation as possible gets done before departing for the field. That way, field crew members can devote more of their precious, limited time in the field to repeating photographs. Such groundwork includes packing, locating surveys and preparing images. For the general MLP packing list and the personal packing list for field crew members, see Appendix A.

Locating surveys is a challenging but essential part of the MLP process. Once the rapid appraisals are obtained, researchers must figure out where the photos were taken from, such that the field crews know where to go to take the repeats. This task is performed by zooming into the general area in Google Earth and looking for the mountain profile seen in each image. With lots of trial and error, zooming in and out of views on Google Earth, the researchers are usually able to determine the peak from which each photograph was taken. They then record the approximate spatial coordinates of the station and add that to a kmz file. This kmz file will be added to a GPS device by the field crews using the software BaseCamp.

As for preparing images: crew members print the historical photographs that they are to reshoot on 8 ½ x 11 pages in black and white. These prints are prepared in Lightroom and Photoshop using the following methods:

1. The images are cropped to remove unnecessary borders.
2. They are adjusted (exposure, contrast, highlights and shadows) to improve clarity.
3. A grid is overlaid on the images. Typically, it consists of one vertical, one horizontal, and two diagonal lines.
4. The images are batched into pdf format, one image plus its metadata per page (metadata: surveyor, year, image number).
5. The pdf's are printed and inserted into binders, organized by station.

**Repeat photography**

The field season for the MLP can be short (6-8 weeks in July/August), but hundreds of stations can be visited. Thanks to generous in-kind support from Alberta Agriculture and Forestry, the crew generally stays at fire bases where food and lodging is provided, then hike or, depending on funding and availability, take helicopters to stations to take photographs.

When acquiring repeat photographs, the objective is to get the exact same view as in the original. The first consideration is to make sure the repeat is taken from the exact same location. Usually, MLP members can reproduce this with sub-meter accuracy. However, in some cases the original site may no longer be accessible. For instance, it may have been on a glacier which has since disappeared, or on soil that has eroded away, or in a place where vegetation has now grown, or where a building has been erected. In such cases, it may be impossible to get an exact repeat of the original photograph, so an approximation will have to do, followed by more difficult image processing and analysis.

The second consideration is that the repeats should be taken in the same season, at the same time of day and with the same air quality conditions as the original. Unfortunately, with the MLP's dataset, it is not always possible to be perfectly faithful to historical lighting and visibility. First, the date and time were not always included in historic surveys and are thus unknown for many historic photographs. Second, repeats are limited to late summer because of the MLP's short field season. Third, timing during the day is limited by availability of helicopters and the need to return to camp before sundown. Furthermore, atmospheric conditions are virtually impossible to reproduce.

Still, the procedure is straightforward. A day in the life of an MLP field crew looks like:

**Getting to the station – by helicopter**

1. The field crew packs their bags (see Appendix A)
2. Members weigh themselves with their packs and fill out a helicopter manifest, which they send via email to the appropriate Wildfire Operations manager
3. They load their equipment into the helicopter and enter
4. They give the coordinates to the helicopter pilot who flies them to the station
5. They exit the helicopter while it is in hold

**Getting to the station – hiking**

1. The field crew packs their bags (see Appendix A)
2. They drive to the base of the mountain atop which their station is located
3. They inform the Wildfire Operations manager of their location and schedule a check-in via radio
4. They hike up to the station

**Setting up the camera**

6. The image prints are taken out and members search for the appropriate location to set up the tripod
7. Once found, members set up the tripod and the tripod head, and ensure it is level
8. The camera is set up on the tripod
9. Members look through the camera's viewfinder and compare with the photograph prints to confirm that they are in the correct location (to within a few centimeters)
10. They adjust the location of the tripod if they are off
11. They use a bubble level to make sure the camera is level
12. They line up the first image by fine tuning the tripod head and iteratively checking with the image print, using the grid lines for reference

**Taking the photographs**

13. Once the image is lined up, they check the camera settings (ISO, auto/manual focus, aperture, shutter speed – Appendix B)
14. They take the photograph using a remote shutter to avoid camera shake
15. They verify the histogram produced by the image; ideally it forms a bell curve
16. If not (e.g. the histogram is bimodal), they adjust the aperture or shutter speed and retake the photograph (sometimes it is not possible to improve the histogram no matter how hard you try…)
17. Once they are satisfied with the photo, they rotate the tripod head and line up the next photograph
18. They repeat steps 13-17 for all the photos at the station – sometimes moving to separate locations (thus repeating steps 9-12 as well)

**Collecting metadata**

19. While the photos are being lined up and shot, one crew member takes readings of temperature, average wind speed, maximum gust speed, wet bulb temperature, relative humidity and pressure using a Kestrel device
20. They fill out a field notes sheet indicating date, start and finish time, photographers, field note authors, weather readings, key words, a weather narrative and a station narrative (describing how they arrived at the station, in sufficient detail to make it easy for a crew in the future to return there)
21. They also take location photos to show where the tripod was set up

* If they have access to helicopters, crews will usually complete 2-4 stations per day, repeating steps 3-20 for each station. *

**End-of-day back at the base**

22. They copy all the day's raw photo files into folders organized by date
23. They look at the photos and select the best repeat for each historical image, noting it in the field notes

24. They copy the repeats identified in step 23 still as raw files into folders organized by surveyor/year/station
25. They save those copies as 16-bit TIFF files
26. If needed, they edit those files in Lightroom (e.g. applying lens corrections, adjusting exposure, contrast, highlights or shadows)
27. They save field notes and location photos within the surveyor/year/station file structure
28. They copy all of the above (raw files, TIFF files and metadata) onto a second computer or hard drive, as a back-up
29. They clean camera equipment
30. They set electronic equipment up to charge
31. They ensure images and GPS locations are ready to go for the next day's stations

Only once all this is done do they get to rest up, and start all over the next day!

**Safety**

Safety is of the utmost importance during field work, as it involves numerous objective hazards. By completing the required training and having open and honest communication between team members, we strive to minimize risk and to manage these hazards.

First, all members complete helicopter hover exit training at the home base for the summer. This consists of learning how to approach, enter, and exit a "holding" and a hovering helicopter safely. "Holding" means the motor is still on and the wings are still rotating. When members get dropped off on mountain peaks by helicopters, they will almost always be "in hold" – sometimes both skids are touched down on the ridge, sometimes the pilot is only able to touch down one skid for a bit of stability, sometimes it is hovering 3-5 feet above the ground. A few practice runs ensure that crew members are all comfortable embarking and disembarking from the helicopter safely. Crews will receive further helicopter safety training every time they are introduced to a new machine. This also teaches them the preferences of each pilot with which they work.

Second, all members are required to have a valid Wilderness First Aid certificate.

Third, all members complete Transport Canada's Radio Operator Certification at the beginning of the summer. This allows them to schedule regular radio check-ins with the wildfire operations team while on station.

In addition, field crews carry lots of safety gear in the form of survival kits and first aid kits, as well as bear spray.

# Post-field processing

**Data management**

The MLP deals with over 5 terabytes of data in the form of photographs and metadata including field narratives, location pictures, etc. As such, data management and storage is a vital part of the process.

The work begins in the field, as described above. Upon return from the field, all image and metadata files are uploaded onto the MLP's secure server hosted at the University of Victoria. This is done using the Mountain legacy Editing and Administering Tool (MEAT), a customized data structure developed by Christopher Gat. They are then backed up again to an Amazon cloud hosted off-campus.

It is possible for the general public to access the majority of the data through the Explore tool on the MLP website (explore.mountainlegacy.ca). Interested persons can retrieve images by surveyor/survey/year or geographically using the provided map. The data is publicly available for non-commercial purposes through a Creative Commons license.

**Alignment**

Once the repeat images have been taken, edited, and uploaded to the MLP's server, the next step is to ensure proper alignment between images. Typically this is done in MEAT, but is also an existing alignment feature in the Image Analysis Toolkit (IAT; see below).

The procedure is to select two corresponding images (a historic and its repeat) and define four pairs of control points. Ideally, control points are well spread across the image (i.e. minimizing collinearity). Then the historic image is scaled, rotated and translated to match the repeat. Once the tool is run, the alignment can be verified using a slider and the points can be adjusted as needed. When satisfied, the user can confirm and save the newly aligned images, which are ready for further analysis.

# Possible applications

**Public education**

The repeat photographs in the Mountain Legacy Project's collection have tremendous value for helping us understand landscape change in the mountains of western Canada. One of the best uses for the photograph pairs is as a visual aid for public education.

Notably, the photographs we work with are taken from the landscape, i.e. "oblique photos". One could call it a "human's eye view", as opposed to "orthogonal photos" which are a bird's eye view taken from the sky. Oblique photos are easier for us to understand and interpret, as it presents the land in a familiar way. This is particularly useful when eliciting insights from local people; they can instantly recognize the views and situate themselves within a photograph. In addition, aspects of the photograph can incite narratives which are relevant to the changing landscape.

Furthermore, the images bring to light shifting baselines. This occurs when memory of past conditions is not entirely accurate; people might think that no change has occurred when indeed it has, or alternatively, that more change is occurring than actually has occurred. In these instances, the MLP can help by illustrating true historical conditions, allowing people to see genuine, measurable changes.

The relevance of photo-elicitation and public education, beyond simply public interest (which is significant and not to be discounted!) is to help inform public opinion regarding management decisions. For example, the forest near a town may have significantly infilled over the course of the last century, increasing the risk of wildfire, and this is visible in MLP photo pairs. Wildfire management officials would seek to schedule a prescribed burn or other management efforts to decrease wildfire potential near the town. They might use the photographs as a visual aid when explaining their management plan to the people living in the town, to have better understanding and public support.

### Quantitative analysis

Beyond public education, the MLP image pairs are used in scientific studies to quantify landscape change. To aid in this goal, Michael Whitney and Mary Sanseverino, two researchers in the MLP lab, have developed the Image Analysis Toolkit. This customized software runs entirely on JavaScript and is used to analyze and visualize image pairs.

IAT can be used for many parts of the MLP's process. It has an alignment feature to make sure images in a pair correspond. It has a masking feature which enables users to segment and classify images according to their own customizable categories. It has a count feature to quantify the number of pixels in each category in both images. In addition to all this, a number of tools help the user visualize change (e.g. through a slider, "fading", or generating a third mask highlighting similarities/differences between the first two).

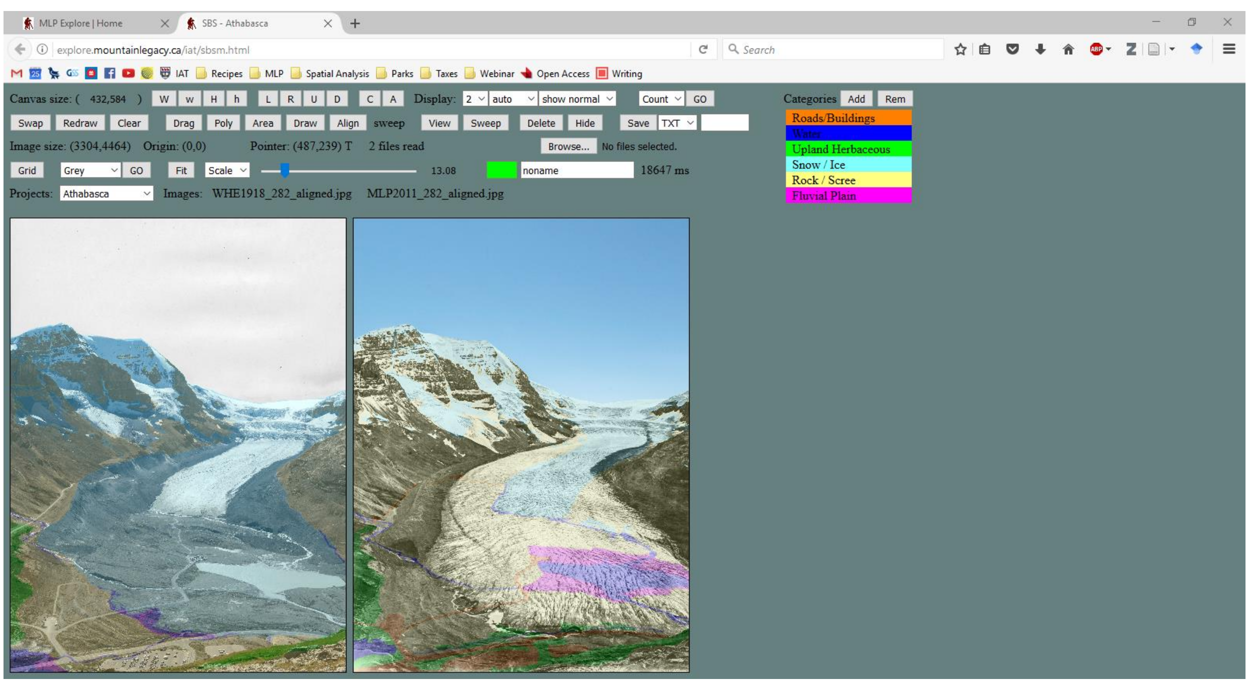


**Fig 5.** Screenshot of the Image Analysis Toolkit in June 2017 working on an image pair of the Athabasca Glacier.

In aerial or satellite remote sensing datasets, quantitative analysis goes a step further from extracting quantitative information to extracting geospatial information about the landscape. This is more of a challenge with oblique photos because of the distortion of the areal surface. Oblique images allow quantitative comparison between pictures but only on a pixel-by-pixel basis; spatial information cannot be extracted. That being said, in recent years, tools (e.g. the WSL Monoplotting Tool by Claudio Bozzini) have been developed in conjunction with advances in Digital Elevation Models to spatially georeference oblique images.

Currently, the majority of analysis using MLP photographs is done manually. For one, the alignment function is fed user-defined control points. For another, segmentation and classification is completed by hand by an expert. The objective is that eventually, these parts of the process will be automated. This would significantly reduce human error and would improve consistency in analysis methods across surveys. Work is being done at the time of this writing to evaluate the accuracy of automated, semi-automated and manual classification of oblique images.

For examples of research projects which have done quantitative analyses based on MLP image pairs, see the works of Lisa Levesque, Adrienne Shaw, Graham Watt, Will Roush, Rick Kubian, Mandy Annand, Christopher Gat, Tanya Taggart-Hodge, Julie Fortin (see Additional Resources).

## Acknowledgements

Thank you to Dr. Eric Higgs for advice and editing, to Kristen Walsh, Tanya Taggart-Hodge, Mike Whitney, Mary Sanseverino, Hyeone Park, for their active contributions, Ellie Stephenson for making an Intro to MLP document in 2010 which I found quite useful, and all members of the MLP, past and present.

# Additional resources

## Readings


- Bridgland, M. P. (1916). *Photographic surveying in Canada*. Geographical Review, 2(1), 19-26.
- Jean, F., Albu, A. B., Capson, D., Higgs, E., Fisher, J. T., & Starzomski, B. M. (2015). Visualizing Category-Specific Changes in Oblique Photographs of Mountain Landscapes.
- Sanseverino, M., Higgs, E., Whitney, M.J. (2016). Exploring landscape change in mountain environments with the Mountain Legacy Online Image Analysis Toolkit. *Mountain Research and Development.*
- Smith, T. (2007). Repeat photography as a method in visual anthropology. *Visual Anthropology*, *20*(2-3), 179-200.
- Webb, R. H. (2010). Repeat photography: methods and applications in the natural sciences. *Island Press.*


## Websites/tools

- www.mountainlegacy.ca
- MEAT User Guide: http://142.104.186.168/user_guide
- IAT: http://web.uvic.ca/~msanseve/sbs/sbsm.html
- Repeat photography process: http://web.uvic.ca/~wanthony/phenology/docs/Documenting-Landscape-Change-Repeat-Photography-and-Photo-Point-Monitoring.pdf
- Before/after photography: https://www.fourmilab.ch/images/lignieres_then_and_now/craft.html
- WSL Monoplotting Tool & how to use it with MLP: http://learnsharenetwork2014.sched.org/event/33f89df3cc99477592d3780254b6786a#.VCR4ritdV0Q