Lab 7: Glacier extraction

1. Introduction

This lab uses the Landsat 9 OLI 2023 image of the 'Resthaven Icefield' (rh) from the Willmore Wilderness, AB (September 9, path 46-23) .
The file contains bands 1-7
The PAN (chromatic) band 8 remains as a separate pix file because if we included it in the multispectral file, it would lose its higher resolution (15m).

In windows explorer, copy to your own folder, these files from *L:/geog357/*

rh2023.pix
rh2023pan.pix
rh2023thermal.pix

This is a good late summer image with little remnant snow outside the glaciers – which would look the same spectrally as snow on glaciers, but the shadows are heavy.

2. Data display

Open the 3 files, with the multispectral file visible -not hidden below the Pan/thermal:
rh2023.pix – change display to 432 in RGB and zoom in on some shadowed glacier areas – can you see glaciers in the shadows ?
now change display to the 654 composite (enhance) – the shadows are likely darker

click the display between the 654 composite and thermal file to see how they relate to each other. The thermal is lower spatial resolution.(100m) but certainly picks out the ice and shadows (cooler) versus the two 'recent' fire areas (2007/2015) as 'warmer' – due to the removed vegetation, not from remnant heat from the fires (='drier' in SWIR band).

Examine the histogram for the thermal layer (right-click on filename -> histograms)
Q1a. What are the minimum and maximum DN values ?
Q1b. How does the standard deviation (range) compare with the reflective bands (654)

- *Comment generally, don't need exact values – and explain why this is the case*

click the thermal layer off

Compare the 654 and Pan displays in the glacier areas
– zoom in to see the higher resolution (15m) - look for glaciers/snow in the shadows and compare with the RGB display.

3. Glacier extent extraction

a. Unsupervised classification

Run a quick Isodata classification (analysis->Image classification) – input bands 4,5, 6 and use the default values – 16 classes; you will need to add a new empty 16 bit (unsigned) layer to hold the classification output

You will likely find it can't distinguish shadows from other features and does not isolate glaciers sufficiently into clusters. Could you group several clusters to extract glaciers – maybe not exactly, but it's not a tidy method.

Q2a. How many clusters cover ice/snow – and which ones ?
They should be consecutive cluster numbers
Q2b. Why are there several just for snow/ice when there are so many other cover types?
(this was noted in the lecture on glaciers)

b. NDSI

Use the raster calculator (RC) to create NDSI: (Green – SWIR) / (Green +SWIR)
remember to single click on operators and double-click on bands selected
Output to 32-bit layer (display) .. and save to your Resthaven (rh) file

Glaciers have the highest values for clean snow and ice, but can't always isolate these. three problematic features: shadows, water and debris-cover. What seems to be a good lower threshold value for snow/ice ? (and excluding most water).

View the histogram for NDSI and see what DN might separate the two peaks in the curve (land / ice). Run THR with your best guess (minimum) threshold value

Q3a. what is your chosen NDSI threshold value for snow/ice ?
3b. If you reduce it slightly, which other land cover types does it start to include ?

c. Create a Red/SWIR ratio

Use the Raster Calculator to create the Red/SWIR ratio (4/6)
Output to a 32-bit layer and save to your multispectral .pix file (ALWAYS!)

Tools-> Raster calculator .... you know how to do a ratio - make it so. Run.

Edit the description for the new layer/channel to: something like Red/SWIR ratio
Review the histogram for the new channel – a suitable threshold value should be somewhere in the dip between the two peaks (land and snow/ice).

4. Thresholding snow and ice

Click around the ice surfaces to see possible threshold values, especially the darker ice near the snouts. To compare with the 654 display, highlight the ratio channel, but check it off, and view the 654 RGB; click around to review ratio values on the darker ice areas.
For TM data, we normally use 2.0 as a threshold to identify snow and ice, but here with OLI data, 2.0 captures most ice and snow but not all the darker ice near the snouts.
It could be more like 1-7 or 1.8 – otherwise we lose some glacier snouts..

The exact value is always a toss-up between getting all the ice but include some non-ice. Make your own judgement - there may not be a perfect value, and there's always possible sieving and editing afterwards.

We can first use THR to generate an ice bitmap, as we've done before.

THR

We want to send all pixels with high DN in ratio channel DN e.g. > ~1.75 to display (bitmap)
Input = the ratio channel
Parameters: minimum threshold = choose your value (maybe 1.7-1.8 ?)
no value needed for maximum
Run

Check display - too much, too little or good enough ?
- Compare with 654 composite by clicking bitmap on and off

Try different values and settle on your best option
Then run THR again and save to your rh2023 .pix file (NEVER untitled.pix)

We could then run BIT2POLY as we did in earlier labs, to create glacier vectors.

But, there are two issues with the bitmap approach:

a. . There are isolated pixels, and small groups – and you can't sieve a bitmap

b. The threshold fails to find glaciers in shadow as the ratio DN is lower, but does find (silty) water which has higher DNs. Flip between the 654 composite and pan image to better see the glaciers in shadows; in comparison, they are hard to see in the IR.
See also where the threshold has included silty lakes. e.g. 329000E, 5925000N

For this lab we'll finesse the threshold for silty lakes, but leave the shadows for now.

5. EASI MODELLING SCRIPT

We can help solve the silty lakes by adding a condition using the near-IR band – as ice reflects NIR more than silty water. Query the 654 composite on ice and in silty lakes to see the NIR values (displayed in the G gun). the value separating them could be ~8000 ? Check for yourself if this value works

Lakes – if we use a condition where ratio > 1.x AND near-IR > 8000
Then we will write to a new empty channel and set this condition as below:

Set-up

Create a new empty 16-bit (unsigned) channel to contain the result:
Switch to the files tab, and right-click on rh2015.pix
New-raster layer – 8 bit .. add
This should create a new raster 'contents not specified' in the listing on the left

- It should be layer 11 (7 band channels, + unsupervised + NDSI + ratio + new)

Check your rasters if unsure
This will be %y below .. don't type y !!! It should be 11 ?
What is the channel number for your ratio (e.g. 10?) – this is %x below – don't type x !
Why do I emphasise this – because every year someone types X and Y however many times I say "don't" … x and y are only 'placeholders in case your file is different.

First load the new empty channel:
Layer-> add -> pseudocolor -> your empty channel (11?)
Nothing will appear (yet) as its empty

Tools-> EASI Modelling
To extract glaciers and deal with silty water, enter this script:

```
If %x  > 1.x and %5 >8000 then
%y = 255
Endif
```

Where x = your ratio channel and y= your empty channel
DON'T TYPE x and y (did I already say that?)
You must include THEN or then on the end of line 1 (as above)

Run

Can you see the logic ? %x = the channel number, just like in raster calculator
Why do we use 255 in %y – to maximise the difference between ice (255) and not ice (0)

Note: if somehow you mess up the new channel layer, you can refresh it by typing a simply script: %y = 0 run (where y= 11 ?) .. DON'T type 'y' !!
This simply 'cleans the slate' and makes the channel empty again
If you did this to one of your bands, you would wipe out that layer, so check you have the right channel first – it should NOT be 1-10

Check your new channel that should contain ice/snow – it should have appeared on screen, almost the same as the previous bitmap but with silty lakes removed – click the bitmap on and off to see the difference.
If the new layer ice appears as black and a colour would be nice, right-click on that layer and change it using the Representation Editor

It should also have many small areas due to the nature of pixelation plus there are small remnant snow pockets, and we only want the 'real' glaciers which exceed a given size. Check the layer by clicking on and off with the 654 (30m) composite – and then for shadow areas view the 432 (15m) composite. We'll accept we lost some [if you choose glaciers for your project, we could modify the script to add shadow glaciers)

Debris covered ice: we can't do much about this – it's an advanced research topic.
e.g. there's debris-covered ice ~ 340000E, 5922500N

6. Conversion to vector: EXPOLRAS

We used this in the Feature Extraction Lab
Input file will be your new channel containing only glaciers (11 ?)
Output to your rh2023.pix file

The threshold minimum parameter would be 11 for a hectare standard or 22 for 2 ha.
In glacier mapping, we often use 5 hectares as a minimum = 55 pixels.
Set your threshold minimum to 55
run .. if the result looks good, you are ready to smooth

Now smooth these vectors as you did in Lab 5 using **SMBOYLE** in the alg.lib

Input = the vector layer just created in EXPOLRAS

(and always write the result to your .pix file)

Change vector colour if needed by: right-click on vector layer (Maps tab) -> colour

7. Vector attribute table

From the attribute manager:
Q3a. What is the sum total area (km^2) of glaciers in 2023 ?
3b. What is the area of the icefield – the largest glacier polygon

Check the section in Lab 5 if you forget how to do this
You can also save as a shapefile: - Right-click on the vector label in maps tab-> Save as -> Arcview Shapefile e.g. rh-glaciers2023.shp

8. Using the higher resolution PAN band

As described in lecture, some like to use the Pan band on Landsat 8/9 instead of the Red band to create the ratio layer with 15m resolution.

First you will need to add the NIR (5) and SWIR band (6) to the pan file (not vice versa)

File-> Utilities-> Transfer layers…

In the pop-up window, source file = rh2023.pix

Destination file: rh2023pan.pix

Highlight bands 5 and 6, then click add , then 'transfer layers' and close

Display your transferred SWIR layer in the pan file to check it worked:
Layer-add-grayscale .. and pick the SWIR layer in the PAN file
The SWIR band now has the same resolution as the PAN band, but looks blockier as you can't just add detail by duplicating pixels, … this will happen with the new ratio:

Repeat steps 3c->7
… but using the PAN band instead of Red, and pan .pix file instead of rh2023.pix

3c: Pan / SWIR ratio – using the rh2023pan.pix file (it will become channel 4)

4. Thresholding the ratio –examine the best DN threshold – likely to differ from before

5. EASI modelling to exclude silty water – using the pan file (it will become channel 5)

6. Conversion to vector – again all in the pan file

7. Vector attributes – revised glacier area using the higher resolution

.* your ratio and threshold values in 4 may/will be different to before with Red/SWIR, you will need to find this new value to create the best glacier outlines
However the NIR value (8000?) will stay the same. [we had to include the NIR band in the transfer so you can include the silty water factor in step 5].

Q4a. What is your threshold DN this time round ?
4b. What is your glacier area estimate using this method – it should be close to your previous answer in section 7

Q5. Screen capture the main part of the image containing ice, with your vector (either one) overlain in a contrasting colour to the background (rh2023 bands 654 composite). Create a second jpg zooming in to a glacier edge so that both vectors are visible as on the overview, the two vectors would likely complete overlay each other.

Attach these jpg images in your PDF file submitted via Moodle.

One way to screen capture to show your result – you may have other ways.

With the suitable background image: rh2023.pix bands 654
Zoom to the main glacier area so it is all visible
Add your one of your two final glacier vectors (or both), you will likely find they mostly overlap and only the top one is truly visible
ensure colours for your 2023 glacier outlines for best contrast
right-click on vector layer in Maps contents list - -> colour

*If you had issues generating the 2nd one (using the PAN band) or ran out of time, then just display the first glacier outlines created …

On your keyboard, Select PrtSc button - The screen image will turn gray

Draw a ‘clipping box’ around the area you want using the cross-hair

Grab the main glacier area

Open Paint (or some other graphic package) and pick ‘paste’

Save as .jpg