

Lab 7: Change and Glacier extraction

This lab mostly uses the Landsat 8 OLI 2015 image of the 'Resthaven Icefield' from the Willmore Wilderness, Alberta. This contains bands 1-7 plus band 9 (Cirrus) in channel 8. 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).

We'll also view the Landsat 5 TM images from 10 August 1986 and 8 August 2008, near anniversary dates, while the 26 August 2015 Landsat 8 image (rh2015.pix) is two weeks later, with fewer snow patches, but more shadows (and 16-bit data).

1. Viewing the images and changes 1986-2015

Copy these .pix files to your labs folder from *L:/GEOG357/willmore*
rh2015.pix

resthaven2015pan.pix

thermal2015.pix

You will also use these two files, but they can stay in L: as you'll only view them:

resthaven1986.pix resthaven2008.pix

Start Catalyst → Focus

Open the 3 main image files for 1986, 2008 (from L:GEOG357) and 2015 (your folder) change to the optimal combo (SWIR, near-IR-Red) 543 (TM) or 654 (OLI); enhance and try to get equal stretch/contrast on each image – note that you need to highlight each file in turn to enhance that image.

click off the top one, then the second one to see each in turn, and the changes.

The most obvious changes are the two big fires in Jackpine River valley (2007) and Smokey River (2015) ... for location, if you continue up the Smoky River valley, you end up crossing the border into Mt. Robson Park just above Berg Lake. The fire effect is way more imposing than if you view it in 'natural colour' on google earth timelapse.

Here's a first question for you:

Q1. Explain the changes in the Digital Numbers for the two fires for the 3 bands shown i.e. whether red, near-IR, SWIR decreased or increased between the 3 dates and why.

Don't use the colour guns RGB to explain e.g. Green went up, although you may in conclusion say 'this is why it appears' this way on the image.

Do this by examining DN values inside and just outside the fire area for similar forest or by comparing the two Landsat 5 images, as the DNs all change in 2015 with 16-bit data. You can't easily compare 8 bit and 16 bit data values ..

Two small dark objects appeared on the 2008 image, maybe new lakes or maybe not. One is at ~331500E, 5918500N; the other at ~333250E 5937000N – scroll around to find these locations or better - input them using the +x,y button (enter) .. cursor should move there. Use the zoom in button to find them.

An interpretation question – look around where they are for the answers:

Q2. What are the two dark objects that appear in 2008 ... and why are they there ?
(one stays in the 2015 image, the other is gone in 2015)

Another change is the vegetation seems to be advancing up the alpine slopes thru time. – check it out ...

Finally there is evidence of glacier retreat, though this is compounded with less seasonal snow in 2015, as it is two weeks later in the year. Zoom in on the glaciers to see some definite retreat and also new meltwater lakes where there used to be ice.

You can also see where glaciers used to be in the Little Ice Age (~1400-1850).. see for example, the general area surrounding 330500E, 5924000N

There are tricky areas hidden by dark shadows plus debris cover e.g. 341000, 5922000

General repeat notes:

a. The DN value display below the image relates to the highlighted layer, not necessarily the top layer, nor even one being displayed. This can be useful as e.g. you could display the colour composite but query ratio values etc.. or for question 1. to see the DN values for the same pixel in two images, just highlight each image name in turn under maps tab.

b. Always add any new layers to your **rh2015.pix** file (NEVER to 'Untitled.pix')

From here on, we will only use the 2015 image, so it may be less confusing to remove the other two images from the area (use the files tab-> remove from project)

For interest, let's see what is in the Cirrus band (band 9=channel 8)

Layer-add-grayscale – channel 8

You can see the high clouds plus some background imagery

Check the 654 composite and the clouds are slightly less intrusive

Switch your display to the visible bands (432), and now they are slightly more visible.

This demonstrates the IR bands' ability to penetrate haze and 'some' similar light clouds

We will first 'fuse' your OLI high resolution (15m) PAN band with three selected RGB multispectral bands (30m), and view the results, to use for checking derived vectors.

Then we will use the OLI (30m) image to extract glacier extents for 26 August 2015.

These steps will set the final lab assignment questions.

2. Pansharp

Add a normal colour composite to the display
Layer -> add -> RGB -> select 4,3,2 and enhance

Also open the high res PAN .pix for the same area: resthaven2015pan.pix (enhance)
and compare – zoom in on a lake and/or a glacier edge and note the higher detail /
resolution ... check the number of pixels of the PAN file - it has twice as many in x and
y as the main file (files tab, right-click -> projection), and overall 4x the size

In tools -> algorithm librarian find the **PANSHARP** task

Input multispectral channels: 432 bands (in the correct order)

InputPan: Panchromatic Image : Tick the Pan Band file

Output: Viewer-RGB

Note: if you want to save the layer, you must write to the PAN band pix file (we want
15m pixels) – otherwise it would be 30m pixels (but it's enough just to have it onscreen)

Parameter: Enhanced Pansharping: YES

Run

As usual, enhance if needed – this will simulate 15m multispectral pixels

From a distance it may look the same as the 432 composite, but when you zoom in you
should see a less pixelated image. This image will be useful to check the glacier outlines
and to see more details in the shadows.

Zoom in on a shaded glacier area and look into the shadows, then on the pansharpened
composite – in comparison, a downside of the IR bands is they make shadows darker.

3. Glacier extent extraction

Data display

View the 654, 432 and Pan displays - compare the details visible in shadowed areas
versus the 432 and pan sharpened combinations – especially look for glaciers/snow in the
shadows and compare the RGB displays.

Note that this is a good late summer image with little remnant snow outside the glaciers –
which look the same spectrally as snow on glaciers.

We can load the thermal band to see if it helps
file-> open .. select thermal2015.pix (enhance as needed)
it's lower spatial resolution..(100m) and certainly picks out the ice versus the two fires;
click between the thermal band and 654 composite to see how they relate to each other.

a. Unsupervised classification

Run a quick Isodata classification (analysis-Image classification) – input bands 4,5,6 and using the default values – 16 classes; you will need to add two more 8-bit layers

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, but it's not a tidy method.

b. NDSI

Use the raster calculator to create NDSI: $(\text{Green} - \text{SWIR}) / (\text{Green} + \text{SWIR})$
remember to single click on operators and double-click on bands selected
Output to 32-bit layer – save on viewer and as a new layer in your pix 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 create the ratio. (Run). Close RC

Edit the description (files tab) for the new layer/channel to: something like red/SWIR

Review the histogram for the new channel – a threshold value should be somewhere in the dip between the two peaks.

4. Thresholding snow and ice

Click around the ice surfaces to see possible threshold values, especially the darker ice near the snouts are tricky. 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 1.8 – otherwise we lose some glacier snouts..

The exact value is always a toss-up between getting all the ice but including 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.

THR

We want to send all pixels with ratio channel DN e.g. $> \sim 1.8$ to display (bitmap)

Input = the ratio channel

parameters - minimum threshold = choose your value (maybe 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 rh2015.pix file (NEVER untitled.pixyawn!)

We could then run BIT2POLY as we did last week, to create glacier vectors.

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 pansharpened 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 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 DN values (displayed in the G gun). I find the value separating them is ~ 8000.

Lakes – we will use a condition where ratio > 1.8 AND near-IR > 8000
So we will write to a new empty channel and set this condition as below:

Set-up

What is the channel number for the next empty channel you created under 3a. above ?

Check your rasters if unsure

This will be %y below .. don't type y !!! It could 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 ‘placeholders in case your file is different.

First load the new empty channel:

Layer-> add -> pseudocolor -> your empty channel (12?)

Nothing will appear (yet) as it's empty

Tools-> EASI Modelling

To deal with silty water, enter this script:

```
If %x > 1.8 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?)

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= 12 ?) ..

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 !

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.

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 pansharpened 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 and also 3337000E, 5930000N

6. Conversion to vector: EXPOLRAS

We used this in the Feature Extraction Lab

Input file will be your new channel containing glaciers (12 ?)

Output to viewer and as a new layer in your **rh2015.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 6 using **SMBOYLE** in the alg.lib

Input = the vector layer just created in EXPOLRAS

(and always write the result to your .pix file – have I said that before ?

7. Vector attribute table

From the attribute manager, What is the sum total area of glaciers in 2015 in km²

Check previous labs if you forget how to do this – right-click on ‘area’ -> table definition

Also save as a shapefile:

Right-click on the vector label in maps tab-> Save as Arcview Shapefile

(with a suitable name e.g. rh-glaciers2015.shp)

8. Glacier area extent change

Using the 654 composite as background image, ensure your glacier outlines from 2015 are displayed and also load glacier extents from 1985 (provincial mapping) and 2005 (UNBC glacier project).- as follows:

These are stored in L: /geog357/shapefiles: rh85.shp and rh2005.shp

Pick suitable colours for each of the 3 years so they are visible and distinct.

Your outlines won't be perfect – neither were these two historic layers, but ideally new extents do not extend beyond the old ones, as no glaciers would have advanced.

Q4. The glacier area declined from 67.84 to 57.30 km² between 1985-2005.

*How much has it changed 2005-2015 based on your new glacier vectors ? **

**you could also do this estimate in ArcGIS or QGIS if you prefer ...*

Zoom to the glacier area so it is all visible onscreen, ensure a good colour for your 2015 glacier outlines for best contrast (yellow?); you can remove the 1985 and 2005 outlines for better clarity and use a screen capture to save the glacier area image and 2015 outlines – there is a Snipping Tool app to save this image as jpg ... just the main glacier area [draw a window around your selected area, and in the new window, save asjpg
You could also use Windows Paint

please email me if you are not sure how to do this- you need the image only in best detail, not the surrounding Focus or frame/window. (see example on next page)

Q4-5. Include this jpg with your answers for the last mark out of 5.

Please email your answers to wheate@unbc.ca by Monday 11am

I suggest a word document with both the text answers and .jpg embedded inside rather than a separate doc and .jpg

First questions repeated:

Q1. Explain the changes in the Digital Numbers for the two fires for the 3 bands shown i.e. whether red, near-IR, SWIR decreased or increased between the before/after dates and why. (use spots inside/outside fires for a clearer view)

Q2. What are the two dark objects that appear in 2008 ... and why are they there ?

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 ?

Optional extra

There is also a matching DEM in the labs/willmore folder
We would have used it if we hadn't lost a lab or two

You can copy it over to your folder

Display the DEM in grayscale

Generate a slope layer (they combine slope and aspect in 'SLASP') / display in grayscale

You could also create perspective views, or a fly-through – we might view this in the last labs if you wish. If you wanted to include DEM layers in analysis, you'd have to transfer the DEM layer into your multispectral file e.g. write a query to require that all water bitmaps also had Zero slope (were flat).

Sample glacier snip:

