# Lab 8: Change, Glacier extraction and Image fusion

This lab mostly uses the Landsat 8 OLI 2015 image of the 'Resthaven Icefield' from the Willmore Wilderness. The file contains bands 1-7 plus band 9 (Cirrus) in channel 8. The PAN (chromatic) band8 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 */home/labs/geog357/willmore2015* (the other .tif files in the folder were used to create these)
rh2015.pix
resthaven1986.pix
resthaven2008.pix
resthaven2015pan.pix
thermal2015.pix

**Start Geomatica Banff → Focus**
Open the 3 main image files for 1986, 2008 and 2015 (in that order)
change to the optimal combo (Mid-IR, near-IR-Red) 543 (TM) or 654 (OLI); enhance
try to get equal stretch/contrast on each image
click off the top one, then the second one to see each in turn.

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, mid-IR decreased or increased through 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 also newly appeared on the 2008 image, maybe new lakes or not. One is ~331500E, 5918500N; the other ~333250E 5937000N – scroll around to find these locations or input them using the +x,y button (enter) .. cursor should move there. An interpretation question:

*Q2. What are they ... and why are they there ?*
(one stays in the 2015 image, the other is not present)

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 snow in 2015, as it is 2 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 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

**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)**

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

**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

## 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 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 Pansharpening:  YES
Run

As usual, enhance as needed – this will simulate 15m multispectral pixels
From a distance it will 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 – a downside of the IR bands is they make shadows darker.


## 3. Glacier extent extraction

**Data display**

Compare 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 one or more 8 bit layers – add
three (3) for use in this lab

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: (Green – Mid-IR) / (Green +Mid-IR)
remember to single click on operators and double-click on bands selected
Output to 32-bit layer and save to your rh2015.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).

## c. Create a Red/Mid-IR ratio (OLI 4/6)

Use the Raster Calculator to create the red/mid-IR ratio (4/6)
Output to a 32-bit layer and save to your multispectral .pix file

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

Close RC

Edit the description for the new layer/channel to be ratio-red/mir
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. 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 > ~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

We could then run BIT2POLY same 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 ?
This will be %y below .. don't type  y !!!  It could be 12 ?
What is the channel number for your ratio  (11?) – 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 its 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 mamkes 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 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


## 5b. SIEVE

We will use SIEVE to reduce pixel groupings for minimum glacier size and retain the interior valid non-glacier islands ('nunataks') which are often small by entering 0 in the 'exclude values' parameter. Choose 55 (5 hectares) for polygon size threshold.
 Input = the channel number created in the last step; Output to your rh2015.pix file
Be sure to view the sieved result
The resulting channel will be input into the next step.
 I had removed this step as EXPLORAS can reduce small areas, but it doesn't always seem to work, so we still need to sieve first.


# 6. Conversion to vector:  EXPOLRAS

We used this in the Feature Extraction Lab
Input file will be your new sieved channel containing glaciers (13 ?)
Output to your rh2015.pix file

The threshold minimum parameter would be 11 for a hectare standard or 22 for 2 hectares. In glacier mapping, we often use 5 hectares as a minimum = 55 pixels.
**Set your threshold minimum to 55 (again!)**
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)

## 7. Vector attribute table

From the attribute manager, What is the sum total area of glaciers in 2015  $km^2$
Check previous labs if you forget how to do this
Also save as a shapefile:
Right-click on the vector label in maps tab-> Save as Arcview Shapefile
 (with a suitable name  e.g. glaciers2015.shp)


## 8. Glacier area extent change

Using the 654 composite as background image,  load glacier extents from 1985
(provincial mapping) and 2005 (UNBC glacier project).- as follows:
These are stored in /home/labs/geog357/shapefiles:  rh85.shp and rh2005.shp
The 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.

*Q3. The glacier area declined from 67.84 to 57.30 $km^2$ between 1985-2005.*
*How much has it changed 2005-2015 based on your new glacier vectors ?*


Turn off the 1985 and 2005 glacier vectors and keep your 2015 vector layers.
Zoom to the glacier area so it is all visible onscreen, choose a colour for your 2015
glacier outlines for best contrast (yellow?) and use a screen capture from Osmotar
– there is a Snipping Tool app in Osmotar  to save this image as jpg  ..

please email me if you are not sure how to do this-  I need the image only in best detail,
not the surrounding focus or osmotar frames


*Q4-5. Include this jpg with your answers for the last 2 marks out of 10.*