GEOG 357, Remote Sensing:
Lab 7 CHANGE DETECTION

1. Introduction and goals

We will look at 'change' comparing image data for the Resthaven Icefield subset – same image area as Lab 6 - Path 46, row 23, images subset from their full-resolution bundles

1a. Follow up from lab 6: glacier retreat
Load (open) **rh2023.pix** .. and display the SWIR-NIR-Red composite
add the BC TRIM 1985 glacier vectors: from L: \GEOG357\shapefiles\rh85.shp
(remember to click below on the available segments after selecting the filename)
Click OK on the projection warning box…

When you zoom in, you can see general glacier retreat from 1985-2023, the total area is reduced from 1985, which was the BC provincial TRIM mapping from aerial photography. Review the attribute table for the 1985 shapefile and see if you can display the total glacier area (click on the blank table record above the yellow space). You should find: Glacier area 1985 = 67.84 km^2

Q1a. Using your area answer from Lab 6, what was the % glacier area loss 1985-2023 ?

Q1b. For the 3 prominent Icefield outlet glaciers on the SE side, what has been the approximate general linear retreat 1985-2023 (in metres) ?
use the line measuring tool – this will be very approx.. A ballpark figure of 10m /year is typical.

We'll go back in time to see the glaciers then and impact of two major fires in 2008 and 2015.

The images are as follows:
1. August 10 1986 Landsat 5 TM
2. August 8 2008 Landsat 5 TM
   (almost 'anniversary dates' with similar snow patches)

3. August 26 2015 Landsat 8 OLI-1
4. September 9 2023 Landsat 9 OLI-2 – you already have this one

These two later dates involve longer shadows but fewer remnant snow patches, so they should be superior for glaciers but they also have late summer vegetation (= declining NDVI values).

The goal of the lab is to enhance and capture 'actual' change (in the DNs) from 1986-2023.
The biggest events were two major wildfires in 2007 and 2015, plus gradual glacier retreat.

2. Viewing the images and changes 1986-2023

Copy these three .pix files to your labs folder from *L: \GEOG357\labs2025*
resthaven1986.pix
resthaven2008.pix
rh2015.pix

Open these image files for 1986, 2008, 2015 (your folder)
change to the optimal combination for each (SWIR /NIR/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. Rearrange so they are in time sequence – i.e. move 2023 to the top
Click off the top one, then the second one to see each in turn, and the changes.
Enjoy the animate / time travel - watch the glaciers grow if you go backwards 😊

Features: Resthaven Icefield, Ptarmigan Lake (top), Twintree Lake (SE corner),
Jackpine River fire (top) and Smoky River fire (running south-north on the east side)

The most obvious changes are the two big fires in Jackpine River valley (2007) and Smoky River (2015) … for location, if you continue south up the Smoky River valley, you would cross into Mt. Robson Park just above Berg Lake. The fire effect is much more imposing than if you view it in 'natural colour' on google earth timelapse. There is steady glacier loss 1986-2023.
You can also see in the Smoky River some new wetlands and several channel changes.

There are some pesky clouds in the 2015 image, above the 2015 fire.
Load the Cirrus band to see how it looks: But not much we can do about it …
Layer-> add -> grayscale -> cirrus (band 9 in channel 8) – finish
Untick the grayscale display (and right-click – remove from display)

Here's another question for you:

Q2. Describe the changes in the Digital Numbers within the 20007 fire for the 3 bands shown i.e. whether each of Red, NIR, SWIR decreased or increased between 1986-2008 and approximately by how much?

The best way to do this is to click inside the fire on the 2008 image, and then in the Maps tab highlight first the 1986 image, then the 2008 image, while the cursor stays on the same point; note the 3 DN values; you can try this for a couple of sample points.
This is not as easy for the 2015 fire as you can’t easily compare 8 bit and 16 bit data values ..

There is also a new landslide between 1986-2008 just south of Jackpine River (~ 334100, 5937000) which has created a small lake (~333000, 5936900) . zoom in on this feature.

Interesting geography: You could use Google Earth Time Lapse and zoom in to determine when this slide occurred. (Google Earth / time lapse is able to find Resthaven Icefield)

Can you see where the landslide was initiated – zoom in on Catalyst, possibly glacier melt failure

Another may look like a new lake ~331500, 5918400 but it's a shadow –see the cloud (to the SE)

A small change is vegetation may be possibly advancing up the alpine slopes through time. I'm often asked this by outdoors people – whether we can see the treeline advancing upslope.

Finally there is less seasonal snow in 2023, 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. But the 2023 image does have more snow on the glacier accumulation area – a good glacier summer!

3. Simultaneous display

Display the equivalent bands from the first 3 dates simultaneously: **layer-> add -> RGB**
Start with the NIR bands: for 2015, 2008 / 1986 in RGB to contrast the fires
.. 2023 would show subsequent regrowth / green-up
NIR: Band 5 (2015) in Red, band 4 (2008) in Green and band 4 (1986) in Blue -
You'll need to select the file and band each time … Enhance as needed

Overall, the 16 bit band in red dominates the image colour; otherwise an increase in DN (vegetation health) over the (~30) years will show as red, and no change as gray/pink shade; decreases will show in blue/green

Q3a. Briefly explain the relative DNs and thus resulting colors of the two fires over these years ? Answer in terms of the vegetation cover and that you are viewing the NIR band.

3b. what is the nature of the area that shows as yellow in the extreme SW corner of the image ? (refer back to the 654 composite for any of the four years)

Now use the RGB Mapper to switch these 3 channels to the SWIR1 band (Band 6 / 5 / 5) for each image (enhance) .. this may be more illustrative as glaciers will be black (no SWIR reflection). Increased SWIR reflection = increasing dryness (less trees, less water/ice). This should pick out both the fires and glacier change … and also changing shadows (longer in 2015).

As commented in class, it is tricky working with individual bands – especially with a mix of 8-bit and 16 bit data, so the next section will involve image subtraction using two indices: NDVI and NBR (burn ratio), which as normalized indices avoid individual band DN differences.

To save time, and avoid some past issues with Raster Calculator and new channel creation, I did some work for you and prepared a pix file containing the four NDVI layers, and another with burn ratios and delta burn ratios (the change between two burn ratios).

4. Image differencing

Copy over these two files from L: \GEOG357\labs2025 to your own folder:
rh-ndvi.pix
rh-burns.pix

NDVI

Open the NDVI file
– the layers are in chronological order, so it opens with dates 1-3 in RGB.
Switch to the Files Tab to check what the raster layers are, and then back to the Maps Tab
'No change' displays in gray where the 3 years have similar DNs for those locations
Annoyingly you will see some 'no data' (N/A) pixels where Raster Calculator cannot handle a Zero value in the NDVI equation i.e. where Red = NIR reflection DN for any pixel..

For the Jackpine fire area, review the NDVI values in RGB and looking at one or two points, what are typical DNs for 1986-2008-2015; their relative values should make sense as you are seeing before the fire, directly after, and then after almost a decade of recovery.

4a. What is the approx. mean NDVI value for the two Landsat 5 images and for the two later images (2015/2023). Two decimal places are enough.

Possibly any difference between the two pairs might be due to changes from the large fires or 8-bit v 16-bit data or most likely the recent years being slightly later in the season.

4b. Explain briefly why NDVI values are expected to be lower in September ?
(see lecture notes in terms of the NIR and Red band reflectance seasonal changes)

The small landslide that first appeared in the 2008 image should show up in 'pure red'.
Why: high NDVI before the fire (Red Gun), low after (G), only partly recovered in 2015 (B)

FIRES / BURNS
Open the rh-burns file ..
As with the NDVI file, check the raster list to see what the 5 channels are …

RGB – by default it should show as R: 1986, G: 2008 , B: 2015
I didn't create a burns ratio for 2023, as there is no new fire, only recovery from previous fires
Again there are blank pixels with a N/A value (where NIR=SWIR2), but fewer than with NDVI.
Gray = no changes 1986-2015 .. it's like the previous simultaneous display in section 3, but with 3 similar burn ratios instead of 3 similar bands, and colours show as changed pixels.

Click inside the fire and notice the DN difference in the R and G display guns; now click outside the fire and these first two DNs will be very similar

You can also view just the difference layers – add Channel 4: 1986-2008 in grayscale:
Layer-> add-> grayscale -> channel 4

Querying the decimal DN values should be highest for the Jackpine River valley fire
Do it and see what are typical values inside the fire versus neighbouring treed areas outside

According to the webpage below ..
DBNR values > +0.66 are considered to be 'high severity' and > +0.27 'moderate severity'

https://www.earthdatascience.org/courses/earth-analytics/multispectral-remote-sensing-modis/normalized-burn-index-dNBR

Fire bitmaps

I've spared you the Threshold THR tool this week and created 4 bitmaps (properly labelled).
Use the Files Tab to see what they are – they are numbered 4,5,8,9 - I made a few errors 😊

Display the first bitmap: layer-Add-Bitmap . choose bitmap 2 (1986-2008, medium severity)
It seems to capture the fire but also some recently deglaciated (Glacier retreat) pixels. Can you see why this makes sense .. pixels changed from ice to bare rock is similar to those burned from treed to bare earth – in both cases, becoming drier ..
Note that we could easily exclude the glacier areas and limit it to the fire by roughly drawing a polygon around the fire area and using that as a mask.

Right-click on the fire bitmap layer in the Maps tab -> representation editor and record the number of pixels in the bitmap, (which will include those glacier change pixels..)

Repeat this for the high severity burn (0.66) bitmap, and record this number as well
A count in pixels is too specific, and should be converted to hectares. This can be easy:
1 pixel = 30x30m = 900m^2
1 ha = 100 x 100m = 10,000m ^{2}
To convert to hectares, multiply the number of pixels by 900/10,000 or more simply .09 (use the Windows Calculator);

Q5a. What is the calculated size of the 2008 fire in hectares (medium + high severity)?
5b. What % of the fire would be considered to be high severity ?

Now display channel 5 (dNBR 2008-15) - you can either add this layer, or change the RGB Mapper 'grayscale' display from the previous channel 4 to now channel 5. Channel 5 will highlight the Smoky River fire (2015).

Add the two bitmaps for this fire, medium then high severity
Layer-Add-Bitmap .. bitmap 4 and then same for bitmap 5
Yikes – that didn't work so well

Now, the high DNs are in the fire area, but also in much more than just glacier change areas. Bitmap5 highlights parts of the fire, though not as convincingly as the 2008 result, with highest severity in the NW section. The Landsat image was captured more than 2 months after the fire (June 10); though the 2008 image was the year after the 2007 fire ? Maybe the dNBR is more effective with Landsat 5 TM data ?

Note again if we were trying to extract the burn area, we would mask out the other areas.

As per usual, submit your PDF/TXT to Moodle by friday

Image cross-classification – for reference only

You could classify each 3+ band image, and compare the classifications -
You would need to train areas and do a supervised classification for this area, apply the training areas to each image (bands 5,4,3) data, using similar training areas.

We can also re-classify areas that have stayed the same, and those that have changed e.g.
1 Water 2 Deciduous 3 Coniferous 4 Cutblocks 5 Bare rock ...
We would look at only the classes that we think may have changed (or the matrix is huge)
under multi-layer modelling, select **MAT (matrix analysis)**
Input channels will be your two classifications
Output channel = any channel you don't need
MRV1 and MRV2 - for the example above, these would be 3,4,5