GEOG 357, Fall 2024:
Lab 8 CHANGE DETECTION

1. Introduction and goals

We will look at 'change' comparing image data for the Resthaven Icefield subset – same image area as Lab 7 - Path 46, row 23, images subset from their full-resolution bundles

1a. Follow up to lab 7: glacier retreat

Load rh2023.pix .. and display the SWIR-NIR-Red composite

- add the BC TRIM 1985 glaciers: from L:\GEOG357\shapefiles\rh85.shp
- (remember to click below on the available segments after selecting the filename)

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, change the table definition to 2 decimals (the last decimal will be in hectares, as there are 100 ha in 1 square kilometer – you knew that!).

Q1a. What was the total glacier (km2) in 1985 ?
1b. What was the smallest glacier polygon in hectares (right click on Area and sort descending)

1c. What is the approx. maximum linear retreat 1985-2023 (this is a very approx. measure.
1d. Then what is the approx. average annual linear glacier retreat- metres / year ?
(I suggest you check the outlet glacier near the SW corner of the Icefield at ~ 343450, 5915600)

We'll now go back in time to see the 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
   so these are almost 'anniversary dates' with similar snow patches.

3. August 26 2015 Landsat 8 OLI
4. September 9 2023 Landsat 9 OLI2 – 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 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 .pix files to your labs folder from *L:\GEOG357\willmore (note the subfolder)*
resthaven1986.pix
resthaven2008.pix
rh2015.pix

Open the image files for 1986, 2008, 2015, 2023 (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.
click off the top one, then the second one to see each in turn, and the changes.
Enjoy the animate / time travel 😊

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

The most obvious changes are the two big fires in Jackpine River valley (2007) and Smokey 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 way more imposing than if you view it in 'natural colour' on google earth timelapse. There is also glacier loss 1986-2023.

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

Here's a question for you

Q2. Explain the changes in the Digital Numbers within the two fires for the 3 bands shown i.e. whether red, NIR, SWIR decreased or increased between the 2 pairs of dates and why.

a. *1986-2008 (8 bit DN values)*
b. *2015-2023 (16 bit DN values)*

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 cover or by comparing the two Landsat 5 or 8/9 images, as the DNs all change with 16-bit data.
You can’t easily compare 8 bit and 16 bit data values ..

You should be able to see these changes:

- the fires of course
- Glacier retreat
- some changes in the Smokey River including some new wetlands ~352000, 5917000 ?

also a new landslide 1986-2008 just south of Jackpine River (~ 334100, 5937000) has created a small lake (~333000, 5936400) – find it by using the 'cursor control' (+x,y icon – top row)

and another may look like a new lake ~331500, 5918400 but it's a shadow –see the cloud (to the SE) …. there is no change on bare rock slopes

Another small change is the vegetation seems to be advancing up the alpine slopes thru 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.

3. Simultaneous display

Display the equivalent bands from each date simultaneously: **layer-> add -> RGB**
Start with band 4 – for 2015, 2008, 1986 in RGB to contrast the fires
.. 2023 would show subsequent regrowth / green-up

Band 4 (2015) in Red, band 4 (2008) in Green and Band 5 (1986) in Blue-
You'll need to select the file and band each time … Enhance as needed

an increase in DN (vegetation health) over the (~30) years will show as red, and no change as gray shade; decreases will show in blue/green

3a. Can you explain the relative DNs and resulting colors of the two fires over the 3 years ?
b. what is causing the area that shows as green in the extreme SW corner of the image ?

Now use the RGB Mapper to switch these 3 to the SWIR1 band 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 and 16 bit data, so the next section will involve image subtraction using two indices: NDVI and NBR (burn ratio).

Last week, we found that the Raster Calculator and new channel creation have been acting up, so 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\willmore to your own folder:
rh-ndvi.pix
rh-burns.pix

Open the ndvi file – they are in chronological order, so it opens with dates 1-3 in RGB.
No change displays in gray as the 3 years have similar DNs for those locations
The small landslide that first appeared in the 2008 image should show up in 'pure red'.

Q4a. Explain why it displays as mostly red =the same as why it has those NDVI DN values

4b. 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.

Add the rh-burns file .. in RGB – by default it should show as R: 1986, G: 2008 , B: 2015
Gray = no changes 1986-2015 .. it's like the simultaneous display in section 3, but with 3 similar burn ratios instead of 3 similar bands, and colours show as changed pixels:
You can try changing their display in RGB Mapper, but don't spend a lot of time on this

It might be easier to view just the difference layers – add Channel 4: 1986-2008 as a grayscale display: 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 ..

https://www.earthdatascience.org/courses/earth-analytics/multispectral-remote-sensing-modis/normalized-burn-index-dNBR/
DBNR values > +0.66 are considered to be 'high severity' and > +0.27 'moderate severity'

Use the THR tool (threshold) to display onscreen all pixels > 0.27 DN
Make sure channel 4 is selected
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 here include those glacier change pixels..)

Repeat the threshold for high severity burn (0.66), and record this number as well

Q5a. What percentage of the burn would be 'high severity' and what is that area in hectares OR square kilometres (one pixel = 30x30m) .. check your answer to be a logical number.

Now display channel 5 (NDBR 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 Smokey River fire (2015).

Use tool THR with threshold 0.27 as you did for 2008
Now, the high DNs are in the fire area, but also seem to be in much more than just glacier change areas. Increase the threshold to 0.50 and run THR again to limit it more to the fire.

Run THR again to identify high severity areas (0.66). This highlights parts of the fire, though not as convincingly as the 2008 result. 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 ?

Q5b. Where in the 2015 fire are the highest severity DN values ? (describe by relative location)

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

The last section below the questions repeat is for reference only – I considered adding this to categorise how much had changed from forest to fire and then back to regrowth, but it might make the lab too long; it could be a good part of a project.

Repeat of questions for Lab 8

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Q5a. What percentage of the burn would be 'high severity' and what is that area in hectares OR square kilometres (one pixel = 30x30m) .. check your answer to be a logical number.

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Image cross-classification – for reference only

You can also 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