GEOG 357: Fall 2025

Lab 1: Introduction to PCI Catalyst / image data

Learning Outcomes:

- Introduction to the Catalyst RS software and digital imagery
- View imagery and the Digital Numbers (DN) that make up image bands
- Learn display options and bands relative to RGB display guns
- Note: Some of the topics will become more clear after tomorrow's lecture
- 'Simple' questions are inserted – note your answers in a word file
- Submit lab answers this week (by Friday 5pm) on Moodle (if it's ready)

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1. GIS lab access

Handy to do as much as possible in the lab period; this first lab should be easily do-able in the time.

If you leave before you are done today, you can finish off later this week in the Lab or remotely.

The lab schedule will be posted on the webpage and lab door. After hours access can also be arranged.

2. Catalyst tool bar

Login and select the (green) Catalyst icon or use the start button and (start to) type Catalyst (it will find it after ca…). Note: I may refer to the software as PCI, the company who owns it. Catalyst is just their most recent name for the software – and I don't like it – it's also the name of a brand of cat litter – which seems a better fit …

The Catalyst professional task bar appears with 10 options – we'll likely only use the first - 'Focus' which should automatically open an image window. As with other courses, your home folder is on K: and the lab data on L: … all data for the course will be stored in (Labs) L:\GEOG357.

Create your own **geog357** folder for the course- I recommend not including any spaces in the name

copy this file: **pg14sept2011.pix** to your new folder; use this copy NOT the original in the L drive

3. Load satellite imagery

file -> open -> **pg14sept2011** - your copy, not the original in L:

The native raster file format for this software is **.pix** although it can also open standard raster files e.g. tif

PIX is a powerful super format that can contain many layers, both raster and vector

The filename is self-explanatory – the date the image was captured. This was near the end of the life cycle of Landsat 5 in fall 2011. The scene has been clipped to reduce size and the need to pan / zoom much in labs. The pixels are 30 x 30 metres in size – standard for most Landsat imagery. This may look pixellated in urban settings, but is a good resolution overall for BC / Canada.

Resize

For best display, you should be able to see most of the whole dataset without panning; resize the image window using the corner tags - I prefer NOT to maximise as then you have no other display space except monitor 2 .. - most students ignore me here, then I dish out sarcasm when they ask for help 😊

Satellite Imagery review: Landsat 5 bands

Landsat TM: Visible: 1,2,3 (Blue, Green, Red) Near IR: 4 SWIR: 5,7 Thermal IR: 6

Thematic Mapper (TM)	Landsat 4-5	Wavelength (micrometers)	Resolution (meters)
	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.76-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	120* (30)
	Band 7	2.08-2.35	30

- The thermal data are collected with 120m pixel size, but 'resampled' to 30m to match the other bands in the file; they remain lower resolution – see later in the lab

Note the difference throughout between RGB – the display guns and the image bands (1-7)

Your default opening display will be Band 1 in Red, Band 2 in Green and Band 3 in Blue

Image Bands: Refer to the individual Landsat TM bands (wavelengths) from 1 - 7.

Channels: the database layers -initially the same as the band numbers (see Lab 2)

Display guns (RGB): any three layers can be displayed simultaneously in red-green-blue (RGB).

4. Maps and files tabs

On the top part of the left panel you can see two tabs: maps and files.

The default is maps, which enables display options, while 'files' shows database information.
e.g. Switch to files tab

Click raster → it will list the bands / channels available (7)

General tab gives file size (pixels=x and lines =y) – easily converted to km

History and metadata – not always filled in

Projection – UTM with corner coordinates and pixel size: 30m

Switch back to the Maps tab – we use this most of the time in working with images / image data

5. Basic image display

a. Display Options

The 'RGB' image opens with the first band layer in Red, the second in Green and the third in Blue. For Landsat, and most imagery these are the blue, green and red bands so they are in reverse order (most GIS software does this), so the first task is to 'flip' bands 1 and 3 into their proper display sequence – Blue band in Blue, Green in green, Red in red.

Click the + for this file in the (Maps tab) 'Table of Contents' – it will show which band is in each of RGB. One could Right-Click (RC) on each one to change them – this would be how to do it in GIS, but remote sensing software has a slicker way:

Right-click (RC) on the filename and select RGB mapper. In the table move the 'ticks' to put bands 321 (red, green, blue respectively) in the RGB display and close. Now the display may look odd – because it based colours on the previous display layers and they have changed. You will ALWAYS need to 'enhance' (as below) when you change the input layers.

b. Enhancement

right-click filename → enhance → linear or root

See which gives better contrast. Usually linear seems best in mountain scenes, and root in urban.

The enhancements will be based on what is displayed onscreen. Hopefully you can recognize some of the features on the display – e.g forest v fields, industrial v residential. Notice also the different colours for the Nechako (clear water) and Fraser (silt, mill effluent?). You can also enhance using the icon in the 2nd row below the scissors icon – I find this more convenient – and why it is there !

c. Zoom and Pan

Use + and – to zoom in and out, and more useful, use the box symbol to the left of + to outline an area of interest (same as in GIS software); check out the campus or your house area; zoom in enough to see the pixels. The next box to the left zooms back out to full extent (same as RC -> overview of layer).

d. View coordinates

Note the UTM coordinates (displayed at the bottom) as you move – scenes are downloaded in the local UTM zone; see Lat/Long as well for a point by clicking the +x,y button – check what is the lat/long of UNBC ? Note that the 4 decimal second places are 'precision overkill' as each pixel is only ca. 1 second (30m) across. When you give numbers and distances, use suitable precision.

e. Digital Numbers (DN) values

The DN values (0-255) at the cursor position are given for the bands displayed (in R-G-B). These represent the 'brightness' or level of reflection (in this case in a scale from 0-255) for each of the bands displayed in the 3 colour guns. The brightest area may be the Canfor Mill chip piles (in the meander of the Fraser just before the confluence) - move your cursor there to see these highest DN values. The lowest DN values are usually in water and/or shadows.

Q1. Query the DN values near the confluence of the two rivers – how do they compare between the clear Nechako and silty Fraser ? The Fraser is brighter due to suspended sediments in the water increasing reflection. What is the approximate difference in DN values for bands 1,2,3 ?

Note: All DNs except for the thermal band 6 are a measure of solar energy reflected.

f. Changing the bands displayed

You already flipped the visible bands (3,2,1); now add a colour IR display for comparison:

From the dropdowns at the top:

Layer -> Add -> RGB -> and select bands 4 … 3 … 2 in that order. Finish.

This will simulate the "false IR look" to show healthy vegetation in red. You will need to enhance, as the display contrast is still based on the previous visible bands.

You can now 'flicker' between the visible and IR displays by turning the top one on and off.

SWIR bands were conceived and developed after the Near IR (band 4), so we include one of those when we have them. One more step then: use the RGB mapper to display bands 5-4-3 in RGB instead of 4-3-2 (and ENHANCE).
This is our **optimal display for maximum contrast** showing vegetation health and dryness. This should be the 'default' or best display for almost any image scene. It is superior to the 'False colour IR' combo which basically duplicates two visible bands.

Flicker between the 543 display and the 3-2-1 natural colour to see the contrast.

Note that the DN values displayed at the bottom – will be for the highlighted layer. You may need to highlight the layer you want, otherwise you would get the last layer activated.
This is the same in GIS software where you don't always query the layer you intended.
Flip to view DNs between the 321 and 543 images to see their different numbers, first by clicking the top layer on and off, then just by picking an area feature e.g. water or forest and highlighting each colour combination in turn, not even changing the display.

Zoom in on the N-S service road behind the EFL (Enhanced Forestry Lab) – the road is not super visible as it is less than 30m wide, note that it's more visible on the 543 combo than 432 or 321, showing the higher contrast in the IR bands, but it would be more dramatic if the road was wider

– possibly it straddles 2 pixels width, mixing with some vegetation, instead of focussed in one pixel width. Band 3 (B gun) is visible reflectance; band 4 (G) is NIR = vegetation health; band 5 (R) is dryness ('negative moisture').

Click on Shane Lake to see much lower DN values – and thus why it displays in black.

On Cranbrook Hill, west of campus, logged areas are visible showing in pink/red where beetle killed pine trees have been removed (like wounded scars!). Some beetle-kill tree stands remain showing as brown instead of green for healthy stands.

Q2. If you query a brown and adjacent green area, one band doesn't change much, one band has higher DN values, and one has lower. Please explain which is which and why in terms of what the SWIR, NIR and visible bands show.

6. Other display options

a. View the individual bands in grayscale:

Layer->add->grayscale->next; select band 1 and finish .. and as always enhance as needed

Right-click on the grayscale layer in the Maps list and select RGB mapper – note that all 3 colour, guns are ticked for Band 1; change this now to band 2, close and enhance as needed.
Displaying the same band or channel three times in RGB will always produce a gray tone image

Do the same to view bands 3-7 (always enhance as needed)

Note that bands 1-3 are similar, band 4 (NIR) is perhaps the most striking, bands 5 and 7 are similar, band 6 is 'fuzzy' – larger pixels. Some striping will be evident from the low contrast and limited data range in band 6, and somehow, we lost a wee chip in the SW corner (no data)

b. Examine histograms

Highlight the 321 display layer name and View the histograms by selecting:
Right-click -> histograms OR also select (in menu bar at top) **Layer -> Histograms**
We will discuss these more in lecture tomorrow.

This displays the histograms for the selected RGB guns - note that all operations relate to the layer highlighted in the TOC, not always the one displayed, unless they are the same.
Also: the histogram relates to the area displayed, so will <u>be different</u> if you are zoomed in

Get more detail and information for each one by clicking on its histogram (yes, try it!)
Note: the 3 histograms are similar in shape (all are visible bands);
All have a low range of values compared to the 0-255 possible range
Also the minimum DN decreases as wavelength increases as bands are less affected by haze – which adds fake 'brightness' so there are no pixels with lowest values, especially for blue.

Now highlight the 5-4-3 composite display
View the histograms for this composite
Generally, higher standard deviation (SD) = higher contrast; the SD value is an indication of data

spread (lower for Visible bands), and the bimodal graphs for IR reflect the very low DNs just for water. Check this out by clicking your mouse in water, view the DNs at the bottom

The NIR/SWIR bands usually have higher SD than the Visible – thus they contain more data ..

Display Band 6 in grayscale and check its histogram: it has the lowest SD – a very narrow range, and there are 0 values only due to missing data in the SW corner.

Historical change 1996-2011

The Landsat archive 1984-present makes change comparison easy, and the different years are georeferenced to overlay perfectly.

Copy and open/add in Catalyst this file (UNBC early years) **L: \GEOG357\pg11sept1996.pix**

Change display to the optimal: 5-4-3 display and visually compare the changes 1996-2011
Note that the two images 1996-2011 are almost exactly 15 years apart, thus little seasonal change.

Enable (tick) only the 2011 and 1996 543 displays; compare by ticking the top one on and off

Zoom into the UNBC area and note the change with the construction of the NSC (Northern Sports Centre). Compare the DNs for 1996 and 2011. This is easiest by clicking in the middle of the NSC and noting the 2011 DNs; and then without changing display highlight the 1996 filename – you can flip between the two files this way if you need to review the DNs. The query is based on whichever layer is highlighted, not necessarily the one displayed.

Surprisingly perhaps, NIR has increased a little, possibly as it was not highly productive conifers in 1996, but the visible and SWIR DNs have increased significantly. Why? Visible = it's brighter; SWIR: it's now 'drier'.

Now move to the airport and see the runway expansion extending south – 3rd longest in Canada !

3a. Use the measuring tool to record how much length they added (2007) to the nearest 10 metres. This is the tool icon top row on the right. What is the answer ?

3b. While at it, what are the dimensions of this image (x and y) to the nearest km ?
Note that you could also do this by checking the number of rows and columns of pixels (files tab -> properties) and multiplying by 30m … but it may be easier with the measuring tool

Go further east to Tabor Lake and note the two green spots in the lake – these are algae blooms – one of our Geography professors was working on this problem in UNBC's early years. The algae is a widespread toxin threat to ecosystem, wildlife and human wellbeing, and is a common issue in the Central Interior of BC as well as the oceans.
Flicker on and off to see the bloom and their absence in 2011.

4a. The difference comparing 1996 to 2011 shows mainly in one band – which one, and approximately by how much change in the DN values ?

To the Northeast of Tabor Lake, you can see the Tabor Mountain ski resort, now sadly out of use since the lodge burned down in 2018. (eastern edge of the image, midway down). Zoom in and flicker between 1996 and 2011. The ski runs seem to have greened up over those 15 years. Later in the lab we can view a more recent image.

4b. In the Northwest corner of the image, next to Swamp Lake, there are some distinctive bright blue-green patches amongst more neutral patches. These are all likely some kind of wetlands next to the lake. Which band is primarily causing this contrast, and therefore without knowing more, what generally might be causing this colouration ?

7. Landsat 8 (OLI) – 20 July 2023:

Copy this file into your folder **L:\GEOG357\pg20july2023.pix**

We will add an image from 2023 – and shift to Landsat 8 OLI (Operational Land Imager), with more bands than Landsat 5 TM, and 16-bit data so DNs are now potentially 0-65,535; there is also a higher resolution Panchromatic band (15 metres). More on this in class lectures.

Landsat 8	**Bands**	**Wavelength (micrometers)**	**Resolution (meters)**
Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	Band 1 - Ultra Blue (coastal/aerosol)	0.435 - 0.451	30
	Band 2 - Blue	0.452 - 0.512	30
	Band 3 - Green	0.533 - 0.590	30
	Band 4 - Red	0.636 - 0.673	30
	Band 5 - Near Infrared (NIR)	0.851 - 0.879	30
	Band 6 - Shortwave Infrared (SWIR) 1	1.566 - 1.651	30
	Band 7 - Shortwave Infrared (SWIR) 2	2.107 - 2.294	30
	Band 8 - Panchromatic	0.503 - 0.676	15

File-> open **pg20july2023.pix** - your copy, not the original in L:

Note that this file is from July instead of September, resulting in higher sun angle, lower shadows and different vegetation conditions. In addition DNs would be higher due to the time of year compared to September. More on OLI and TIRS in class next week.

Switch to the Files Tab to see the Band descriptions -> click on rasters
Band 1 is extra compared to Landsat 5 TM ('Coastal blue') - note that the bands are nicely described with Landsat 8 so you know what they are. The standard RGB natural colour is now bands 4-3-2 but some displays already know this, so you don't need to switch them as you did for the Landsat 5 data. Clever Landsat (and/or software) !
But you need to remember that now red-green-blue bands are 4-3-2 and SWIR-NIR-Red bands are 6-5-4. For us not working on coastal scenes, this renumbering is a bit of a nuisance ☹

Switch back to Maps tab.

Ensure you have 432 displayed and enhance - note the DN display at bottom - in 16-bit numbers
View the histograms – they will look different to the previous images with the 16-bit DNs, but all three visible bands have similar histograms.

Change the band combination to 654 (SWIR/NIR/Red) and enhance – note that the RGB mapper shows bands for all files loaded – this can get confusing if you load too many images.

Now view the histograms for Bands 654

Query the DNs in

a. water b. coniferous c. deciduous

you should appreciate why these relative values represent these types of features in visible, near IR and mid-IR, though its more complex than with the simpler Landsat 5 TM 8-bit data. We'll look at these further in the next two labs.

Lastly, copy to your folder and open the panchromatic band (L: GEOG357) **pg20july2023pan.pix** …it will open in grayscale as it is a single band

The PAN band needs its own file, as it has higher resolution (15m); flicker from this to the colour composite to see the effect of the higher resolution in terms of detail e.g. UNBC campus.

You will likely need to zoom in to better see the higher resolution at work.

You should be able to see four PAN pixels for each 'colour' pixel.

8. Adding vector lines

RS is mostly about images, but we can display (and also create) vectors. We will add a vector layer for the rivers:

Layer dropdown -> add -> vector -> next

Browse button -> navigate (browse) to **L:\GEOG357\shapefiles** and click on **rivers.shp …** Open

In the lower panel, click on 1 (VEC) rivers

You may get a warning that the projection does not match exactly, but click on OK anyway

click on Finish, and Rivers will appear (in red)

To change colour, right-click in Table of Contents vectors, colour -> blue

You may see some mismatch between the vectors and image where either the rivers have changed and there are seasonal exposed sand banks or as a result of pixel size – as the city vectors were created from higher resolution aerial photography.

Repeat the process to add the **city boundary (pgcity) –** and edit the colour for best contrast

9. Viewing satellite imagery in QGIS (or ArcGIS) – for the GIS nerds … !

Note that GIS software can display a PCI .pix file, though if you plan to do major analysis, it's more stable to convert it to a more common format such as .img or .tif (or GeoTIFF)

QGIS -> Add a raster layer and select one of your multi-band pix files: - do what is needed to enhance – it's not as intuitive as in PCI or maybe it is if you are a GIS pro ?
I prefer to go with QGIS as it has more RS plugins than ArcGIS – and is FREE !

Layer -> Add Layer -> Raster layer
Click on the 3 dots and navigate to your 2023 .pix file … -> add
The Image should show up, badly in need of enhancement

Right-click on the file name in the layers (content)
Right-click -> zoom to native resolution
Right-click -> stretch using current extent

Still looks poor, switch to bands 654 combo:
Double-click on filename, and in the new window, change RGB at the top to bands 6,5,4… Apply

QGIS wizards may be able to further enhance this, but it's not as simple as in PCI, and lacks the quick stretch options; the display gives the UTM coordinates, but not the Band digital numbers.

You can also add the two vector layers – rivers and city boundary (stored in L:\GEOG357):
Layer -> add layer -> add vector layer and navigate to your vector layer files

We will make limited use of GIS software in this course, unless you want to …

Q5: Last question: Go to this NRCan (Natural Resources Canada) webpage:

https://natural-resources.canada.ca/maps-tools-publications/satellite-elevation-air-photos/image-enhancement

What is their guide for when to use 'Root' enhancement (histogram equalization) versus 'Linear' and why? (This can be done any time – does not need the software)

Done …file->exit and logout,
It's not critical to save unless you want to re-open this image setup ('project') later without having to repeat open/enhance etc.., then you would save as (in your folder): e.g. lab1.gpr

Please do NOT power down – the machines should stay on for the next user
The sign out option is within your name after you select the Windows icon

Submit your answers via Moodle as a PDF file - save your draft word doc as .pdf

I only need the answers, not the questions or rest of the lab text

Deadline: Friday 5pm

10. Repeat of Lab 1 questions:

1. Query the DN values near the confluence of the two rivers – how do they compare between the clear Nechako and silty Fraser ? What is the approx. difference in DN values for bands 1,2,3 ?

Q2. If you query a brown and adjacent green area, one band doesn't change much, one band has higher DN values, and one has lower. Please explain which is which and why in terms of what the SWIR, NIR and visible bands show.

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