GEOG 357: Fall 2024

Lab 1: Introduction to PCI Catalyst / image data

Learning Outcomes:

- Login to the GIS lab computers and exposure to the Catalyst RS software
- View imagery and the Digital Numbers (DN) that make up image bands
- Learn display options and bands / channels versus RGB display guns
- Some of the topics will become more clear after Thursday's lecture
- Submit lab answers this week (by Friday 5pm) on Moodle (if it's ready)

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1. GIS lab access

If you leave before you are done today, you can finish off later this week in the Lab or remotely.
The lab schedule is posted on the door.

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…)

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 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

3. Loading 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

It 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 later in 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.

Resize

For best display, you should be able to see most of the whole dataset without panning; resize the image window - I prefer NOT to maximise as then you have no other display space except monitor 2 ..

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 ranging from 1 - 7.

Channels: the database layers -initially the same as the band numbers

Display guns (RGB): 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. (For GIS geeks, you could think of them as parallel to ArcMap and Catalog. – and their equivalents in ArcGIS Pro and QGIS)

Switch to files tab

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

→ right-click filename → properties

You will see much fewer options than when you right-click in the maps menu

General 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

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 (nearly all software does this e.g. ArcGIS, QGIS), 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 Arc or QGIS, 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 best contrast. Linear seems best in mountain scenes, and root in urban.
The enhancements will be based on what is displayed onscreen. No data numbers will be changed by enhancement, only how the imagery looks. 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 that one more convenient - which is 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 – see what is the lat/long of UNBC ? Note that the 4 decimal second places are 'precision overkill' as each pixel is only about 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 range from 0-255) for each of the bands displayed in the 3 colour guns. The brightest area may be the Canfor Mill chip piles- move your cursor there to see the highest DN values.

Q1. 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 ?

All DNs are a measure of solar energy reflected.

Q2a. Using the shadows, in which direction was the Sun when the image was scanned (which of the 8 cardinal compass directions) – easiest place to look might be Connaught Hill downtown (use Google Maps if you're not sure where it is). Q2b. therefore which time of day was it captured: e.g. early morning, mid-morning, noon, early afternoon, late afternoon, or evening.

f. Changing the bands displayed

You already flipped bands 1-3 – the visible bands; now change the display to include the near-infrared band (4): RC-> RGB Mapper, show 4-3-2 in RGB and ENHANCE
This will simulate the "false IR look" to show healthy vegetation in red.

One step more: change the RGB mapper again to display 5-4-3 in RGB (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.

For an easier comparison with 'natural colour', we can reload the layers 3-2-1 in RGB using the layer dropdown -> add-RGB -> next, and select 3-2-1 – finish (enhance as needed); you can now more easily compare the 543 and 321 colour composites by clicking the top one on and off. The 543 is superior for natural habitats, but may hold less advantage in urban landscapes.

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 one on and off, then just by highlighting each 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 pixel width, mixing with some vegetation, instead of being focused 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.

Possible 15 minute break here for a wee walkie outside to get a better idea of how we see image features as we do on satellite imagery, but maybe not ….

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. Examining histograms

Highlight the 321 display layer name and View the histogram by selecting:
Right-click -> histograms OR also select (in menu bar at top) **Layers -> Histograms**
We will discuss these in lecture tomorrow.
This displays the histograms for the selected RGB - 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 be different 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), 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 ..

The lowest SD is for Band 6 – a very narrow range, and there are 0 values only due to missing data

Historical change 1996-2011

The Landsat archive 1984-present makes change comparison easy, and the different years are usually georeferenced to overlay perfectly. This part should be FUN !

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 see the changes 1996-2011
Note that the two images 1996-2011 are almost exactly 15 years apart, so minimal 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.

Q3a. Briefly explain why the visible and SWIR reflectances would increase with the new building ?

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

3b. Use the measuring tool to record how much length they added (2007) in metres. This is the tool icon top row on the right.

Go further east to Tabor Lake and note the two green spots in the lake – these are algae blooms – one of our Geography professors (Dr. Petticrew) was working on this problem in UNBC's early years. Only the NIR band is different 1996-2011, otherwise similar visibly, and in 'moisture'. Flick on and off to see the bloom and its absence in 2011.

7. Adding vectors

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 again 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

8. Landsat 8 (OLI) - 3 September 2013:

Copy this file into your folder **L:\GEOG357\pg3sept2013.pix**

We will add an image from 2013 – the year Landsat 8 was launched 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)

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	**Bands**	**Wavelength (micrometers)**	**Resolution (meters)**
	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 **pg3sept2013.pix** - your copy, not the original in L:

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 !

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 with the 16-bit DNs.

Q4a. What is the general range for visible bands - ignoring the outliers in long statistical tails ?

Note some annoying clouds in the SW … and annoying shadows. Their location relative to the clouds should confirm your answer to the earlier question on sun location and time of day.

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

Now view these histograms for Bands 654
Q4b. What is the general range for the two IR bands - ignoring the outliers in statistical tails ?

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 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) **pg3sept2013pan.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); flick 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 see the higher resolution at work.
You should be able to see 4 Pan pixels for each 'colour' pixel.

9. Viewing satellite imagery in QGIS (or ArcGIS)

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 any 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 ?

Now add the two vector layers – rivers and city boundary

I prefer to go with QGIS as it has more RS plugins than ArcGIS – and is FREE !
We may even use it in place of PCI next year …

5. Go to our NRCan (Natural Resources Canada) webpages – also cited in Tuesday lecture
http://www.nrcan.gc.ca/earth-sciences/geography-boundary/remote-sensing/fundamentals/2187

What is their guide for when to use 'Linear' enhancement versus 'Root' (histogram equalization) ?
(This can be done any time – does not ened the software, just an internet question)

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 save as (in your folder) lab1.gpr

Please do NOT power down.
The sign out option is within your name after you select the Windows icon

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 ?

2a. Using the shadows, in which direction was the Sun when the image was scanned (which of the 8 cardinal compass directions)

2b. …therefore which time of day was it captured: e.g. early morning, mid-morning, noon, early afternoon, late afternoon, or evening.

3a. NSC: the visible and SWIR DNs have increased significantly from 1996-2011 as a result of its construction. Briefly explain why this is so.

3b.Use the measuring tool to record how much airport runway was added (2007) in metres.

4. Landsat 8 OLI 2013:

a.What is the general DN range for the visible bands - ignoring outliers in long statistical tails ?

4b. What is the general range for the NIR and SWIR bands - ignoring outliers in statistical tail ?

5. Go to our NRCan (Natural Resources Canada) webpages – also cited in Tuesday lecture
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What is their guide for when to use 'Linear' enhancement versus 'Root' (histogram equalization) ?