From last week

Two lectures – only #2 was recorded – on Teams (can you see it?)
neither yet on webpages (slides only)

Lab setup

Cannot access K\: solved – only GIS students had been linked, not RS
All are linked now – you should be able to access K:

VPN2 should be superior to VMware but has limited access

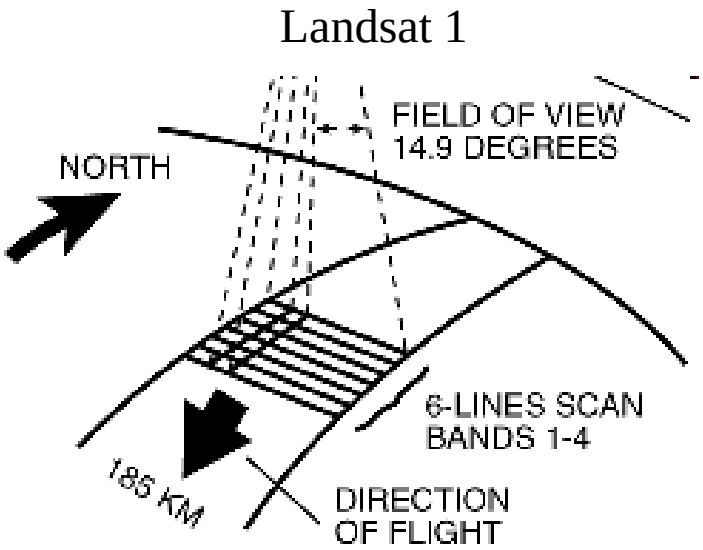
For labs, you can try VPN2, but use VMware otherwise
VMware – go to *desktop.unbc.ca* –> VMware : html access
Remote desktop connection to *osmotar.gis.unbc.ca*

Lab and lecture channels added for GEOG357

DIGITAL DATA and DISPLAY

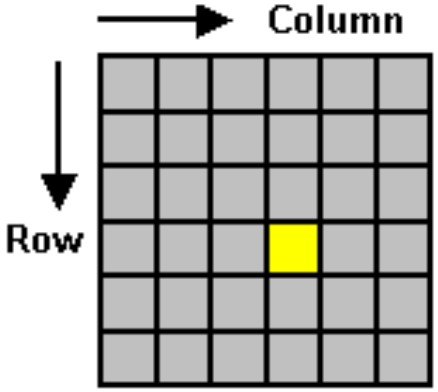
Satellite image data - capture

Onboard scanners capture the energy reflected by band (wavelength) for each pixel (picture element)
by row and column (captured row by row)

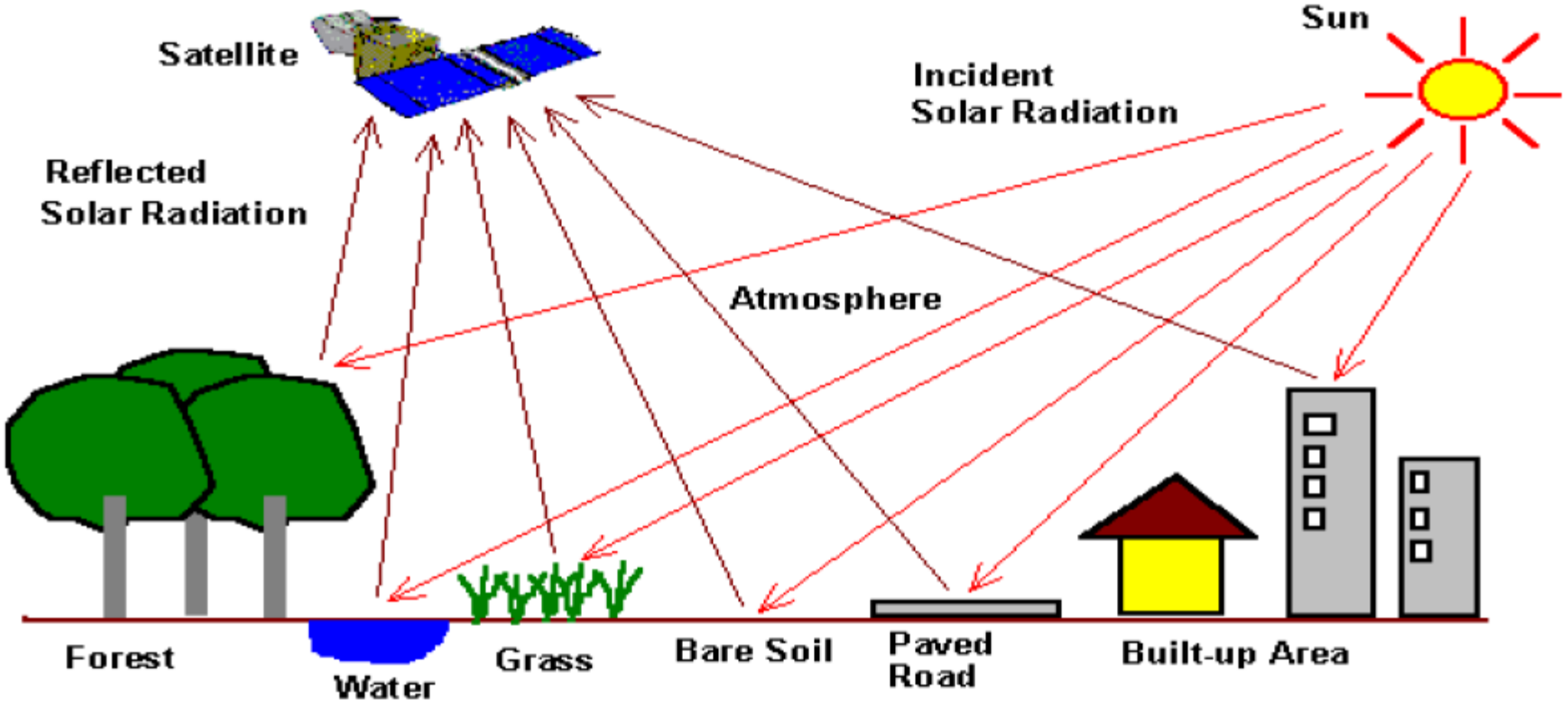


http://earthnow.usgs.gov

Data are recorded in a continuous swath and then cut into scenes several thousand pixels in x and y.



Data = digital measure of energy reflected/emitted from ground (or reflection recorded on film in the case of photographs)



Each pixel records a digital number (DN) giving the amount of reflection

Data characteristics: Spatial resolution (pixel size)

Spatial resolution is the size of the picture elements (pixels). This is determined by the sensor design, satellite altitude, and available energy.

Remote sensing data generally varies from <1 metre to 10km

Very high res: 25cm < 5m

High resolution: 5-50metre

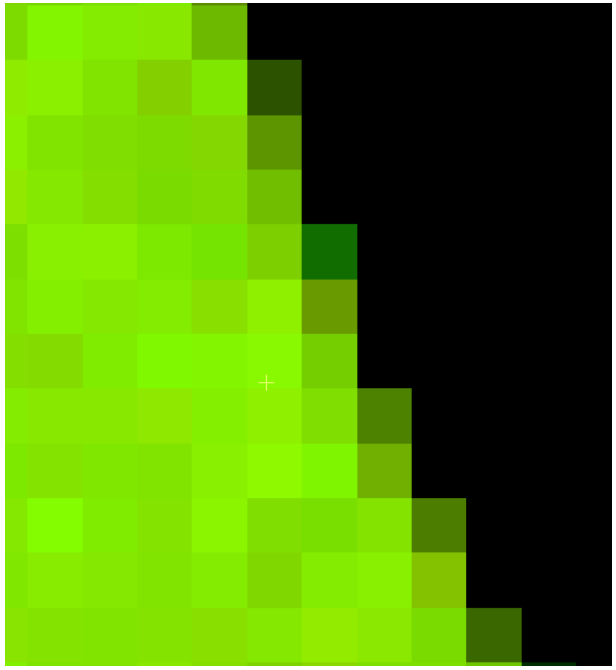
Medium res: 50-500m

Low res: > 500m (1km +)

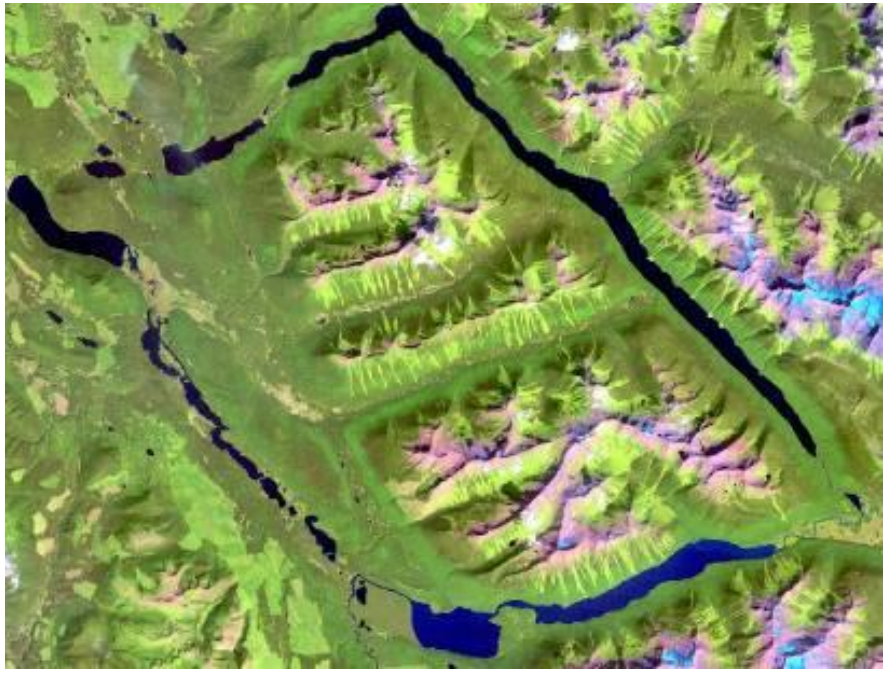
Side note: Pure and Mixed Pixels

One pixel = one digital value per layer (often 0-255)

Remote sensing data and raster GIS data give the impression that a pixel has one uniform value across its width. This may be true for a small pixel or a homogenous cover, such as a large lake, or field, but often we need to know the nature of geographic data and understand that what we are seeing is an average value for a variable forest or a mixture of different surface covers. Landsat example: Bowron Lakes



1 pixel = 30 x 30m

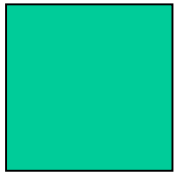


Radiometric resolution

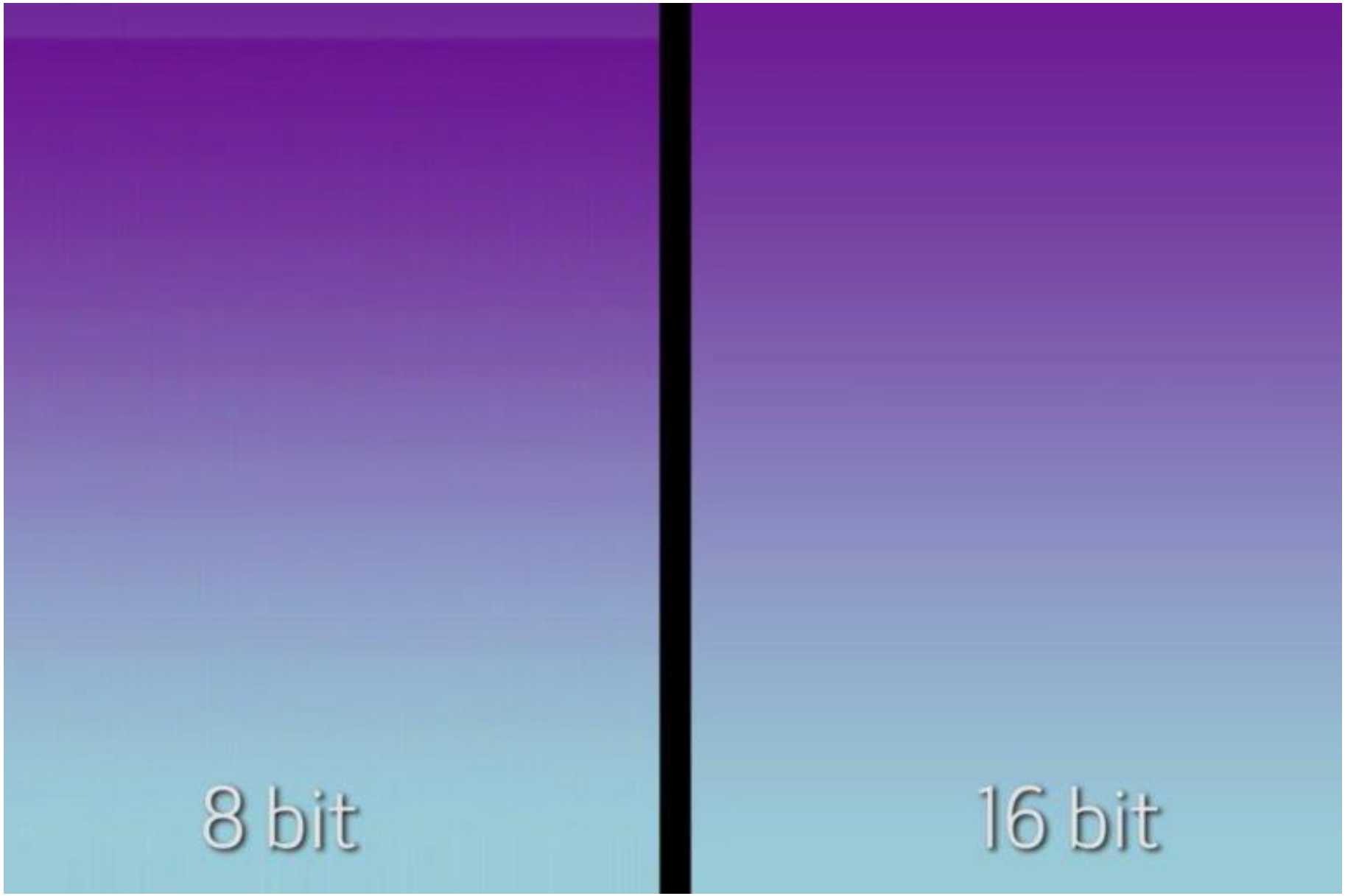
Scanner input (amount of reflectance) is converted from a continuous radiance value (watts / sq metre) into a discrete value known as the digital number (DN).

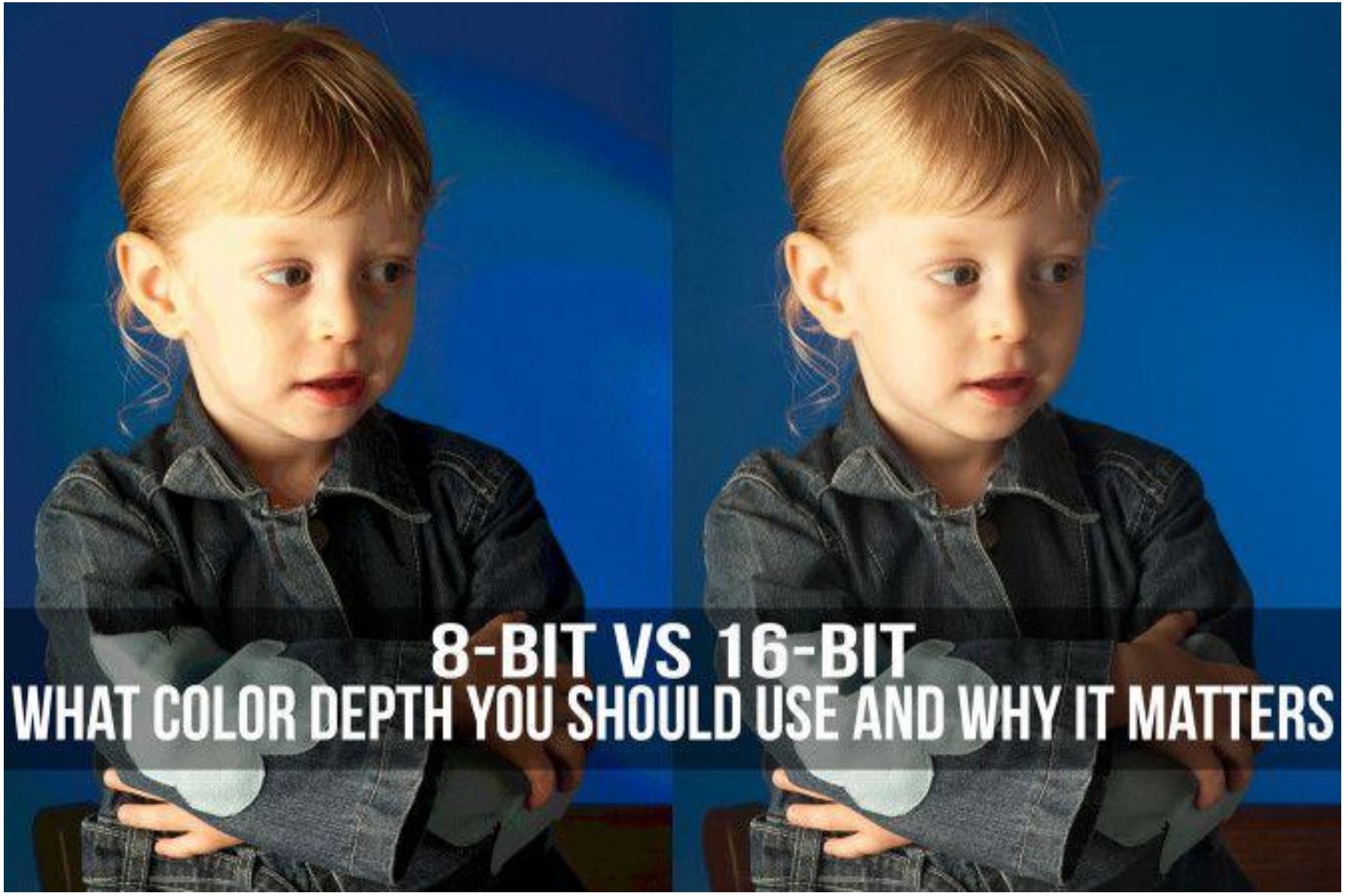
These are integer numbers .. *commonly 8-bit (256 values)* for easier handling and smaller overall file size: one value per pixel per band.

- Each value can range e.g. from 0 (no reflection) to 255 (for 8 bit data)
- They can be converted back to radiance in 'real' numbers if required.



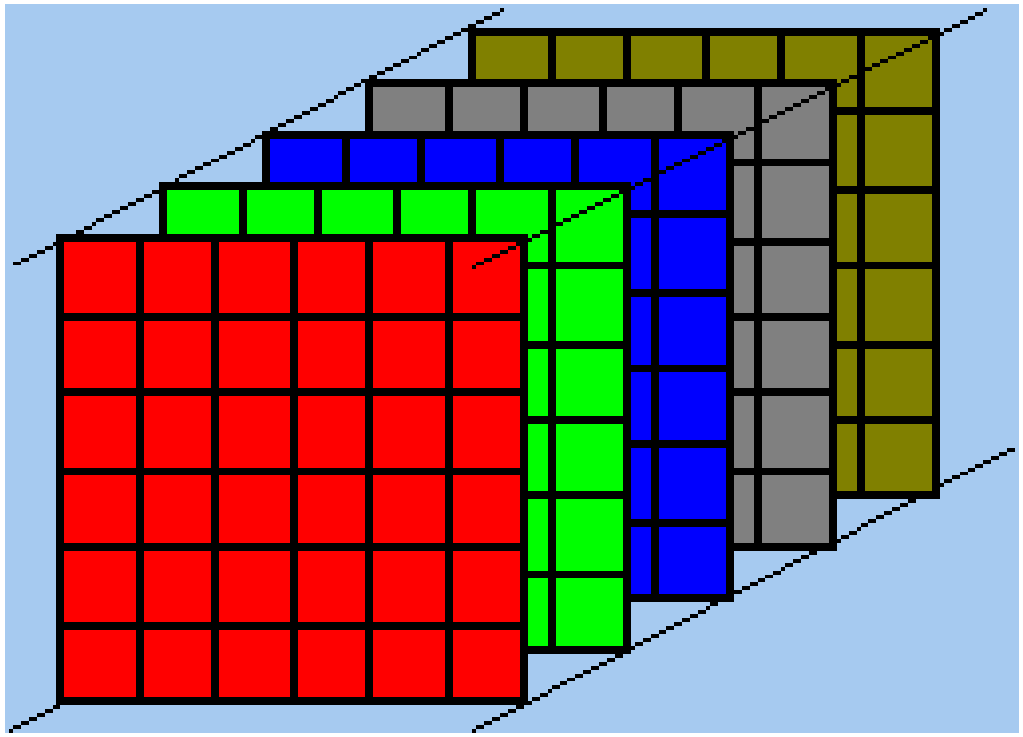
Powers of 2	*Digital Value*	
2^0	1	
2^1	2	Bitmap
2^2	4	
2^3	8	
2^4	16	
2^5	32	
2^6	64	Landsat 1
2^7	128	
2^8	256	Landsat 5
2^9	512	
2^{10}	1024	
2^{12}	**4096**	
2^{16}	**65,536**	Landsat 8


8 bit
16 bit


8-BIT VS 16-BIT
WHAT COLOR DEPTH YOU SHOULD USE AND WHY IT MATTERS

Digital Numbers (DN)

- Each satellite image has multiple layers (bands)
- The pixels line up perfectly between bands
- The ‘attribute’ = the brightness / reflection level
- e.g. dark = 0, bright = 255



Landsat 4,5 Thematic Mapper bands (1982-2011)
- also Landsat 7 1999-> present (?)

Band No.	Wavelength Interval (µm)	Spectral Response	Resolution (m)
1	0.45 - 0.52	Blue-Green	30
2	0.52 - 0.60	Green	30
3	0.63 - 0.69	Red	30
4	0.76 - 0.90	Near IR	30
5	1.55 - 1.75	Mid-IR	30
6	10.40 - 12.50	Thermal IR	120
7	2.08 - 2.35	Mid-IR	30

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) 2013->

Reference

Barsi, J.A.; Lee, K.; Kvaran, G.; Markham, B.L.; Pedelty, J.A. The Spectral Response of the Landsat-8 Operational Land Imager. *Remote Sens.* **2014**, *6*, 10232-10251 doi:10.3390/rs61010232

Band	Wavelength	Useful for mapping
Band 1 – Coastal Aerosol	0.435 - 0.451	Coastal and aerosol studies
Band 2 – Blue	0.452 - 0.512	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 3 - Green	0.533 - 0.590	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - Red	0.636 - 0.673	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.851 - 0.879	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.566 - 1.651	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.107 - 2.294	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.503 - 0.676	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.363 - 1.384	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.50 - 12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture

Landsat 4-5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+)

Band	Wavelength	Useful for mapping
Band 1 - Blue	0.45 - 0.52	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 2 - Green	0.52 - 0.60	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 3 - Red	0.63 - 0.69	Discriminates vegetation slopes
Band 4 - Near Infrared	0.77 - 0.90	Emphasizes biomass content and shorelines
Band 5 - Short-wave Infrared	1.55 - 1.75	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 6 - Thermal Infrared	10.40 - 12.50	Thermal mapping and estimated soil moisture
Band 7 - Short-wave Infrared	2.09 - 2.35	Hydrothermally altered rocks associated with mineral deposits
Band 8 - Panchromatic (Landsat 7 only)	0.52 - 0.90	15 meter resolution, sharper image definition

1984-2011

Display: Bands, Channels, and RGB Guns

Bands scanned by the sensor (limited by the data captured)
e.g. 1-7 for Landsat TM, 1-11 for Landsat 8 OLI

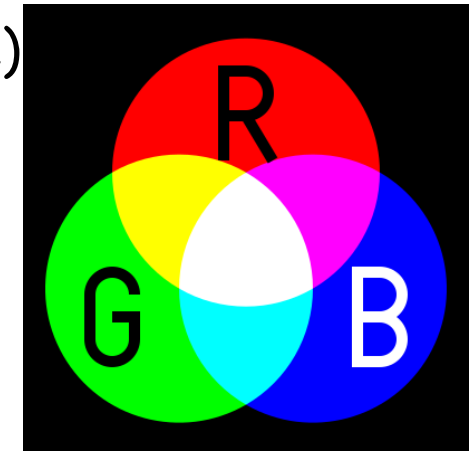
Channels data layers (including bands) stored in a database: no limit

PCI: .pix
Esri: .img [.grd]
Other: .tif (geotiff)

RGB the three colour display guns (Red, Green, Blue)

A monitor has 3 guns (RGB), so only 3 bands can be displayed at the same time

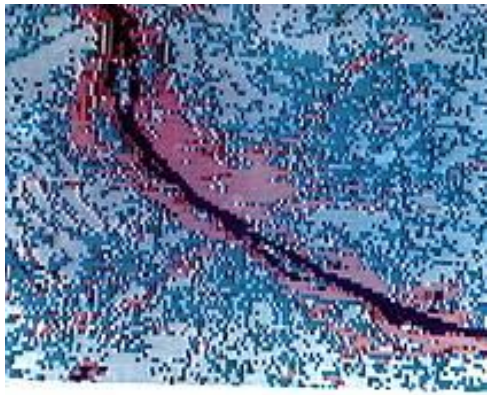
http://www.colorspire.com/rgb-color-wheel

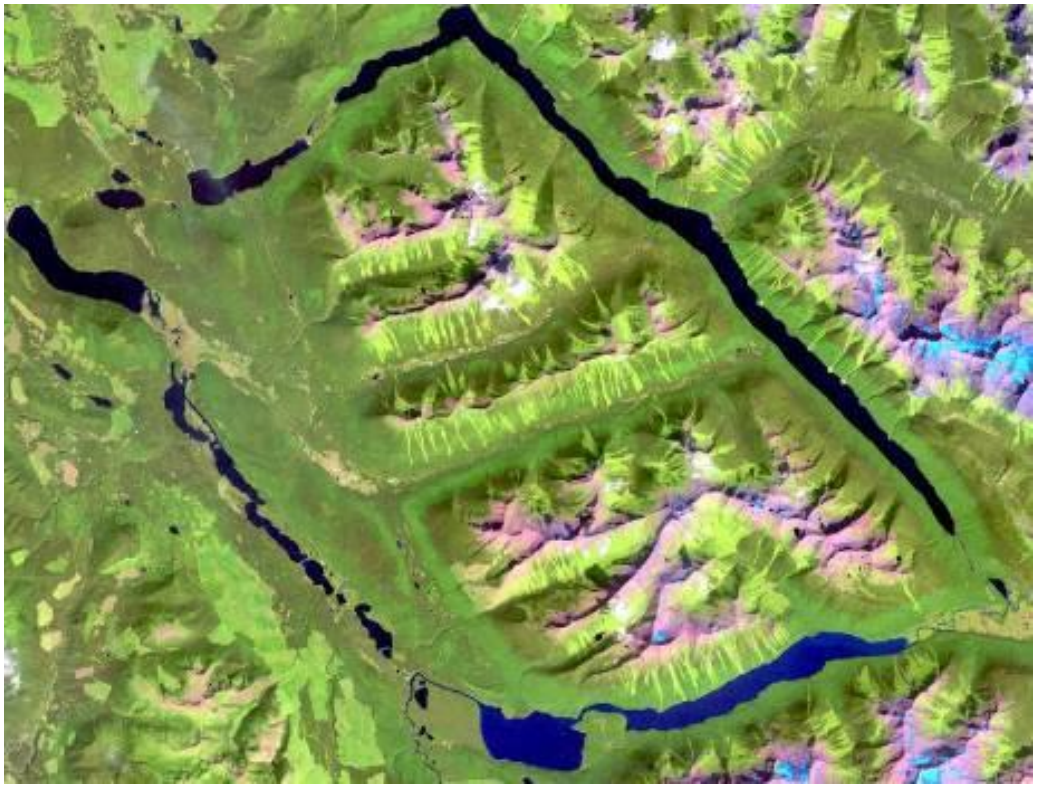


Data display

Modern computer screens display 24 bit colour - 8 bits each (256 shades) in red, green and blue (RGB) for a realistic image (right)

early PCs had fewer e.g. 2 bit = 4 colours (1982) and 8 bit = 256 colours (1990)





Note: we can display more vector than raster layers as they are ‘discrete’

Display Modes
A: Colour composites

•Three different channels compose a **RGB colour composite**: any three channels can be selected. Selecting TM band 1 in Blue, 2 in Green and 3 in Red displays a 'normal colour' composite.

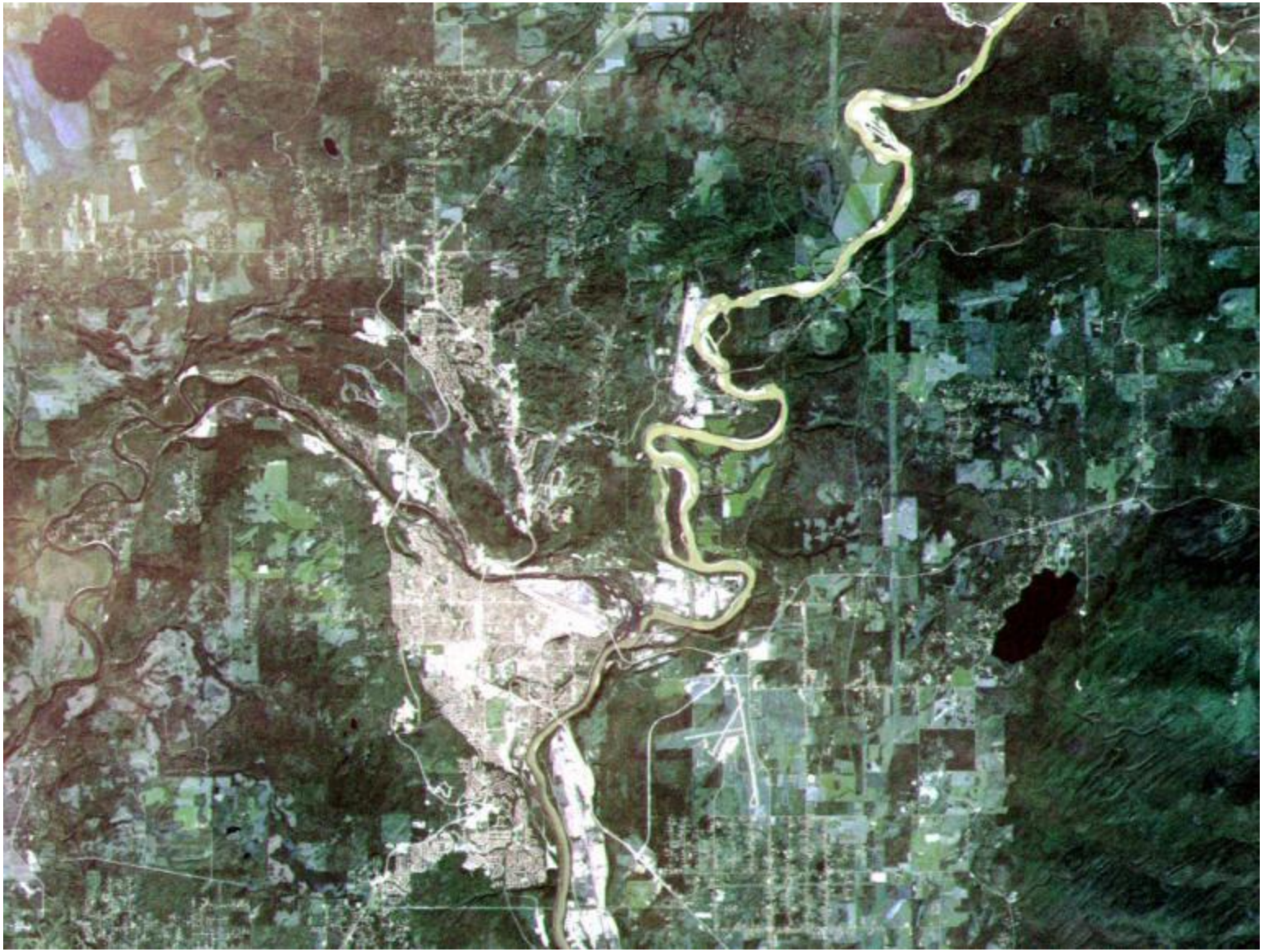
•But software automatically loads these in reverse as the display is 'RGB' … so you need to flip them (3-2-1 instead of 1-2-3)

• A TM 4-3-2 combination is similar to false colour film.

• A TM 5-4-3 composition gives a higher contrast image as it incorporates 3 bands from different portions of the EM spectrum - or any combo with visible-Near-IR, mid-IR e.g. 742 or 541.

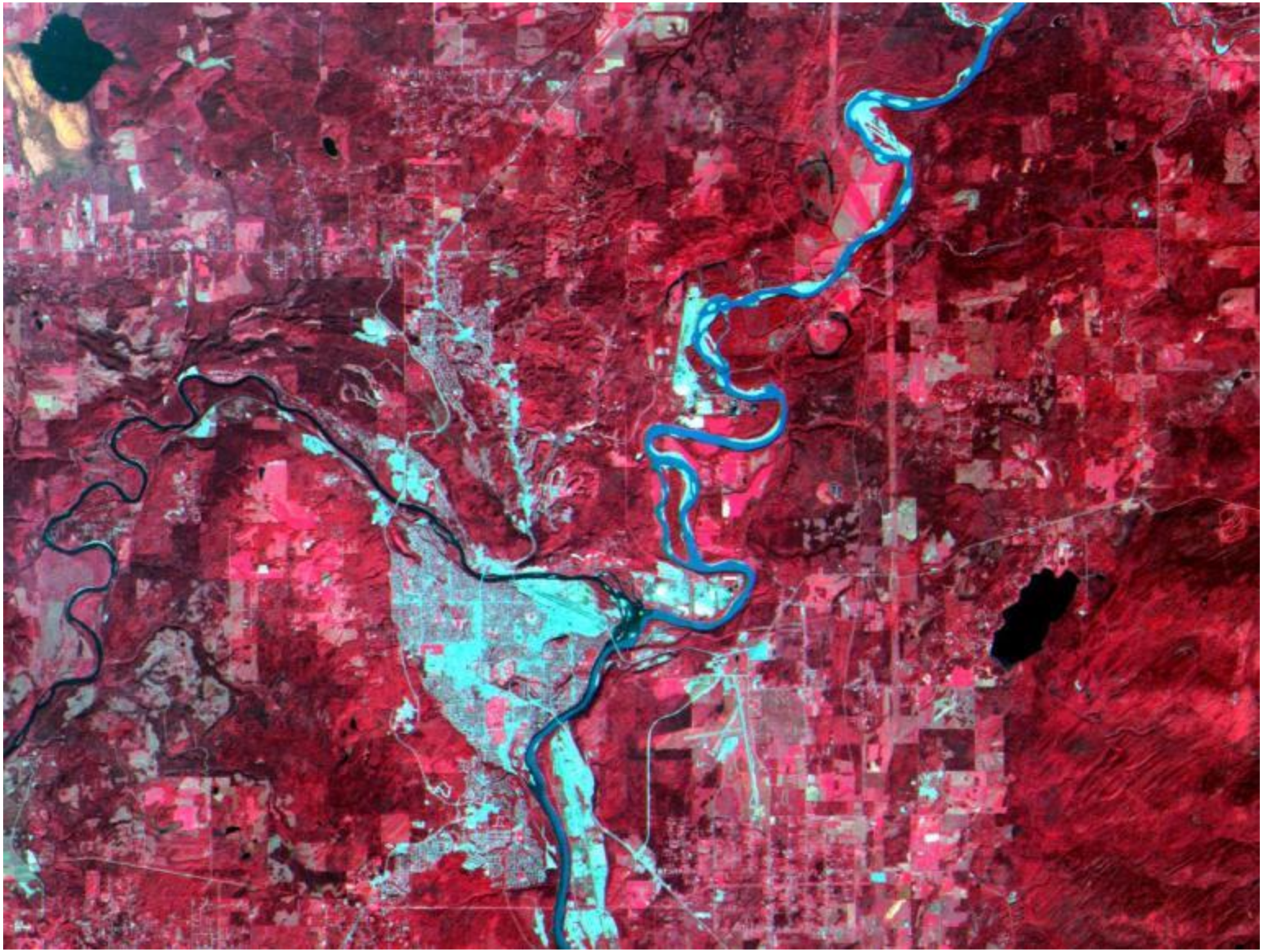
http://www.geo.mtu.edu/rs/keweenaw/

Blue-Green-Red (1-2-3)

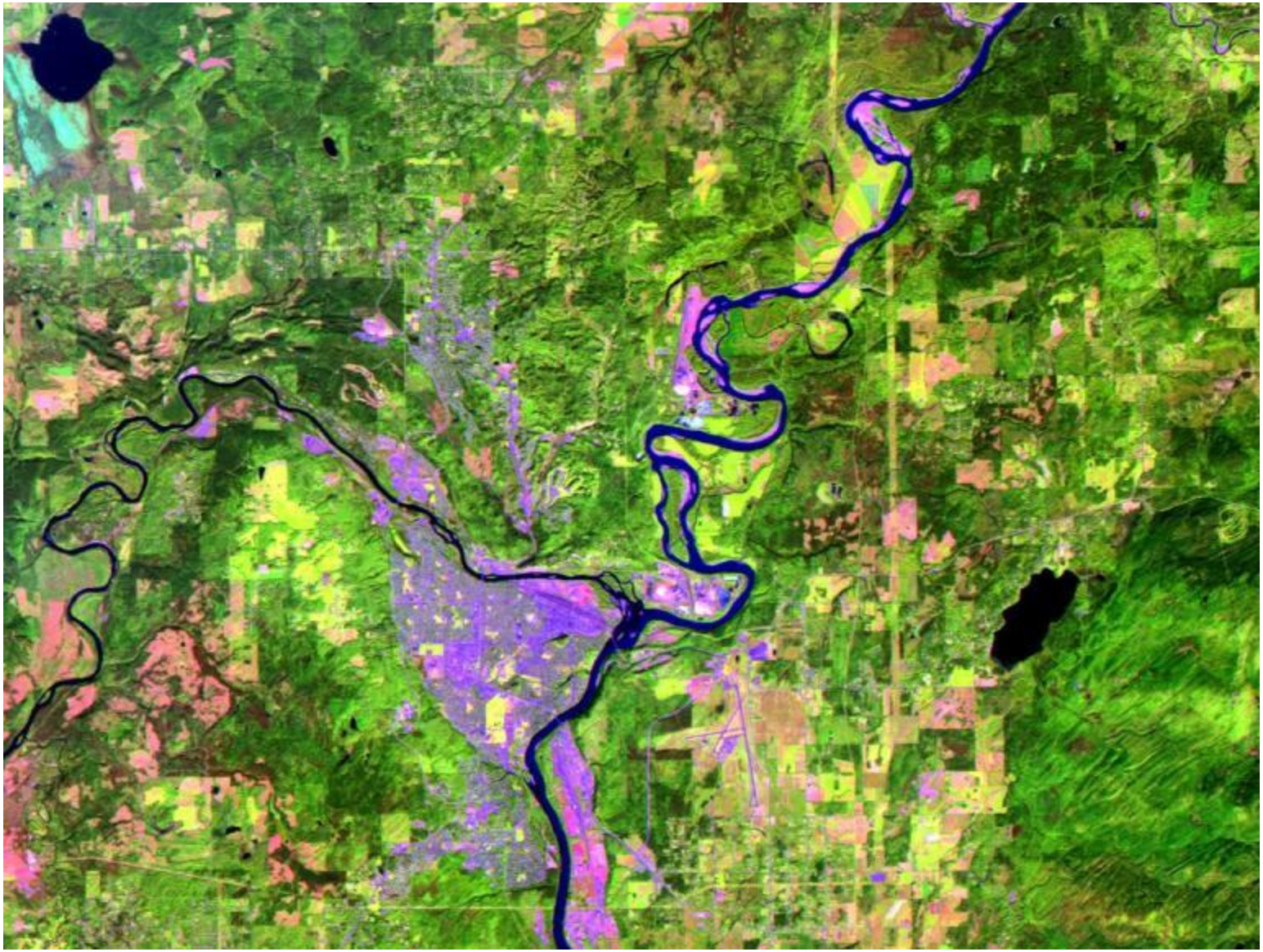


Red-Green-Blue (3-2-1)

‘False’ colour (4-3-2)



TM 543 stretched



RGB screens (Red-Green-Blue)

Default display: 1-2-3 to RGB

Band	**Colour gun**	Flip B and R !
Blue ->	Red	
Green ->	Green	
Red->	Blue	

False colour (camouflage film)

Near-IR -> Red

Red -> Green

Green -> Blue

Maximum contrast

Mid-IR -> Red

Near-IR -> Green

Red -> Blue

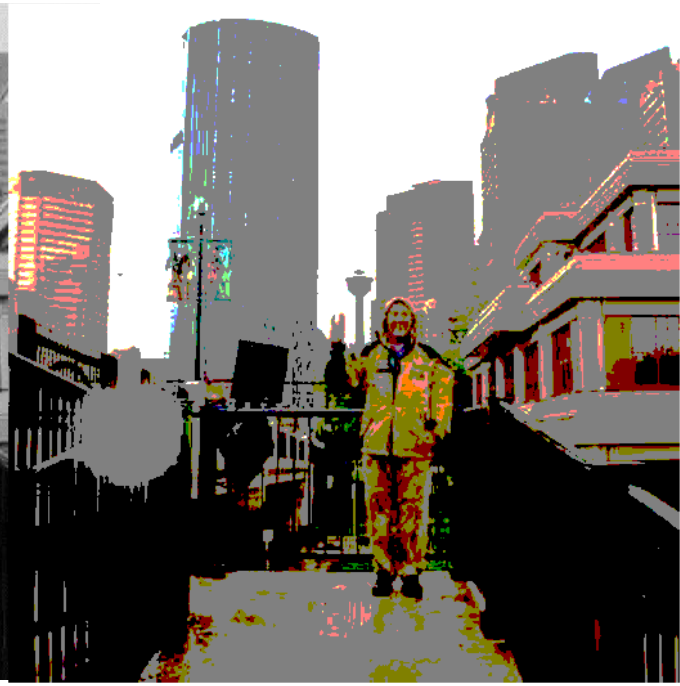
Other display modes: Single band displays
B. Grayscale C: Pseudocolour

B. The same one band or channel in all three guns creates a **grayscale image**:

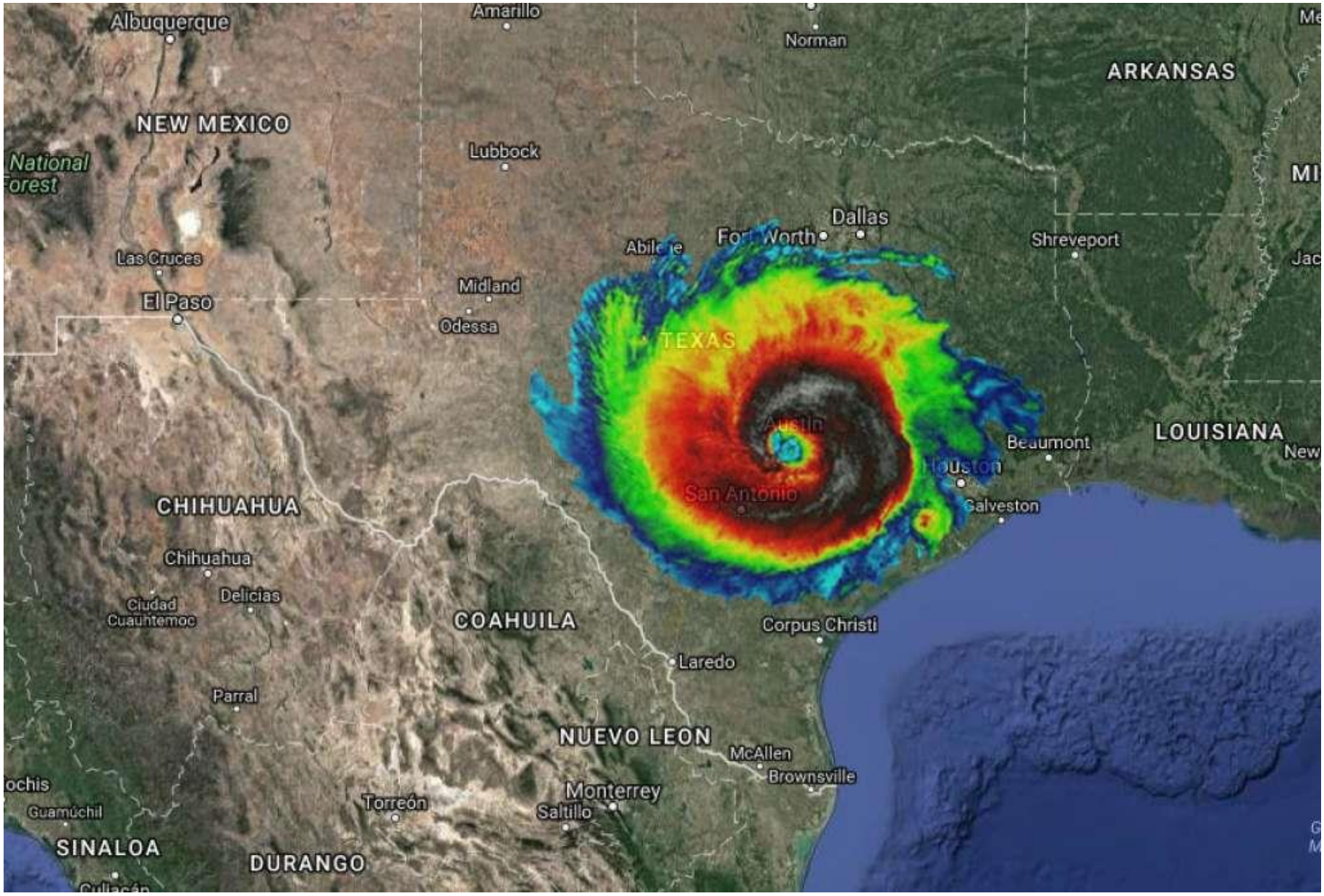
C. One band or channel can also be displayed in **pseudocolour (PC)**: less useful for single bands, but used for thematic layers, Also thermal bands

a. Colour composite b.Grayscale c.Pseudocolour



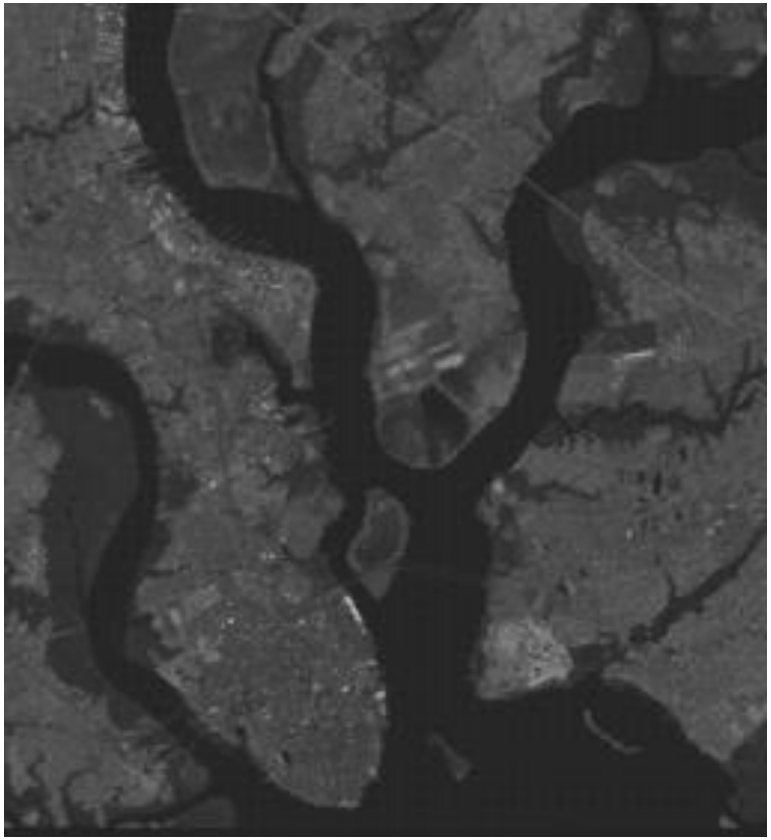


Pseudocolour display – Hurricane Harvey; colours represent temperature



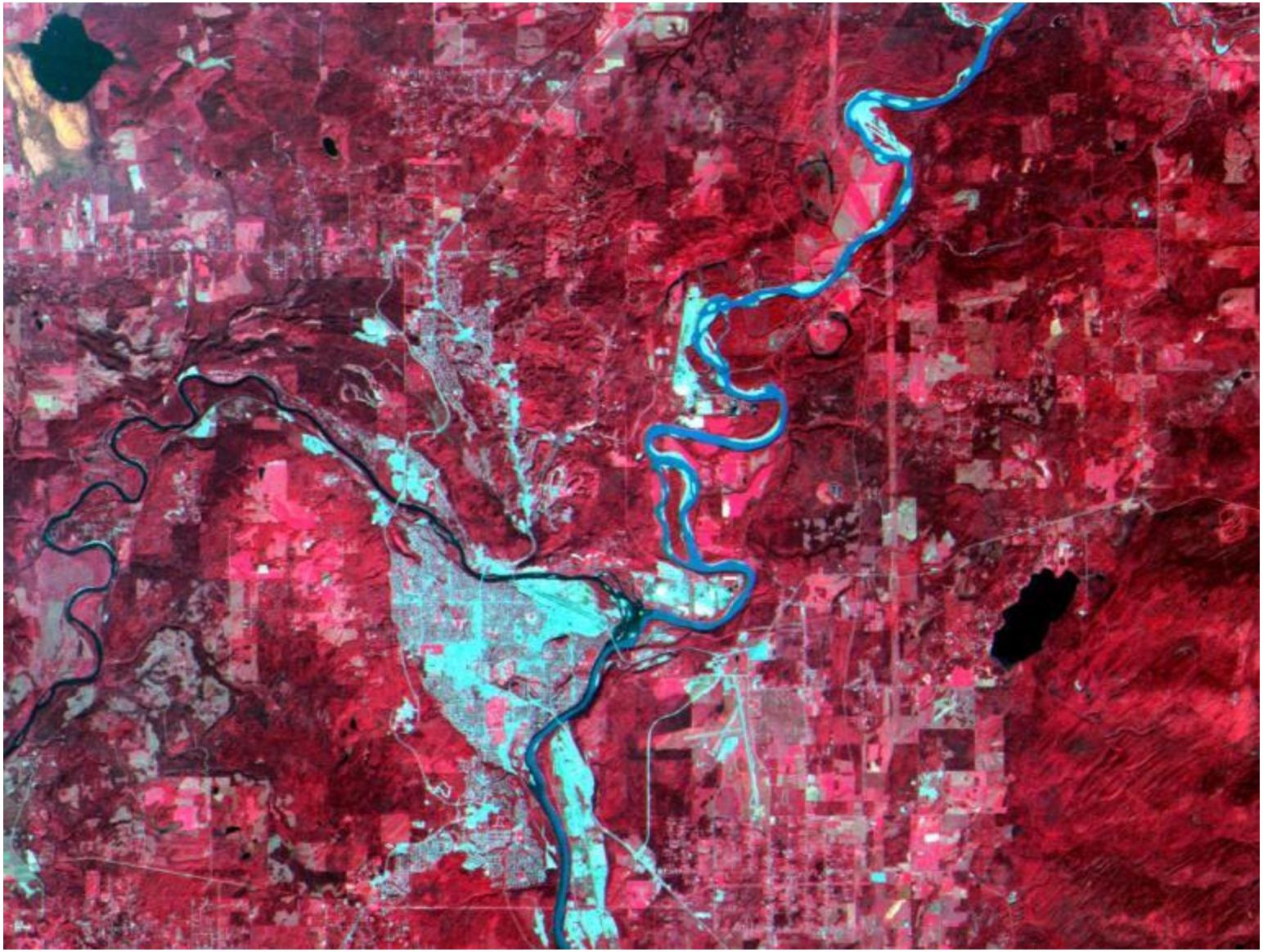
Enhancement / Histogram Stretching

The data rarely fill the maximum display range, so the screen image lacks contrast at first, and needs stretching



False colour Unstretched

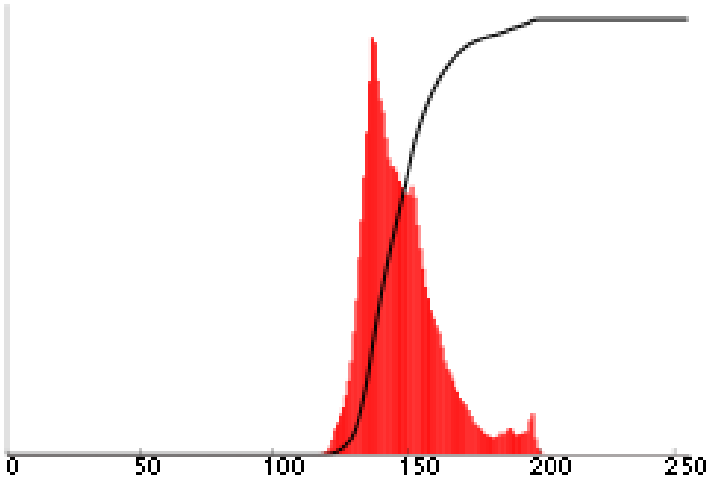
‘False’ colour (4-3-2) enhanced

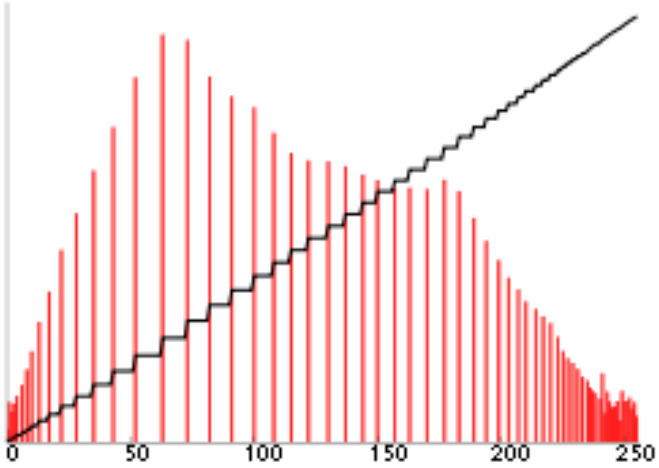


Histogram equalization / contrast stretching / image enhancement

A histogram plots the Digital Numbers (DN) e.g. 0-255, on the x-axis against the frequency of values with those DNs.

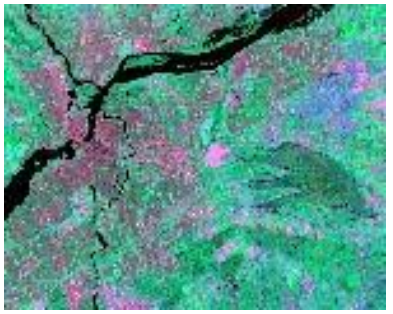
From Wikipedia

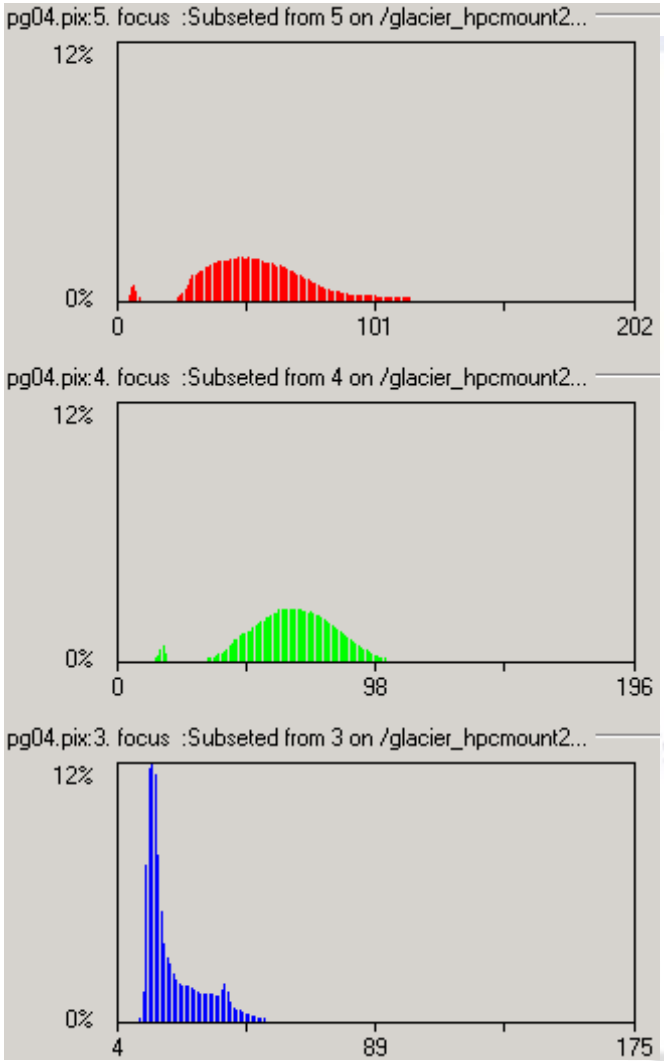




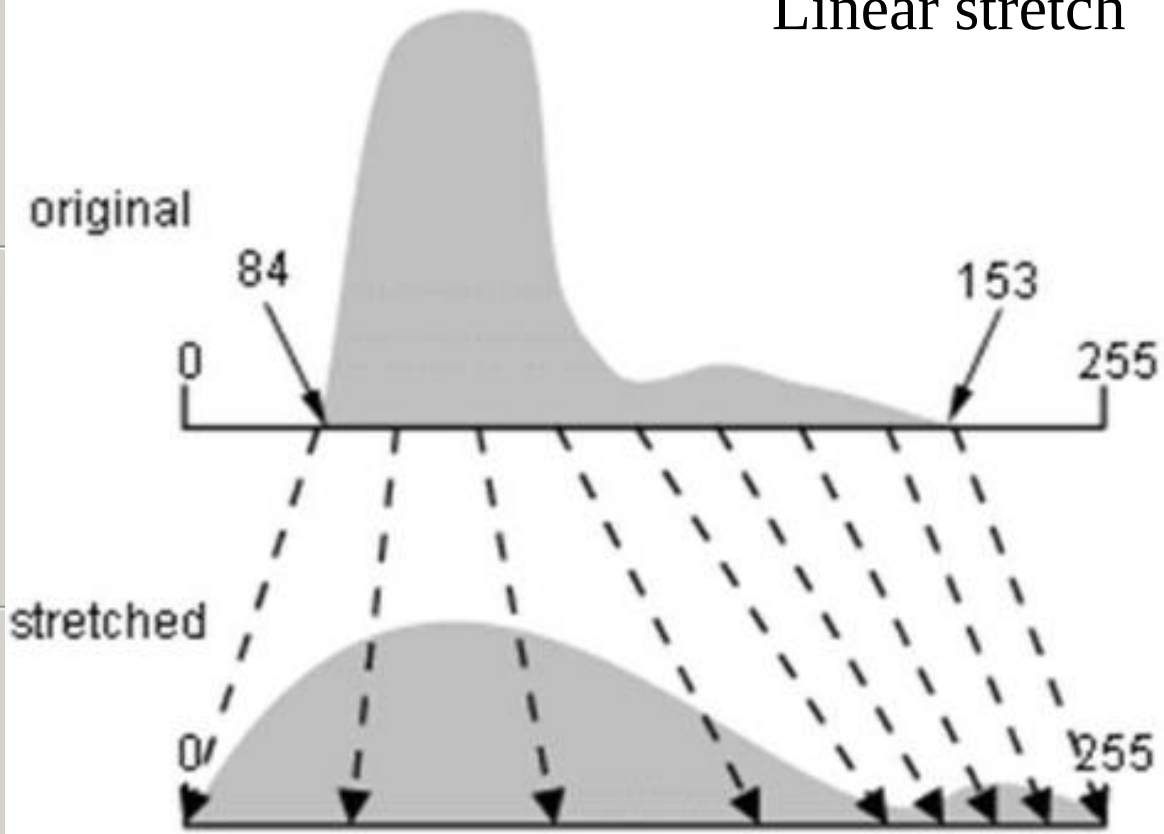
http://www.nrcan.gc.ca/earth-sciences/geography-boundary/remote-sensing/fundamentals/2187

Contrast stretch / enhancement
DNs do not fill the display range





Linear stretch



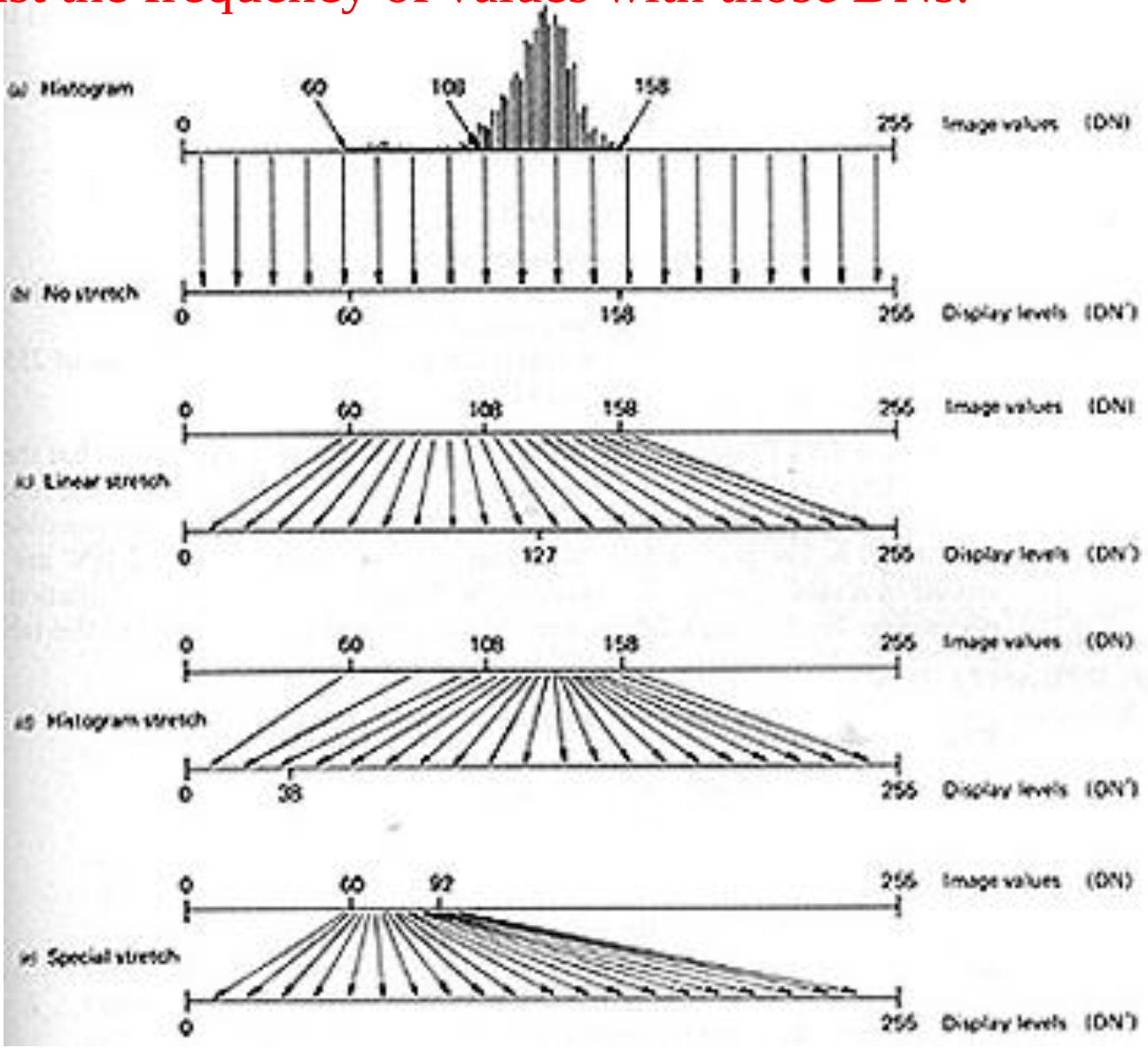
A histogram plots the Digital Numbers (DN) e.g. 0-255, on the x-axis against the frequency of values with those DNs.

None

Linear

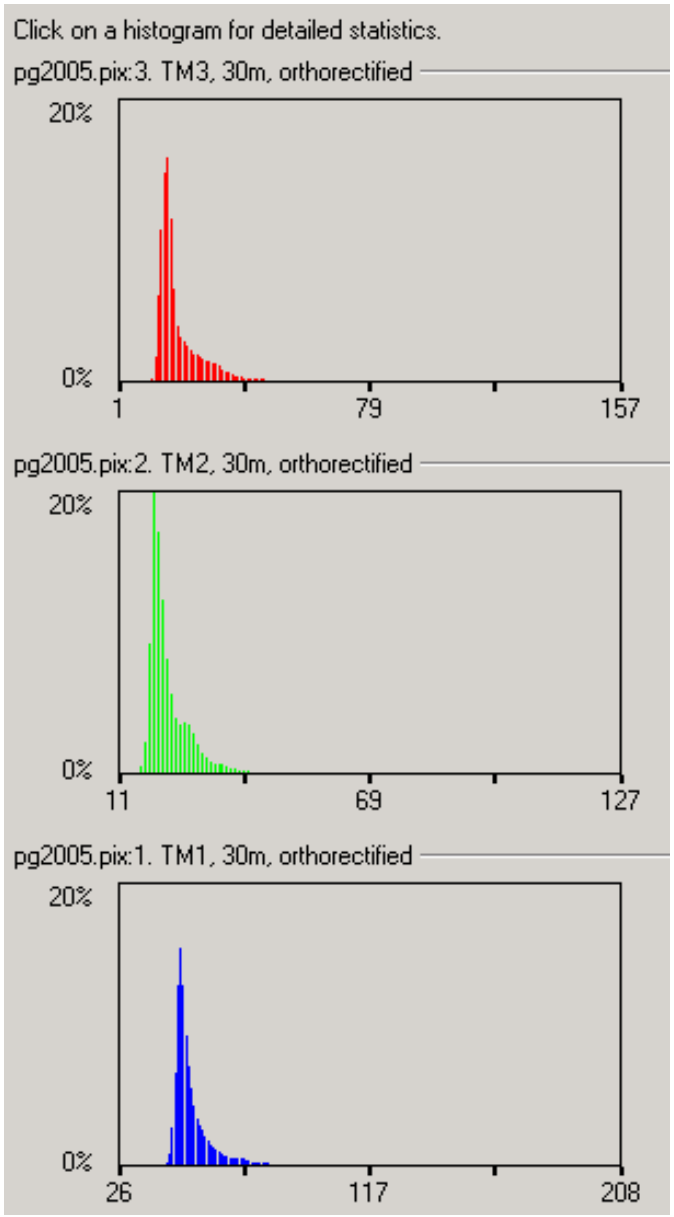
Root

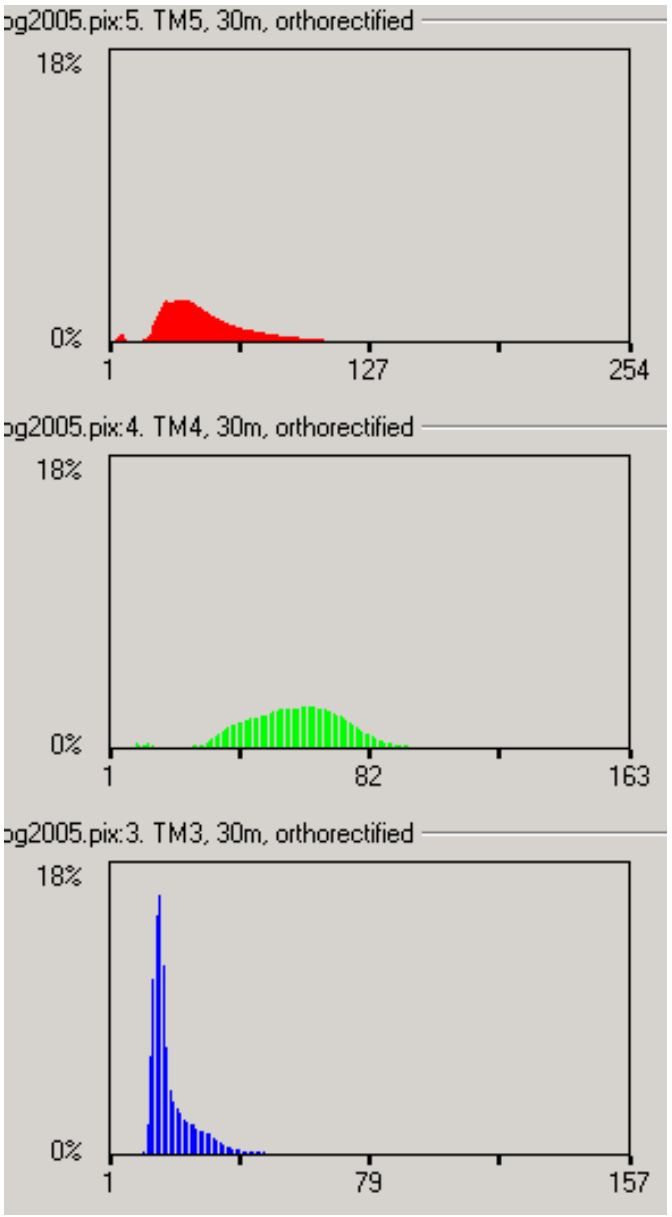
Special



Stretching is the manipulation of display colours to fit the DN ranges:

Bands 3-2-1 Histograms for Landsat TM Bands 5-4-3





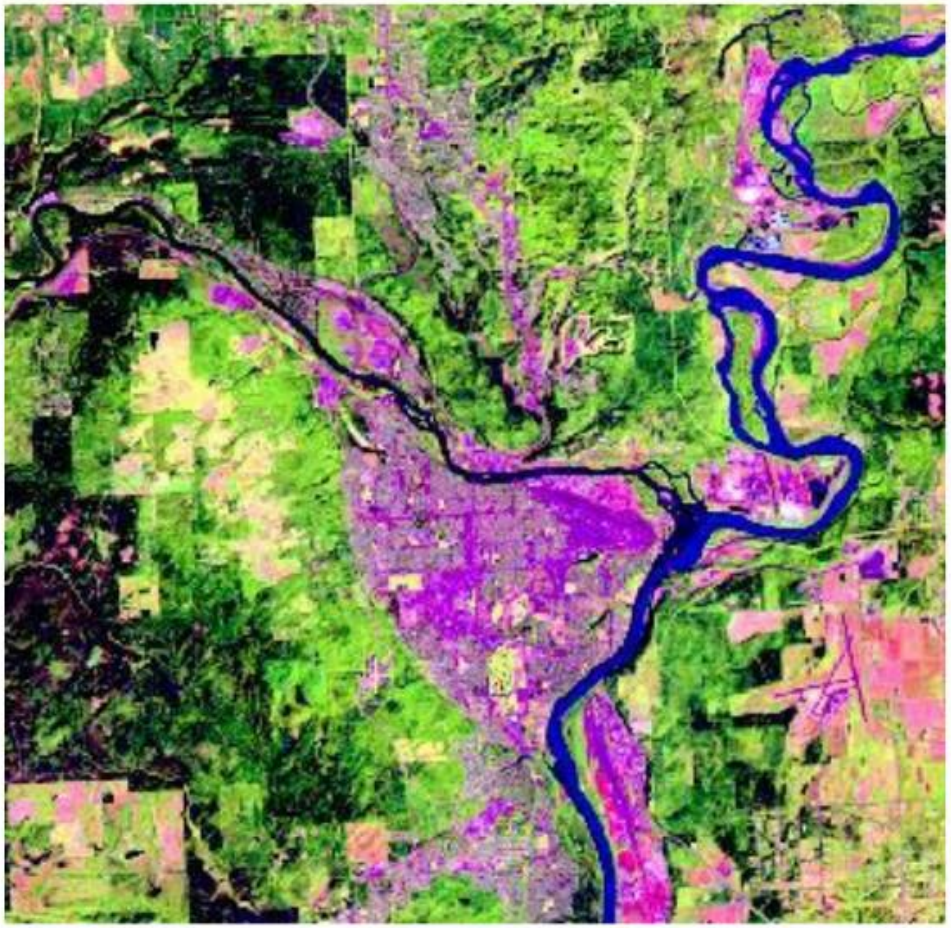
> **2013: Landsat 8 DNs: typically are 5000-20000**

Enhancement is based on screen display

Based on whole scene

Based on zoom into UNBC campus

Screen enhancement does NOT affect digital numbers - **For visual display only**



Digital data summary

1984-2011: mostly 8-bit 0-255

2013-> mostly 16-bit 0-63,536
= higher potential results / detail
but more to understand / greater complexity

no longer a 1:1 ratio in display (0-255)

1984-2011 Landsat 5 DNs: typically 0-120 (plus snow)
2013-present: Landsat 8 DNs: typically 5000-20000

Thursday Lab – Sept 17

Please check ahead of time that you can connect to Osmotar
- not at 11.25am ! email me today/Thursday if you have problems

I have 2 screens in the lab – but you may not, though you may be good at switching from software on osmotar to lab instructions. Some students have a second computer e.g. notepad for the lab text – last year I printed it for most students, which I can't do now.

I hope by Thursday I will be able to load it on the GEOG357 webpage; if I have issues I will email it by 11am

May the VPN/VMware Force be with us …