GIST 8118
Lecture 03 – Image Enhancement

- Lecture
  - Digital image processing
    - Storage
    - Display
    - Enhancement
      - Contrast stretch
      - Indices
    - interpretation
- Lab
  - Image Enhancement
    - Spectral enhancement with LUT
    - Vegetation indices

Digital Image Processing

- View, change, interpret digital data with computer software
- Issues with digital image processing
  - Storage
  - Display
  - Processing
  - Interpretation

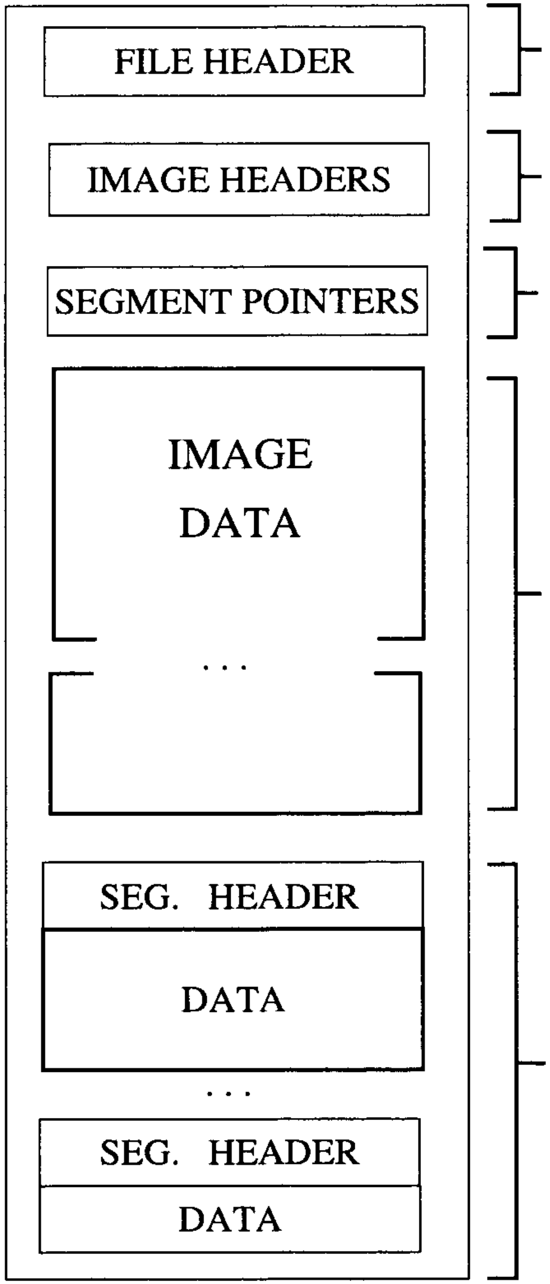
Basic data storage

- All computer information is stored as bits, representing a 0 or a 1.
- We use combinations of bits to store more information, and the information increases exponentially the more bits we use.
- 1 Byte is 8 bits so we can store 256 values. 2 byte is 16 bit and we can store 65,536 values.
- Unit of spatial image data is a Pixel and represents the data from all spectral bands at one spatial location.
- The value for pixel is called a digital number or DN.

PCIDSK database elements

- Raster data – divided into channels
  - Channels contain any image data
    - Satellite image (BAND)   Air photo (digital)   Raster / grid
- Segments – contains non image info
  - LUT – equation of a line y=ax+b
  - BIT maps – rasters with 1 or 0 (on off)
  - PCT – psuedo color tables
  - Georeferencing – projection/coordinate sys info
  - GCP – ground control points
  - Vectors

- Can view with FILES TREE in focus.
  - Not STORED



File type (BIP, BSQ,FIL), amount of data, creation date, location, etc.

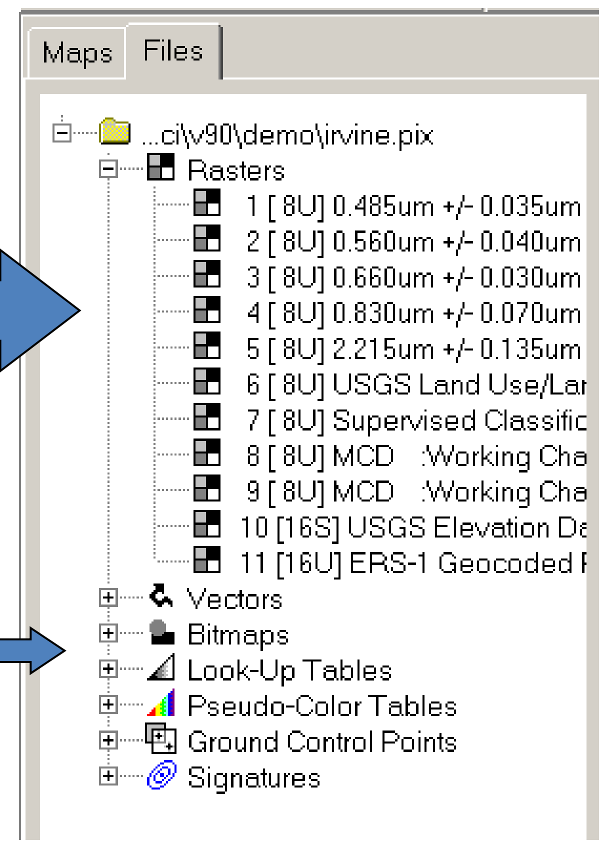
Data type (8U, 16S, 16U,32R), history and descriptive text. Path names stored if FIL database.

BIT	PCI CODE	VALUES
8-bit unsigned	8U	0 TO 255
16-bit signed	16S	-32,768 to + 32,786
16-bit unsigned	16U	0 to 65,535
32-bit real (floating point)	32R	approximately +/-1.2E-38 to 3.4E+38

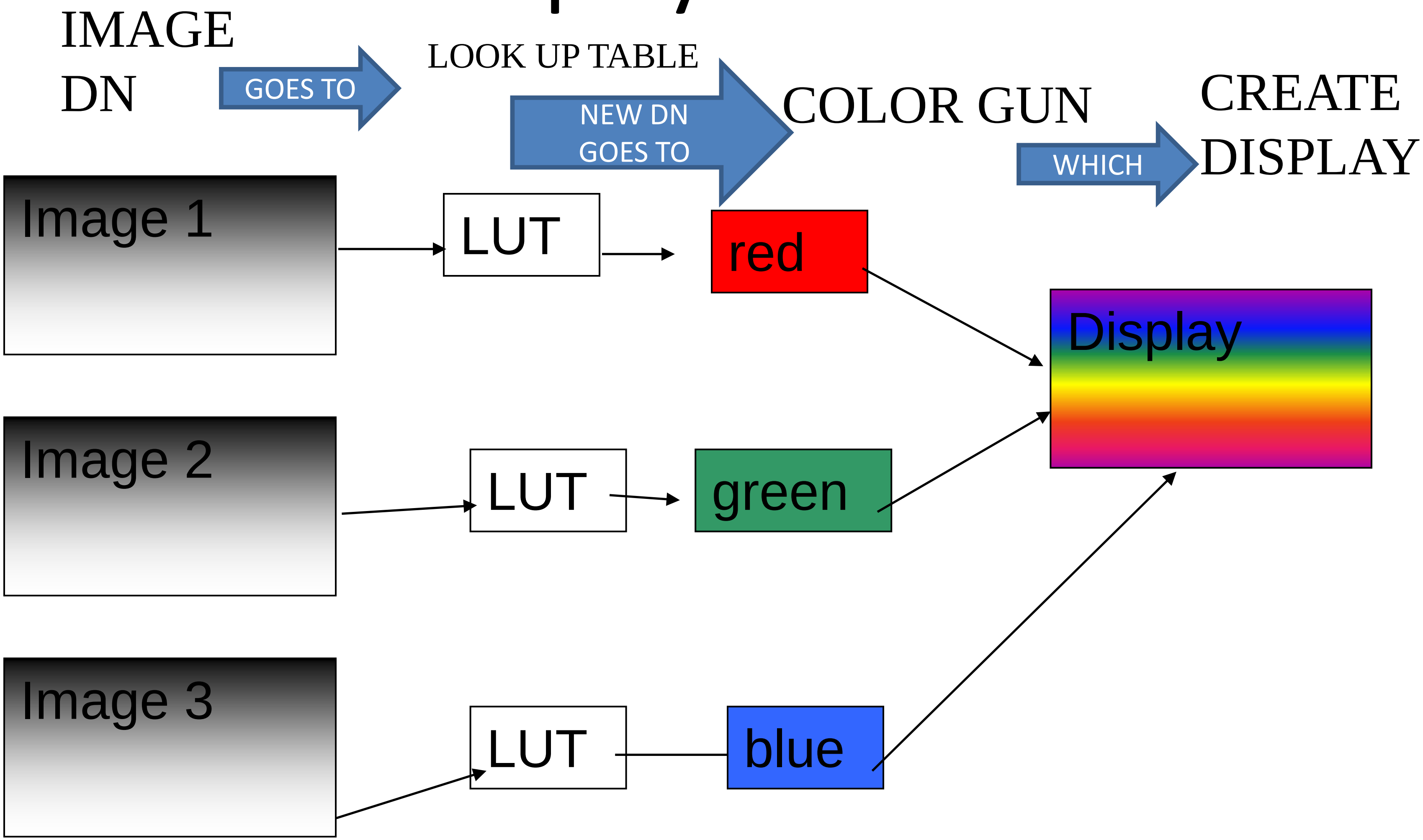
Location of each segment in the database and its size.

Storage location of the actual image data for BIP and BSQ databases (usually takes up most of the database space).
FIL databases do not have this component in their structure; their image data is stored on separate disk files.

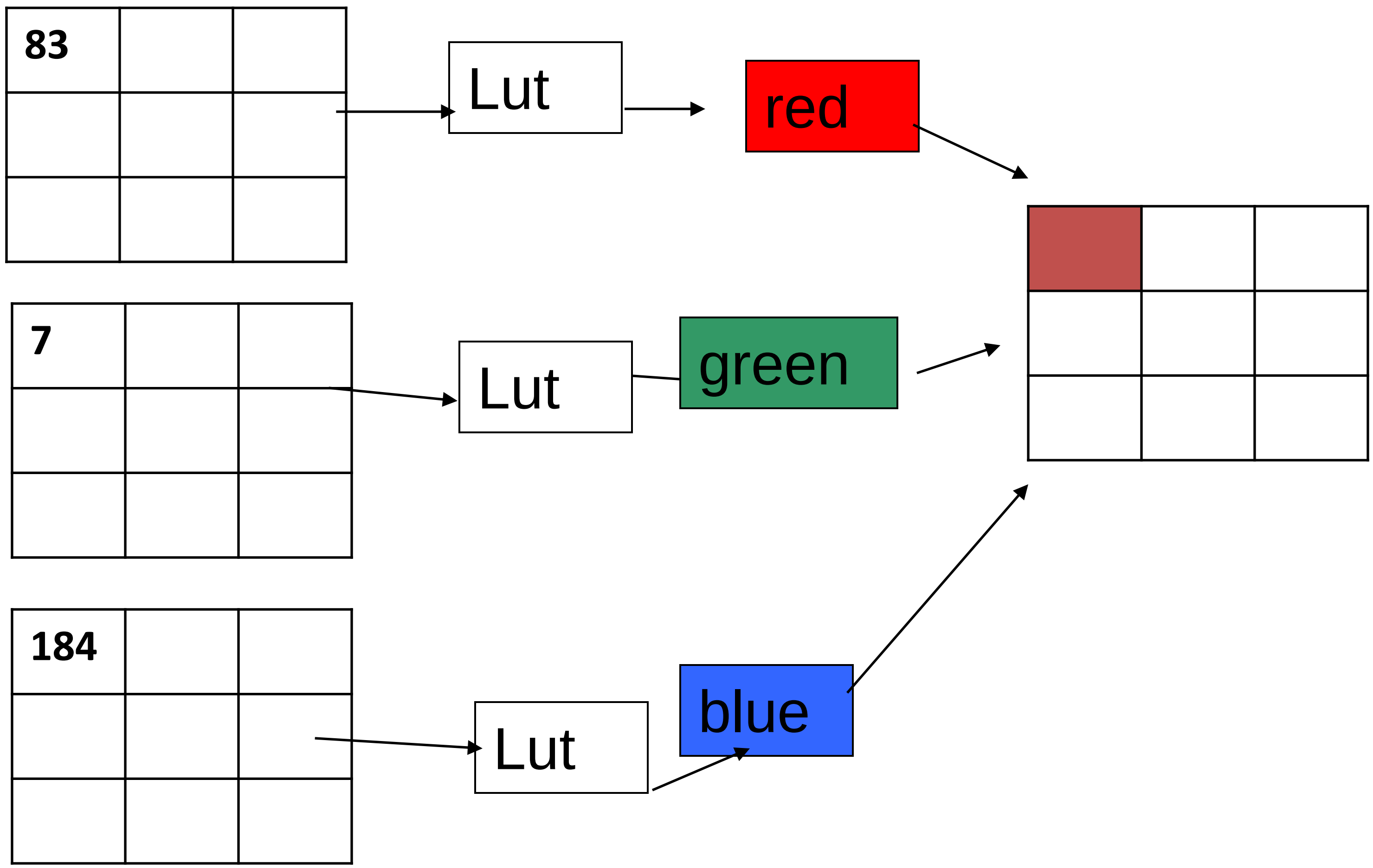
Can store up to 1024 segments. Each segment is made of a header (description and history) and the actual segment data. Segments hold data related to the imagery in the database (bitmaps, vectors, text, signatures, lookup and pseudo-colour tables, ground control points, and georeferencing information).



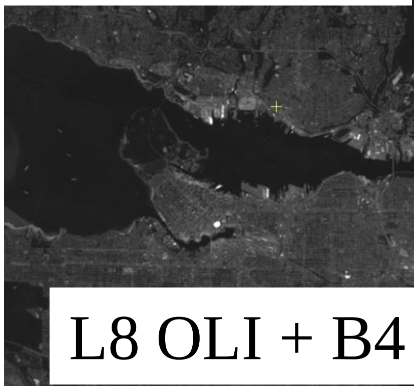
Display Process



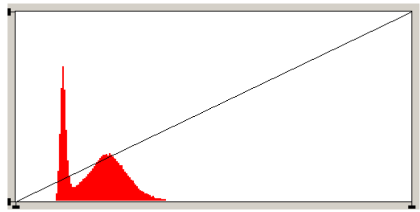
Display Process (2)

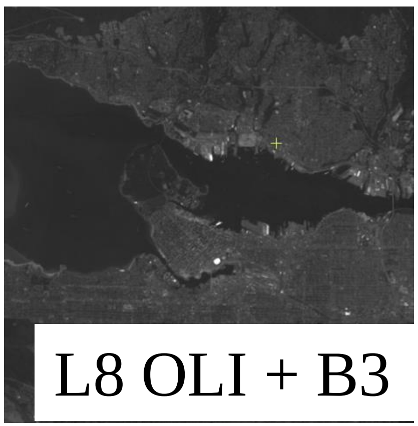


Original Data

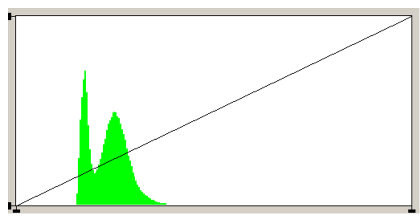


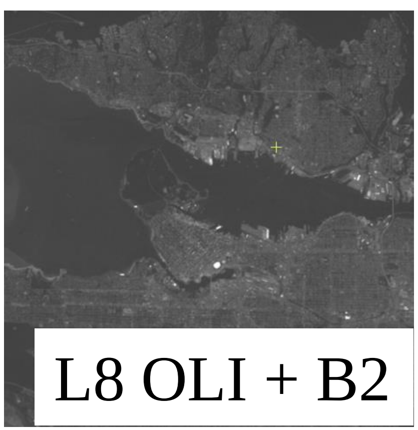
L8 OLI + B4



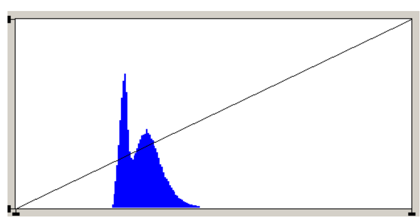


L8 OLI + B3

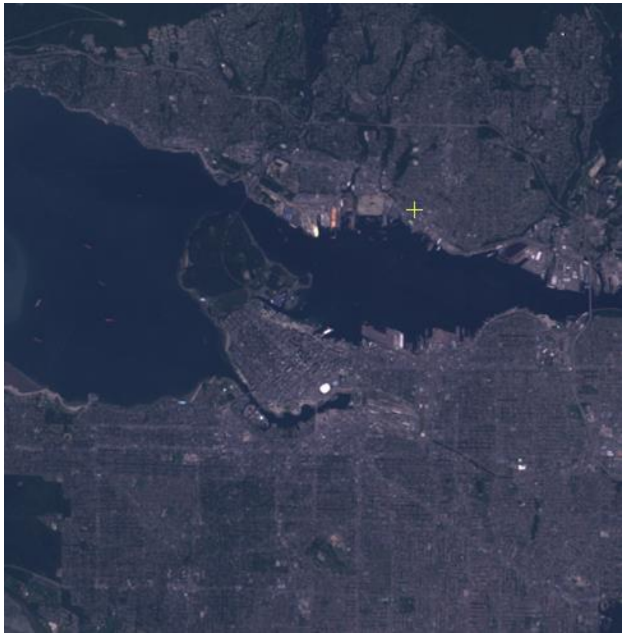




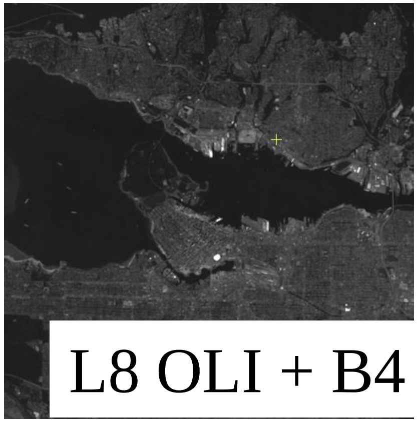
L8 OLI + B2



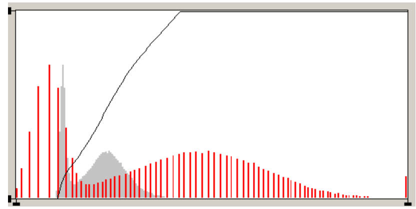
No enhancement



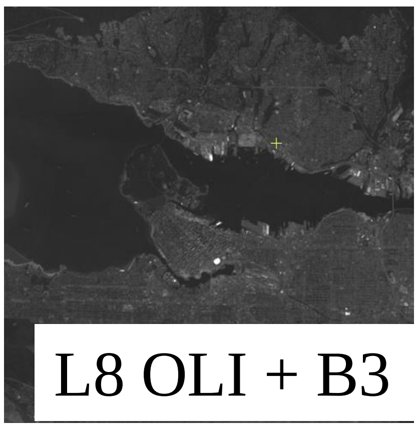
Color Display



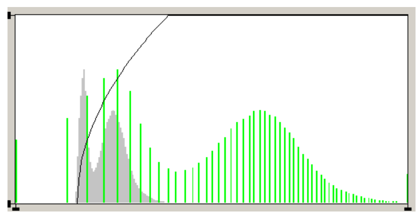
L8 OLI + B4



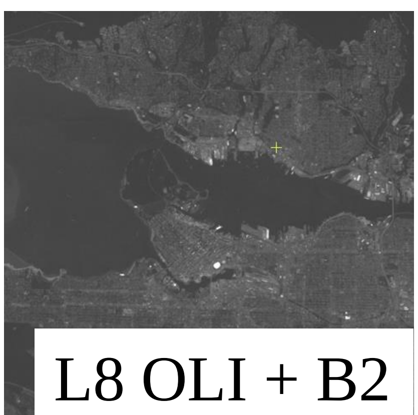
Adaptive



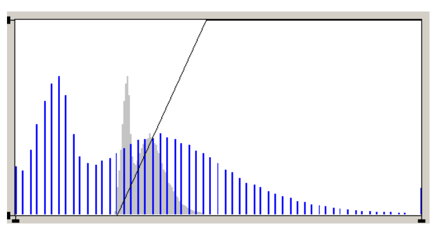
L8 OLI + B3



Root



L8 OLI + B2



Linear

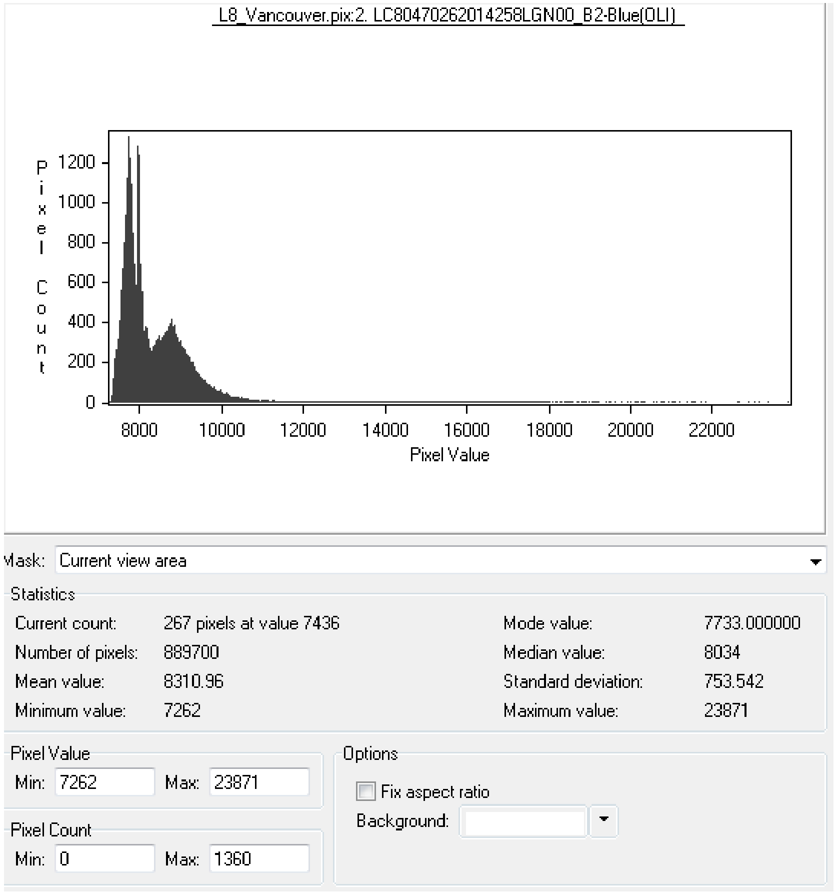
Color Display

Basics of Digital Image Viewing

- Our eyes can see many different colors.
  - we can usually only identify 100 different colors on a page or screen.
  - only see fewer than 32 grey shades
- Our first task is to try to optimize the viewing of the data
  - CONTRAST STRETCH

Image Statistics

- Optimizing the viewing requires knowledge of the image
  - Min DN value
  - Max DN value
  - AVERAGE
  - variance
  - standard deviation
  - histogram



Numeric pixel values

pixel in urban area

Numeric Values

Raw data   Enhanced data

...ncouver.pix: [2]   LC80470262014258LGN00_B2-Blue(OLI)

	390	391	392	393	394	395	396
470	8623	8981	8783	8843	8688	8562	8552
471	8486	8671	8641	8637	8562	8505	8612
472	8764	8957	9029	8763	8823	8996	9011
473	8895	9155	8742	8677	8799	9018	8700
474	8812	9089	8653	8468	8639	8894	8872
475	8987	9047	8808	8521	8491	8580	8496
476	9030	9237	9243	9056	8805	8792	8888

Export   Close

raw data (16 Bit)

Numeric Values

Raw data   Enhanced data

...ncouver.pix: [2]   LC80470262014258LGN00_B2-Blue(OLI)

	390	391	392	393	394	395	396
470	19	25	22	23	20	18	18
471	17	20	20	20	18	18	19
472	22	25	26	22	22	25	25
473	24	28	21	20	22	25	21
474	22	27	20	17	20	24	23
475	25	26	22	18	17	19	17
476	26	29	29	26	22	22	23

Export   Close

Raw data (256 scaled) – no spectral enhancement

Numeric Values

Raw data   Enhanced data

...ncouver.pix: [2]   LC80470262014258LGN00_B2-Blue(OLI)

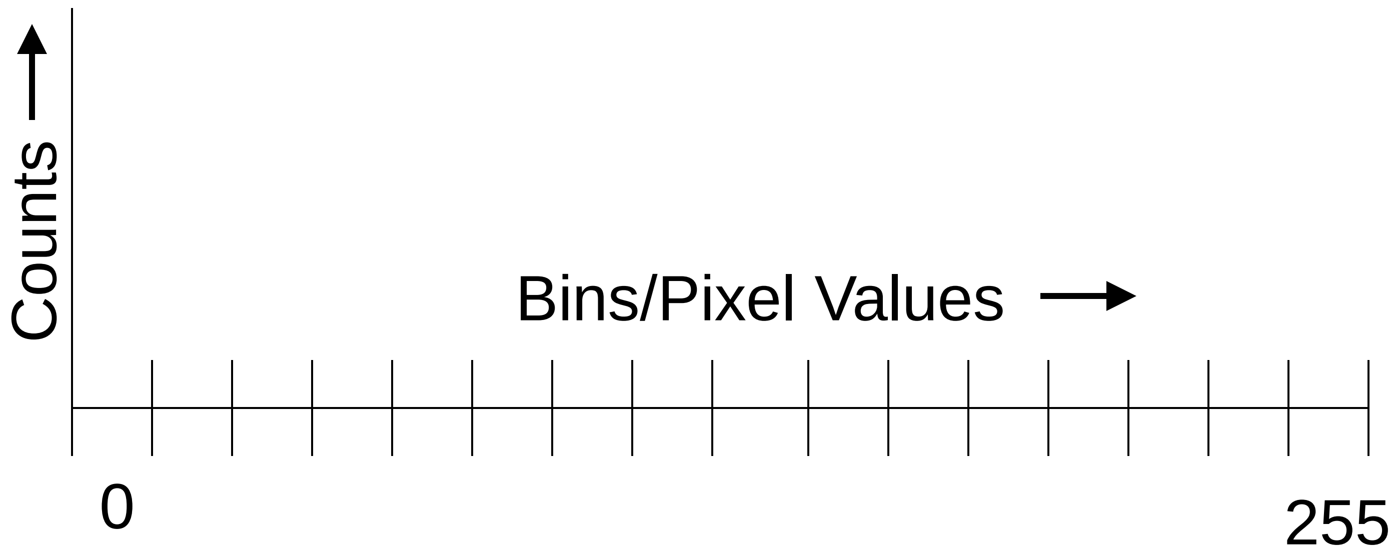
	390	391	392	393	394	395	396
470	116	154	133	139	123	109	108
471	101	121	118	117	109	103	115
472	131	151	159	131	137	155	157
473	145	172	128	122	135	158	124
474	136	165	119	99	117	145	142
475	155	161	135	105	102	111	102
476	159	181	182	162	135	134	144

Export   Close

Linear enhancement (256 scaled)

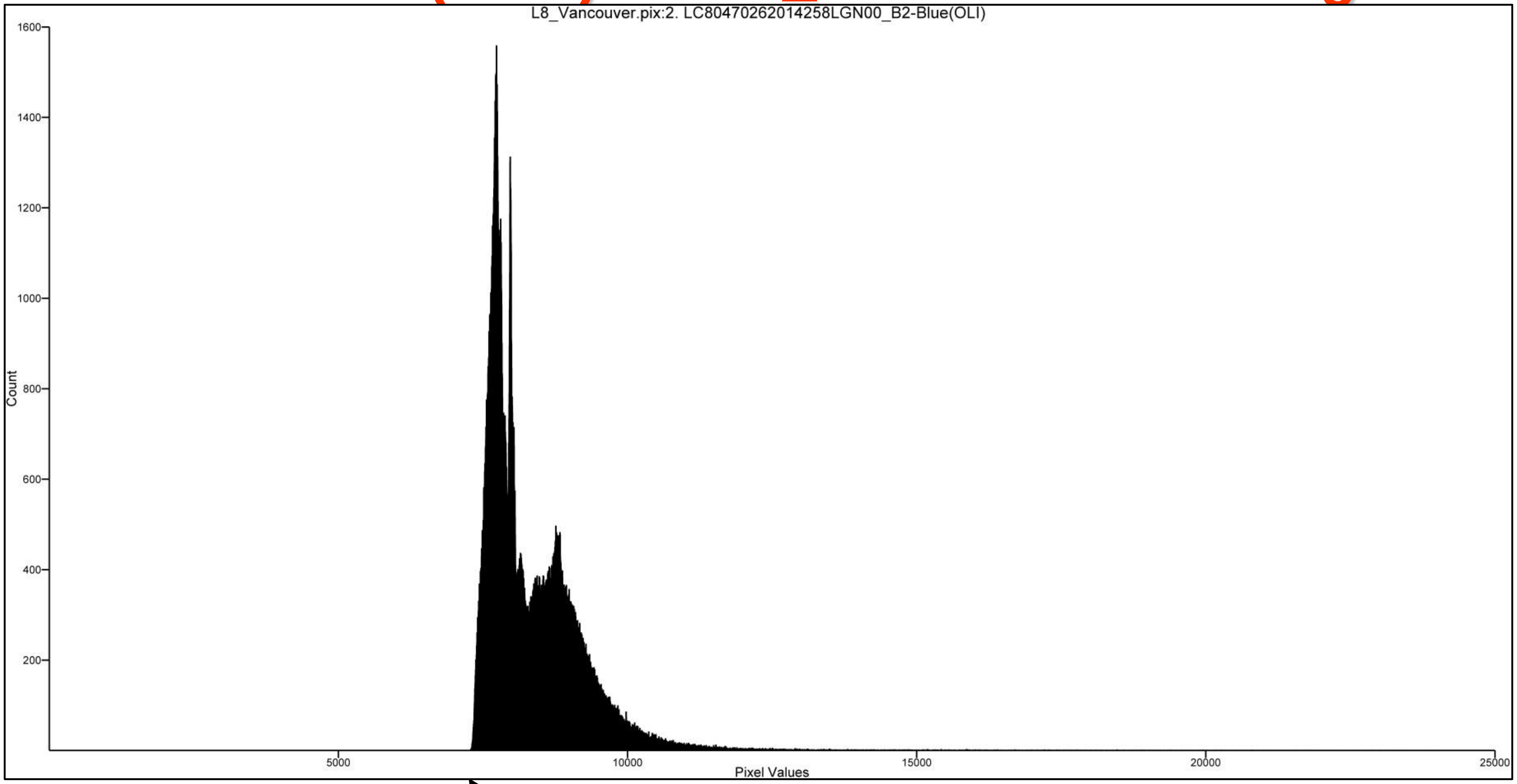
Histograms

- A plot of the number of pixels at each DN within each band (wavelength).



Unstretched Histogram

Band 2 (Blue) for L8_VANCOUVER image

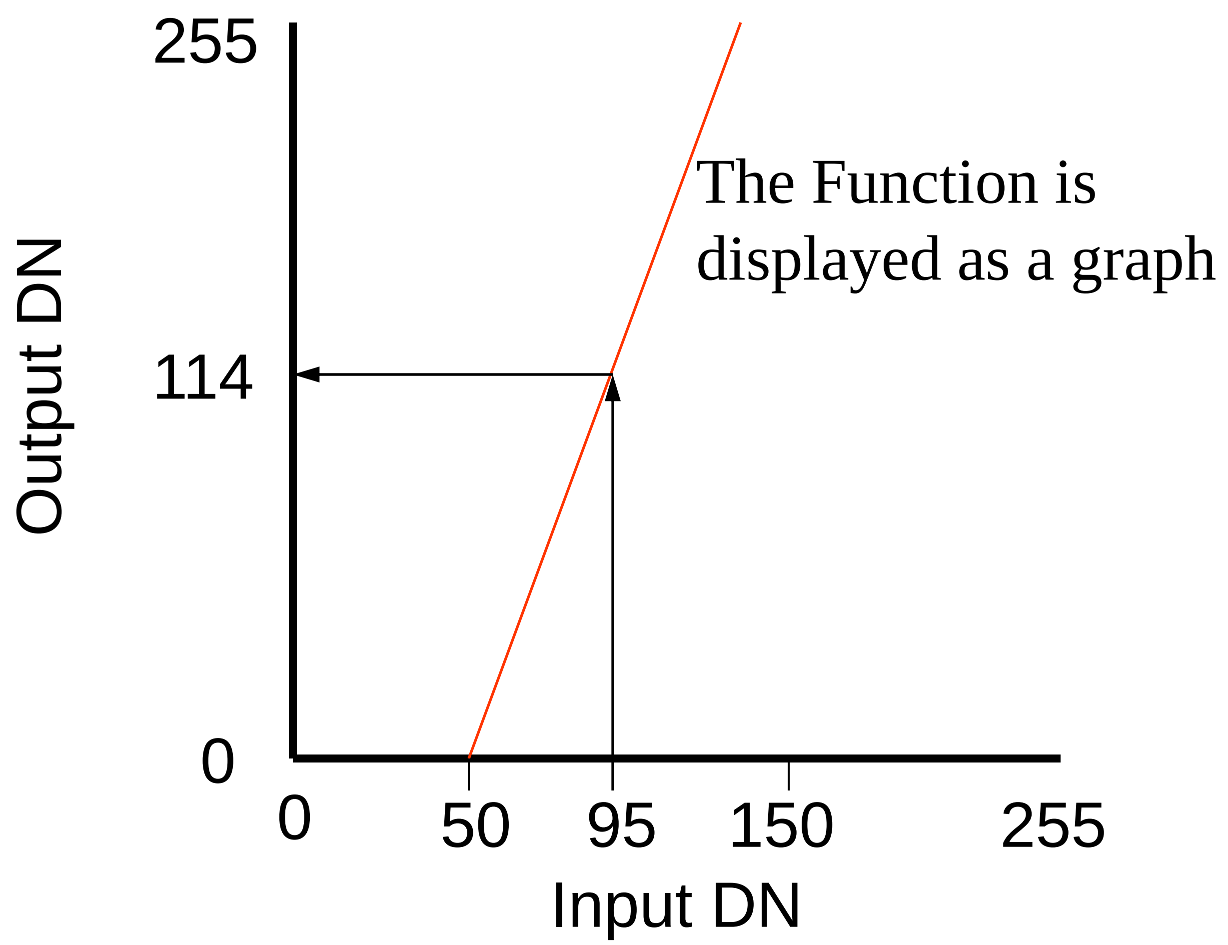


The actual data is only spread over a small part of the total possible range.

Contrast Stretches

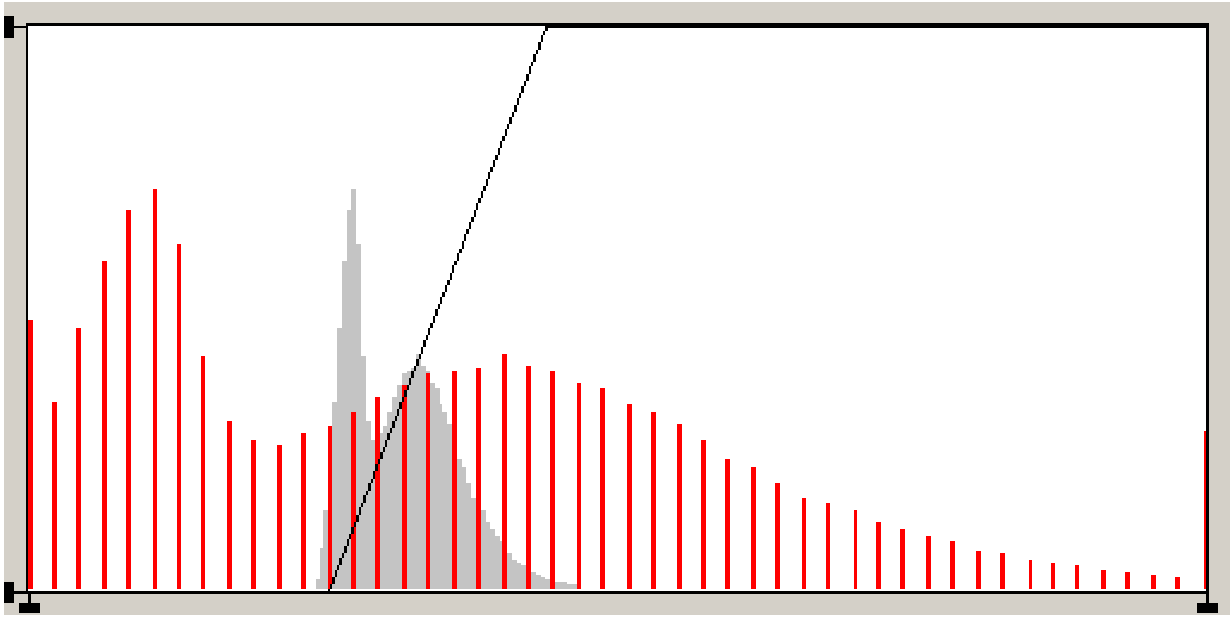
- The purpose
  - to map image data into a different histogram to improve the display of the data.
- A contrast stretch is a function
  - Stretched DN(display value) = F(original DN)
    - Example linear - $y = 1.8 * DN – 57$
- Examples:
  - Linear Stretch
  - Histogram Equalization Stretch

Example of a Linear Stretch Function



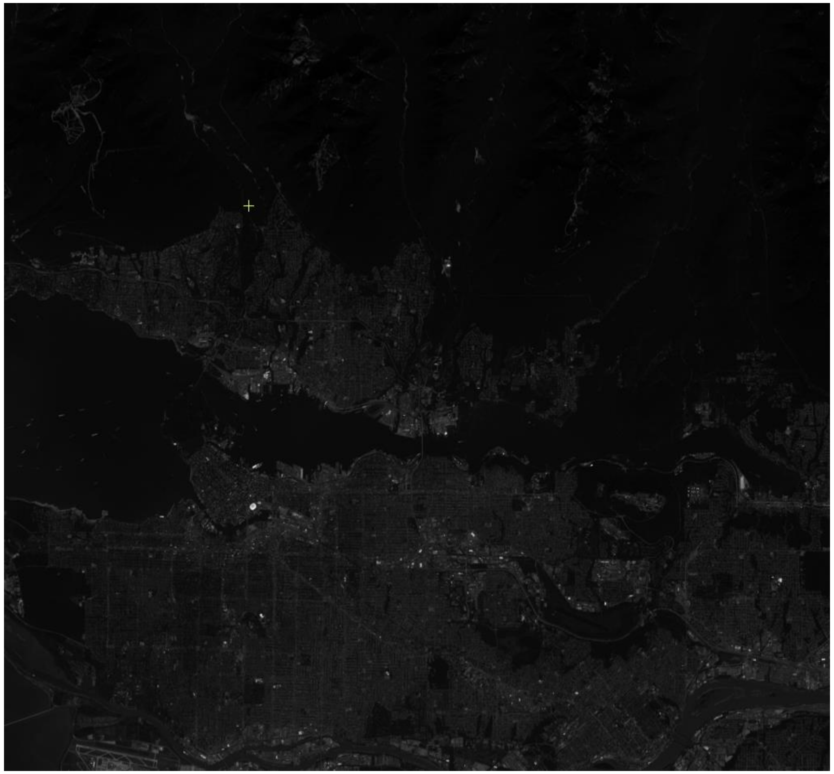
Histogram for Linear Stretch

Band 2 (Blue) for L8_VANCOUVER image



Band 2 (Blue) for L8_VANCOUVER image

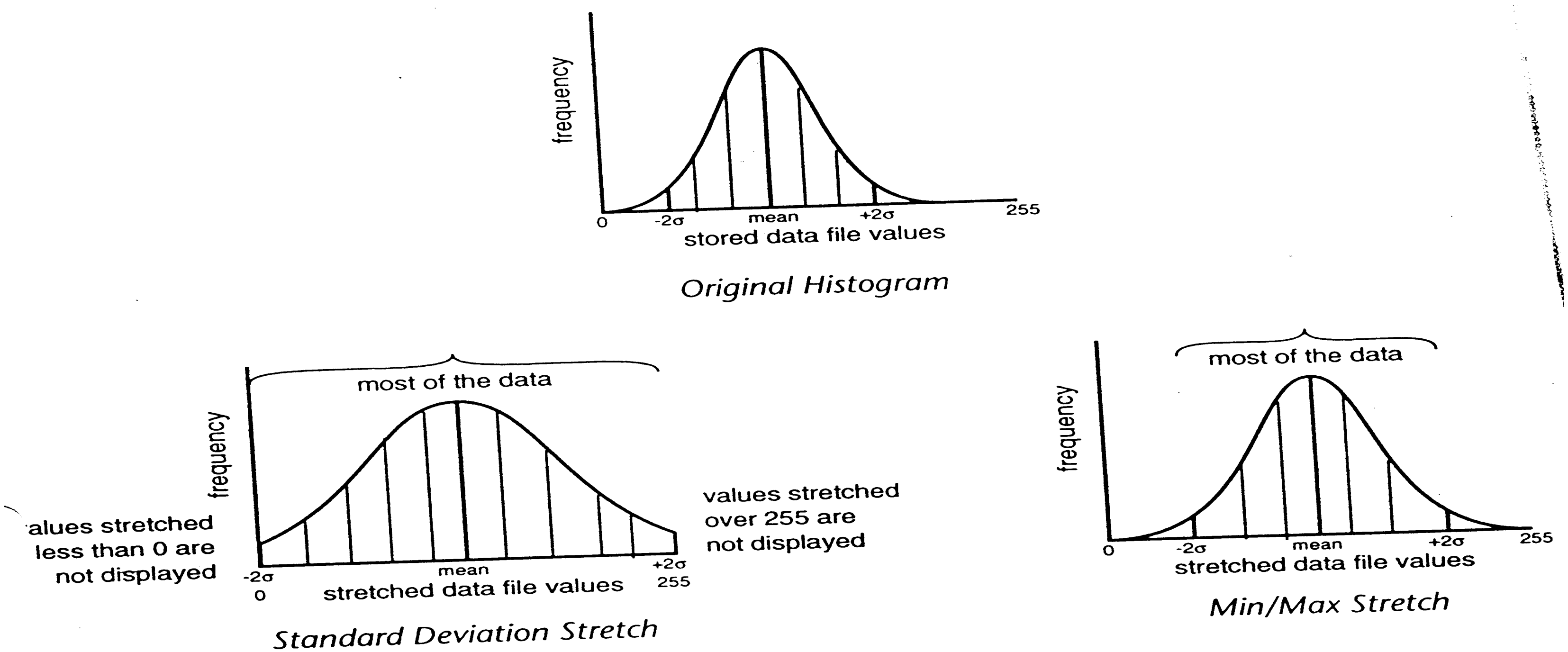
No Enhancement



Linear Enhancement

Selecting Min/Max VALUES

- The min and max value used are not the image min/max values
  - Images typically have one or two 0s and 255



LUT examples

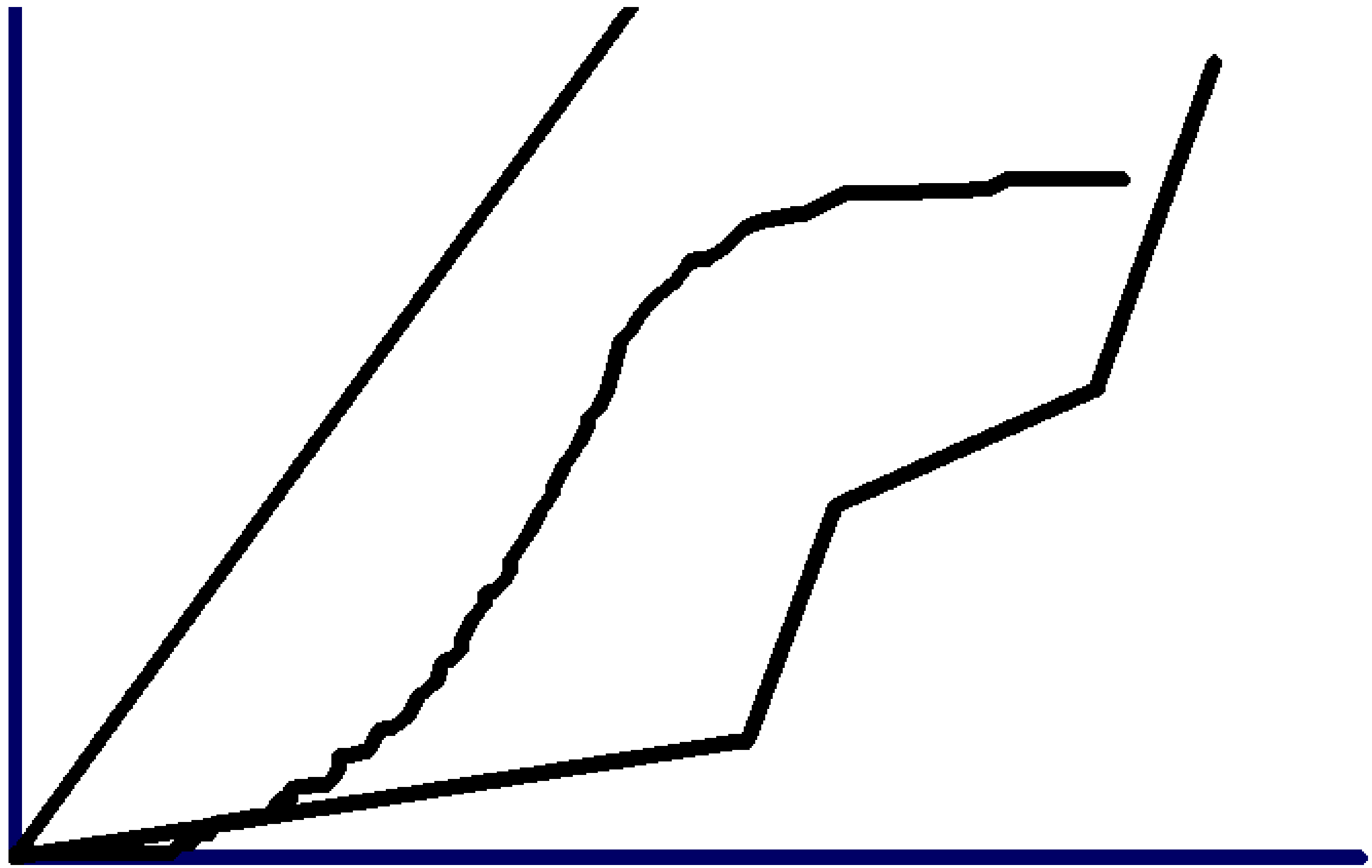


IMAGE INDICES

- Used to create new images by combining the DN of existing images
  - Addition
  - Subtraction
  - Scalars
  - Multiply / divide

Vegetation Indices

- Goal - to create a single number per pixel which predicts or assesses characteristics such as:
  - Biomass
  - Productivity
  - leaf area
  - % vegetative ground cover

Vegetation Indicies

- map the relative vigor of vegetation
  - Vegetation Index =   IR - R
    - where IR = band 5 OLI+ or band 3 Spot XS
    - R = band 4 OLI+ or band 2 Spot XS
  - Ratio Vegetation Index
    - (RVI) = OLI 5/OLI 4
  - Normalized Difference Vegetation Index
    - (NDVI) = [OLI5-OLI4]/[OLI5 + OLI4].

Image Arithmetic

- arithmetic operations are performed on a pixel basis
- IR – R
- BAND 5 – BAND 4
- PIXEL,LINE 517, 479
- 21,352-7,005
- Creates new image
- Value = 14,347

Numeric Values

Raw data   Enhanced data

...ncouver.pix: [5]LC80470262014258LGN00_B5-Near Infrared(OLI)

	515	516	517	518	519	520	521
477	14349	16414	17002	18511	18564	15810	13714
478	16542	20607	17914	16323	16226	13043	14520
479	21752	23077	21352	16615	13391	13126	18041
480	23257	23162	23165	21600	14511	9817	16139
481	22786	23262	22927	19698	12845	11993	12420
482	20595	22437	19175	13512	11084	12638	13252
483	18931	22140	19764	11755	15763	14305	12262

Export   Close

Numeric Values

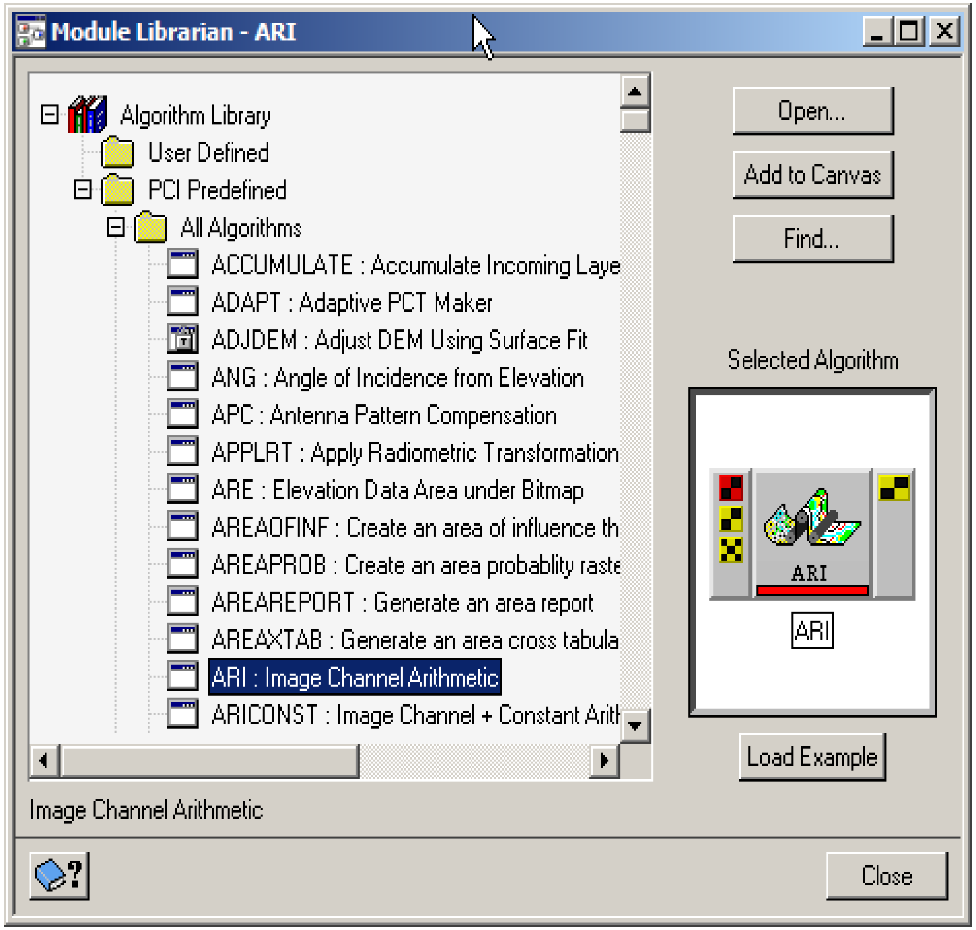
Raw data   Enhanced data

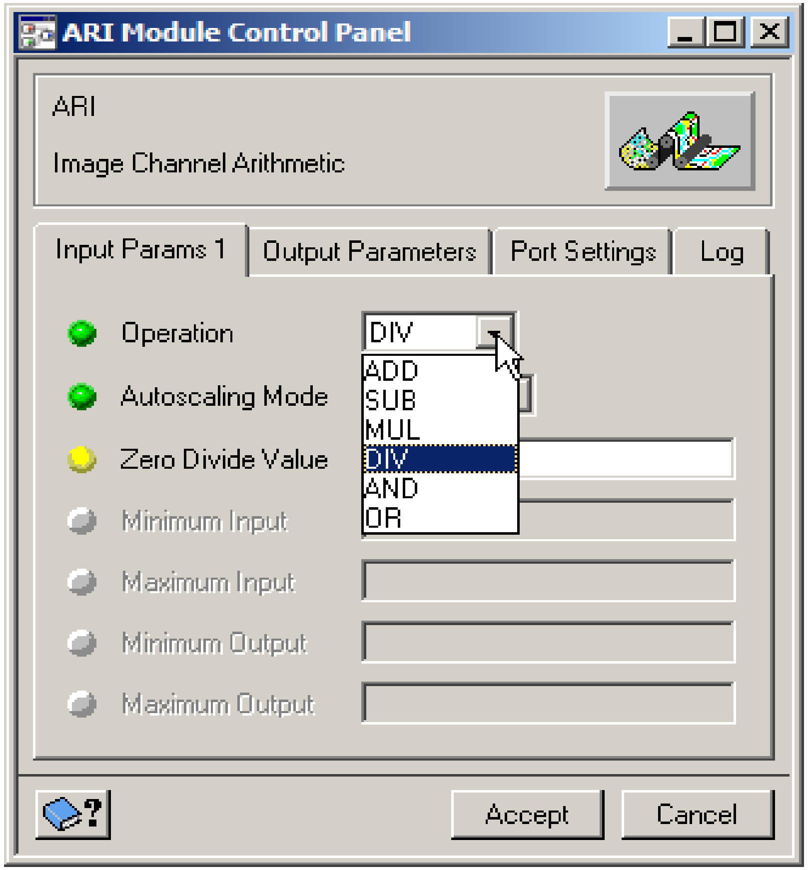
...ncouver.pix: [4]   LC80470262014258LGN00_B4-Red(OLI)

	515	516	517	518	519	520	521
477	6707	7447	7575	6976	7476	8127	7623
478	6642	6746	7499	8129	7501	7091	7040
479	6619	6521	7005	8090	8631	7550	7327
480	6617	6555	6490	6599	7269	6840	7340
481	6569	6534	6528	6503	6816	7425	7123
482	6904	6550	6422	6349	6471	7125	6934
483	7861	6994	6828	6224	6351	6576	6607

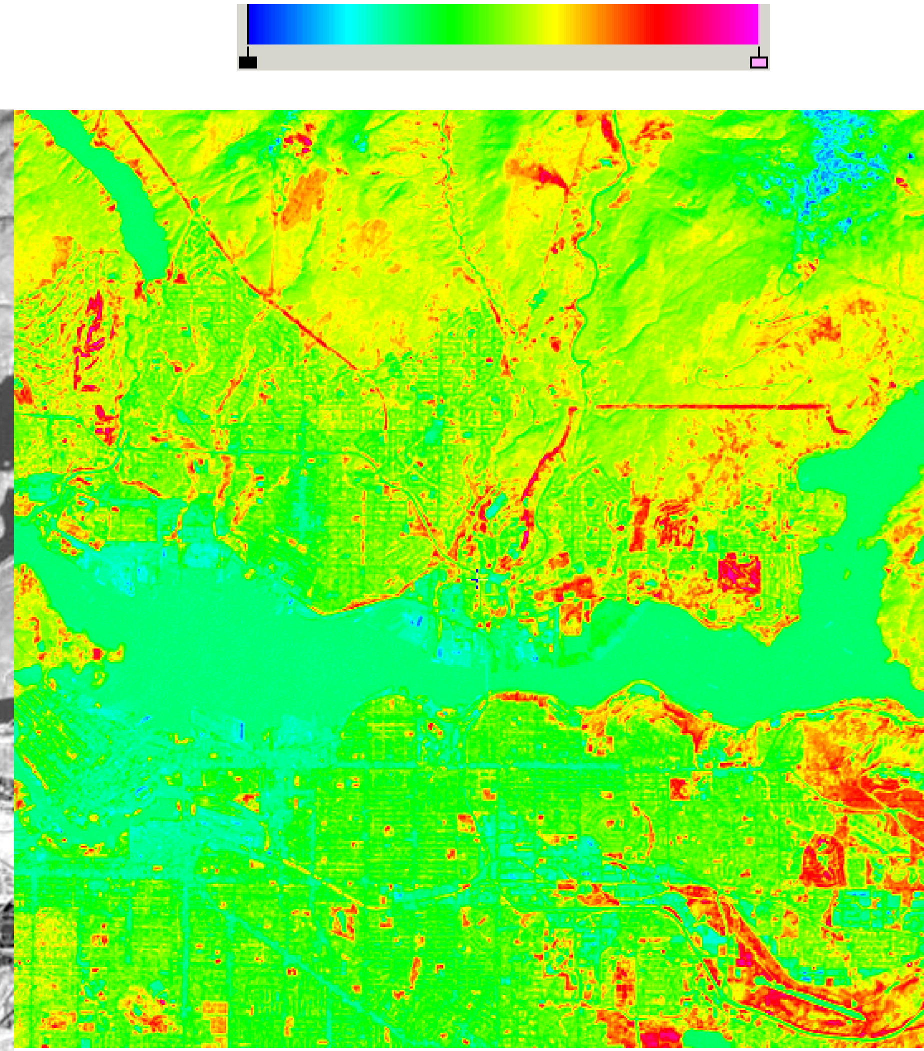
Export   Close

Focus and Image Arithmetic



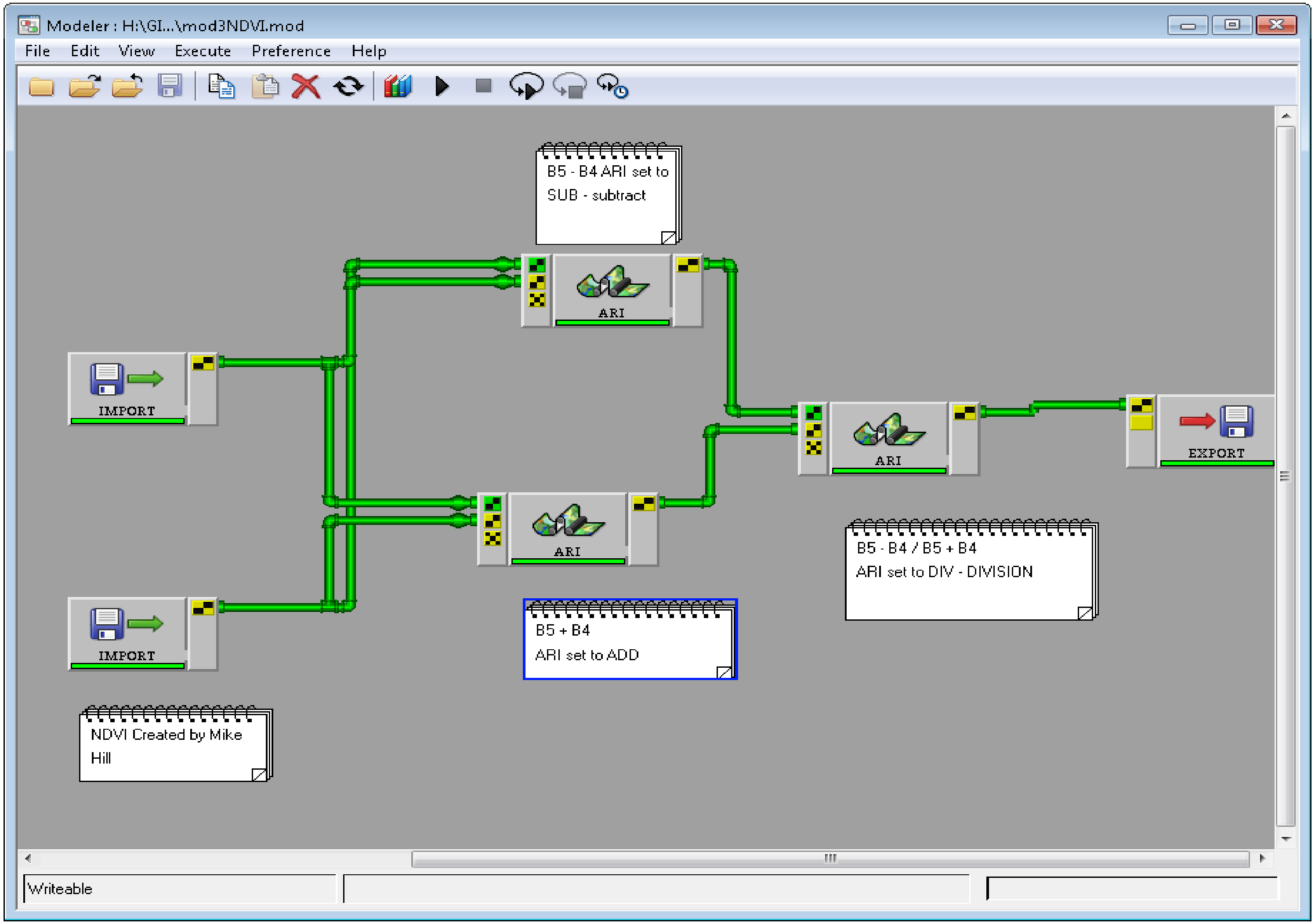


IR - R



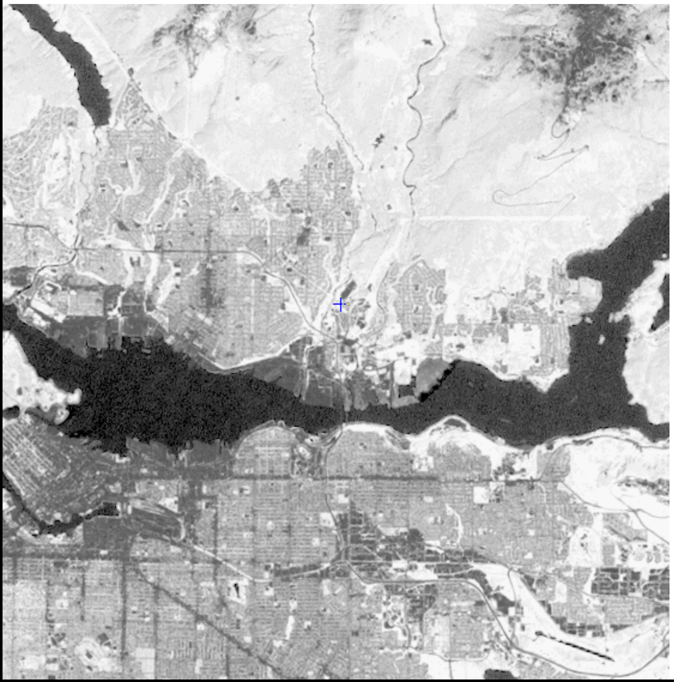
Modeler

(NDVI_OLI) = [OLI5-OLI4]/[OLI5 + OLI4].

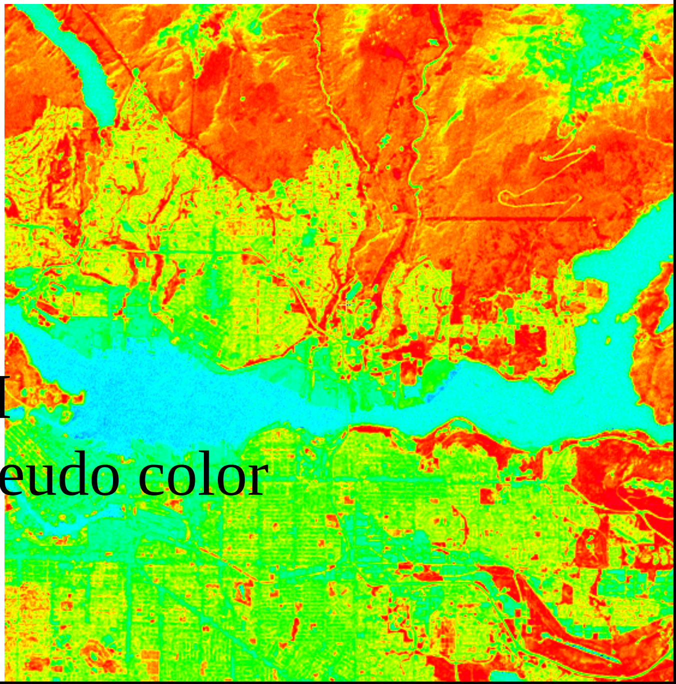


4,3,2

5,4,3



NDVI



NDVI
As pseudo color

Examples

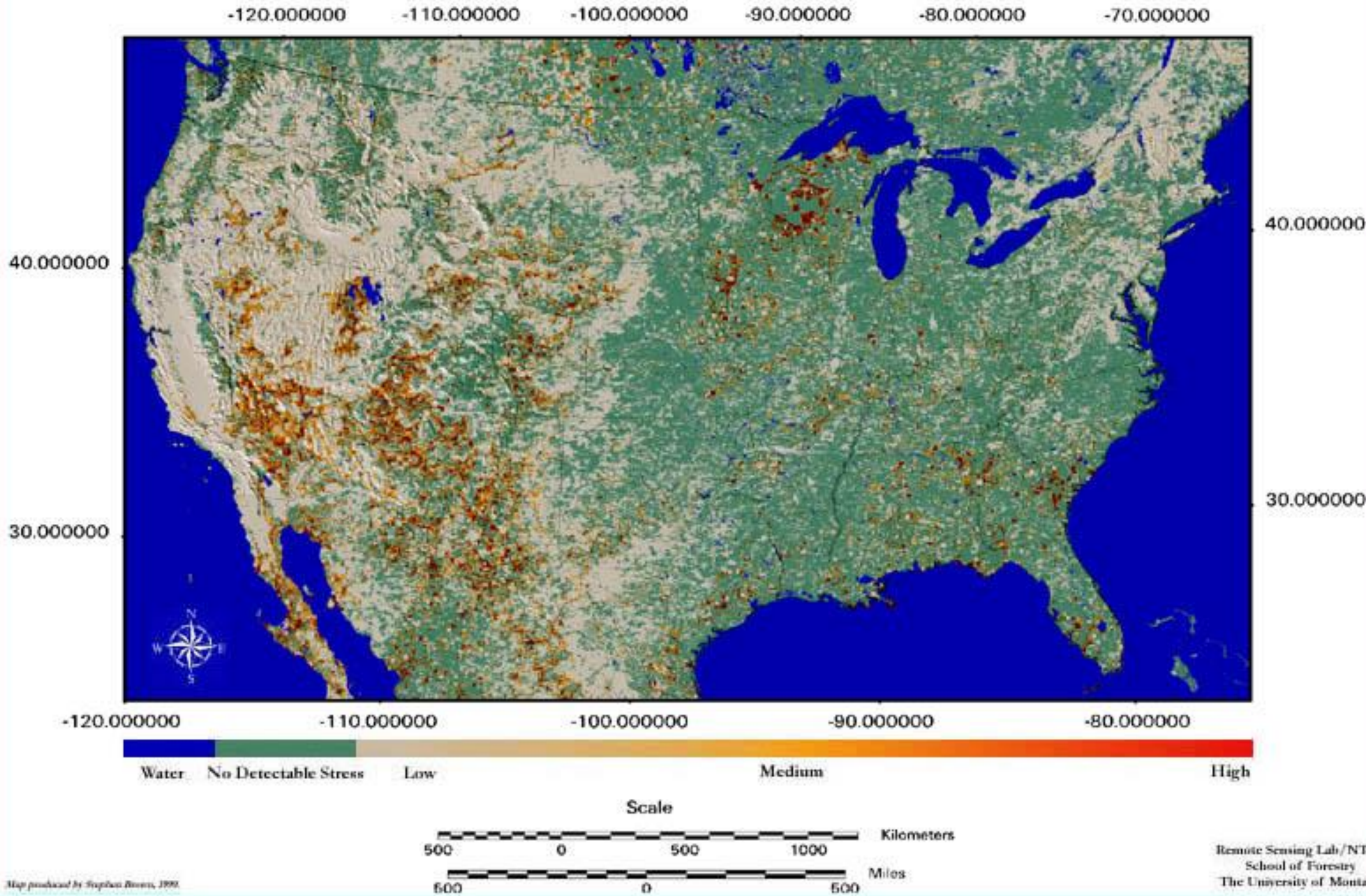
- Assessing Biodiversity from Space: an Example from the Western Ghats, India October 18, 2002
  - http://www.ecologyandsociety.org/vol6/iss2/art7/main.html
  - Demonstrate …satellite imagery to characterize areas of high and low species richness of trees in tropical forests.
  - show a high positive correlation between species richness and the Normalized Difference Vegetation Index (NDVI).

Example 1

- Fire Management
  - http://eostc.umt.edu/forestry/Products/FirePotential.asp
  - Remote sensing applications can be a key component in monitoring vegetation conditions across these broad landscapes. Fire managers have found estimates of vegetation moisture indices important in tracking seasonal fire potential for purposes of resource allocation, budgeting, and fire preparedness
  - Surface Moisture Index
    - Surface Moisture is mapped using two primary inputs; vegetation status as depicted by Normalized Difference Vegetation Index (NDVI) and surface temperature.

Surface Moisture Index

July 16 - July 22



Remote Sensing Lab/NTSG
School of Forestry
The University of Montana

Hyperspectral Sensor Applications to Coal-bed Methane

- Hyperspectral Sensor Applications to Coal-bed Methane
  - http://remotesensing.usgs.gov/researchprojects.html
  - In an effort to analyze impacts on the landscape, related to the development of Coal-bed Methane, surficial clay mineralogy in portions of the Powder River Basin of Montana will be identified using remotely sensed hyperspectral data. Abundant montmorillonite clay will indicate those areas where the soil is susceptible to damage for high-sodium irrigation water. A clay mineral spatial distribution map and a soil irrigation suitability map will be produced from the results.

- End of Lecture now onto practical exercises

Additional material

MATH EXAMPLES

Image 1 is :

$$\boxed{\begin{matrix} 5 & 10 & 15 \\ 10 & 15 & 5 \end{matrix}}$$

Min = 5, Max = 15

Ave = 10

Var = 20, Std Dev = $\sqrt{20}$

$n(5) = 2$

$n(10) = 2$

$n(15) = 2$

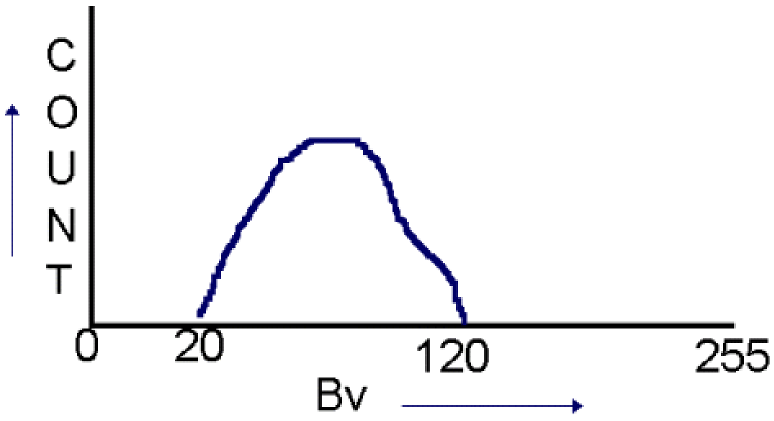
$$Av = \sum x_i / n$$

$$Var = \sum (X_i - X_{av})^2 / (n-1)$$

$$Std\ Dev = \sqrt{Var}$$

Linear Stretch Example

- A technique to expand the range of brightness values found in a digital image so that the values use the entire display capabilities
- For example an image may have brightness min of 20 and max of 120, but the display can use 0 to 255
- Use the equation
- ax + b = y



Linear Stretch Example -2

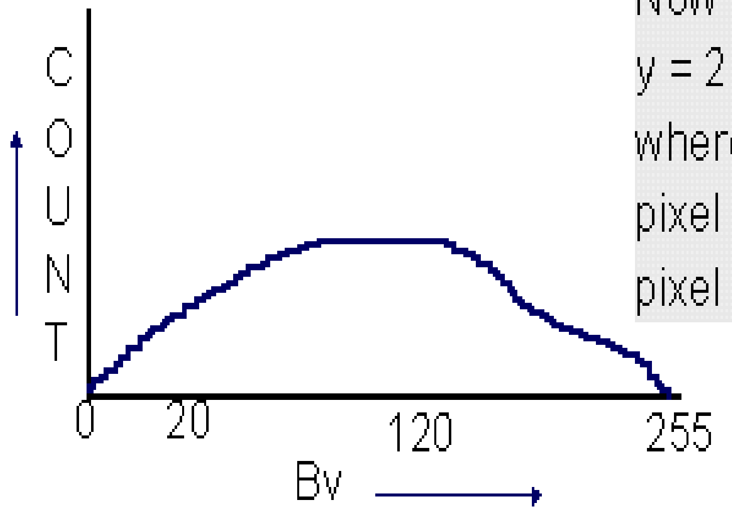
We want

b_v20 to go to 0 $\quad$ **$20a + b = 0$**

b_v120 to go to 255 $\quad$ **$\underline{120a + b = 255}$**

$100a + 0 = 255$

$a = 2.55$ and $b = -51$



Now use the equation

$y = 2.55x - 51$

where y is the new

pixel b_v and x is the old

pixel b_v.