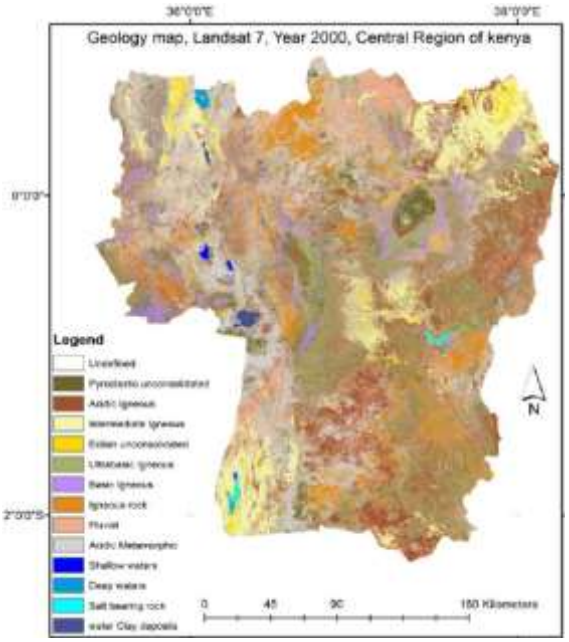
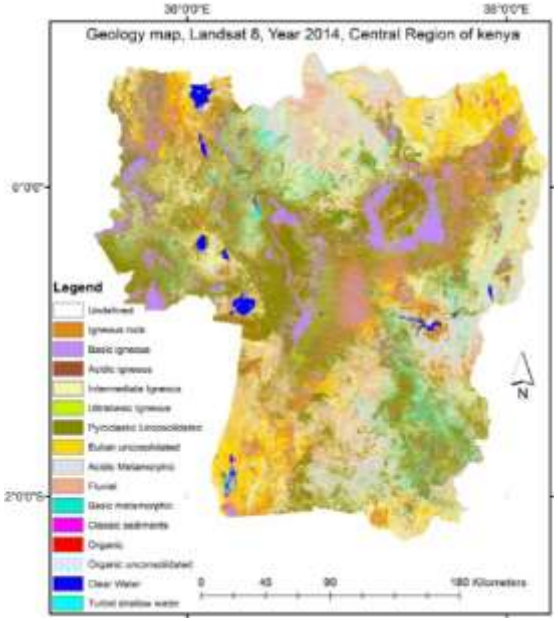
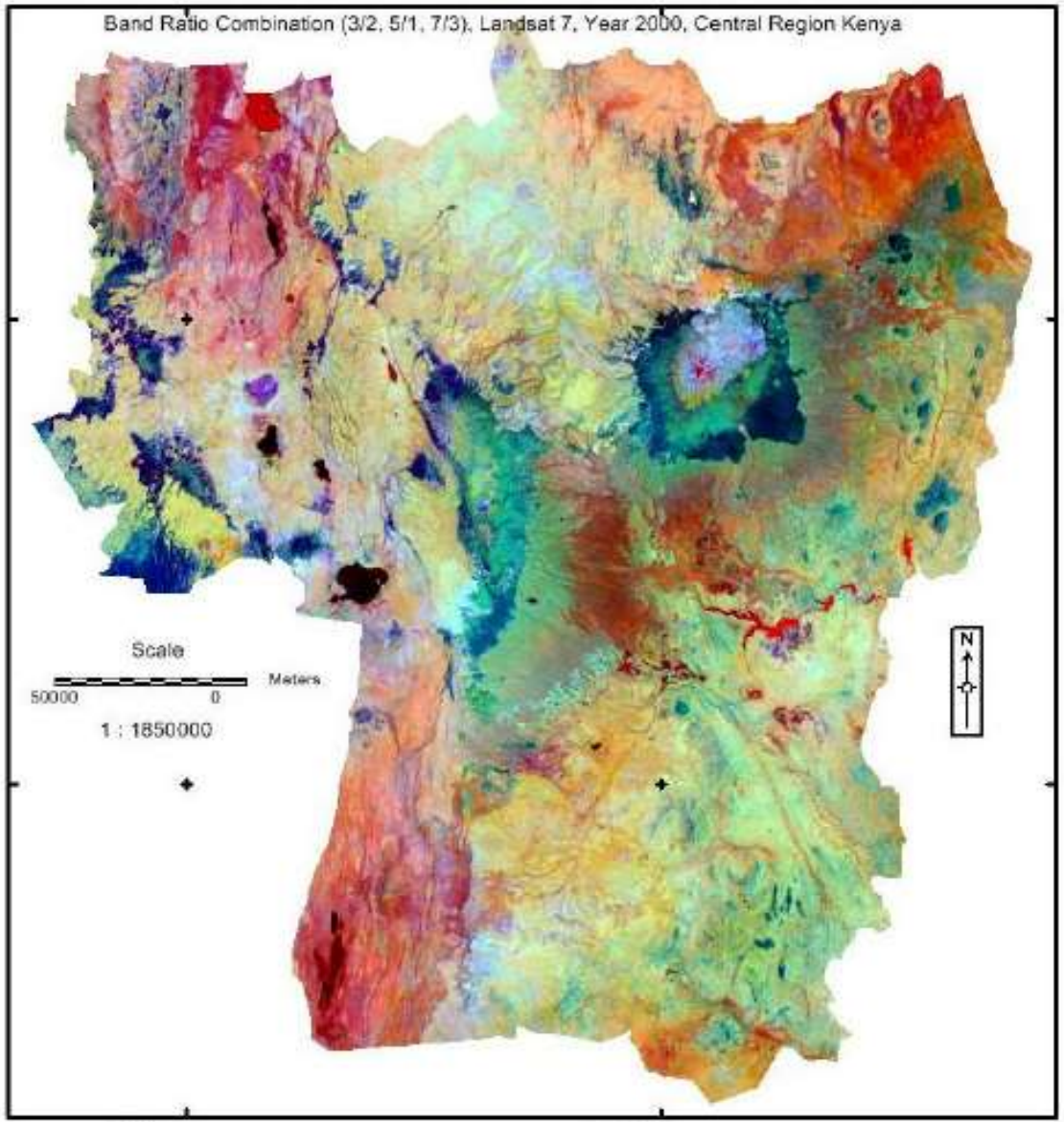
Band ratios







Band ratio combination (3/2, 5/1, 7/3), Landsat 7

https://www.researchgate.net/figure/Geology-classification-map-Landsat-7_fig2_276280545

Band ratios

Band ratioing is perhaps the simplest of multispectral techniques, - *a type of GIS 'overlay' … deriving new information from a set of data*

A band ratio is a new channel of data created by the simple division of two sets of band digital numbers for each pixel

$DN_{new} = DN^{a} / DN^{b}$ for each pixel where a and b are bands

Band ratios

e.g. for a pixel if band a = 50 and band b = 25, then the ratio DN = 50/25 for that pixel

DN new = 2 (2.0)

if a = 100 and band b = 40, then the band ratio

DN = 2.5 (or rounded to 2 if there are only integer DNs)

Ratio DN values

The DNs in a band ratio could range from: 0-255

(e.g. if 8-bit band data ranges from 0 or 1 to 255)

But in practice they rarely exceed: 0-10

Ratio DN values

The result is 'naturally' decimal, but can be written to:

a.32 bit 'real' channel (decimals) if 'real' DNs are needed

b.8-bit (Integer) channel

16-bit is unlikely as DNs won't exceed 255 (16 bit = 0-65,535)

A (scalar) multiplier can create values to fill the 8 -bit range

e.g if DNs range from 0-5, multiplying them by 50 would give 0-250

- This takes less space than a 32 bit real channel

Ratio DN values

So we have 3 options:

1. Retain decimal values e.g. 50 / 12 = 4.167 (32 bit channel)

2. Write to 8-bit: DN^a / DN^b may give a useful 'slice' identifying
= less data storage (e.g. new DNs = 0, 1, 2, 3, 4, 5)

3a. Multiply by a scalar value e.g. 10 or 50 to 8 bit range (0-255)

3b. Select a software 'auto' option to fill the 8-bit data range

Landsat MSS bands 1-4 (also known as = 4-7)

Possible ratios = n (n-1) … 12

Table 4. Some commonly used Landsat MSS ratios and their applications.Adapted from Avery and Berlin (1992, p. 442).

MSS Ratios	Applications
1/2, 1/4, 3/4	Characterizing rocks and soils
1/2 or 2/1	Suspended sediment in water
1/2 or 2/1	Iron-oxide content in rocks
3/1, 3/2	Vegetation and water bodies
4/1, 4/2	Vegetation and water bodies

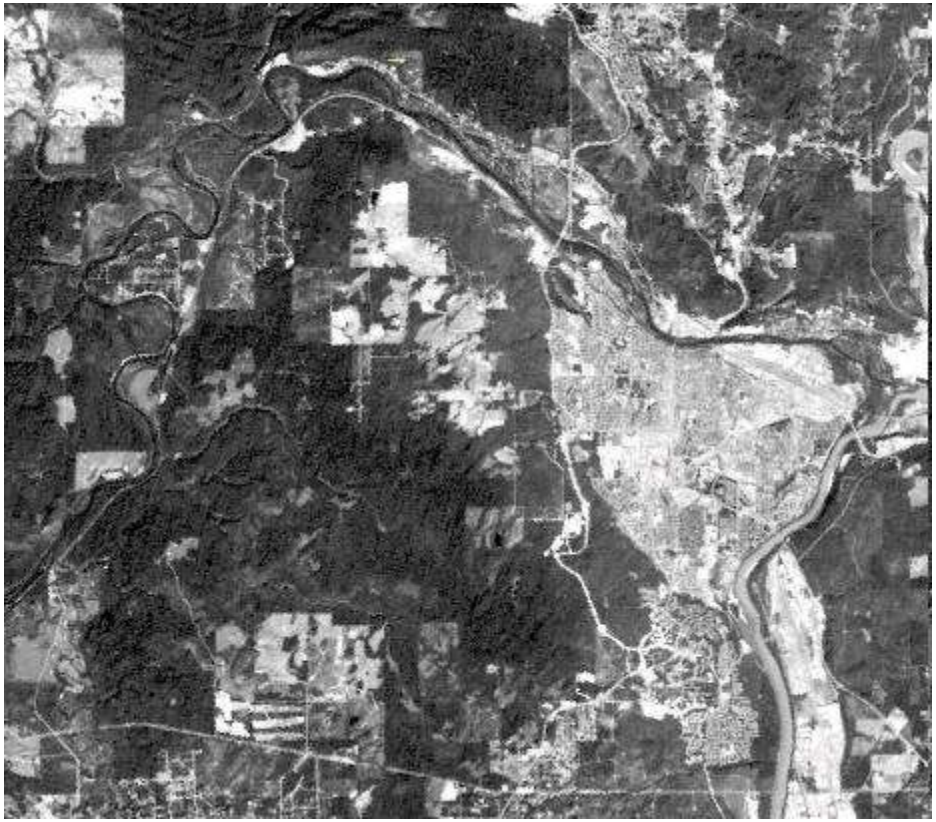
Note: the inverse ratios create negative images, which may be more pleasing visually for certain features.

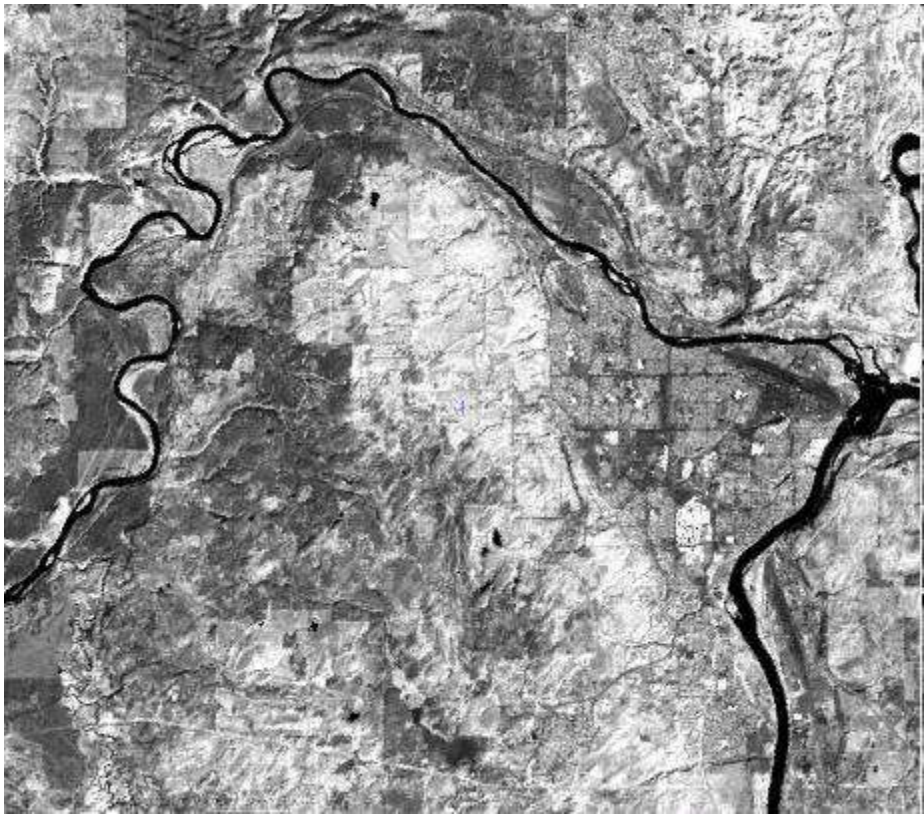
http://academic.emporia.edu/aberjame/remote/landsat/landsat_proc.htm

Why use band ratios ?

They create a new set of data that may be used to highlight features.
This cancels or reduces what is common in two images and exaggerates contrasts.

e.g. Band 3 Band 4 (TM 4/3 = NIR/Red is the most common ratio)





Band ratios

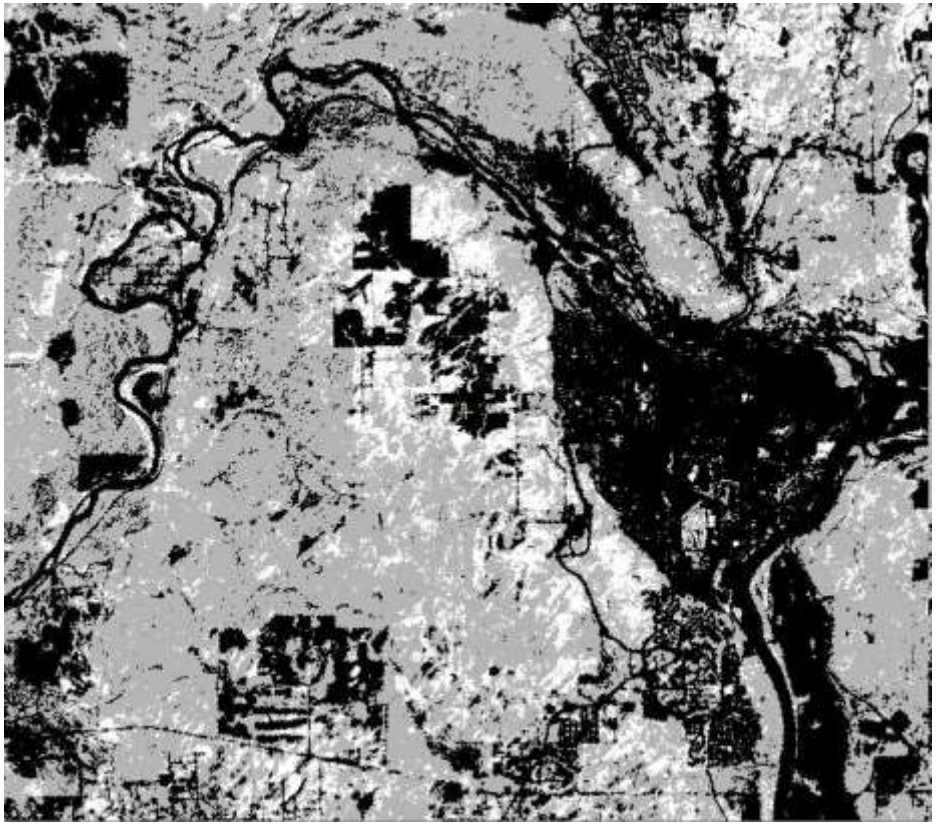
TM4/3 ratio - no scalar (DNs 0-3)

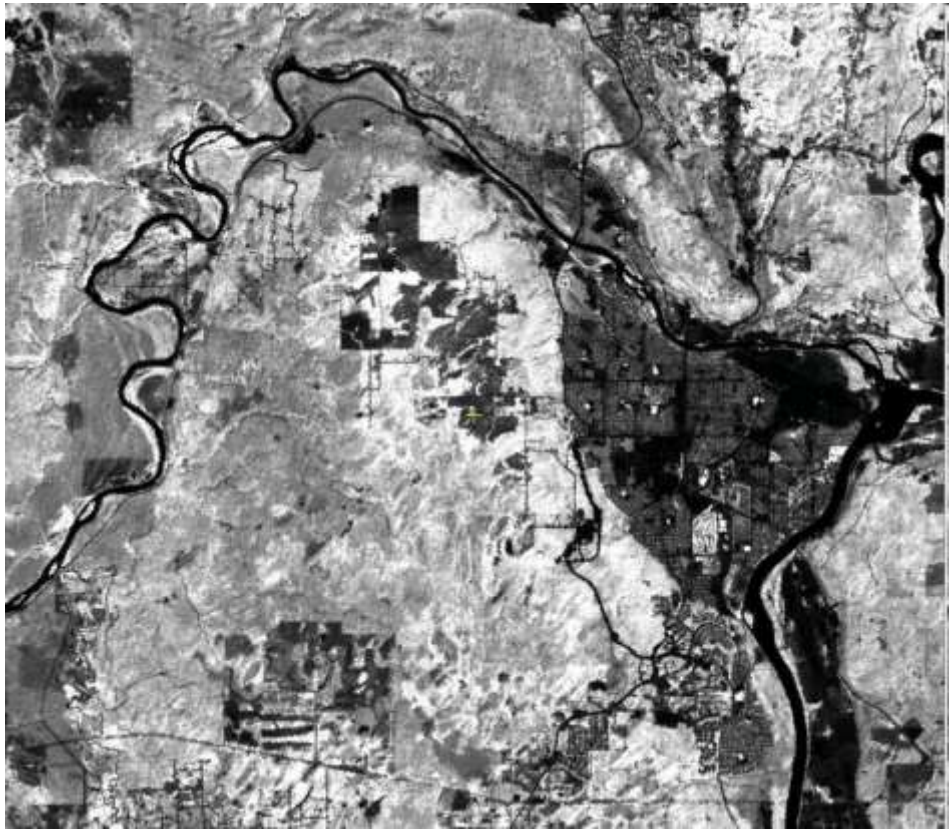
Scaled or 32-bit: DNs ~ 0-255

Vegetation > 1; water < 1

continuum of DNs

0: Water, 1: Urban, 2: treed, 3: deciduous



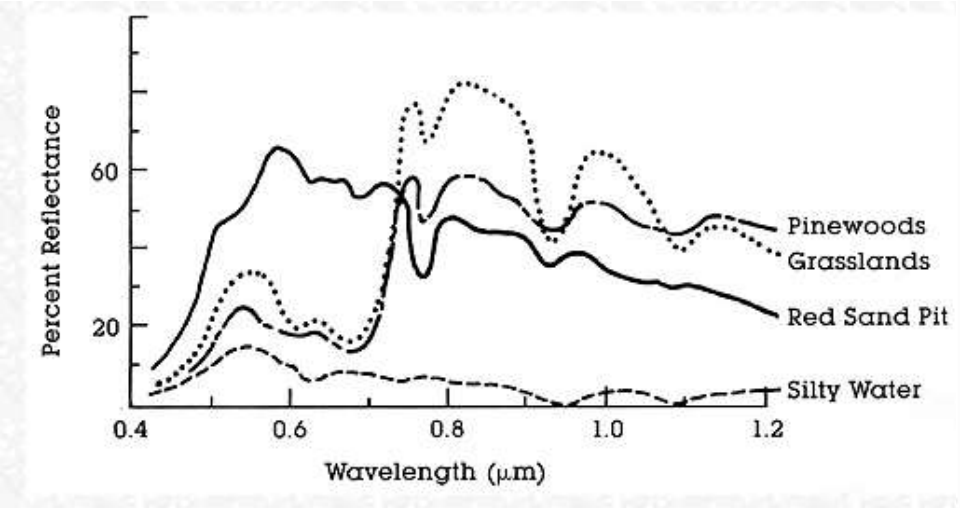


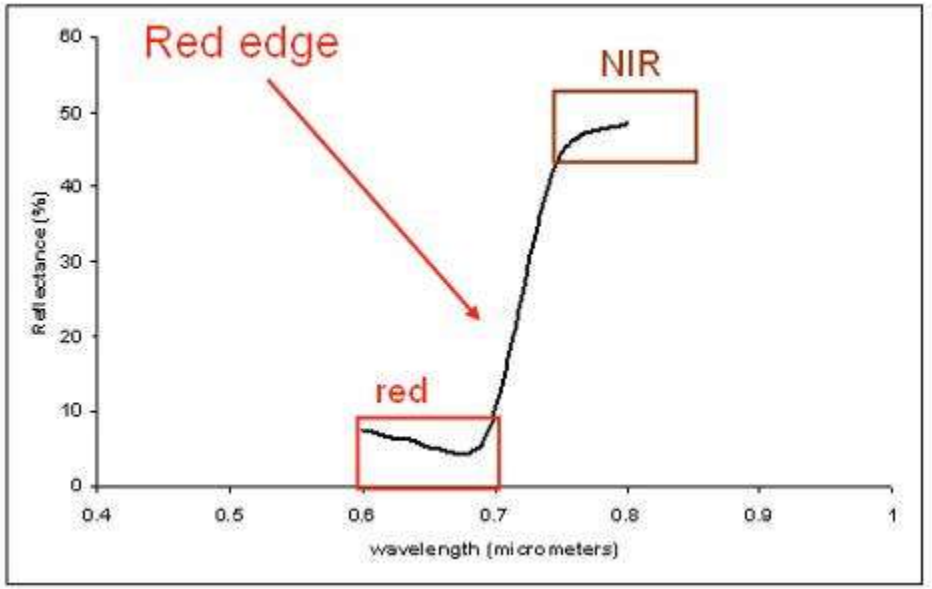
Role of ratios: a. Spectral slope enhancement

band ratioing can emphasise the difference between (adjacent) spectrum sections in an image, the most common being the **Infra-red and red**.

Since healthy vegetation has high reflectance in IR and low in red, any IR/Red (or any visible wavelength) will enhance vegetation differences: 'the red edge'

Higher values (NIR/red) = more vegetation (biomass)
… more clear than band 4 alone (see 3 slides on)





b. reduce topographic effect (shadow)

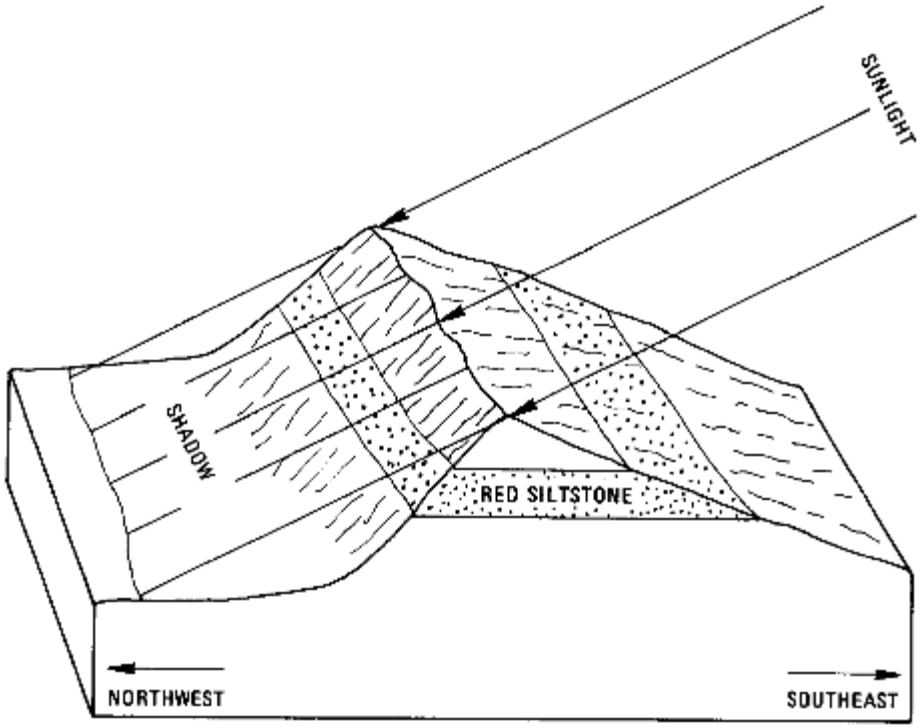
Digital Numbers may be composed of three elements:

a. Atmospheric interference (e.g.haze)

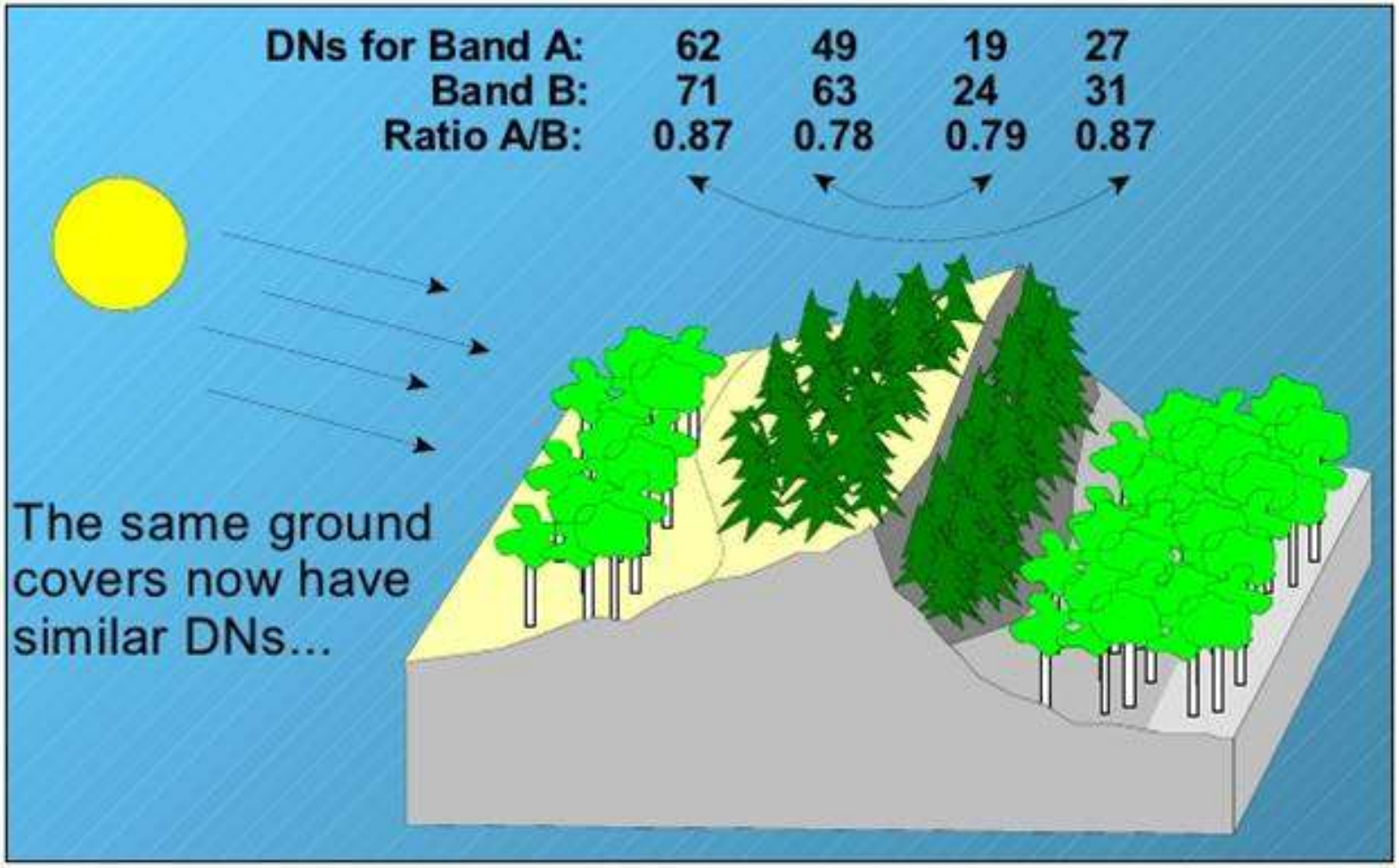
b. Illumination (angle of reflection)

c. Albedo (surface cover)

A ratio can remove / reduce the effect of illumination from topography and highlight the <u>differences</u> in surface cover.



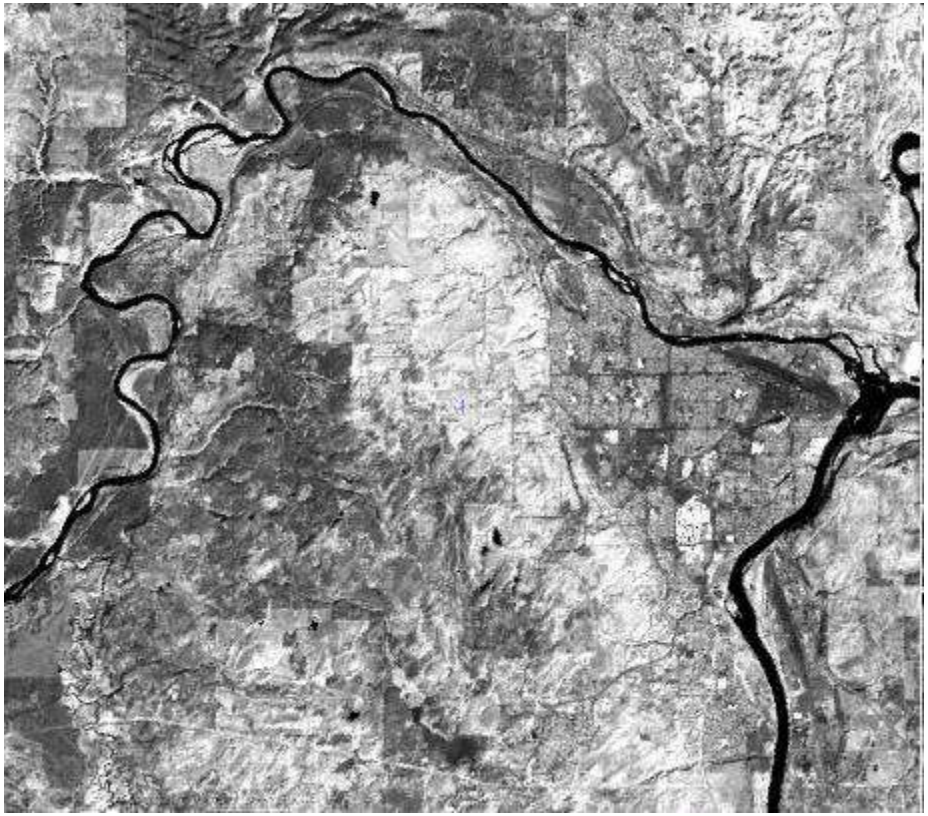
Ratio of Band A to Band B

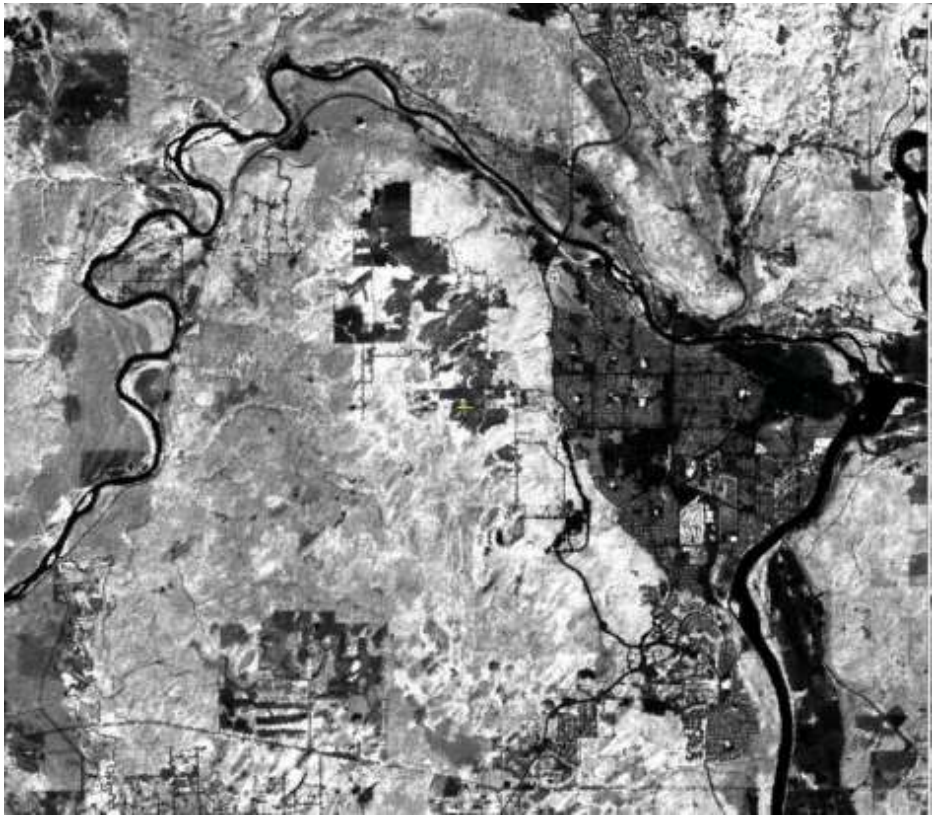


USDA Forest Service, Remote Sensing Applications Center, http://fsweb.rsac.fs.fed.us and UAS ENVS403

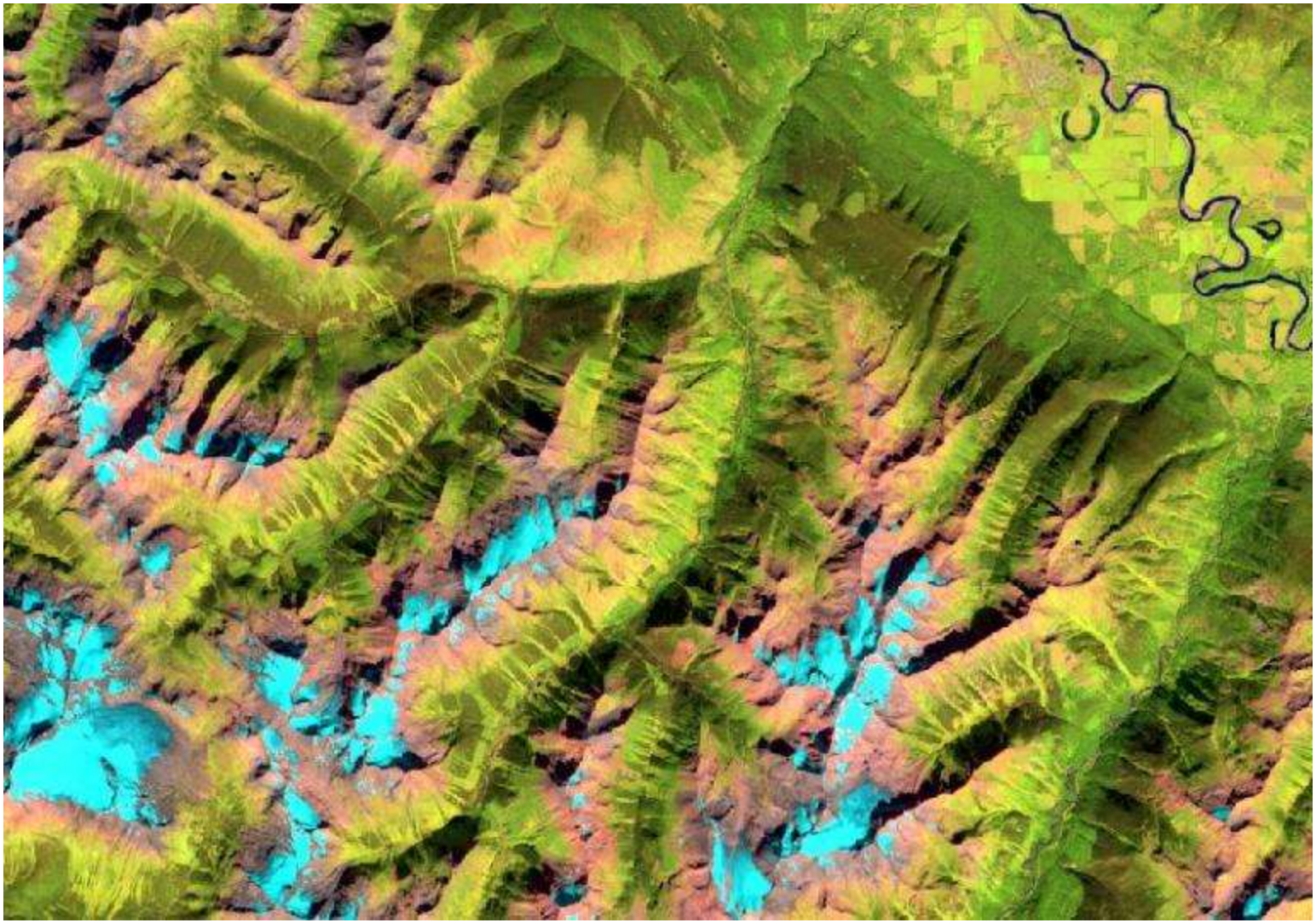
TM Band 4 **Band 4 / Band 3 ratio**

Note suppression of shadows in the ratio (eskers north of the Nechako)

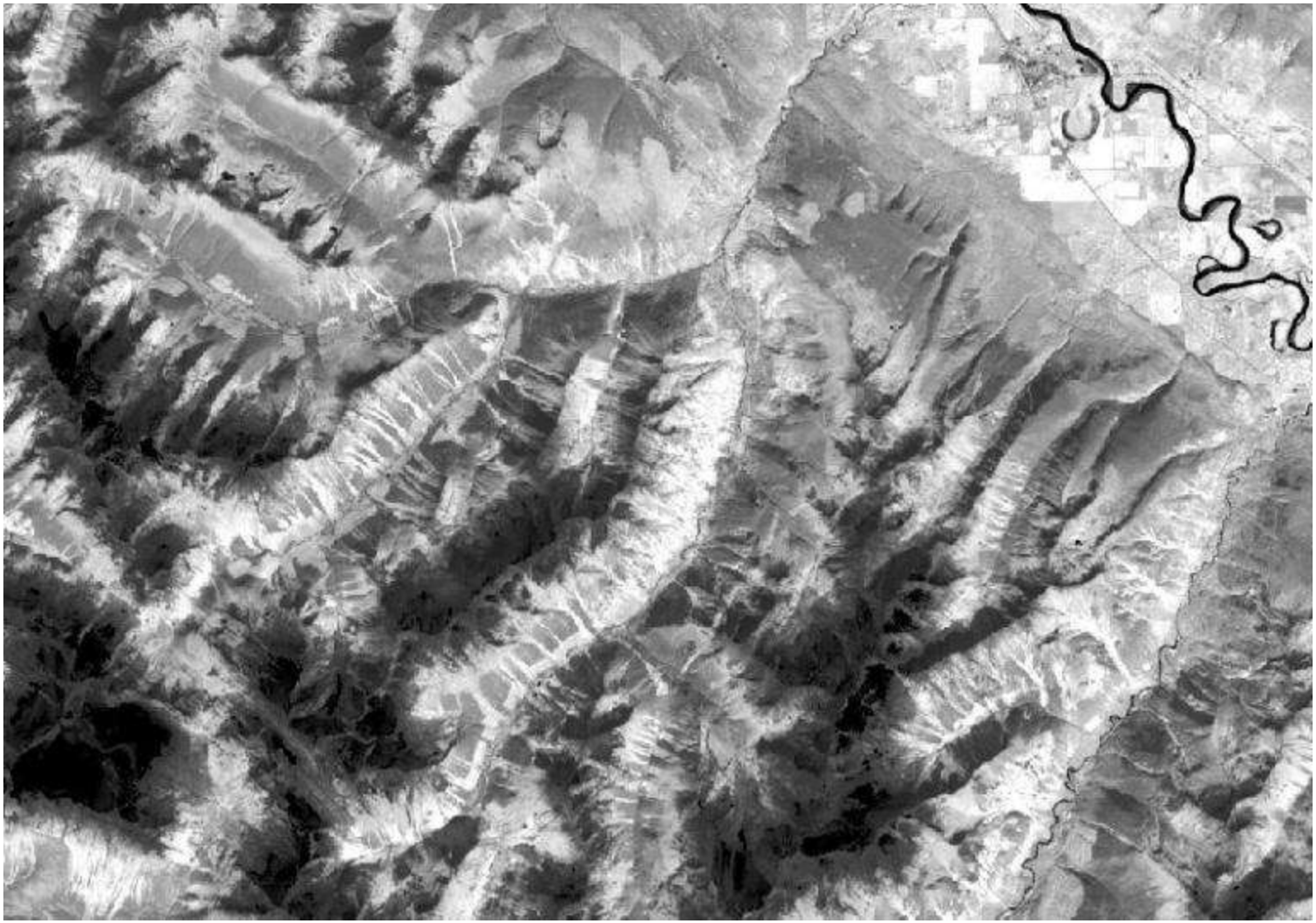




McBride 2014 Landsat 8 OLI

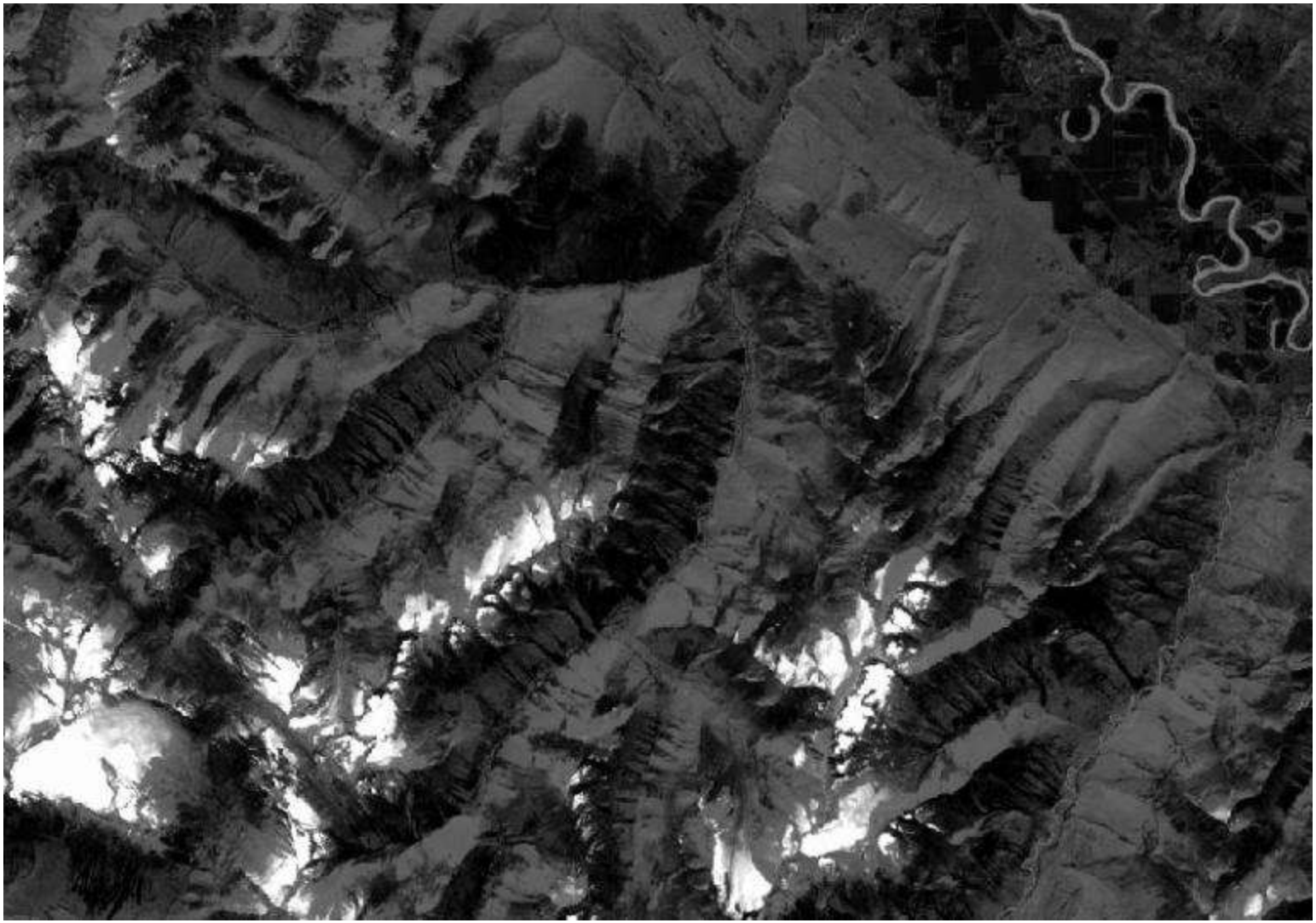


NIR/Red ratio = OLI 5/4 vegetation> 1.0



In mountain landscapes, a ratio only partly corrects for illumibation

Red/MIR ratio = OLI 4/6 snow/ice>2.0 (or maybe 1.5)



More on this when we discuss glacier mapping

Use of ratios: c. Include as input to classification

To include ratios as input channels for classification, they should be on a similar numeric scale

- **Landsat 5 TM: 8-bit 0-255**
- **Use scalar multiplier ~ 50**

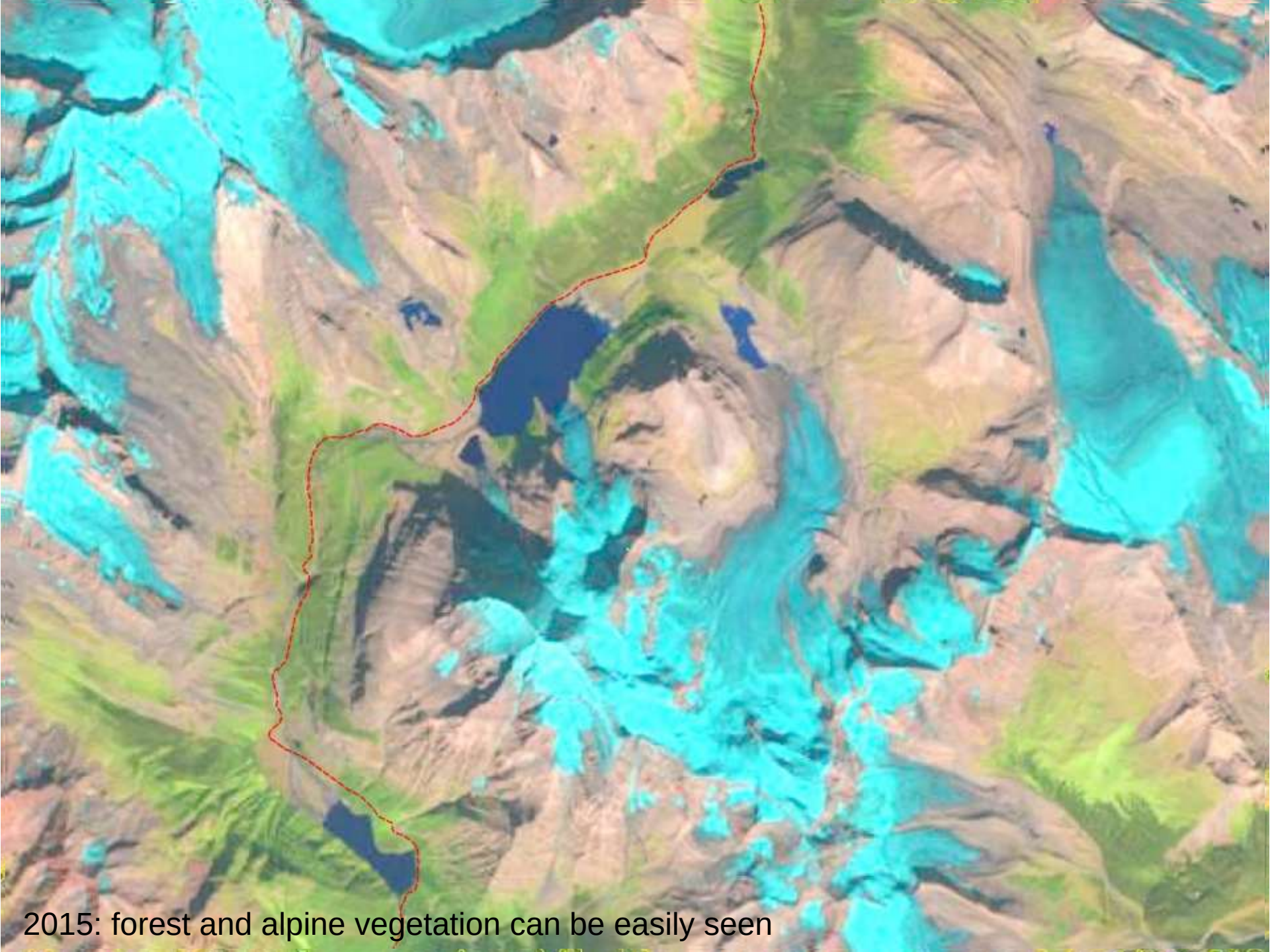
- **Landsat 8 OLI: 16-bit 0-63,354**
- **Use scalar multiplier ~10,000 ?**

Check channel histograms and stats first

Mt. Robson (1975 / 95)

Topo mapping: maps only includes ‘treed’ (>30%)

d. New layers for analysis/display



2015: forest and alpine vegetation can be easily seen

Coniferous - deciduous vegetation NIR/Red ratio

Which other ratios could be useful?

How many ratio options in a multiband (n) dataset:

Total Ratios = n (n-1)

e.g. with bands 1,2,3

Ratios = 1/2; 1/3; 2/3; 2/1; 3/1; 3/2 = 6

1/2 and 2/1 are just the inverse of each other …… they 'look' different to the human eye, but behave the same in an algorithm

Total Ratios = n (n-1) /2

= 15 (6 bands) for Landsat TM (excluding thermal)

Which other ratios might be useful?

Consider the bands and their place in the spectrum:

	Visible	/ NIR	/ MIR
TM	1,2,3	4	5, 7
OLI	1,2,3,4	5	6, 7

Ratios using **different EM sections** enhance **major class differences**, e.g. coniferous versus deciduous, rock versus vegetated (e.g. IR / Visible)

TM	7/3 lithology	3/5	snow and ice	4/5	Moisture
OLI	7/4	4/6		5/7	

pairs of bands from similar parts of the EM spectrum may show more 'noise'

Which other ratios could be useful?

But there are applications using two bands in the same region, e.g. in geology

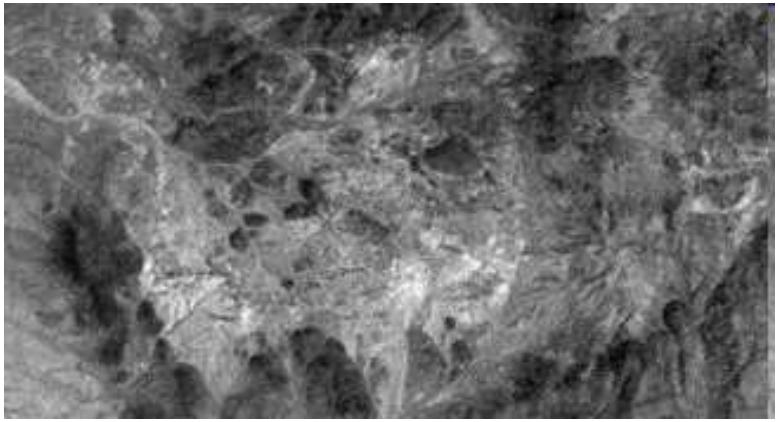
MSS: 5/4, 7/6 (4=green, 5=red, 6,7 =NIR)

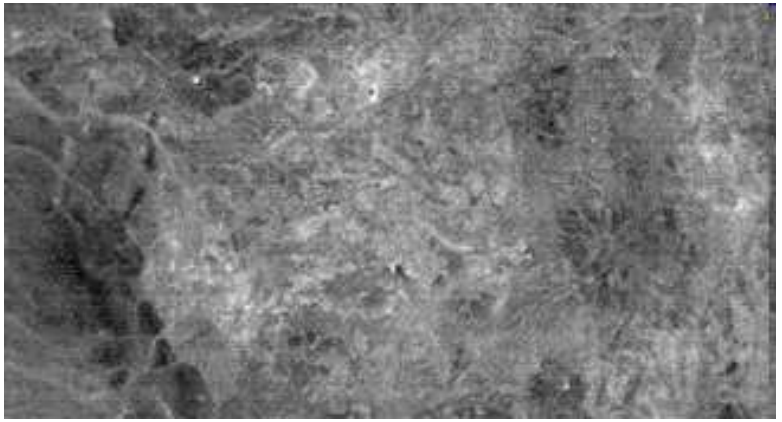
TM: 3/2, 3/1, 5/7 :
mineral enhancement (hydrothermally altered rocks)

Ratio of two bands in the same EM region can distinguish **subtypes** such as soils, and geologic differences

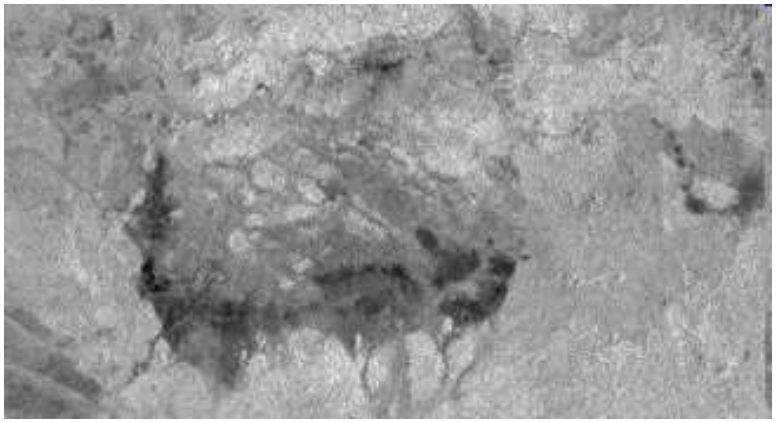
Thematic Mapper ratios, Utah (desert scene)

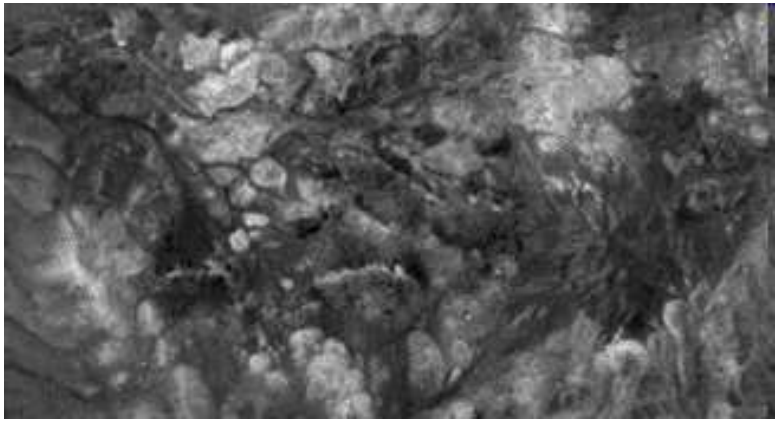
ratios 3/1 and 4/2





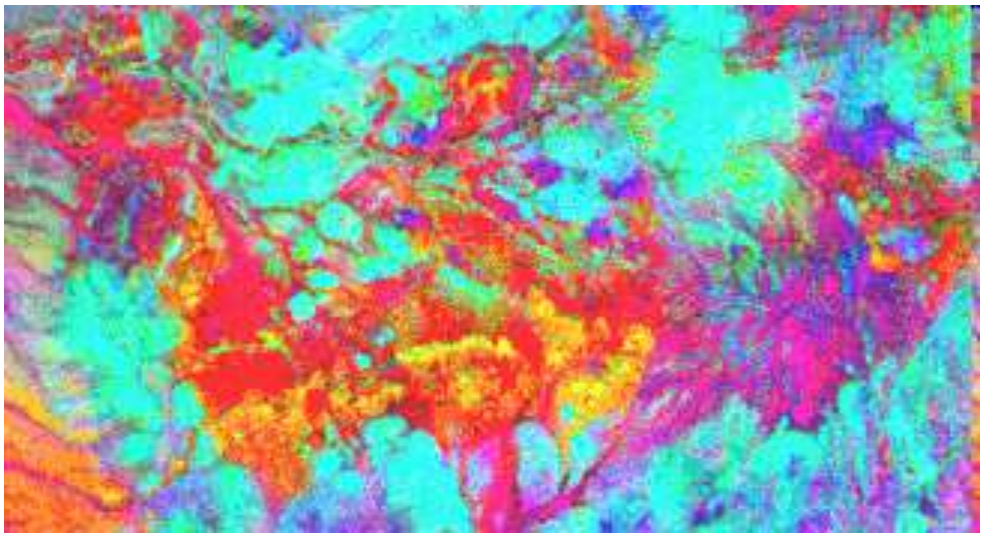
7/5 and 1/7 ratios





Ratios: e. Creating Colour Composites

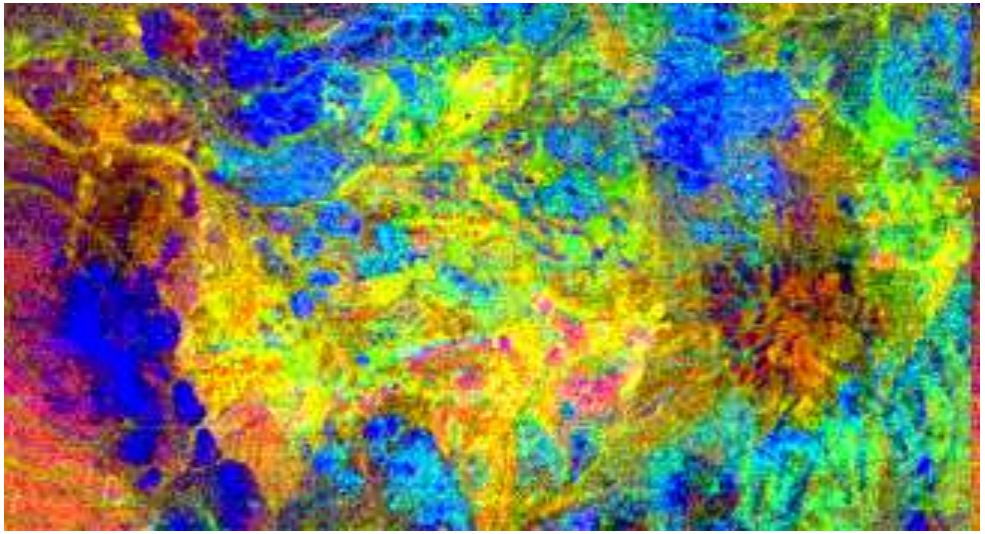
- use any 3 channels, not just bands



7/5 = Blue

1/7 = Green

3/1 = Red



1/7 = blue

4/2 = green

3/1 = red

How many possible colour composites are there from 15 ratios ? (15x14x13)

Other Image Arithmetic (tool: ARI)

also: RTR (ratios) and Raster Calculator

Band ratios are the result of 'division' /

it is also possible to use the other arithmetic operators:

b. Band (image) subtraction -

Yields the difference between two bands; the result will include values that are + and - …… requires a 16 bit signed channel:

useful for showing changes through time with two image dates.

- More on this when we discuss change detection

b. Band (image) multiplication *

Used with a **mask**, where one layer is 1 or 0

e.g. land or water …. your water bitmap in lab 2

or forested vs non-forested in the EOSD Canada mapping project

LAND-WATER MASKS: BASIS FOR AUTOMATED PRE- AND THEMATIC PROCESSING OF REMOTE SENSING DATA Erik Borg, Bernd Fichtelmann

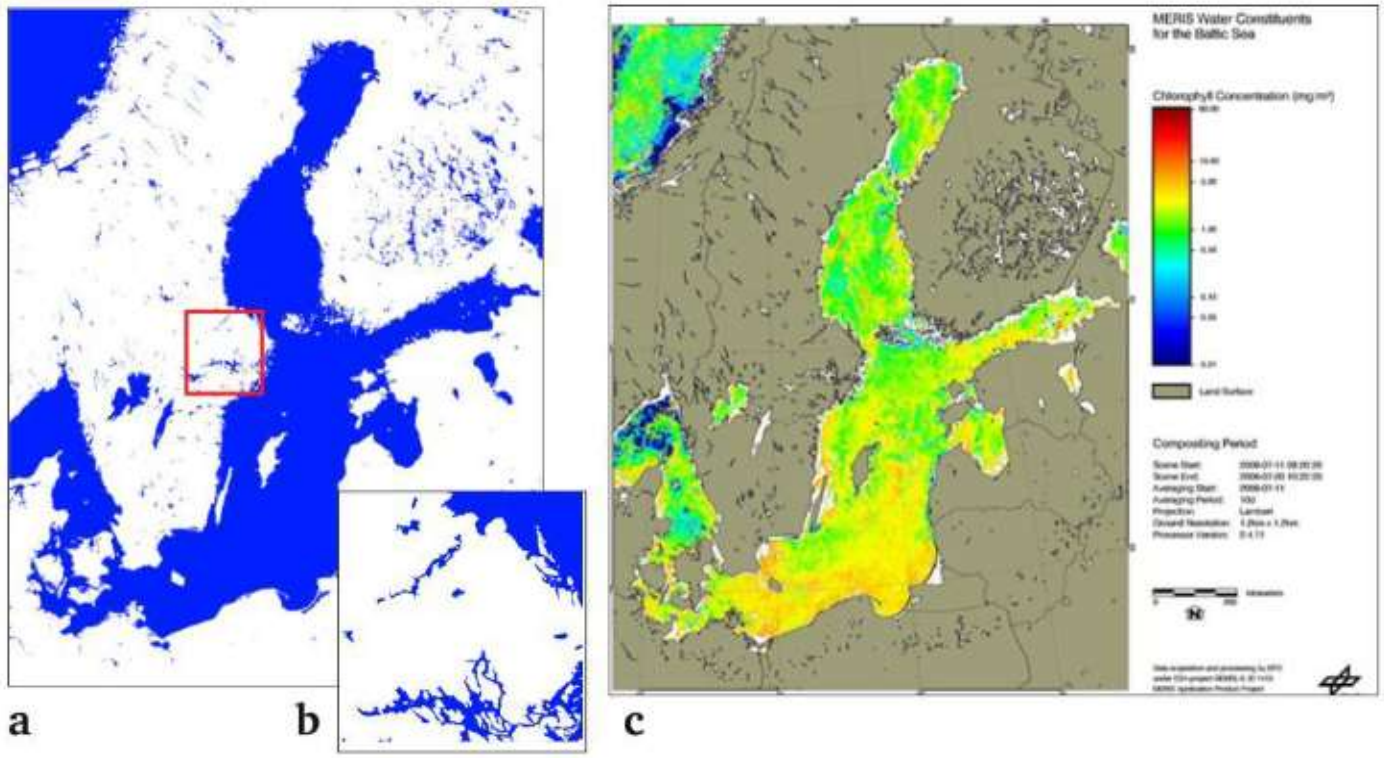


Figure 2: Land-water-mask of limited quality (a). The section shows details of the map around Stockholm (b). Quick-look product "Chlorophyll Concentration in the Baltic Sea" based on MOS data (c).

https://publishup.uni-potsdam.de/opus4-ubp/frontdoor/deliver/index/docId/10345/file/pgp12_77-99.pdf

Other Image Arithmetic

c. Band (image) addition +

Used to create an overall or average image channel,

e.g. (TM1 + 2 + 3) / 3 (=~PAN ?) or (TM5 + TM7) /2

An index uses addition and subtraction (see next lecture)

e.g. Normalised Difference Vegetation Index

NDVI = (NIR - R) / (NIR + R)