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)

8 bit data: The DNs in a ratio could hypothetically range from: 0-255
- even more for 16 bit data

But in practice they rarely exceed: 0-10 (or less)

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

A (scalar) multiplier can create values to fill the 8-bit or 16-bit range

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

- This takes less storage 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 / 16-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

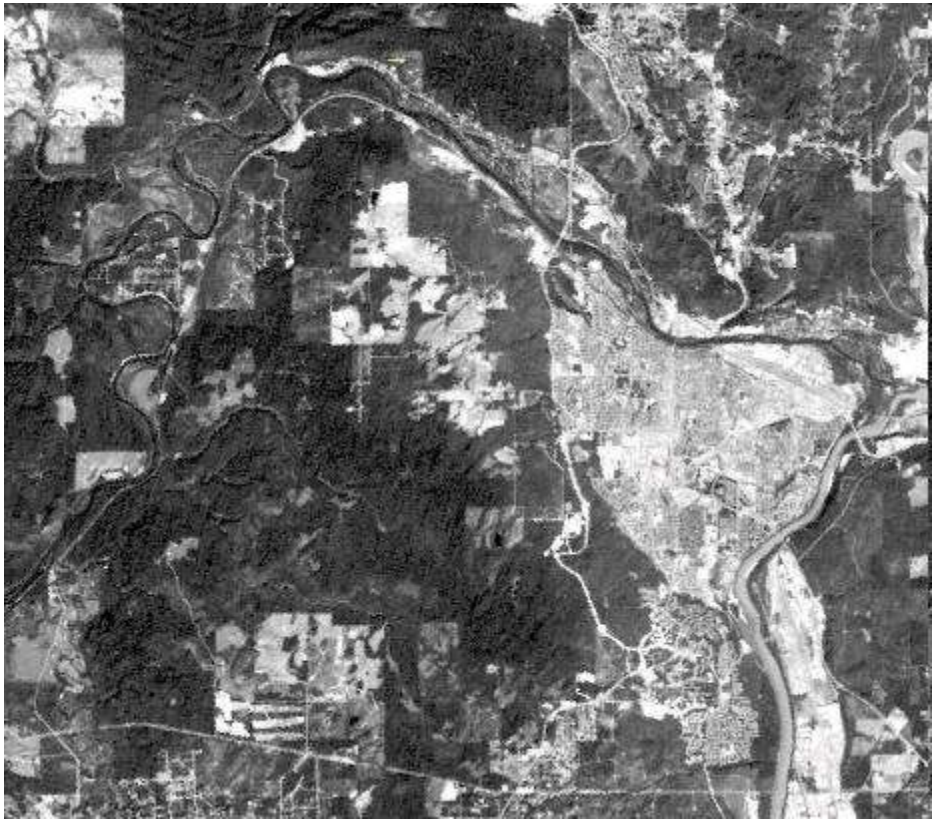
Note: the inverse ratios create negative images, which may be more pleasing visually for certain features.

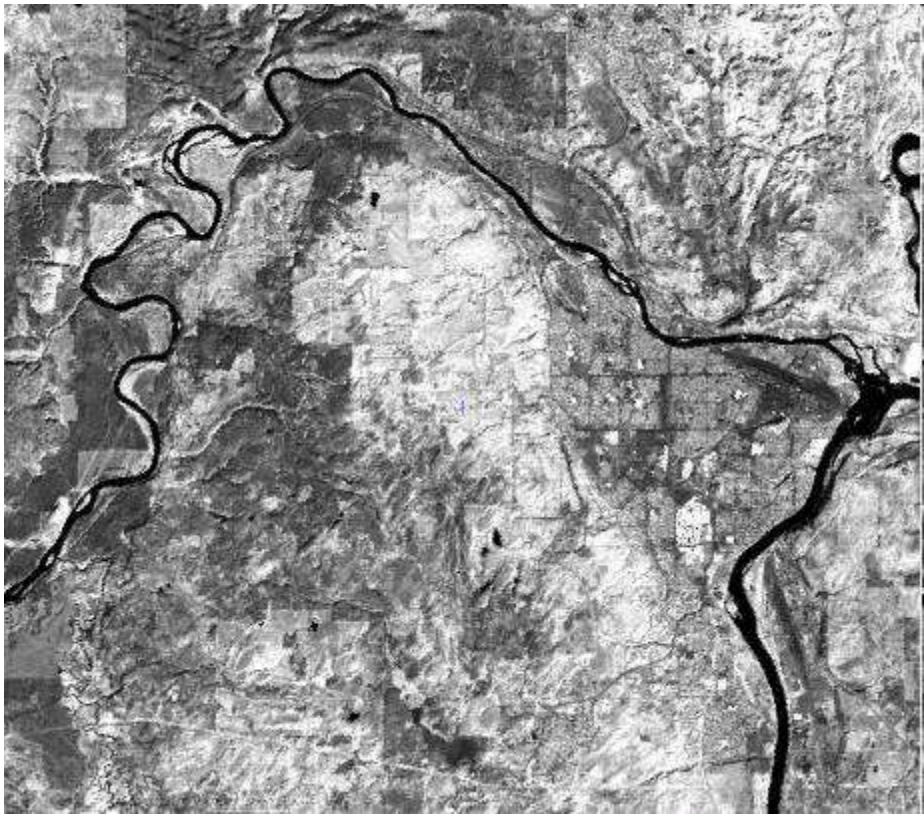
http://academic.emporia.edu/aberjame/remote/landsat/landsat_proc.htm

Why use band ratios ?

They create a new set of data that may be used to highlight features.
They cancel or reduce what is common in two images and exaggerate contrasts.

e.g. Band 3 Band 4 (NIR/Red = TM 4/3 =OLI 5/4 is the most common ratio)





Band ratios

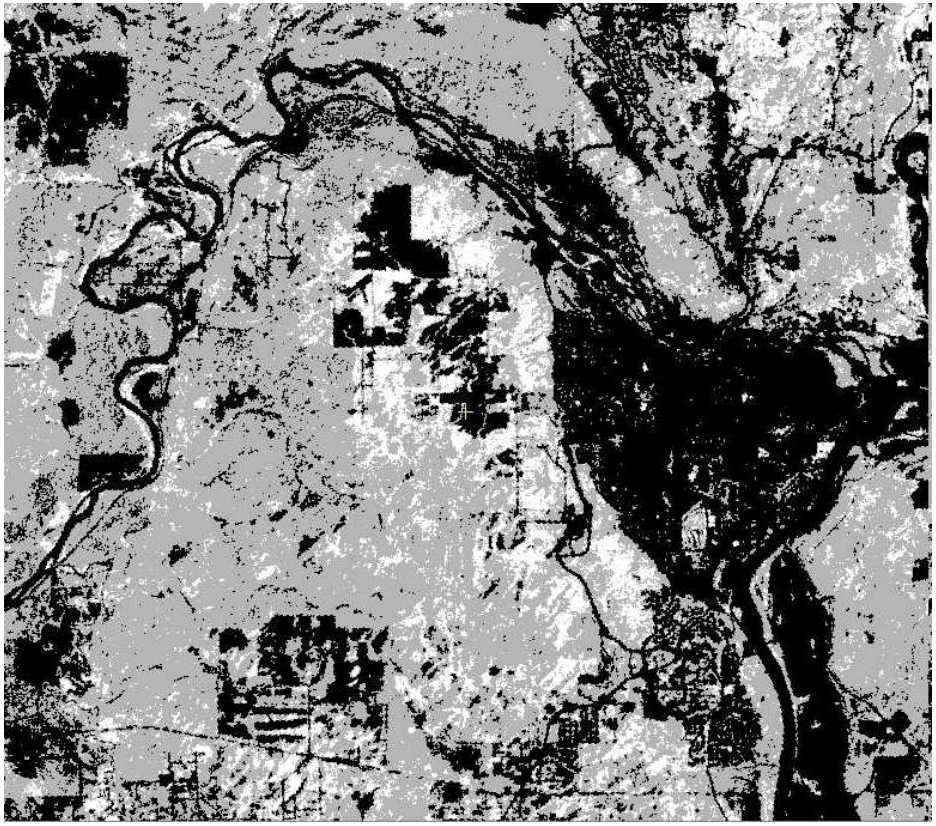
TM4/3 ratio - no scalar (DNs 0-3)

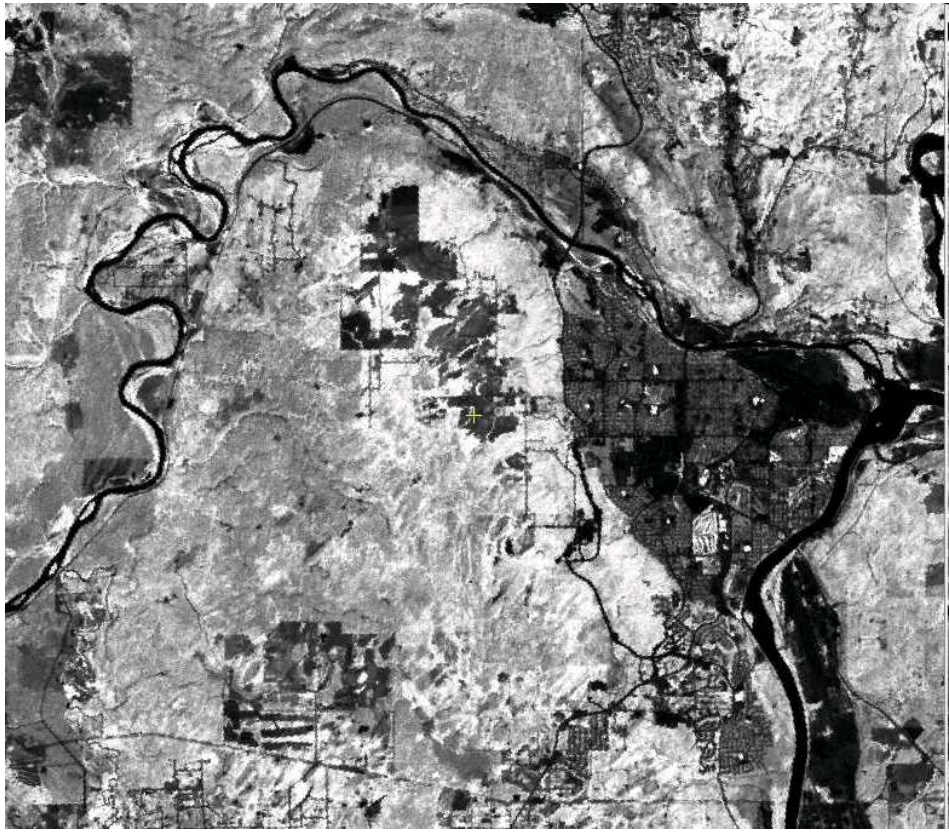
Scaled or 32-bit: DNs ~ 0-255

Vegetation > 1; water < 1

continuum of DNs

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



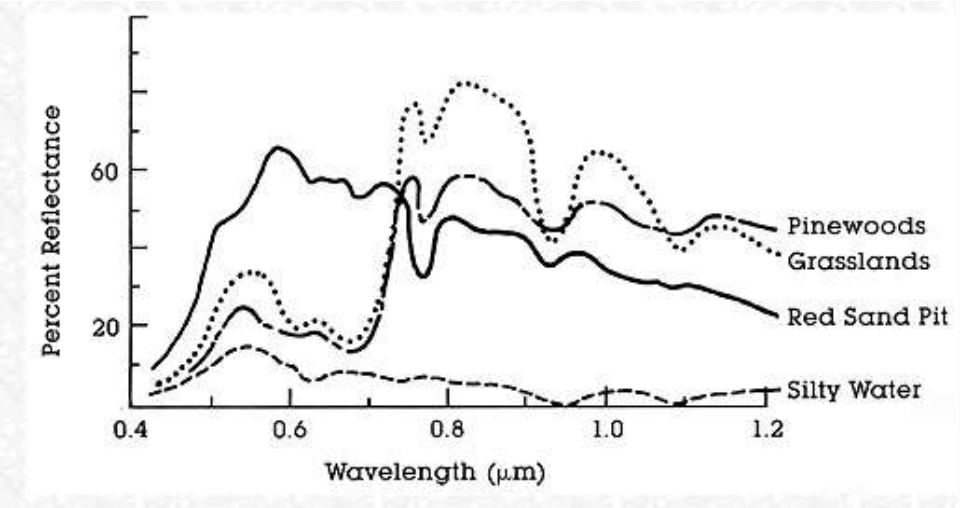


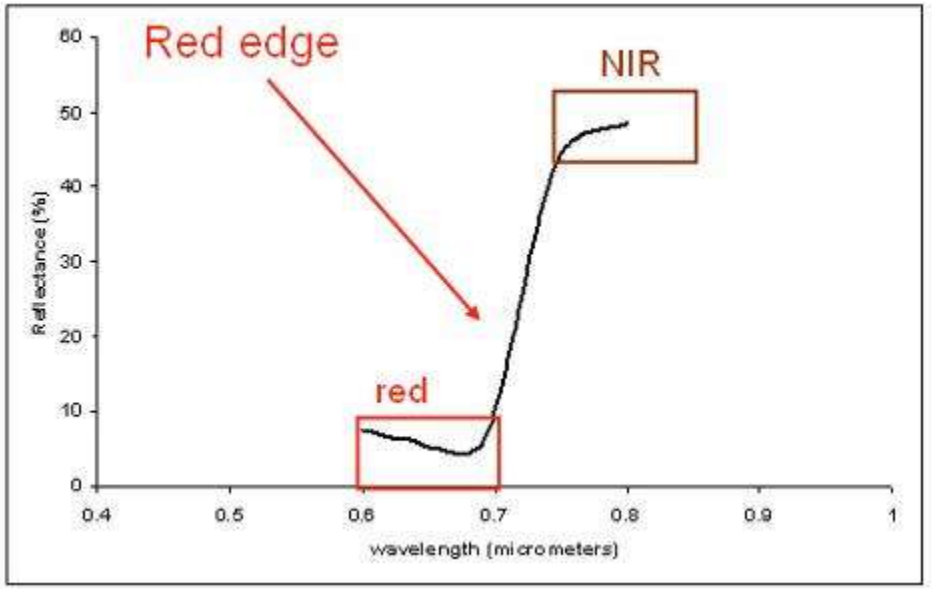
Role of ratios: a. Spectral slope enhancement

band ratioing can emphasise the difference between (adjacent) spectrum sections in an image, the most common being the Near-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





b. reduce topographic effect (shadow)

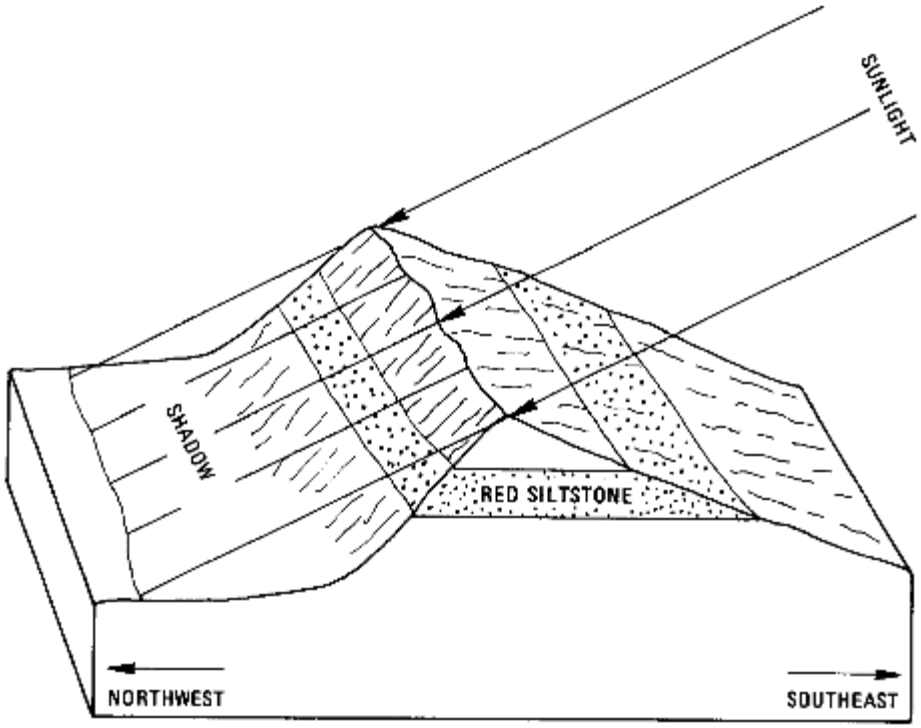
Digital Numbers may be composed of three elements:

a. **Atmospheric interference (e.g.haze)** .. + clouds !

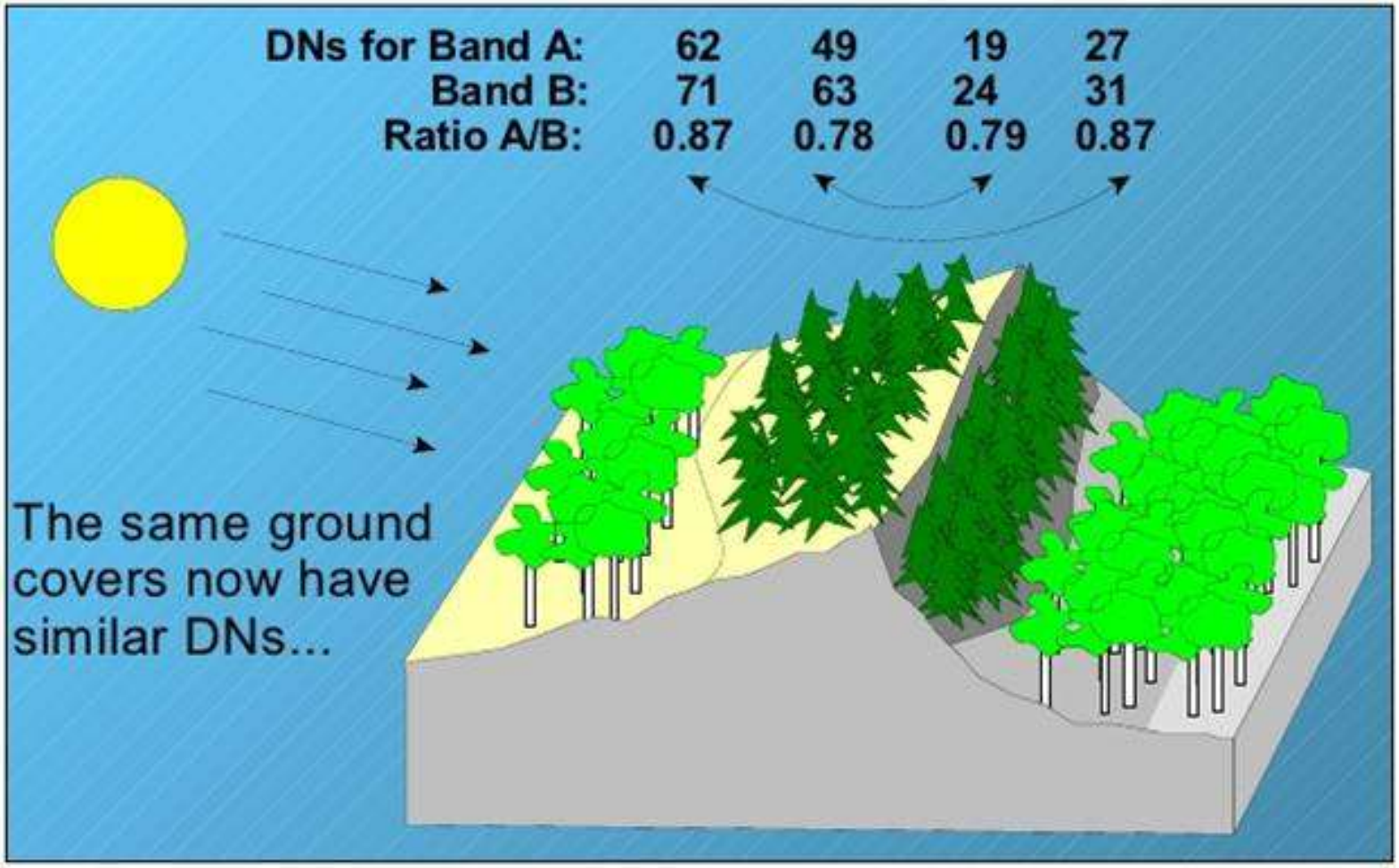
b. Illumination (angle of reflection)

c. Albedo (response to surface cover)

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



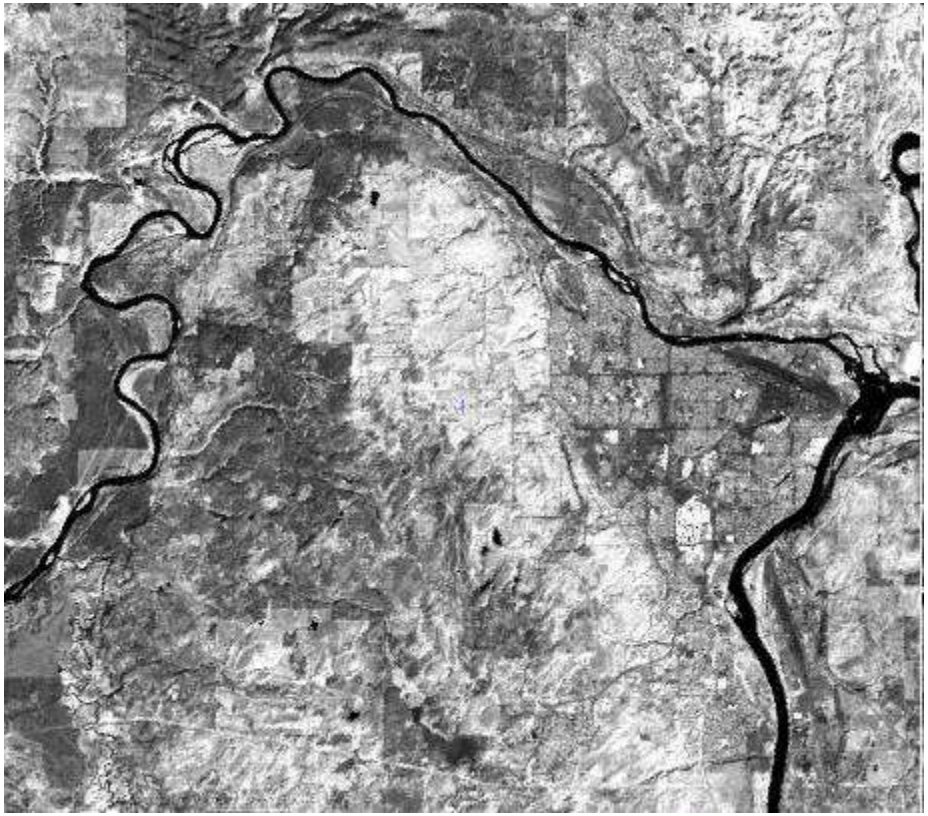
Ratio of Band A to Band B

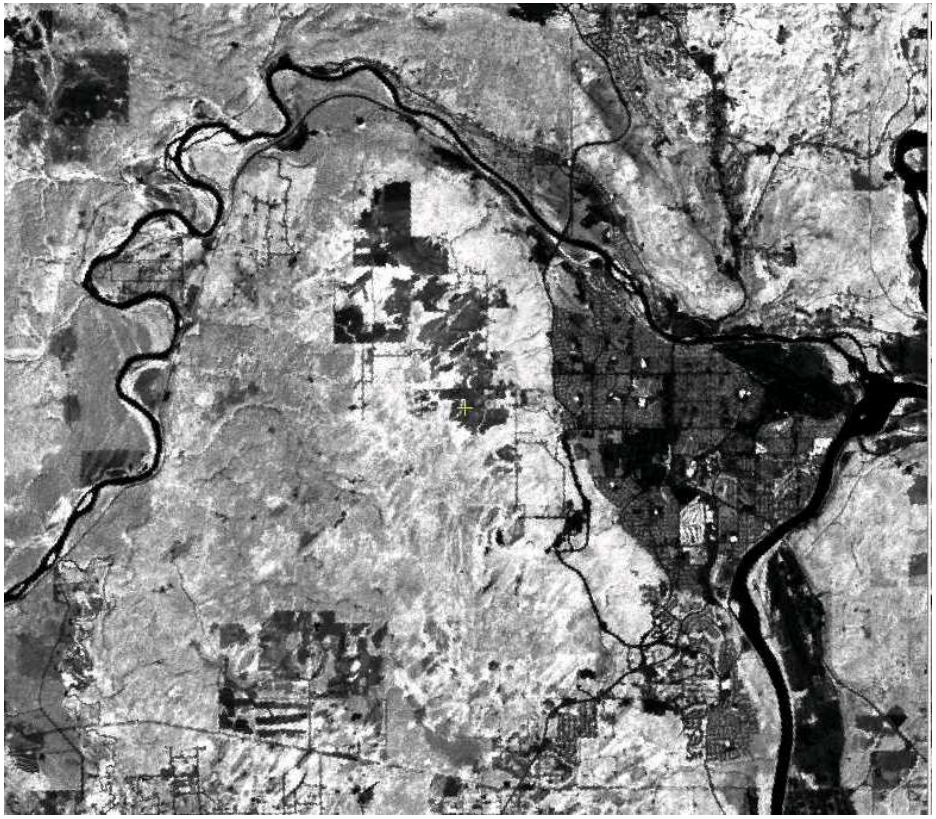


USDA Forest Service, Remote Sensing Applications Center, http://fsweb.rsac.fs.fed.us and UAS ENVS403

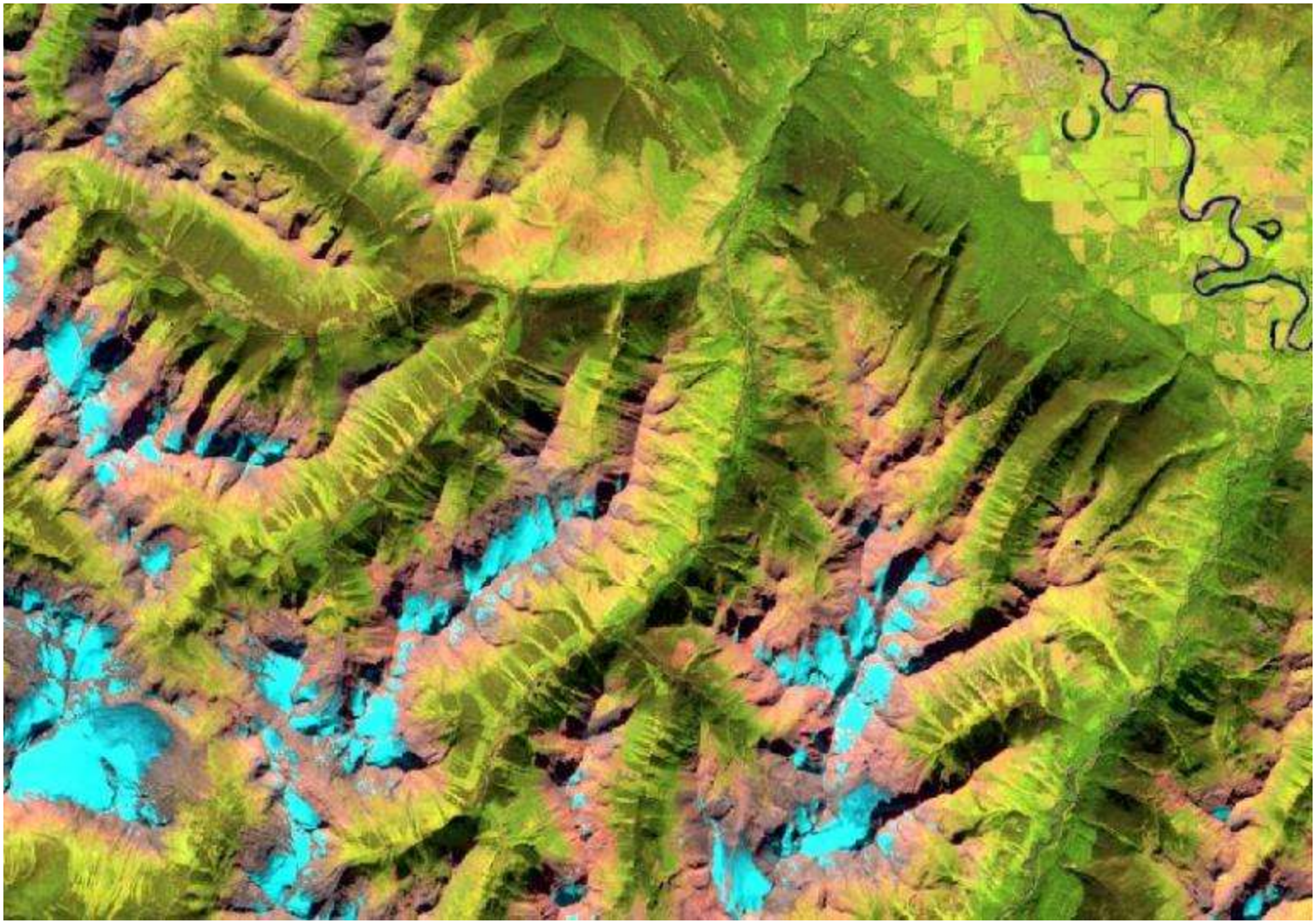
TM Band 4 **Band 4 / Band 3 ratio**

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

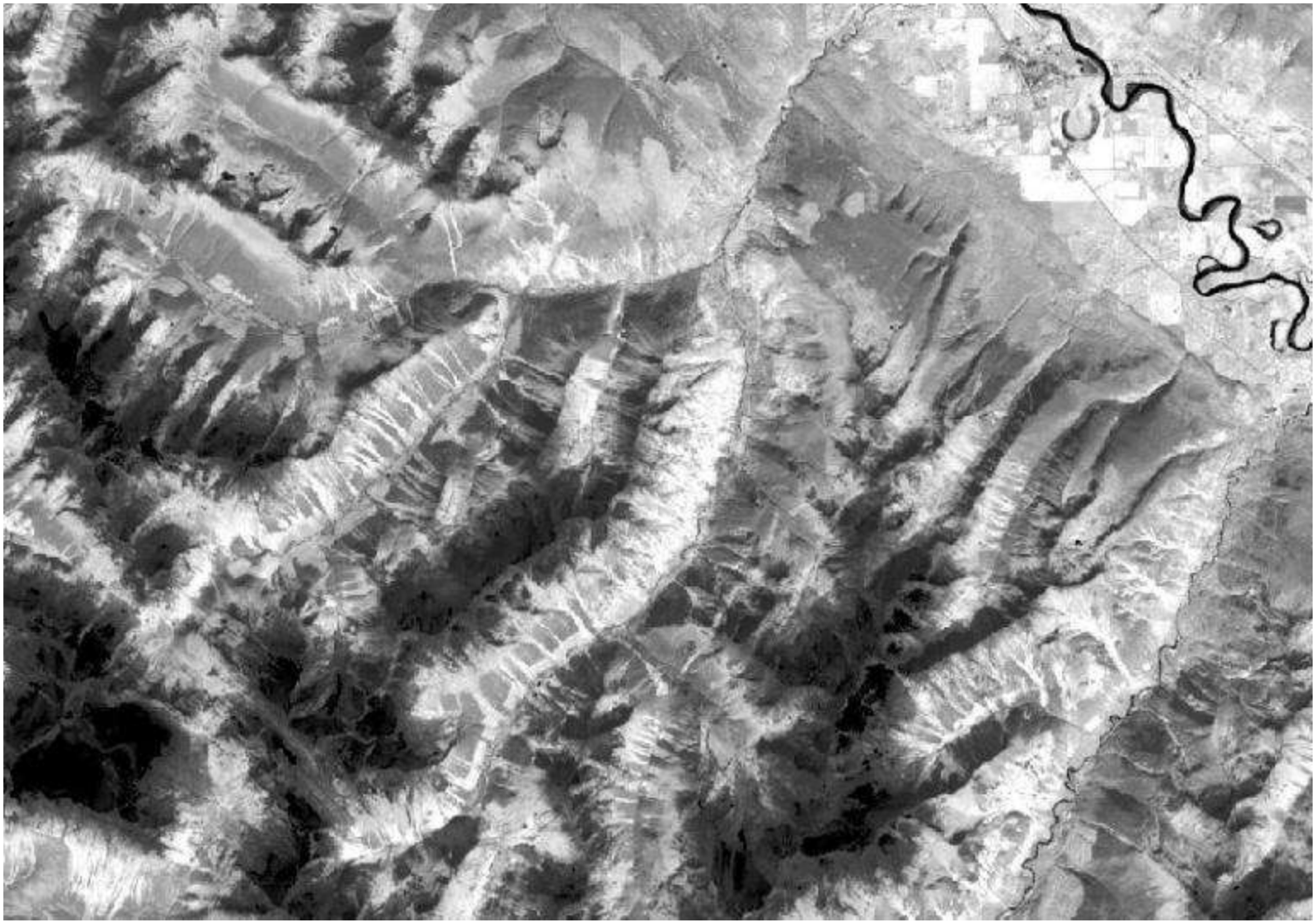




McBride 2014 Landsat 8 OLI

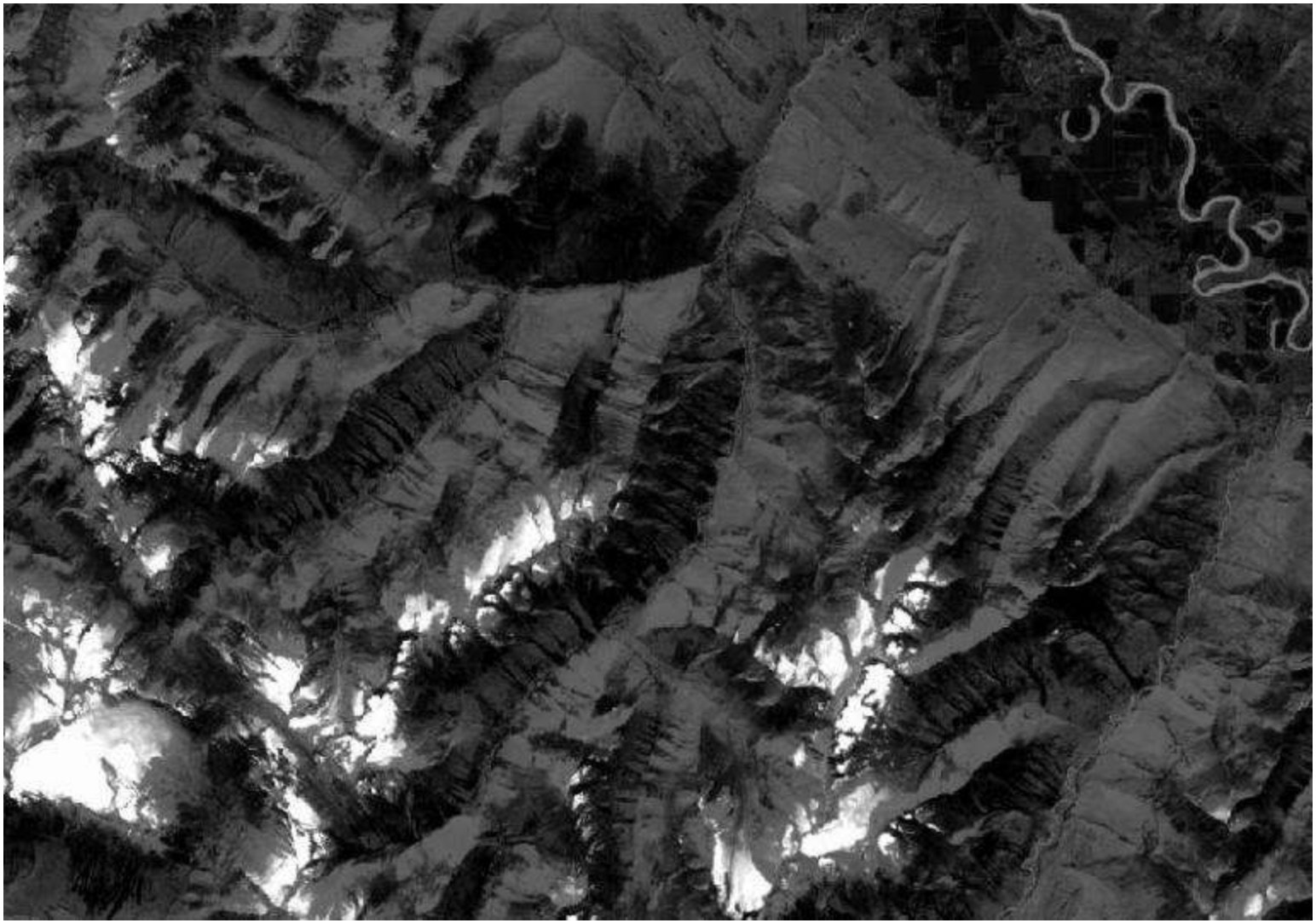


NIR/Red ratio = OLI 5/4 vegetation> 1.0



In mountain landscapes, a ratio only partly corrects for illumination

Red/MIR ratio = OLI 4/6 (TM 3/5)   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 maybe 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

d. New layers for analysis/display

Mt. Robson (1975 / 95)

Topo mapping: maps only include 'treed' (>30%)

2015: forest and alpine vegetation can be easily seen

Coniferous - deciduous vegetation from NIR/Red ratio

Which other ratios might be useful?

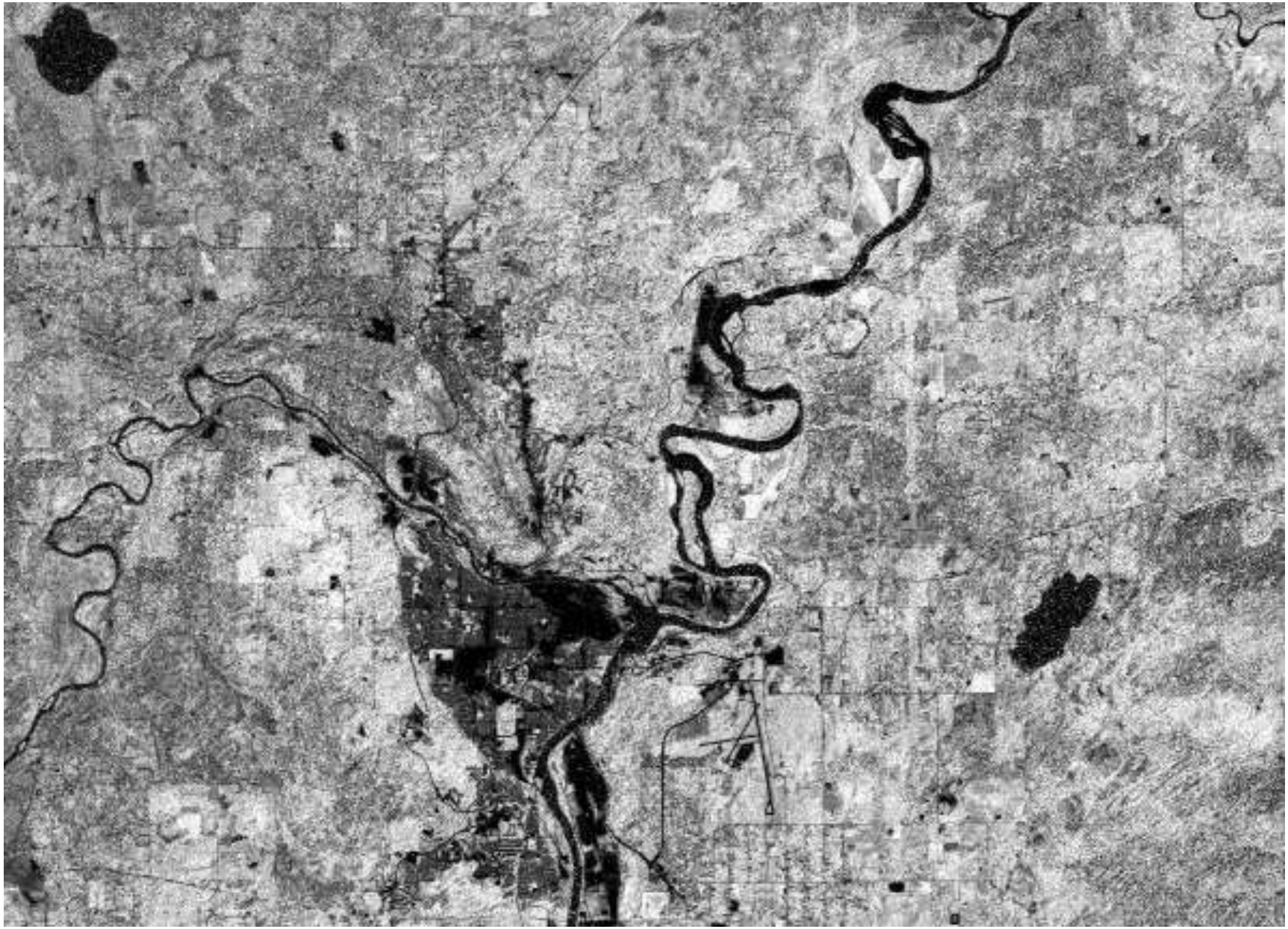
Consider the bands and their place in the spectrum:

	Visible	/ IR	/ SWIR	
TM	1,2,3	4	5, 7	
OLI	1,2,3,4	5	6, 7	(9)

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' e.g. TM 2/3, 3/1, 5/7 (shown here)



Which other ratios could be useful?

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

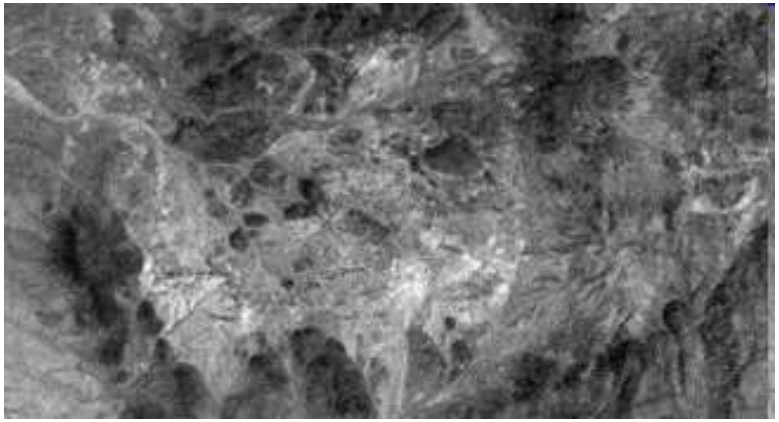
MSS: 5/4, 7/6 (4=green, 5=red, 6,7 =NIR)

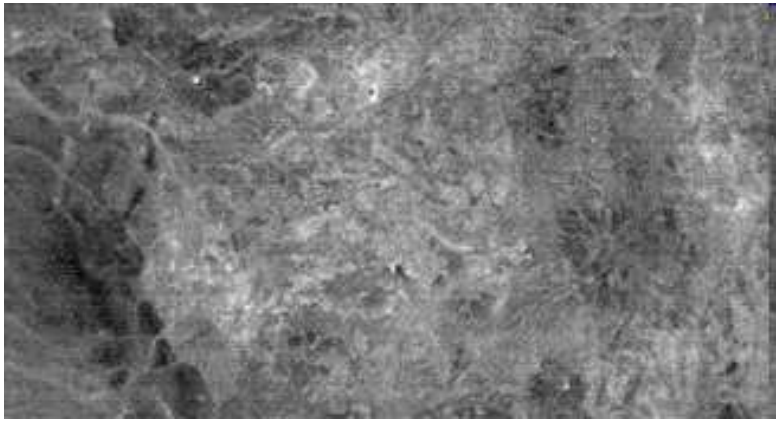
TM: 3/2, 3/1, 5/7 :
mineral enhancement (hydrothermally altered rocks)

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

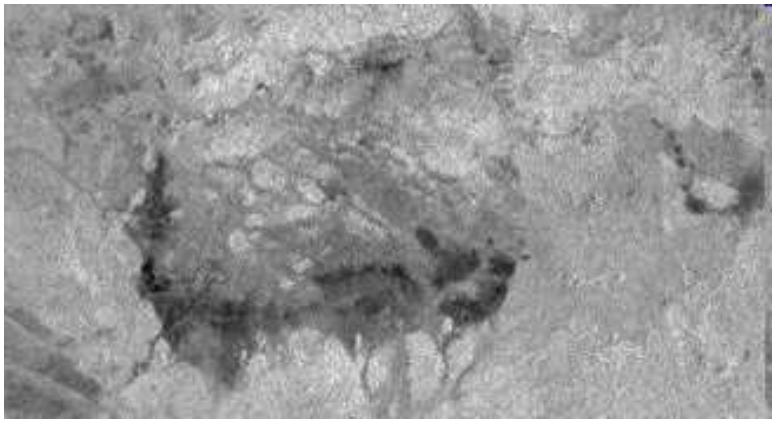
Thematic Mapper ratios, Utah (desert scene)

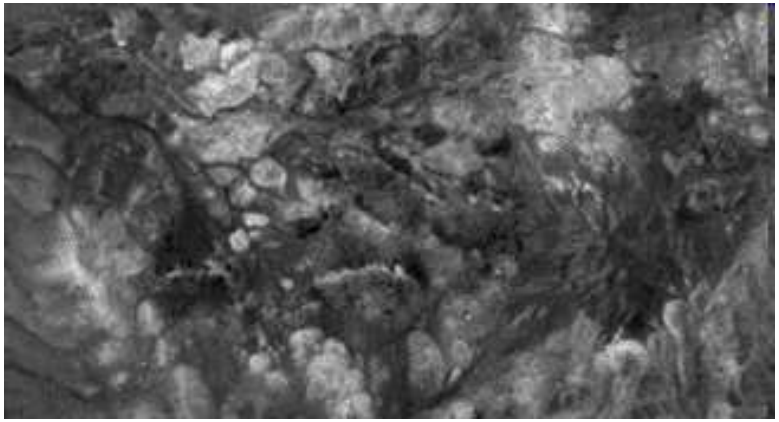
ratios 3/1 and 4/2





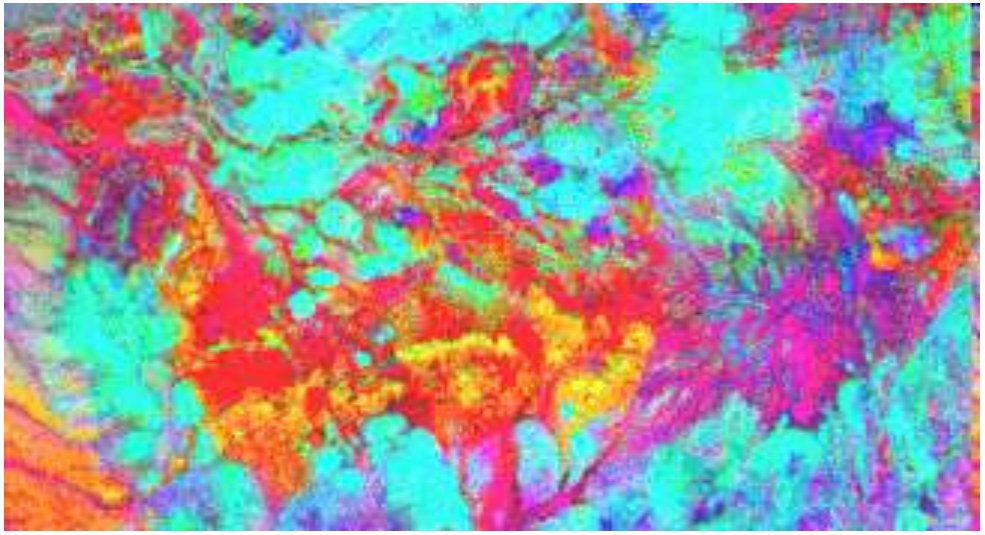
7/5 and 1/7 ratios





Ratios: e. Creating Colour Composites

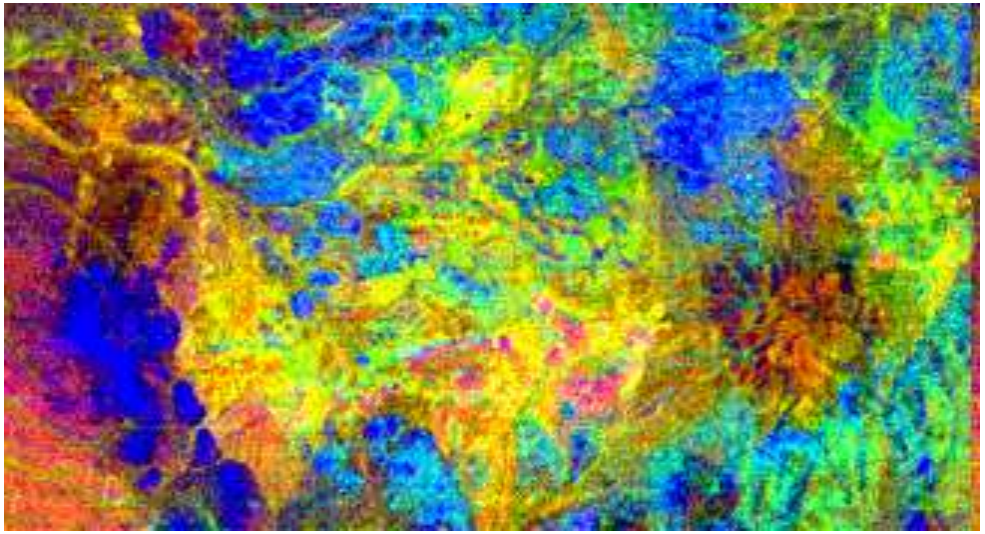
- use any 3 channels, not just bands



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 ?

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)

28 (8 bands for Landsat OLI)

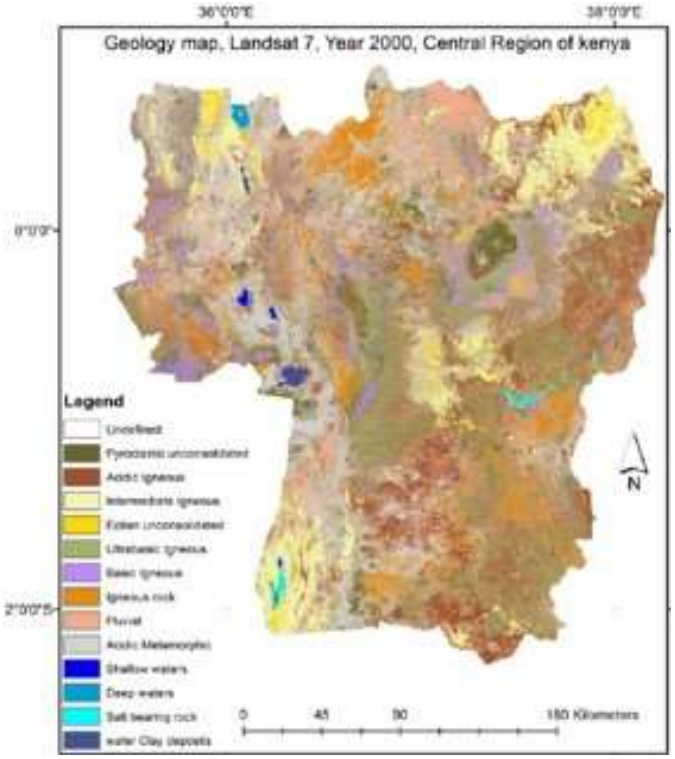
55 (11 bands for Sentinel 2-MSI)

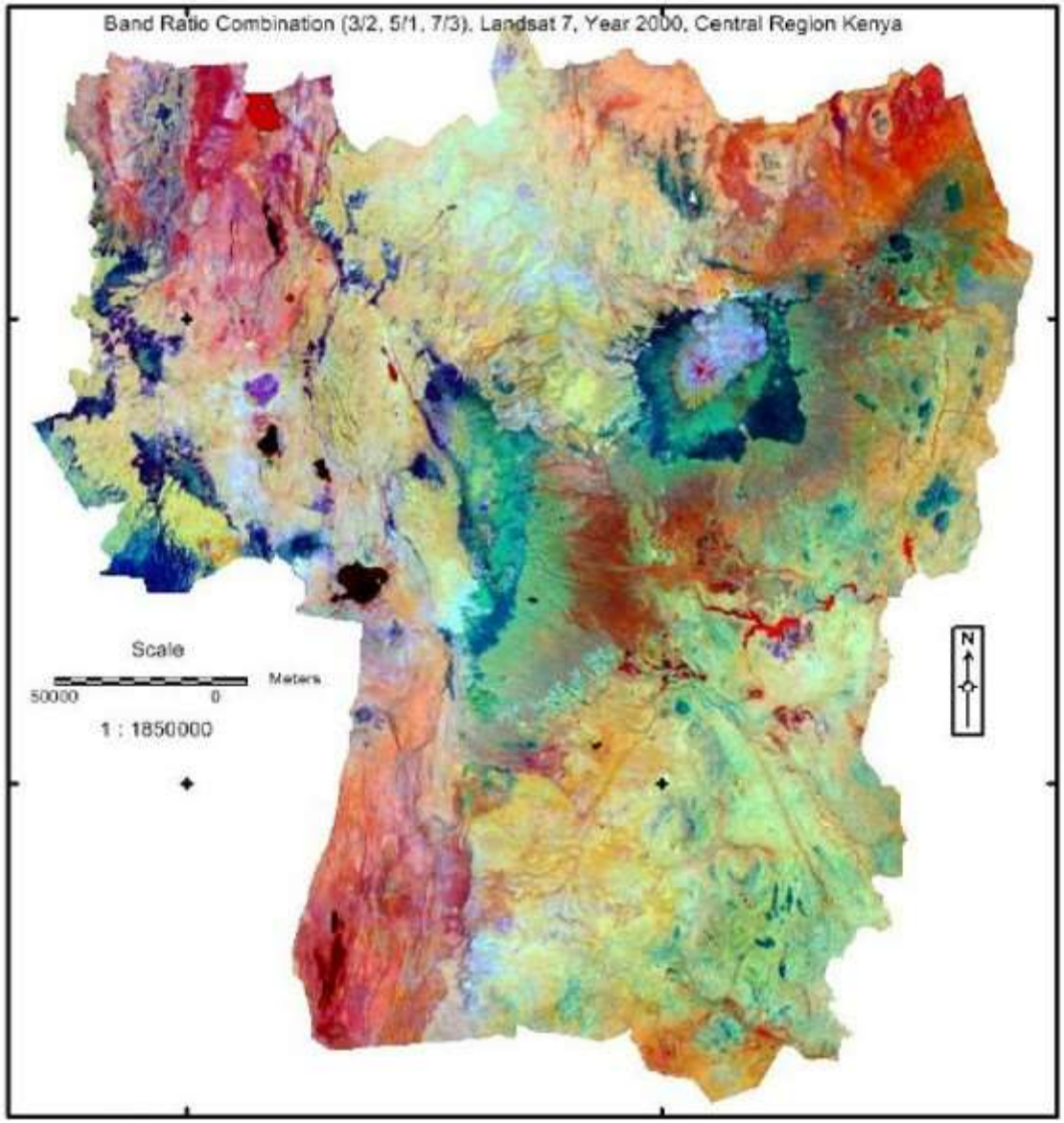
91 (14 bands for ASTER)

https://www.facebook.com/arabnubiagroup/videos/applying-different-band-ratio-composites-on-sentinel-2-imagery-which-equivalent-/252070591799385/

https://www.facebook.com/arabnubiagroup/videos/applying-band-ratios-on-sentinel-2a-multi-spectral-satellite-imagery-could-be-ve/1344438065690657/

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

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 - …… requiring 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 DATAErik Borg, Bernd Fichtelmann

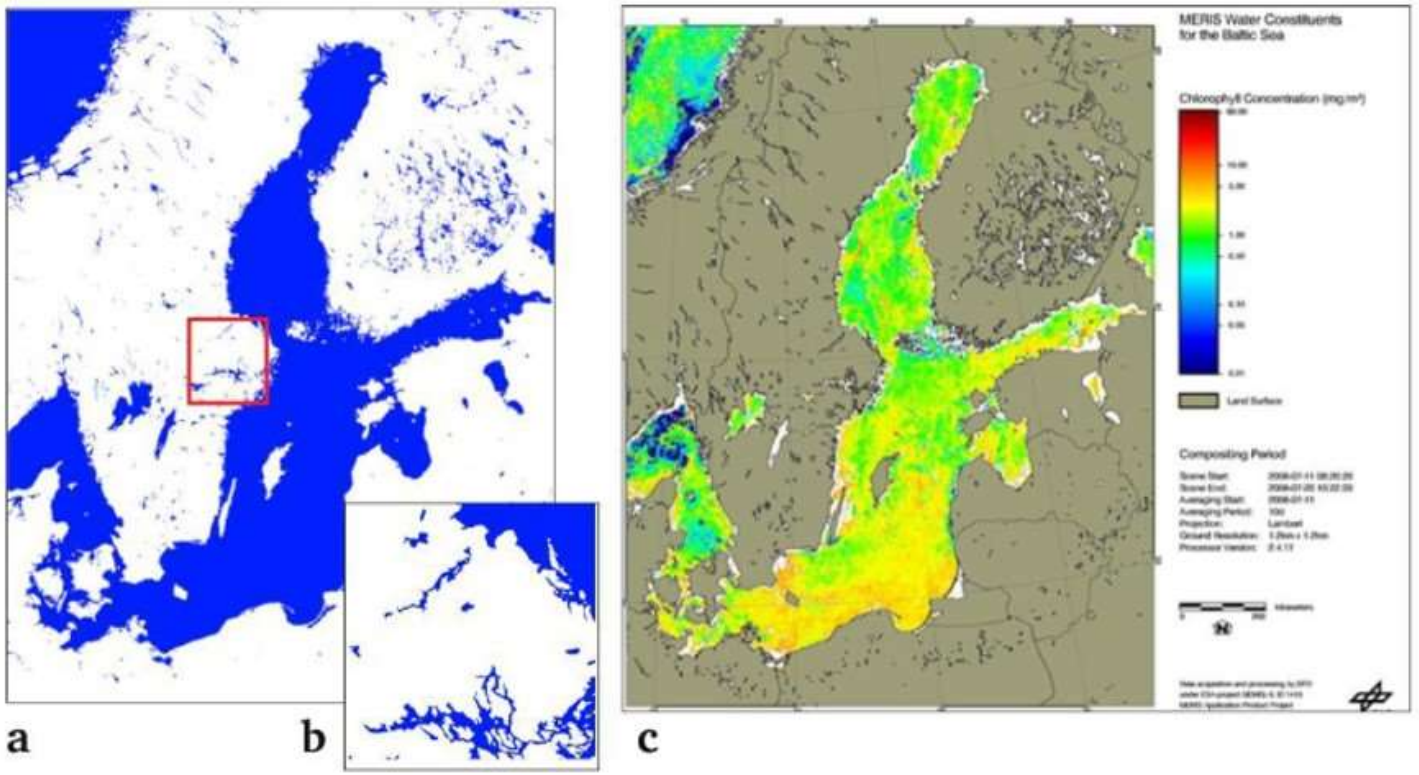


Figure 2: Land-water-mask of limited quality (a). The section shows details of the map around Stockholm (b). Quick-look product "Chlorophyll Concentration in the Baltic Sea" based on MOS data (c).

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 (more next week)

(Band X – Band Y) / (band X + Band Y)

e.g. Normalised Difference Vegetation Index

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