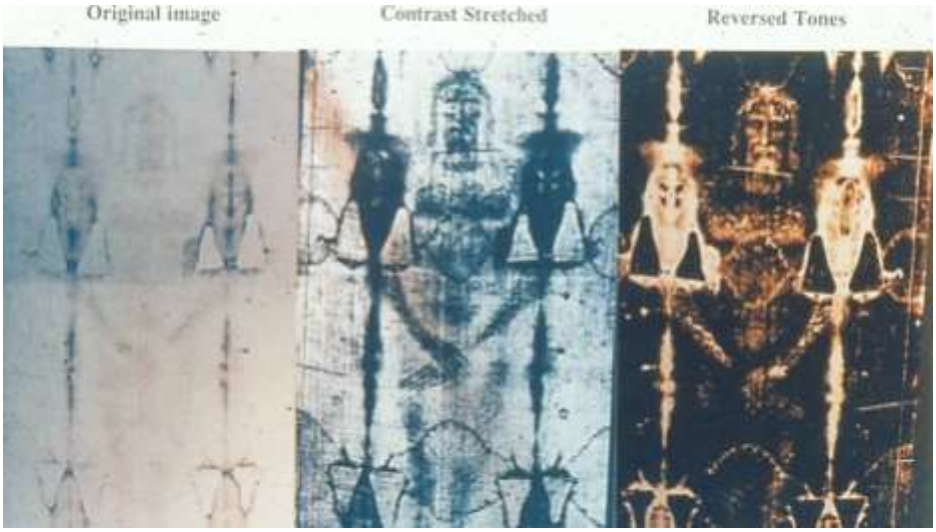
Enhancements: ratios



Shroud of Turin (this is a neat example of image processing, but not ratios !)

Band ratios

Band ratioing is perhaps the simplest of multispectral techniques,
- a type of GIS 'overlay'

A band ratio is a new channel of data created by the 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

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

DN new = 2 (2.0)

.. And if a = 50 and band b = 20, then the band ratio DN =

Ratio DN values

The DNs in a band ratio could hypothetically range from: ?
(if 8-bit data for each band can range from 0 or 1 to 255)

But in practice they usually range from: ?

The result is 'naturally' decimal, but can be written to
a. an 8-bit (Integer) channel or
b. a 32 bit 'real' channel

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

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

Ratio DN values

<u>So we have 3 options;</u>

1. DN^a / DN^b may give a useful 'slice' identifying ~3-8 groups (new DNs)

2a. Multiply by a scalar value e.g. 10 or 50 to give 8 bit range (0-255)

2b. ……. Select an 'auto' option to fill the 8 bit data range

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

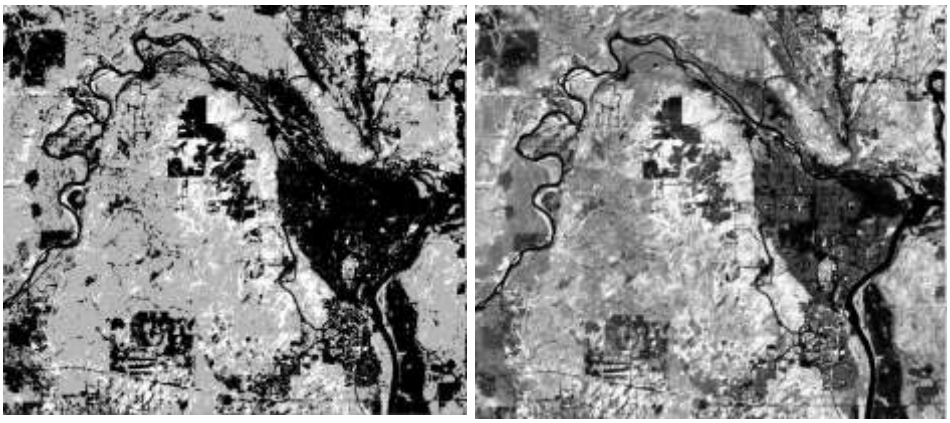
Band ratios

4/3 ratio - no scalar (DNs 0-3)

Scalar: DNs ~ 0-255

Vegetation > 1; water < 1

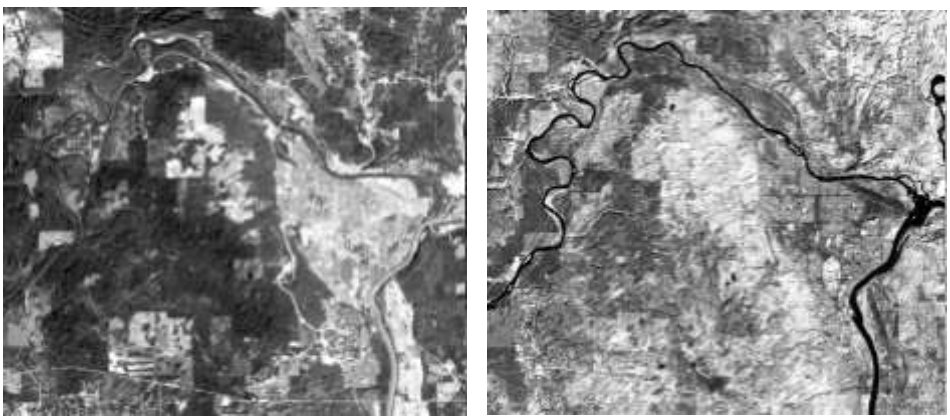
('auto' option may select the scalar)



Why use band ratios ?

This creates a new set of data that may be used to highlight certain features. Logically, ratioing may cancel out or reduce whatever is common in two images and exaggerate where they are different.

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

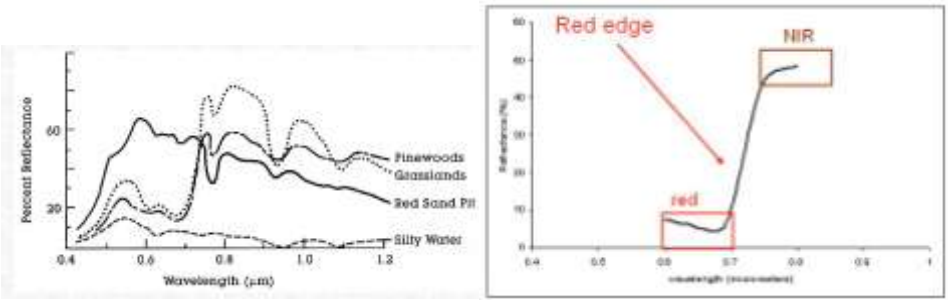


a. Spectral slope enhancement

in general, 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 (IR/red) = more vegetation (biomass)

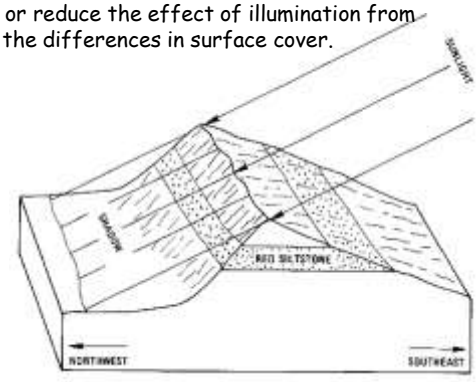


b. reduce topographic effect (shadow)

Digital Numbers may be composed of three elements:

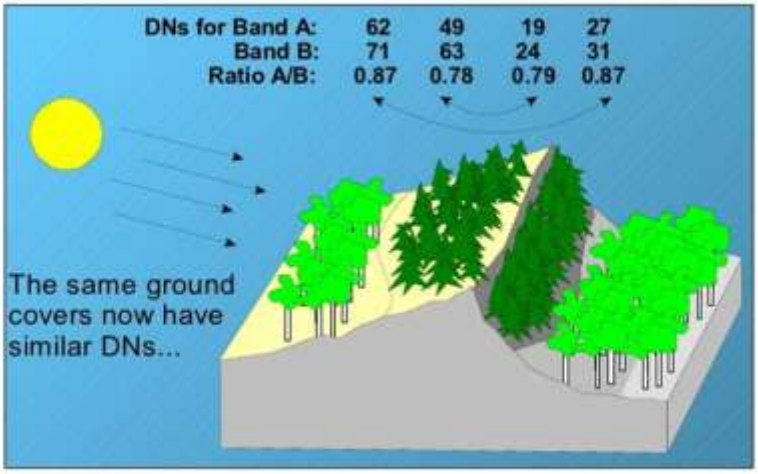
a. atmospheric interference (e.g. haze)
b. Illumination (angle of reflection)
c. Albedo (responding to surface cover)

If haze is minimal, a ratio can remove or reduce the effect of illumination from topography and highlight the differences in surface cover.

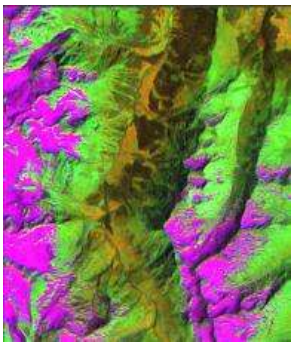


It can be useful to include the 4/3 ration as input to classification

Ratio of Band A to Band B

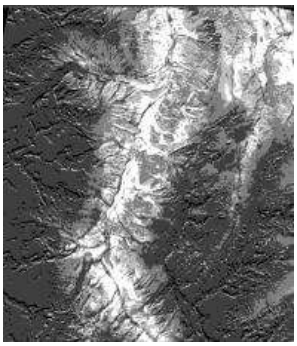


USDA Forest Service, Remote Sensing Applications Center, http://fsweb.rsac.fs.fed.us and UAS ENVS403



NIR/R-images can serve as a crude classifier of images, and indicate vegetated areas in particular.

Note also:
the reduction of the 'topographic effect' ->>



NIR/R (TM4/TM3), with values ranging from 0 to 8, soil to vigorous vegetation, vegetated areas shown in white.

NIR/R, stretched, with values ranging from 16 to 254, giving a smoother transition between surface types.

http://erdas.wordpress.com/2007/12/30/4-band-ratios/

Which other ratios would 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

But 1/2 and 2/1 are just inverse of each other ……

= ***[n (n-1)]*** / 2

= 3 (3 bands), 6 (4 bands), 15 (6 bands)

Which other ratios would be useful?

6 TM reflective bands = 15 potential ratios e.g. 1/2 2/3 3/4 4/7 7/1 …

Generally pairs of bands from similar parts of the EM spectrum will show 'noise' while bands from contrasting portions of the EM spectrum enhance features.

i.e.	**Visible**	**/ IR**	**/ MIR**
TM	1,2,3	4	5, 7

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

e.g. 7/3 lithology 3/5 snow and ice

Which other ratios could be useful?

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

MSS: 5/4, 6/5 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 distinguish **subtypes** such as soils, and geologic differences

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

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

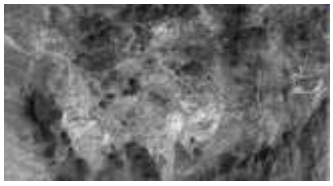
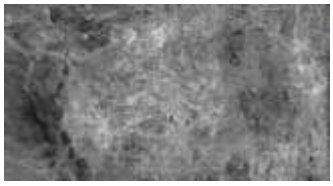
MSS Ratios	Applications
1/2, 1/4, 3/4	Characterizing rocks and soils
1/2 or 2/1	Suspended sediment in water
1/2 or 2/1	Iron-oxide content in rocks
3/1, 3/2	Vegetation and water bodies
4/1, 4/2	Vegetation and water bodies

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

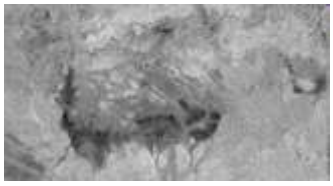
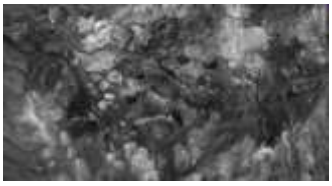
http://academic.emporia.edu/aberjame/remote/landsat/landsat_proc.htm

Thematic Mapper ratios, Utah (desert scene)

ratios 3/1 and 4/2

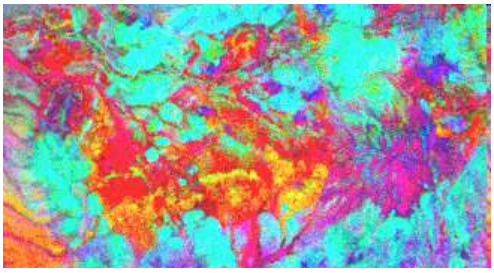



7/5 and 1/7 ratios

Creating Colour Composites from Ratios

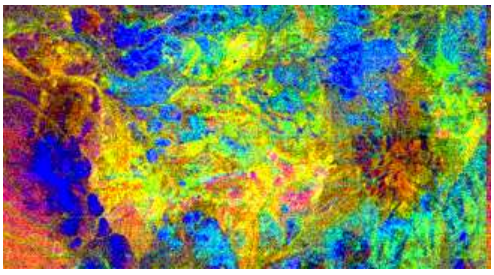
- use any 3 channels, not just bands



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 ?

Other Image Arithmetic (ARI)

also: Raster Calculator (GIS / DIPS)

Band ratios are the result of 'division' /

it is also possible to use the other arithmetic operators:

a. Image subtraction -
Yields the difference between two bands; the result will include values that are + and - (requiring scaling or a 16 bit signed channel):
useful for showing changes through time with two image dates.

b. Image addition +
Used to create an overall or average image channel, e.g. (TM1 + 2 + 3) / 3

c. Image multiplication *
Often used in a masking process, where one layer is either 1 or 0
(e.g. land or water …. e.g. your water bitmap in lab 3)