

VISUALISATION

IMAGE VISUALISATION AND COLOUR COMPOSITES

WAN BAKX – 2023 - WWW.WOOCCLAP.COM/VISCORE



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CONTENTS OF THE LECTURE

- Visualisation
 - **Colour perception**
 - Image display/band selection
- Elementary image enhancement
 - Contrast enhancement (histogram operations)



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OBJECTIVES

- Explain and apply options to enhance an image by histogram operations for efficient and effective visualisation.
- Explain and apply colour composites in relation to spectral properties and spectral bands (use and usage).
 - Textbook Chapter 5, Paragraph 5.1 Visualization and radiometric operations up to “Noise reduction”.
 - Lectures
 - Exercises



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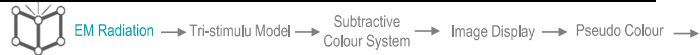
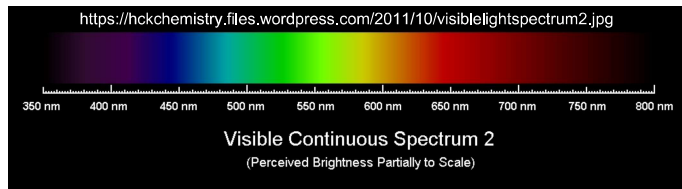
COLOUR AND VISION



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Human eye only sensitive for visible EM Radiation



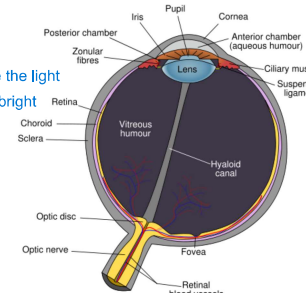
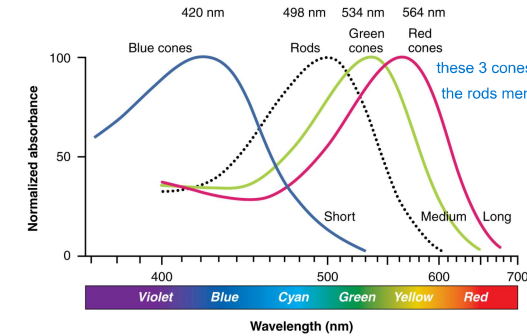
TRI-STIMULI MODEL FOR COLOUR VISION

- Three kinds of cones
- Three layers on colour film
- Red-Green-Blue dots on monitors
- Magenta-Yellow-Cyan (inks) for printing
- Colour cube/spaces
- Sensation to the human has stronger relation to Intensity-Hue-Saturation (Brightness-Colour-Vividness) than to Red-Green-Blue

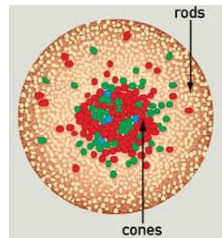


SENSITIVITY OF CONES AND RODS

https://upload.wikimedia.org/wikipedia/commons/9/94/1416_Color_Sensitivity.jpg



<http://www.macroevolution.net/images/human-eye-373-358-20.jpg>



<http://www.webexhibits.org/causesofcolor/images/content/26.jpg>

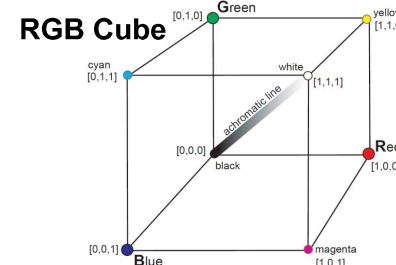
- Cones need high intensities to work well
 - Three types of cones exist with different sensitivity (approx. Red-L, Green-M and Blue-S)
- Rods work well in low illumination, but show only brightness



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COLOUR SYSTEMS (DIS)AGREEMENT

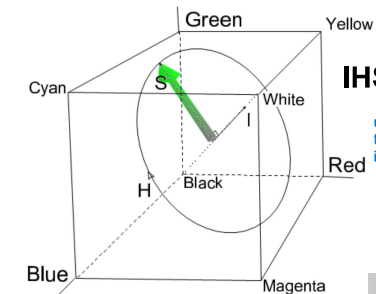


you can go from RGB to IHS



Ostwald

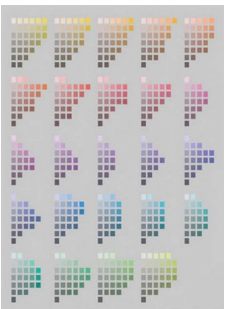
https://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Ostwald_Color.jpg/800px-Ostwald_Color.jpg



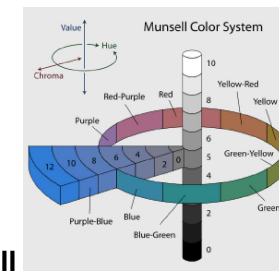
IHS (HLS)

use intensity
the distance of colour show
intensity, how bright how dark

DIN 6164



<https://www.colors-system.com/wp-content/uploads/47din/din6164.jpg>



Munsell

https://upload.wikimedia.org/wikipedia/commons/thumb/d/d5/Munsell-system_sva/290px-Munsell-system_sva.png

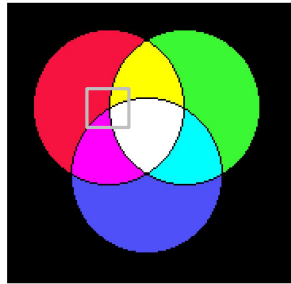


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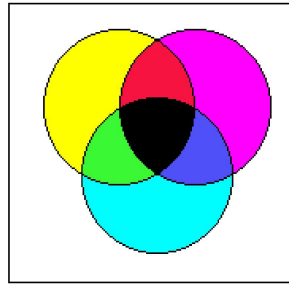
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ADDITIVE AND SUBTRACTIVE COLORS



Additive Color Scheme

Screen display



Subtractive Color Scheme

Printing



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Get your smartphone/laptop and browse to

www.wooclap.com/VISCORE



INTERACTIVE RGB



<https://www.physicsclassroom.com/Physics-Interactives/Light-and-Color/RGB-Color-Addition/RGB-Color-Addition-Interactive>

Question for those interested:

What is wrong with the colour wheel in this interactive tool?



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IMAGE DISPLAY



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TERMINOLOGY

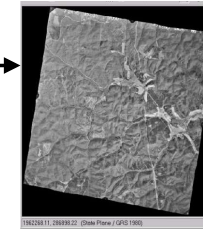
- Raster data sets contain one or more layers
- EO images (\subset raster data sets) contain one or more layers containing measurements in different portions from the EM spectrum. Also referred to as (spectral) bands.
- Monitors build up display using one up to three channels from Red, Green and Blue
- A measurement is stored as a Digital Number (DN) also referred to as value (and tautology DN value ;-)



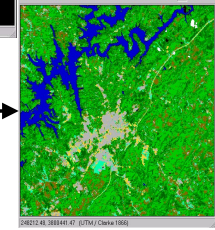
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IMAGE DISPLAY

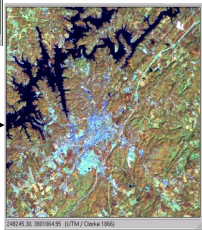
One band \rightarrow Grey scale



One band \rightarrow Pseudo colour table (e.g. classification results)



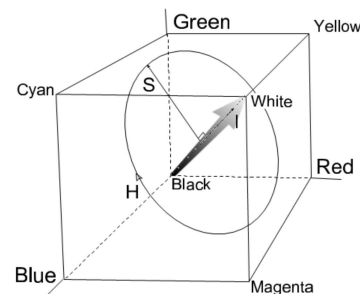
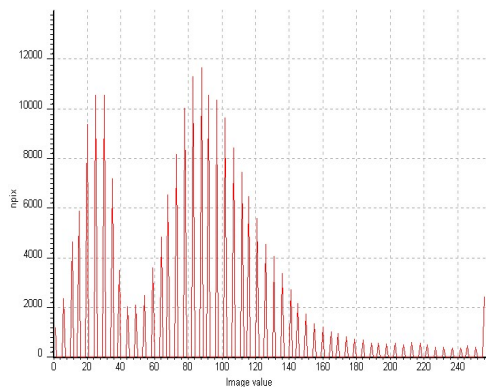
Multiple bands \rightarrow Select 3 \rightarrow Colour composites (e.g. false colour comp.)



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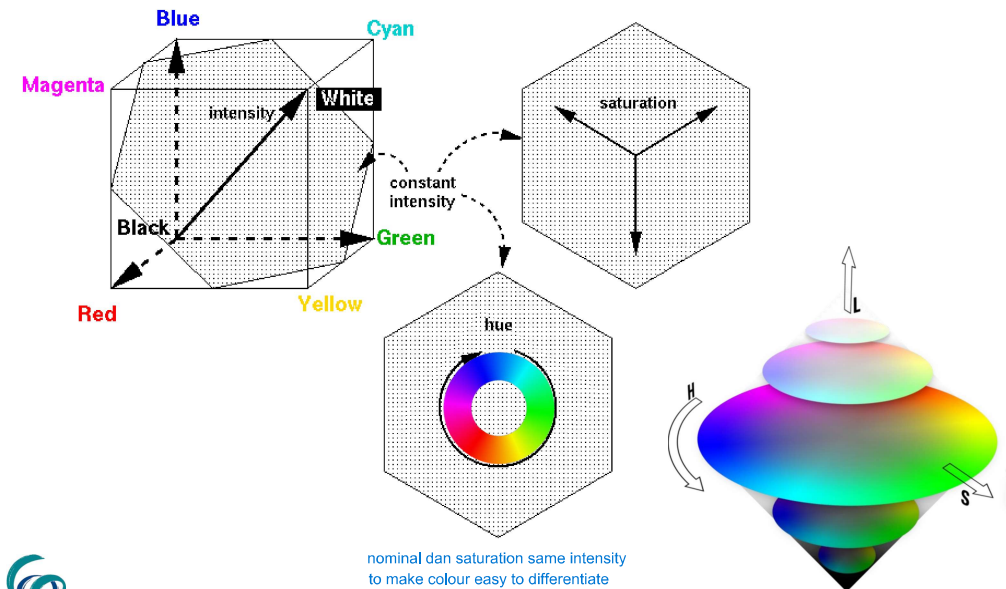
Special types: Anaglyph, Stereo/3D

IMAGE DISPLAY; GREY SCALE



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IMAGE DISPLAY; PSEUDO COLOUR (HUE)

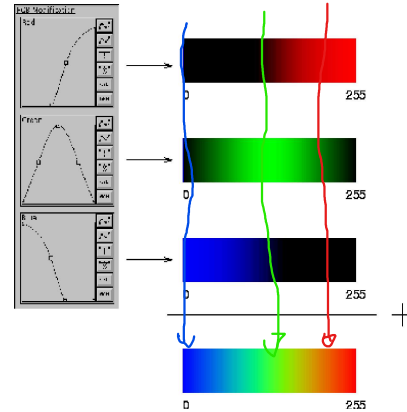
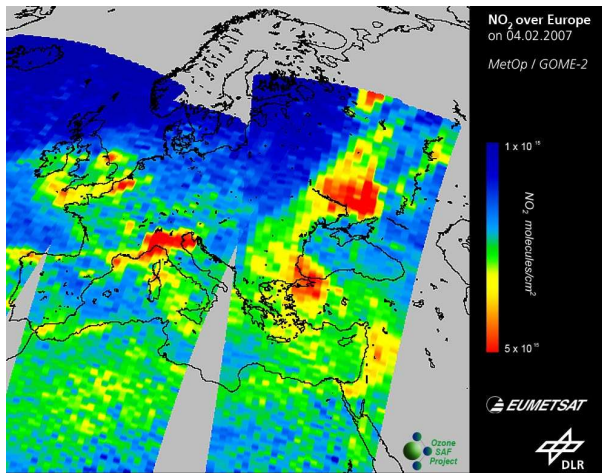


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<http://colorizer.org/img/hsl.png>

IMAGE DISPLAY; PSEUDO COLOUR

- Human eye more sensitive to variations in Hue than in Intensity



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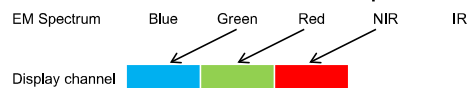
https://www.researchgate.net/profile/Peter_Schluessel2/publication/249615478/figure/fig1/AS:654411294601224@1533035219790/Columnar-amount-of-NO2-over-Europe-retrieved-from-GOME2-on-4-Feb-2007-derived-by-the.png

COLOUR COMPOSITES CLASSIFICATION

- Natural Colour composite



- Standard False Colour composite

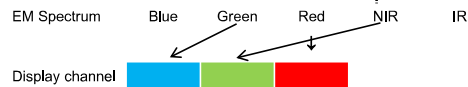


healthy vegetation = reddish

- All other combinations

Selecting prominent bands to interpret specific object classes

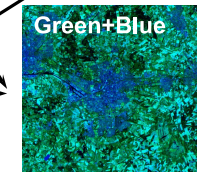
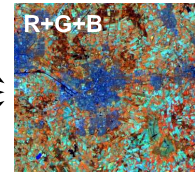
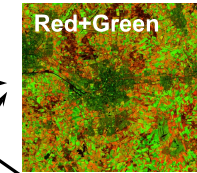
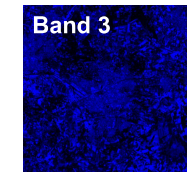
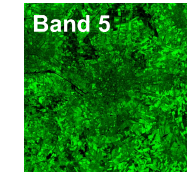
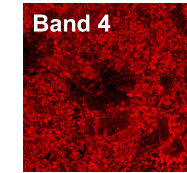
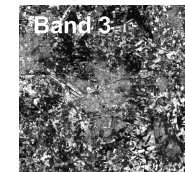
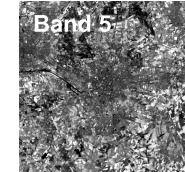
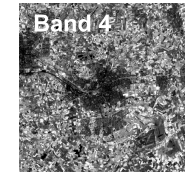
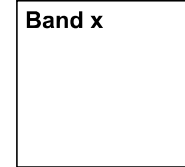
- Pseudo Natural Colour composite



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COLOUR COMPOSITES



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mix RGB = All colour in rainbow, include white
Band 4 + band 5 = Green, orange, yellow, red

COLOUR COMPOSITES

how many composites that you can make

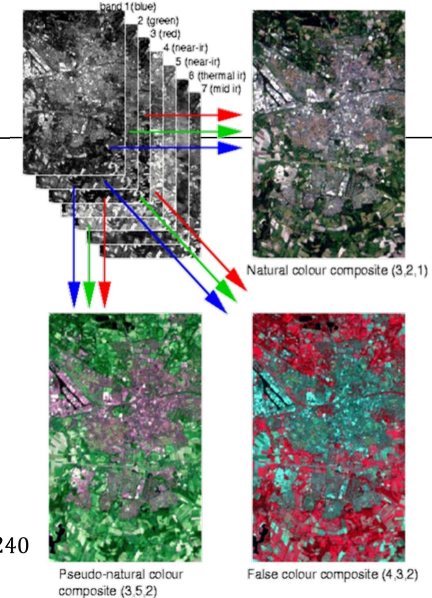
$$\text{TM (6 bands)} = \frac{6!}{(6-3)!} = \frac{720}{6} = 120$$

$$\text{Sentinel 2 (13 bands)} = \frac{13!}{(13-3)!} = 1716$$

$$\text{AVHRR (220 bands)} = \frac{220!}{(220-3)!} = 10503240$$

$$\text{Permutations} = \frac{n!}{(n-k)!} = \# \text{ of Colour Composites}$$

Because for RGB the order does matter



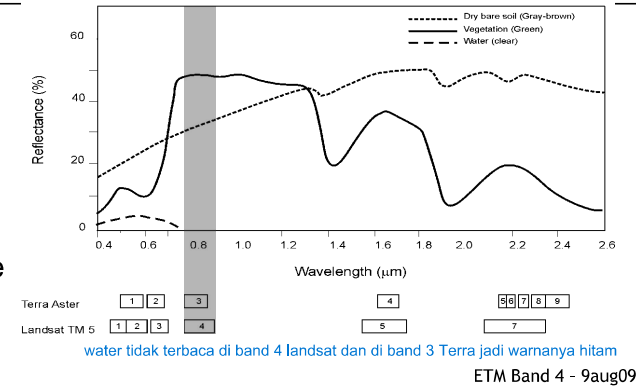
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BAND SELECTION IS ESSENTIAL

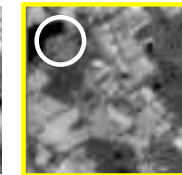
- Analyse spectral char. of objects of interest with respect to (char. of) bands available
- Don't select correlated bands
- Consider User/Usage (experience of user, natural versus false colour, application)

VISUALISATION OF MAIN COVER TYPES

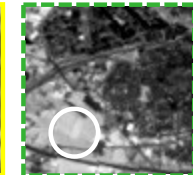
- Identify types of objects
- Find signatures
- Find sensor characteristics
- Translate signature into relative brightness for display



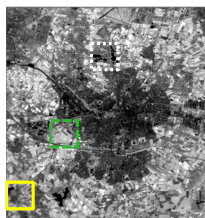
Water ~ Dark(est)



Soil ~ Medium

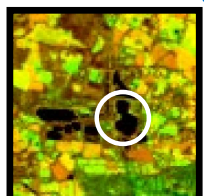
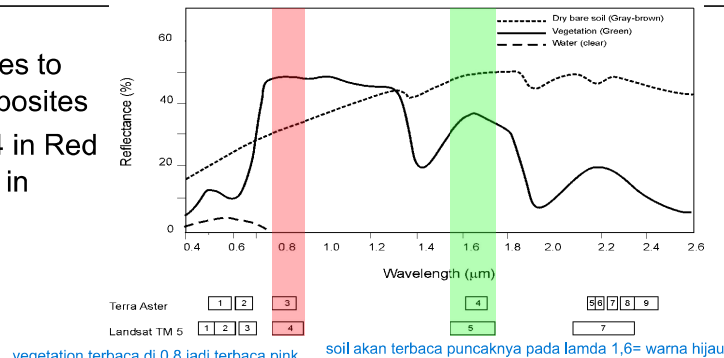
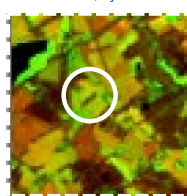
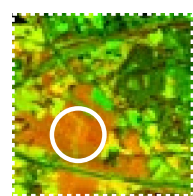
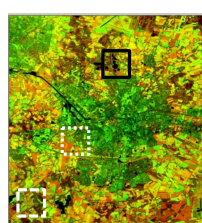


Vegetation ~ Light(est)



VISUALISATION OF MAIN COVER TYPES

- Same applies to colour composites
- E.g. Band 4 in Red and band 5 in Green

Water ~ Black
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GreenishVegetation ~
Orange

ETM - 9 Aug 09

BR/LEAK

ELEMENTARY IMAGE ENHANCEMENT FOR DISPLAY



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ELEMENTARY IMAGE ENHANCEMENT

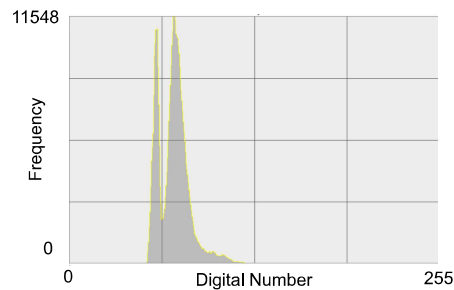
- Enhance the image for a specific purpose through histogram operations
- Global contrast enhancement



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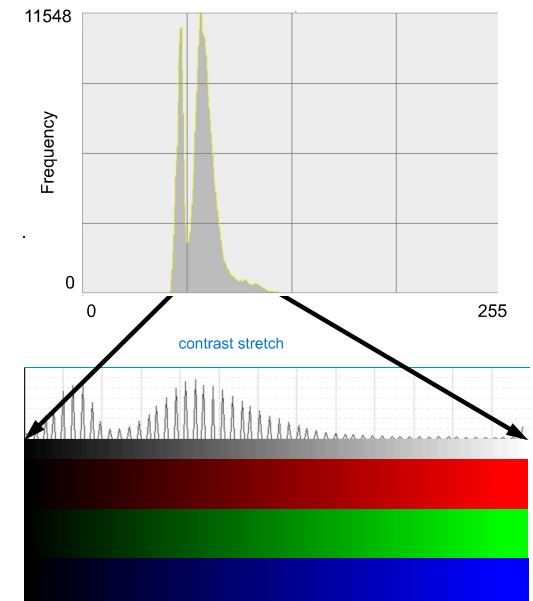
SETTING THE SCENE

- Image is subset of the World
 - Energy range measured in an image is a subset of the dynamic range of sensor -> subset of 8 bit, 10 bit . . .
- Monitor can display $2^8 = 256$ shades of grey
- How to make efficient use of both?



ENHANCEMENT BY HISTOGRAM OPER.

- One way or another 'map' DN value to
 - Grey value
 - or
 - Red
 - Green
 - Blue

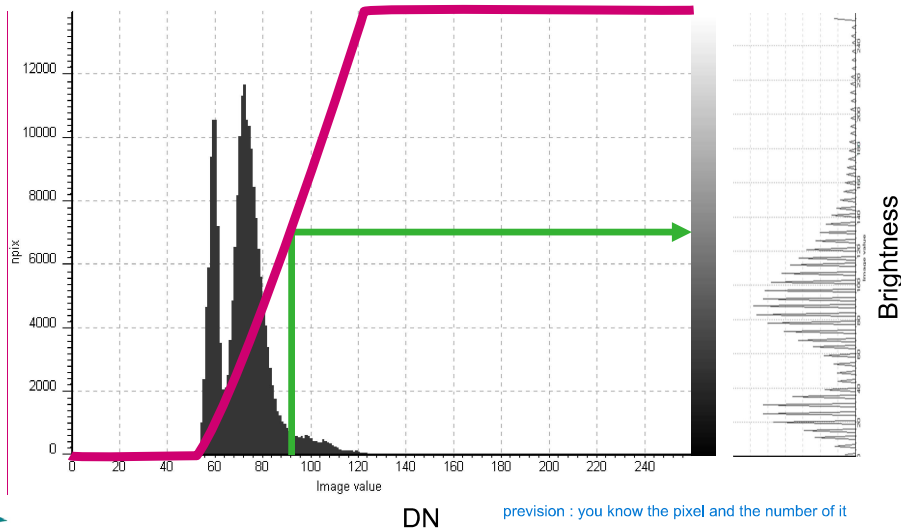


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TRANSFER FROM DN TO BRIGHTNESS

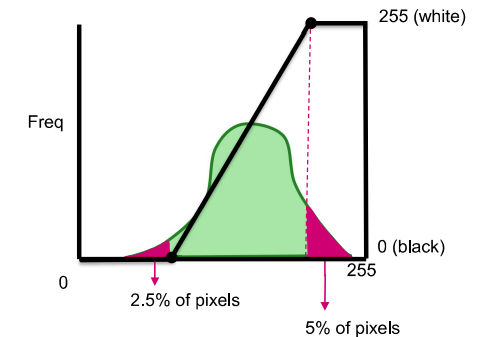
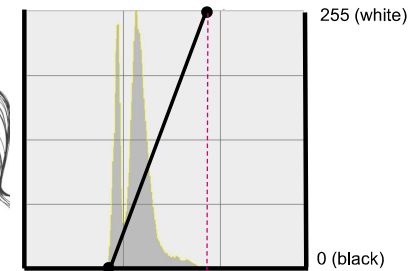


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HOW TO SET EFFICIENT CONTRAST (WOOCCLAP)

Use existing DN values

- Minimum input value and maximum input value for setting the Transfer Function
- Use % to cutoff (eg 2.5/5)
 - Assumes lowest 2.5 % and highest 5 % are obsolete

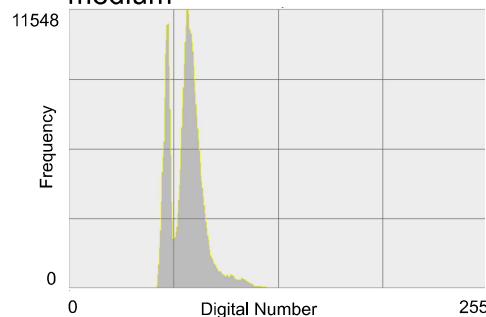


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HOW TO SET EFFECTIVE CONTRAST?

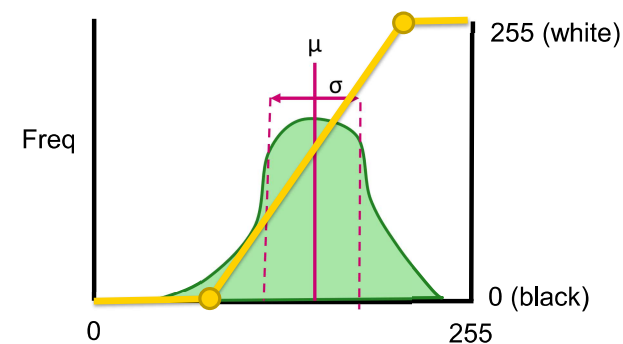
VIP

- Assess expected objects, their signatures and thus representation in the (histogram of the) spectral band at hand
- Set contrast to most interesting ranges (objects)
- SPOT B1 – Green
- Expected objects: water, various crops and forest on land
- Expected DN: water very low, forest low, crops low to medium



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ALTERNATIVE – STANDARD DEVIATIONS (WOOCCLAP)



Based upon

- Mean (μ)
- +/- 2 Standard Deviation (σ)

Nice start **BUT**

Assumes Normal or Gaussian distribution

Is this efficient or effective or both or none?



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RULES (USE WITH CARE)

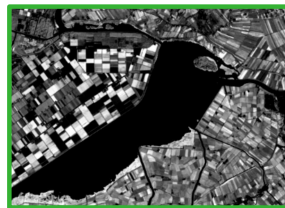
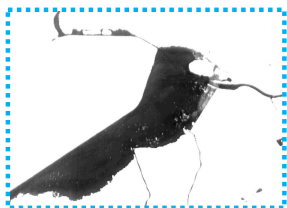
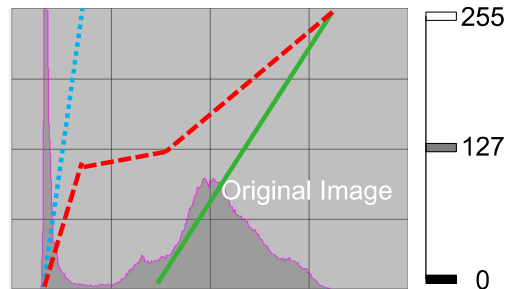
- Steeper transfer function on the histogram -> introduces more contrast
- Transfer function more to the left of the histogram -> brighter image (image with large bright areas)
- Transfer function more to the right of the histogram -> darker image (image with large dark areas)
- Steeper transfer function on some range reduces contrast on other ranges



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(PIECE WISE) LINEAR CONTRAST STRETCH

Original (Spot XS B3)



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STRETCHING METHODS (FUNCTIONS)

- Linear
- Piece wise linear
- Histogram equalisation
- Gamma
- ...
- ...

All transferring DN's to brightness

the value don't change

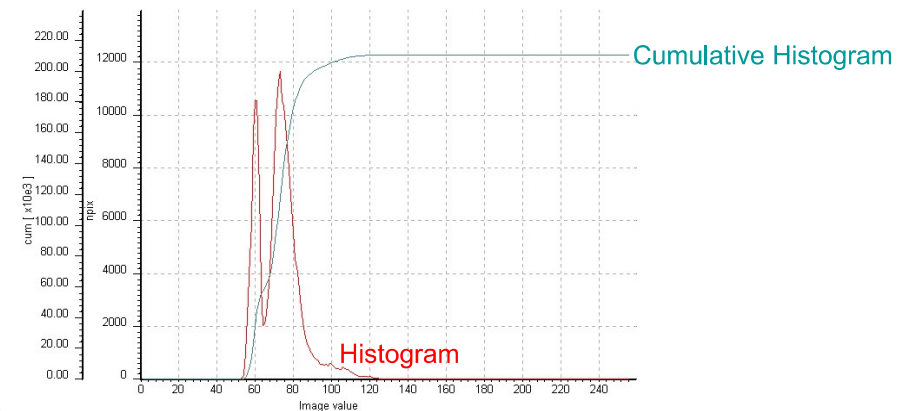


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HISTOGRAM EQUALISATION

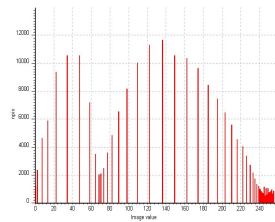
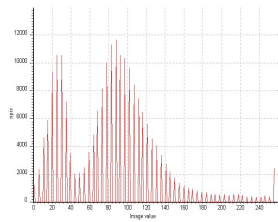
is only push button

- Transfer function is the cumulative histogram (nonlinear)
- Steeper transfer function at higher frequencies!



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LINEAR AND HISTOGRAM EQUALISED STRETCH



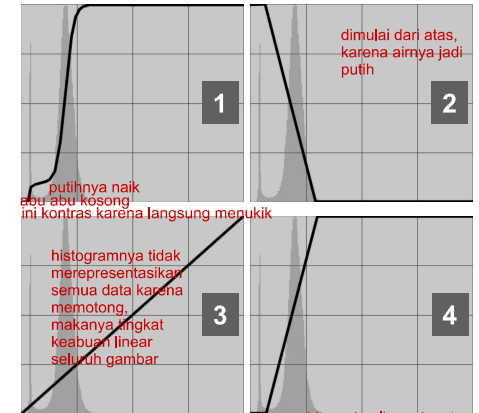
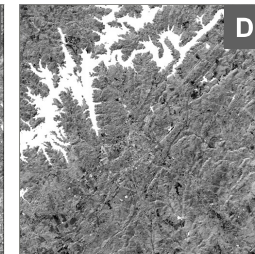
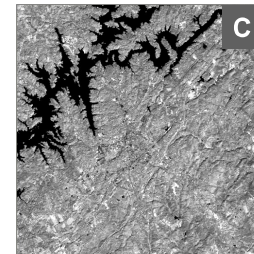
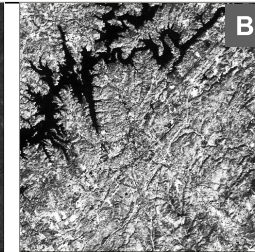
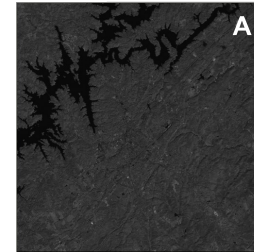
brightness increases with higher frequency

QGIS 3.22.9

- Concept of transfer function is not supported
- Piece wise linear contrast enhancement is not supported
 - QGIS works with 2 breakpoints = linear

Prepare for the Question Hour

QUESTION



lower value will be match to white, dan the high value will be black

Which Contrast belongs to each image? LU image = Original image