Transformations in Remote Sensing

= Converting image bands into secondary channels

- **Ratios and Indices**
- **Image arithmetic e.g. addition, subtraction, multiplication**
- **Tassel Cap Transformation**
- **Principal Component Analysis (PCA)**
- **Pansharpening / image fusion**

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The Tasseled Cap Transformation in Remote Sensing

https://www.sjsu.edu/faculty/watkins/tassel.htm

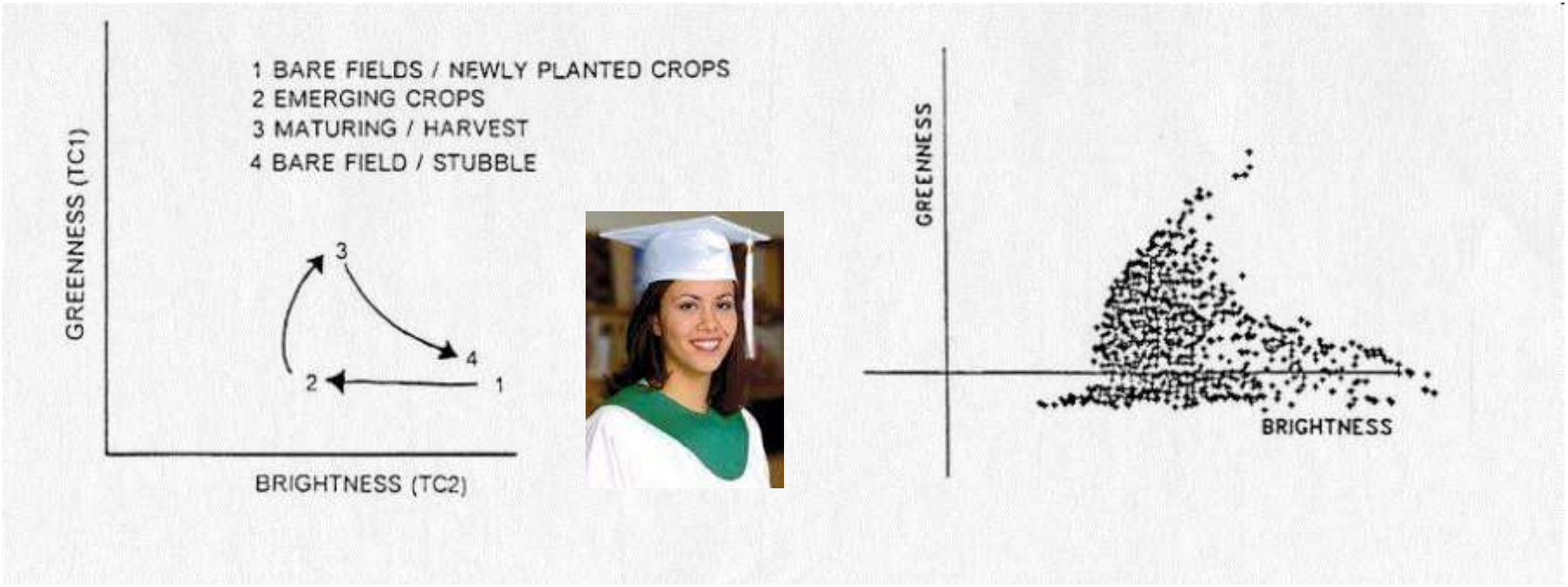
.. the conversion of the DNs readings in a set of bands into weighted sums of **separate channels**. One measures the brightness of each pixel in the scene. The other composite values are linear combinations of the values of the separate channels, but some of the weights are negative and others positive. One of these represents the degree of **greenness** of the pixels and another the **yellowness** of vegetation, or perhaps the **wetness** of the soil.

Usually there are just **three** composite variables.

Tasseled Cap transformation

The technique was named after the pattern of spectral change of agricultural crops during senescence, plotting brightness (visible) against greenness (NIR). As crops grow from seed to maturity, there is a net increase in near-infrared and decrease in red reflectance based on soil color (Kauth and Thomas, 1976)

1. Bare fields / newly planted crops -high brightness, low greenness (spring)
2. Plant Growth - <-<- reduced brightness (early summer)
3. Maturity: -> -> greenness (late summer)
4. Senescence (harvest) - bare/stubble: <-<-greenness, ->-> brightness (Fall)



Tasseled Cap transformation

ArcMap 10.3

The Tasseled Cap (Kauth-Thomas) transformation is designed to analyze and map vegetation and urban development changes detected by satellite sensors.

For each pixel DN:
Brightness channel = 0.433*Band4 + 0.632*Band5 +0.586*Band6 +0.264*Band7
etc.. for Greenness and Yellowness

WEIGHTS FOR TASSELED CAP TRANSFORMATION OF LANDSAT MSS DATA				
Component	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
Brightness	0.433	0.632	0.586	0.264
Greenness	-0.290	-0.562	0.600	0.491
Yellowness	-0.829	0.522	-0.039	0.194
"Non-such"	0.223	0.012	-0.543	0.810

4:Green 5:Red 6:NIR1 7:NIR2

Brightness = a weighted average of all bands
Greenness = visible versus Near-IR bands (like a TM 4/3 ratio)
Yellowness = Green v Red (“Non-such” = the difference between the 2 IR bands)

Tasseled Cap TM data,6-band (no thermal): Brightness, Greenness, Wetness

WEIGHTS FOR TASSELED CAP TRANSFORMATION OF THEMATIC MAPPER DATA						
Component	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**	**Channel 5**	**Channel 7**
Brightness	0.3037	0.2793	0.4343	0.5585	0.5082	0.1863
Greenness	-0.2848	-0.2435	-0.5436	0.7243	0.0840	-0.1800
Wetness	0.1509	0.1793	0.3299	0.3406	-0.7112	-0.4572

New channel !

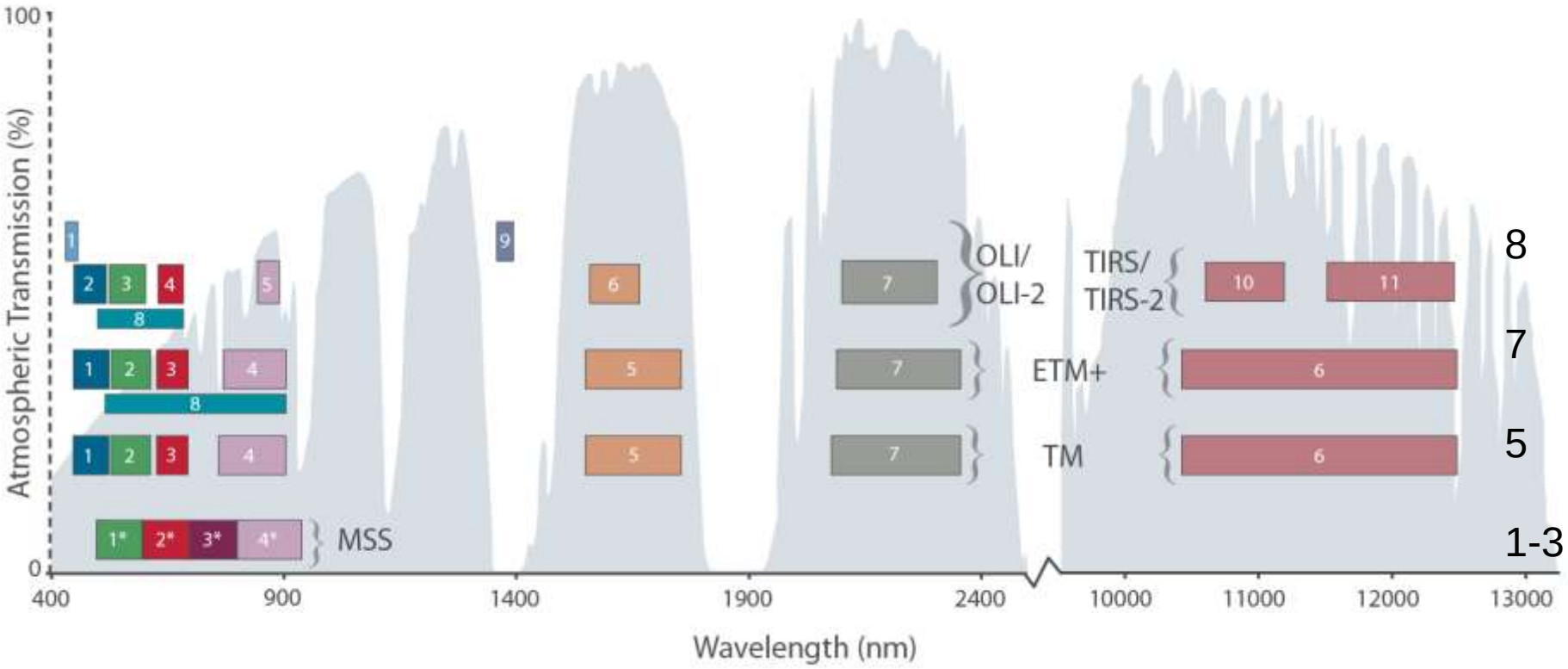
Landsat 8 OLI coefficients

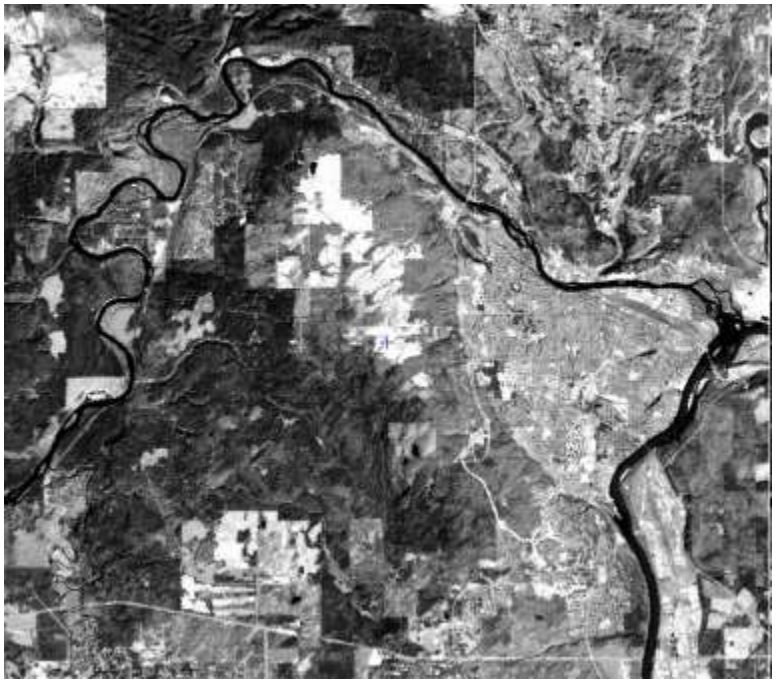
	Coastal Band 1	*Blue Band 2*	*Green Band 3*	*Red Band 4*	*NIR Band 5*	*Mid-IR1 Band 6*	*Mid-IR2 Band 7*
Brightness	0	0.3029	0.2786	0.4733	0.5599	0.5080	0.1872
Greenness	0	-0.2941	-0.2430	-0.5424	**0.7276**	0.0713	-0.1608
Wetness	0	0.1511	0.1973	0.3283	0.3407	**-0.7117**	**-0.4559**

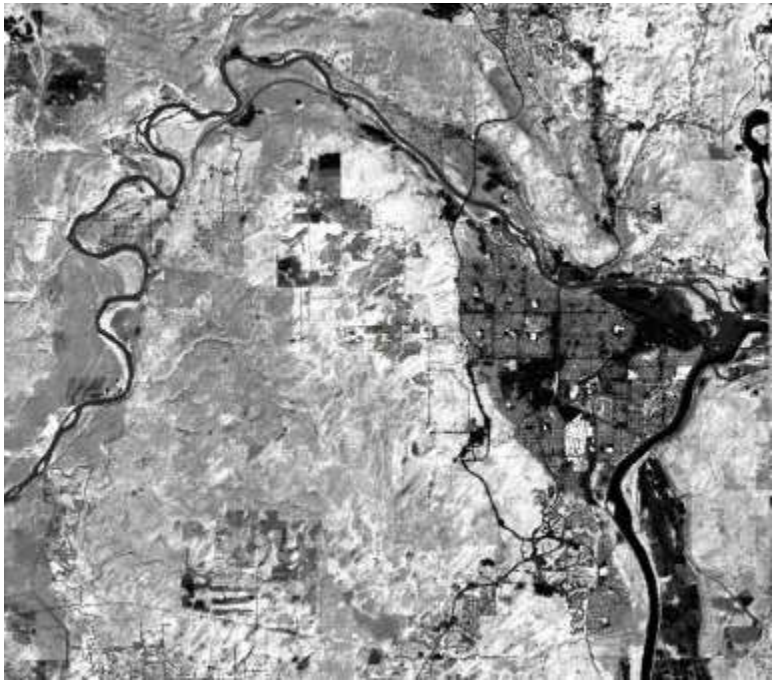
Why are they different at all ?

Landsat sensors and band wavelengths

Landsat 1-3, 4-5, 7 and 8







a. **Brightness** – overall reflectance

b. **Greenness** – vegetation

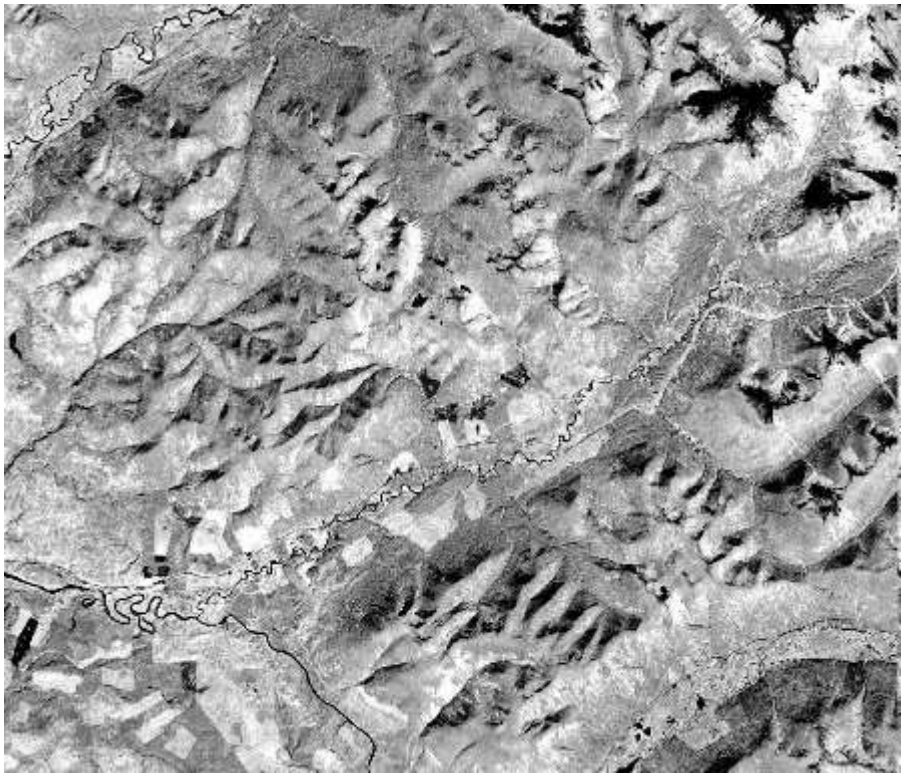
c. **Wetness** – soil / canopy moisture

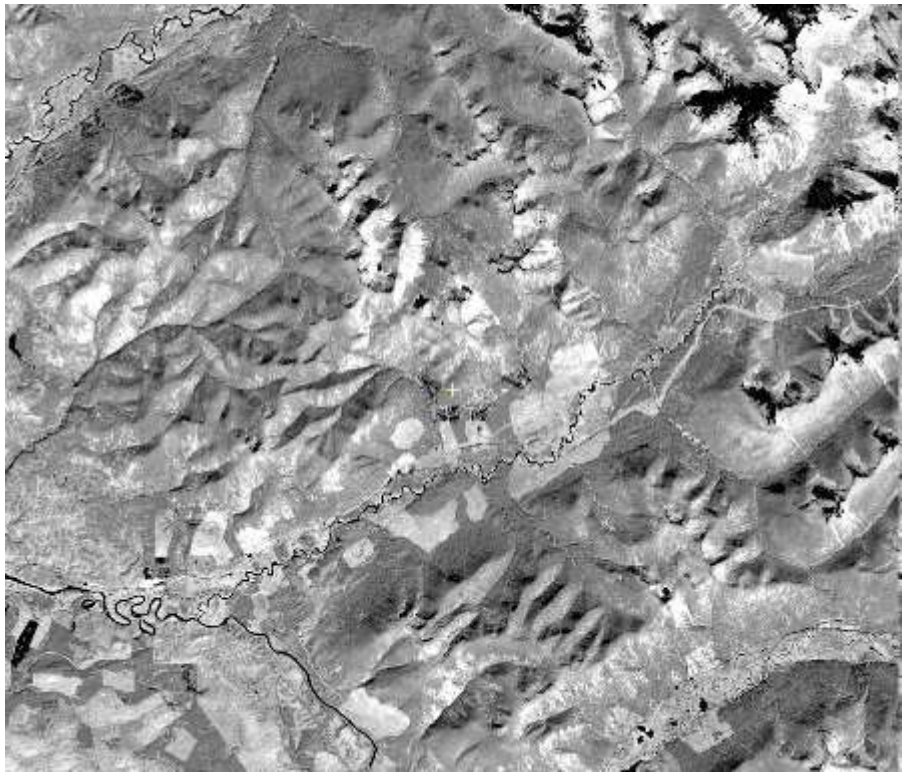
tasseled cap channels 1,2,3

These would yield a higher contrast composite but with unfamiliar colours

NDVI v Tasseled Cap greenness

both contrast NIR versus visible reflectance





TCA Greenness is similar to NDVI, with subtle differences and is used in habitat studies.

Figure : John Paczkowski MSc thesis – **remote sensing and grizzly bear habitat**

Wildlife ecologist, Kananaskis Country, Canmore, AB

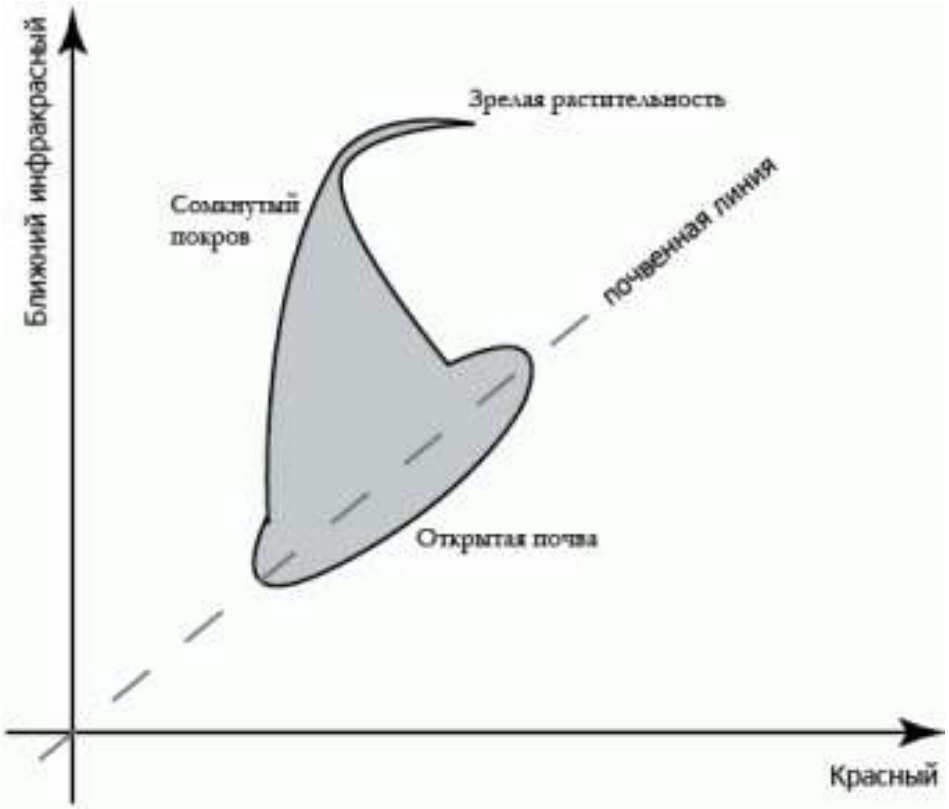
–has only recently been developed for some sensors…
(the coefficients vary according to spectral wavelengths and radiometric resolution)

PCI Geomatica (Banff)

- Landsat 1-3 MSS
- Landsat 5 TM
- Landsat 7 ETM+

Others ? See lab

- Ikonos, Quickbird 2
- ASTER / MODIS
- Landsat 8 OLI



Russian tassel cap

Figure 2. The north-central part of the original true-color Landsat 7 ETM scene P22 R40.

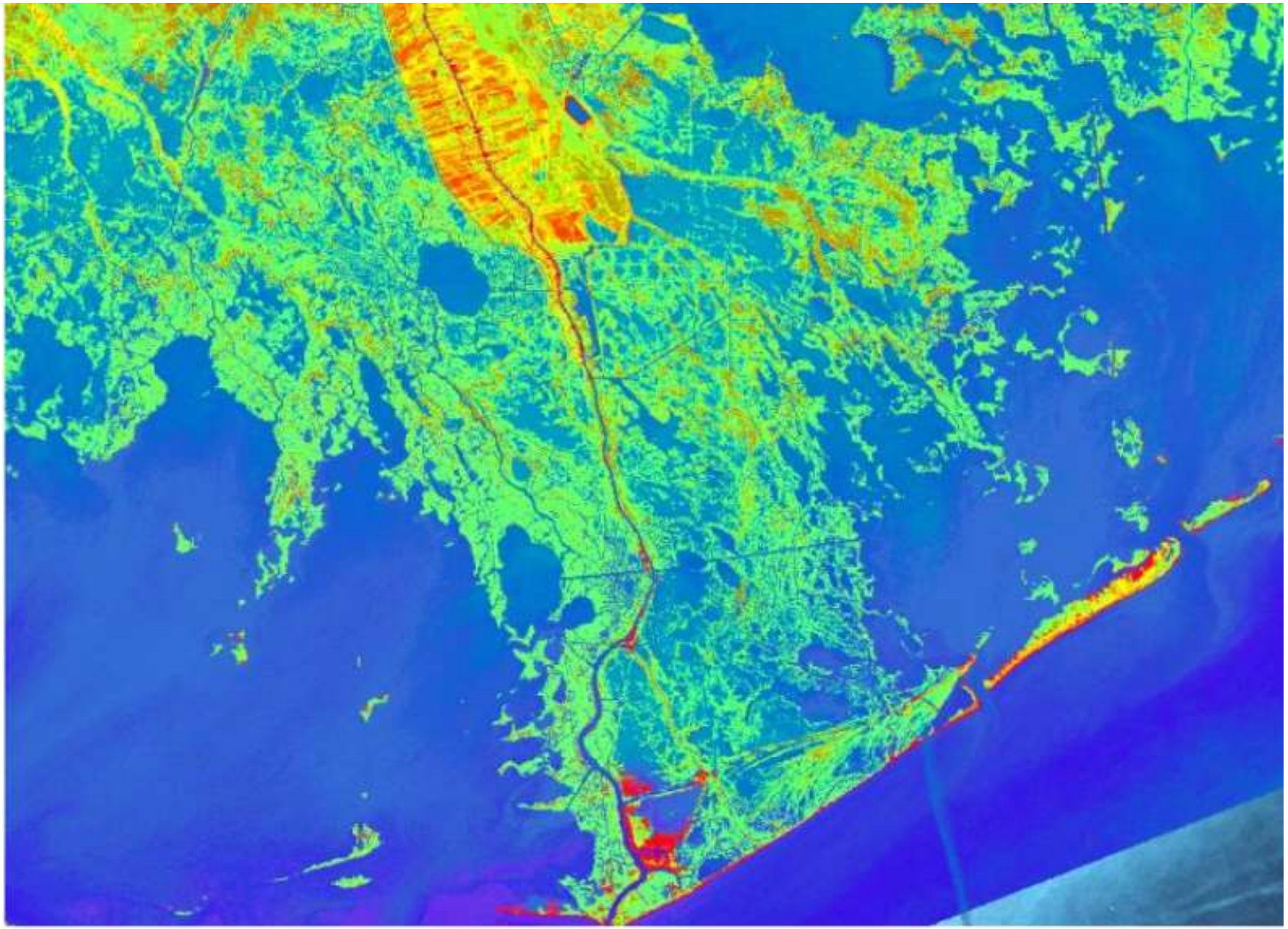


Figure 3. Three-band, 8-bit tasseled cap transformation image of the same Landsat 7 ET

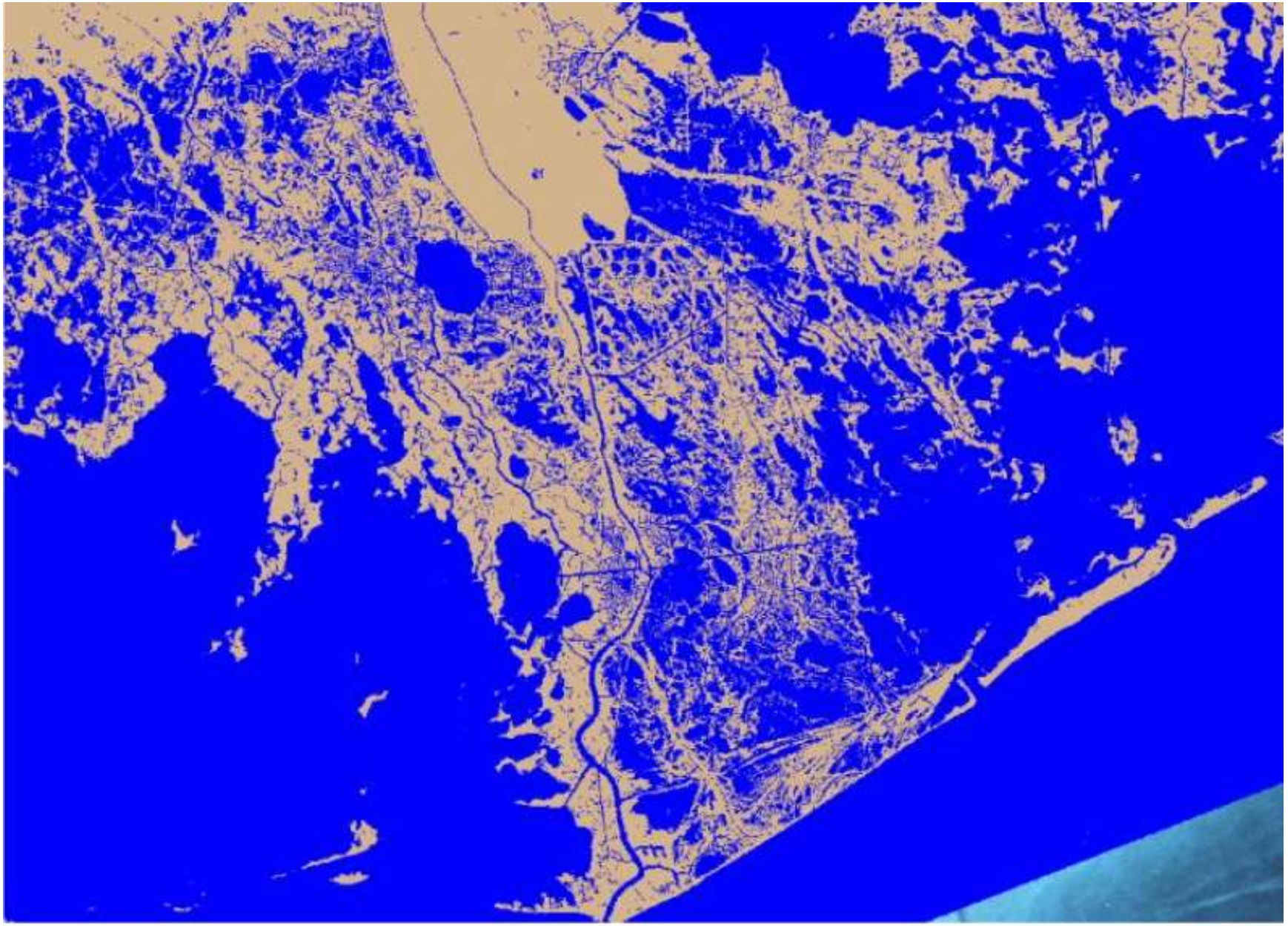


Figure 4. Two-bit raster file of the same Landsat 7 ETM scene showing pixel classificati
(brown) and water (blue).

Reasons to use Tassel Cap Analysis

- **It reduces a multi band dataset (4-6) to 3 channels – Brightness, Greenness, Wetness –** each might be useful

- **The 3 channels could be used in a classification**

- **The coefficients are universal for each sensor**

https://community.hexagongeospatial.com/t5/Spatial-Modeler-Tutorials/Tasseled-Cap-Transformation-for-Landsat-8/ta-p/1609

Principal Components Analysis (PCA)

(Like TC) PCA is a mathematical transformation that converts original data into new data channels that are uncorrelated and minimise data redundancy.

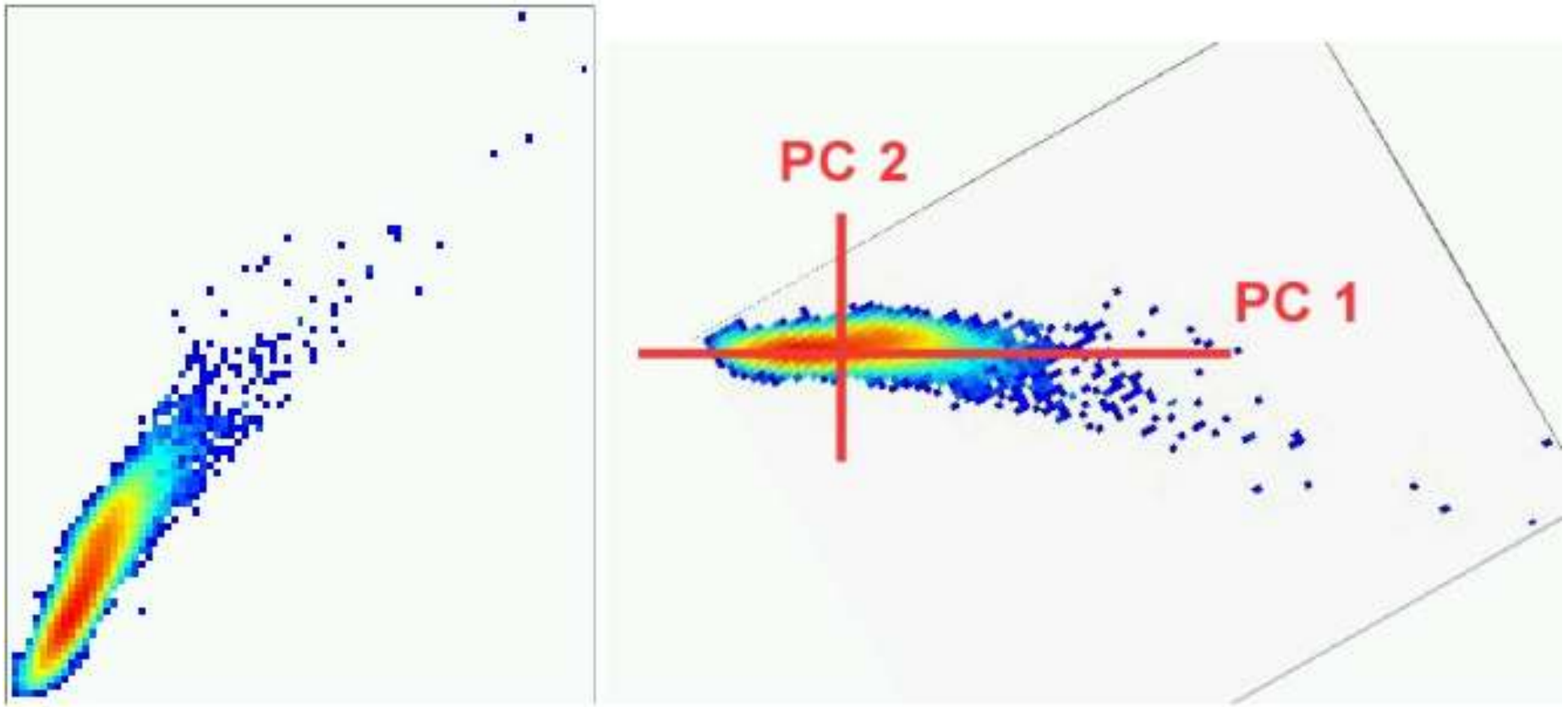
Differences with TCA :

1. PCA transformation is scene specific – while TCA coefficients are 'global'

2. TCA creates three new transformed **channels,**
PCA generates as many as there are input **channels**

e.g. for Landsat TM, there could be 6-7 new component channels

Note: There is a high correlation between all 'greenness' channel types:
NDVI, 4/3 ratio, TCA greenness, PCA component 2 (usually)



The bands can be reduced to their respective 'components', by an 'axial rotation'

Now ! imagine this in 3d, or in 7 dimensions, which includes all of the bands.

http://geology.wlu.edu/harbor/geol260/lecture_notes/Notes_rs_PC.html

The bands can be reduced to their respective 'components', by an 'axial rotation'

The main axis through the points is a 'component'; if all points were on it, correlation=1, the first component (PC1) would 'explain' all the variation.

The 2nd component (PC2) is normal to PC1, uncorrelated and hence two bands are converted to two components, but most variation is explained by the first (the 2nd is always smaller)

PC1= what is explained in both bands (images)
PC2= what is different between them (similar to a band ratio)

PCA consists of :

- **eigenvectors:** the 'loadings' for each band to create new components
- **eigenvalues:** how much variance is explained by each component

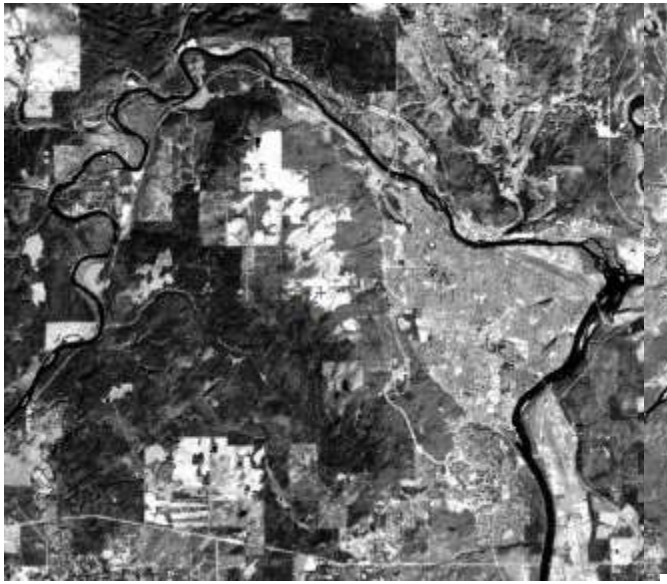
PCA channels (PG scene)

Eigenvectors of covariance matrix (arranged by rows):

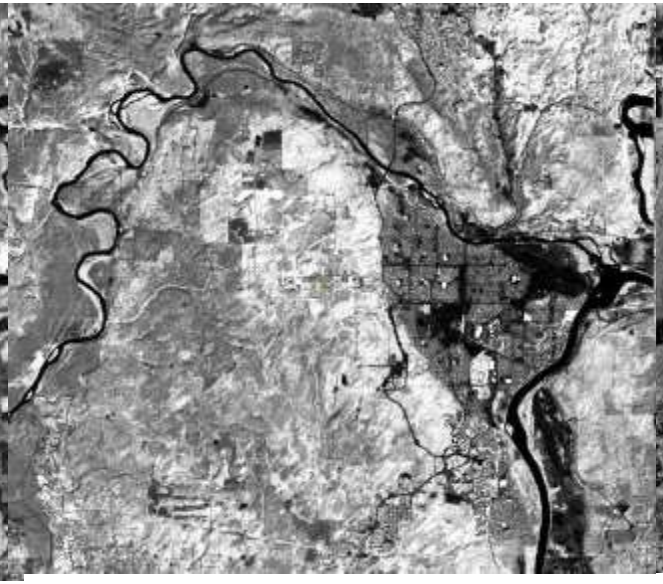
	TM1	2	3	4	5	6	7
PC1	0.22	0.15	0.29	0.16	0.75	0.33	0.40
PC2	-0.28	-0.14	-0.29	**0.82**	0.23	-0.25	-0.16
PC3	0.51	0.31	0.43	0.49	**-0.46**	-0.05	-0.00
PC4	-0.09	-0.09	-0.19	0.19	-0.23	**0.91**	-0.18
PC5	0.31	0.13	0.05	-0.12	**0.35**	-0.00	**-0.86**
PC6	**0.69**	-0.16	**-0.68**	-0.01	0.01	-0.04	0.19
PC7	-0.19	**0.90**	**-0.39**	-0.04	0.00	0.00	0.06

Component
Brightness
Greenness
Swirness / Wetness
Impact of TM6
Band 5 v 7 (MIR)
Band 1 v 3 (B v R)
Band 2 v 3 (Yellowness)

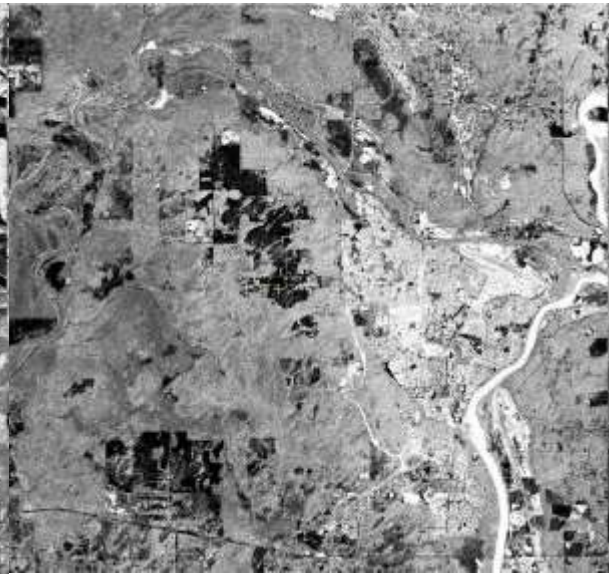
PC1: Brightness,



PC2: Greenness,



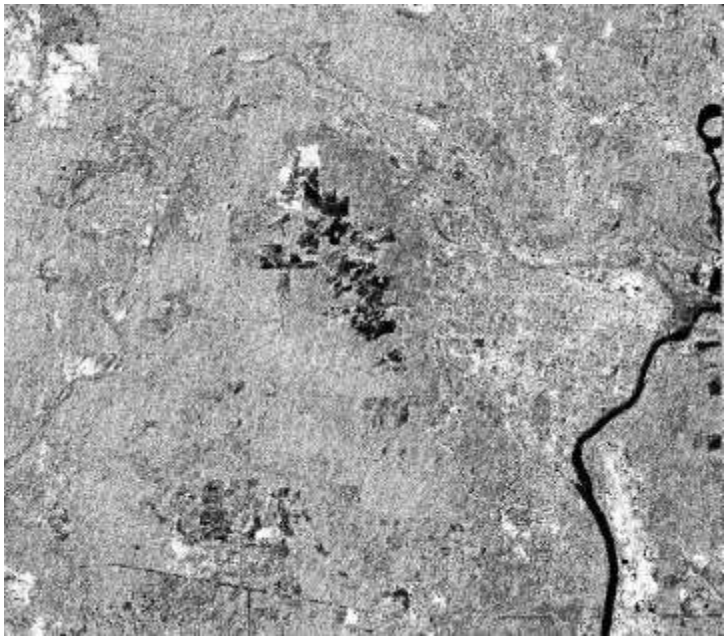
PC3: Swirness / Wetness



PC components (for PG scene) PC4: TM6, PC5: 5v7, PC6: 1v3, PC7: 2v3

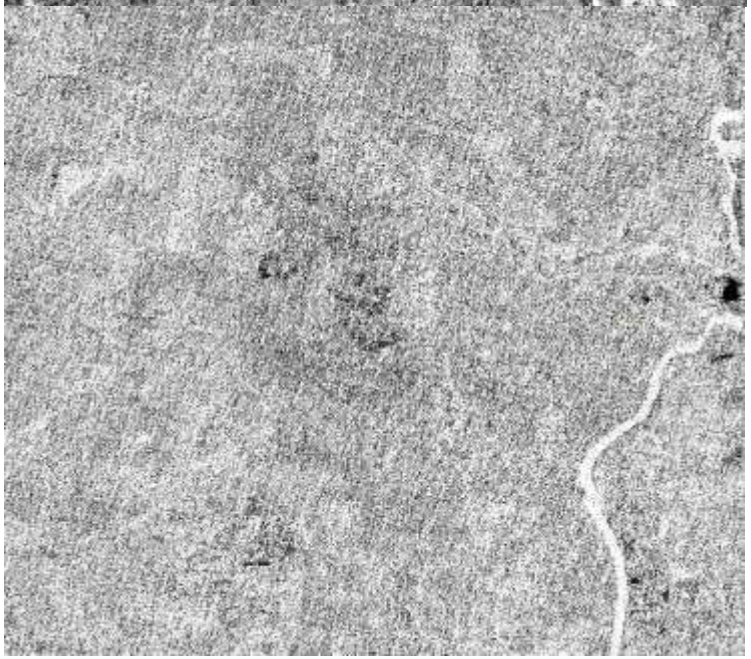
PC4: TM6 <-

PC5: 5v7 ->



PC6: 1v3 <-

PC7: 2v3 ->



Principal Components Analysis ('Hotelling'- Harold, 1933)

Why Use PCA ? (reduces multiband dataset) or more than Tassel..

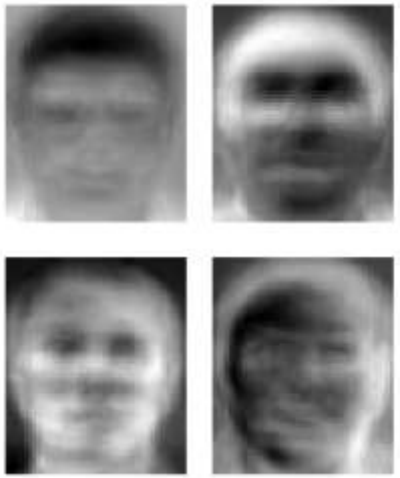
and scene-specific - but are they useful ?

-Can also load bands (channels) from multiple dates – 'time series'

PC1 = what is common between images (no change)

PC2 = what is different – between most different sets

PC3 .... = what is another difference … and so on …



Analogy – e.g. group faces ……"eigenfaces"

Image fusion / Pansharpening

Goal: Combine higher spatial information in one band with higher spectral information in another dataset to create 'synthetic' higher resolution multispectral datasets and images

Common with a higher res. Panchromatic image

Panchromatic Multispectral synthetic higher res.