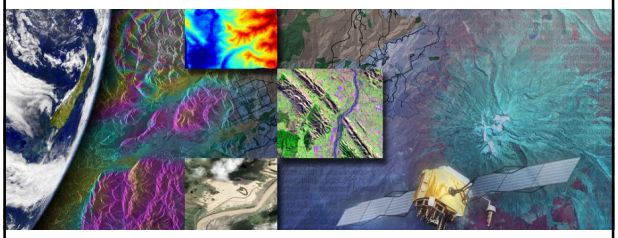
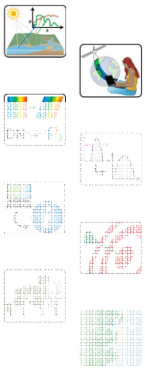
Lecture 9 – Is it Possible to Measure Environmental Change?



Dr Karen Joyce
School of Environment
Bldg Purple 12.3.09

Your Job



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Multi-temporal Analysis
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Information communication for problem solving

In your groups from last class, revise your scenario and summarise your findings related to the following:

1. Define the critical subject information requirements
2. Identify any critical environmental information
3. Determine the ideal sensor dimensions
4. Select an appropriate sensor for the role

Write this in a way that a different group of students can pick up where you left off.

Coral Bleaching

- Coral bleaching events have been linked to prolonged periods of above average water temperatures. How could remote sensing be used in a coral monitoring program for the Great Barrier Reef? Consider both the water temperature monitoring, as well as the health / status of the corals themselves.

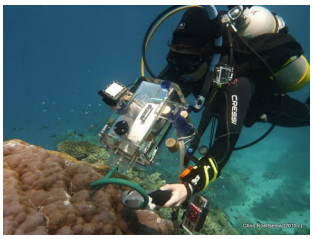
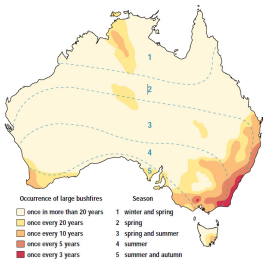


Image source: C.Roelfsema

Bushfire Frequency



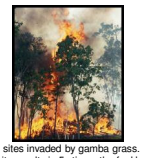
Source: Australia: State of the Environment 1996. An independent Report Presented to the Commonwealth Minister for the Environment by the State of the Environment Advisory Council

- The Australian Government is looking to create a new 'State of the Environment'. The figure on the left needs to be updated with current and accurate information. Devise a plan for remote sensing to address this.

Weeds

- Gamba grass is an introduced plant pest in the NT, causing widespread environmental problems. How can remote sensing be used to map and monitor its spread?

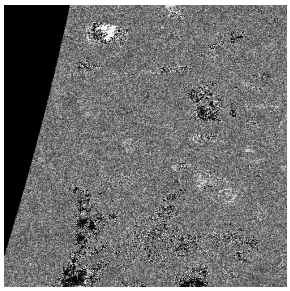
Source: S. Setterfield



Tree-grass balance is altered in savanna sites invaded by gamba grass. Native grass fires (a) burn the grassy understorey while gamba grass productivity results in 5x times the fuel load with crown fires resulting (b). Savanna trees species are killed by such fire intensity and invasion results in a C3 to C4 transformation with an unknown biomass converted to pyrogenic carbon (c). (Source: L.Hutley)

Volcanic Eruption

- Large volcanic eruptions have the potential to create huge and widespread disasters. In addition to the immediate hazards they present to local communities, eruptions can also cause mass disruption and chaos in the aviation industry. Consider the recent eruption of Mount Kelud in Indonesia, and how remote sensing could be used to map and monitor associated ash and gases.



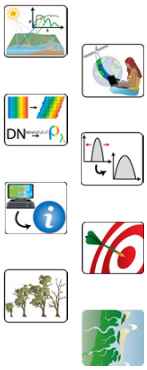
VIIRS image courtesy NASA Earth Observatory http://earthobservatory.nasa.gov/IOTD/view.php?id=83144

Algal Blooms

- Algal blooms are typically composed of hundreds of thousands of microscopic phytoplankton cells. Trichodesmium (sea sawdust) is an example of a bloom that has been evidenced in Darwin Harbour and in local coastal and open ocean waters. How can remote sensing be used for the detection and monitoring of these blooms in NT waters?

Image source: ohnemusatsea - Flickr

Image Processing Sequence



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Information Extraction

- Image classification to produce thematic maps
  - Apply statistical decision rules to assign pixels with similar DN's to a thematic or categorical image class
- Biophysical modelling
  - Quantitatively estimate biophysical parameter(s) and processes based in each pixel by using DN's, radiance or reflectance values in empirical or deterministic models
- Spatial Modelling / GIS Integration
  - Combine original and classified image data with other spatially referenced data sets in spatially explicit models

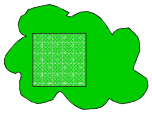
Image Based Analysis for Mapping

- Pixel based "image classification"
  - Main assumption: pixel is smaller than targets
  - Pixels are homogeneous in target
- Image object based "image segmentation"
  - Main assumption: pixel is smaller than targets
  - Objects/classes are not homogeneous – characteristic texture
- Sub-pixel classification
  - Main assumption: pixel is larger than targets
  - Pixel value is an area weighted combination of targets

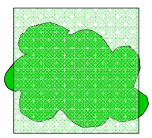
Source: S.Phinn

Image Classification Assumptions

- Several major assumptions
  - A high (H) resolution application i.e. each pixel is made up entirely of one surface cover type
  - The pixels making up one surface cover type are assumed to have similar spectral signatures
  - Different surface cover types have significantly different spectral signatures



H resolution – i.e. pixel is smaller than cover type

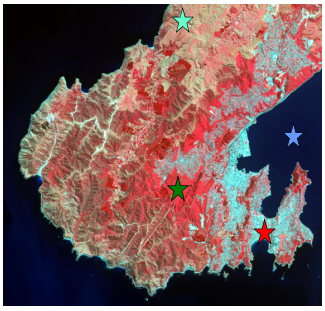


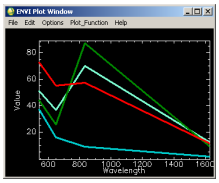
L resolution – i.e. pixel is larger than cover type

The Basis of Image Classification

- Classification
  - Assigning each image pixel to a category based on (spectral) statistical pattern recognition techniques
  - i.e., pixels within the same cover type have similar magnitude DN's
- Goal of image classification
  - To produce a thematic map of surface cover types (e.g. land cover, vegetation type, soil type) by grouping image pixels with similar reflectance characteristics using statistical decision rules.

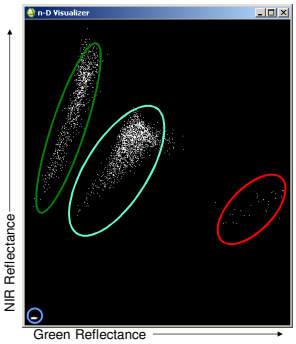
Supervised Image Classification

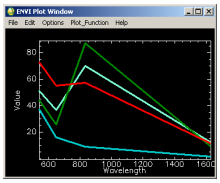




- Water
- Grasses etc
- Dense Veg
- Artificial Surfaces

Spectra Evaluation





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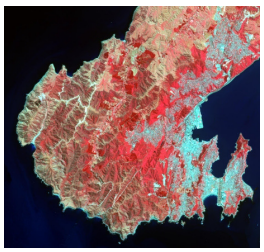
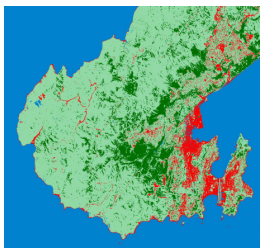
Classification Mapping





- Water
- Grasses etc
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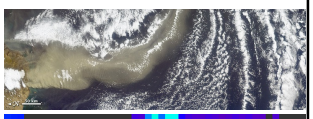
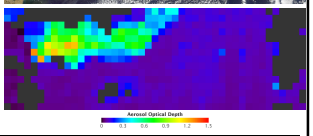
Biophysical Modeling

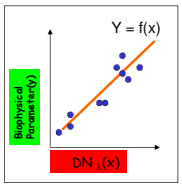
- Quantitatively relate image DN's to biophysical parameter(s) measured on the ground
- Requires understanding of EMR interactions
- Spatially explicit estimation of physical or biological parameters related to the absorption, transmission or scattering of EMR
  - Crop yield estimation
  - Defoliation measurement
  - Leaf Area Index (LAI)
  - Biomass prediction
  - Fire fuel loads
  - Water depth
  - Pollution concentration
  - Volcanic Ash / gases
  - Soil moisture
  - Aerosols



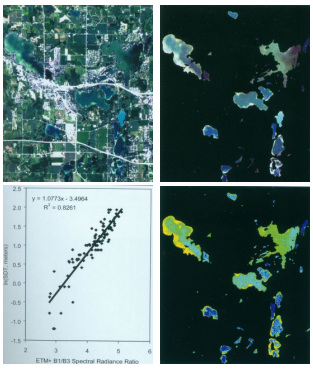


Empirical Models

- Most commonly applied approach for estimating biophysical properties
- Based on the assumption that variations in reflected, absorbed and scattered EMR recorded in image are DIRECTLY controlled by biophysical property of interest



Lake Water Clarity



True Colour Landsat ETM+ image

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Create water only mask image

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Plot B1/B3 ratio vs. natural log of water clarity (measured secchi depth)

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Determine equation of trendline

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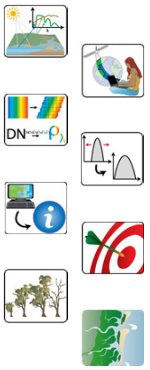
Apply equation to ratio image

Source: Plate 36 – Lillesand et al.

Your Job

- Using one of the given scenarios:
  - Identify the 'baseline' information that needs to be extracted (i.e. don't consider the temporal aspect just yet);
  - Suggest a technique that could be used to do so;
  - Describe what your product will look like.

Image Processing Sequence



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Multi-temporal Analysis

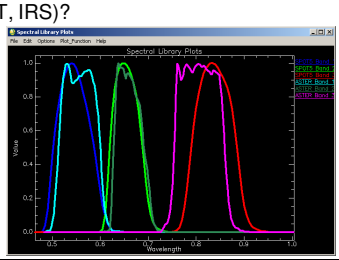
- Identification and measurement of feature change over time
- Discrimination of features based on type and magnitude of change
- Biophysical Applications
  - Calculating, estimating or inferring information about:
    - environmental structures (e.g., plants, landforms)
    - processes (e.g., evapotranspiration, plant-growth, CO_2 flux)
  - Biophysical quantities are obtained by inverting remotely sensed data (reversing the remote sensing process)

Pre-Processing – Geometric Considerations

- Spatial resolution
  - G.R.E. dimensions must be equal
  - Apply re-sampling algorithm if not (to largest common GRE)
- Spatial registration between images
- R.M.S.E. between each image must be < 0.5 pixel
- Mis-registration will produce "false" change signals
- Images must have the same datum, projection and coordinates
- Image acquisition look angles must be the same

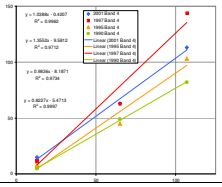
Pre-Processing – Spectral Considerations

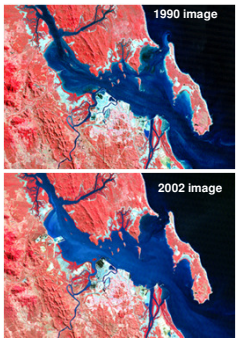
- Ensure spectral band-widths and band-centres between dates match
- Wide spectral bandwidths that don't match (ETM, SPOT, IRS)?



Pre-Processing – Radiometric Considerations

- Ensure sensor quantisation between dates is identical
- Work with calibrated and corrected image data (radiance, reflectance)
- Atmospheric corrections
- Ensure processing history of the data is known

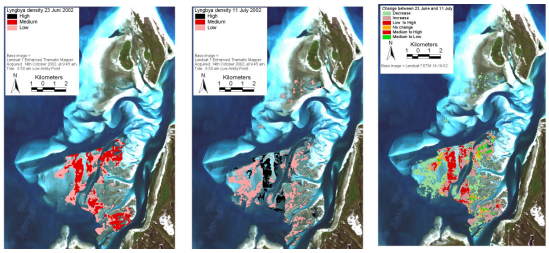




Temporal Considerations

- Solar geometry
  - Time of day & year (anniversary date) i.e. Diurnal and seasonal sun angle effects?
- Fully calibrated and corrected data to remove these effects (corrected for illumination, viewing and slope geometry)
- Atmospheric (clouds, haze, water vapour)
- Careful selection of anniversary date and time images to reduce amount of correction required
- Tidal, oceanic, stream conditions
- Vegetation phenology – ensure type of change is appropriate to mapping question
- Soil conditions – moisture, roughness

Post Classification Comparison



June 2002 July 2002 Change – June/July 2002

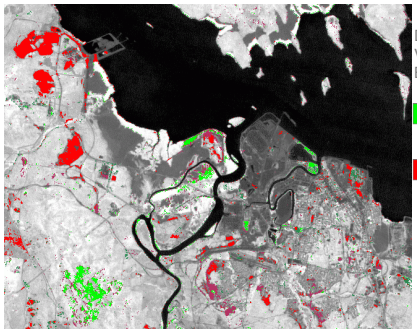
Development of an image based method for mapping *Lyngbya majuscula* distribution in Eastern Moreton Bay

Source: C.Roelfsema

Multi-Temporal Analysis

Source: S. Maier & M. Tovar-Valencia

Image Differencing



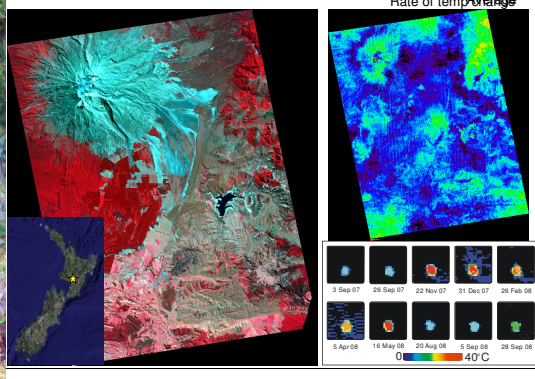
Difference in Vegetation Index Between 1995-1990

Increase (vegetation gain)

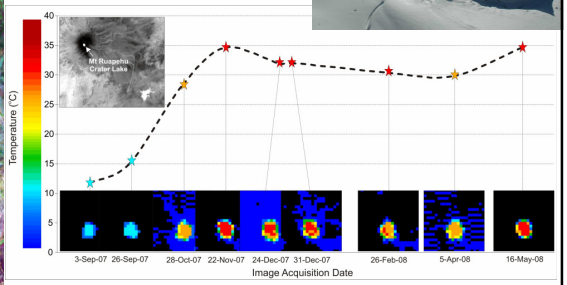
Decrease (vegetation loss)

Source: S.Phinn

Trend Detection

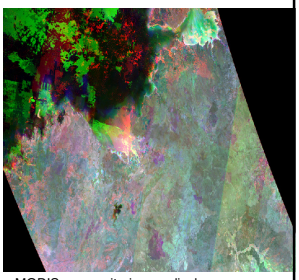


Trend Detection



Multi-Date Image Composition and Classification

- Image data set consists of bands from successive dates
  - Band1 = MODIS blue, 06/09
  - Band2 = MODIS green, 06/09
  - Band3 = MODIS red, 06/09
  - Band4 = MODIS blue, 10/09
  - …etc
- Apply multi-spectral classification and identify areas of change and no-change
- On screen digitising - Interpret areas of change visually
- No quantitative information on change is provided

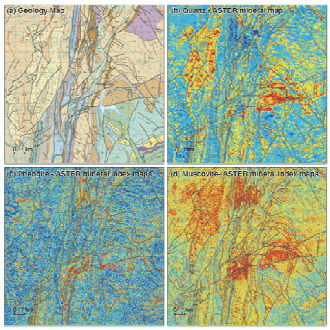


MODIS composite image display:
Red = Green band, 2 Feb 2010
Green = Green band 16 Oct 2009
Blue = Green band 6 Jun 2009

Your Job

- Using one of the given scenarios:
  - Identify the type of multi-temporal analysis that will be most appropriate;
  - Consider the pre-processing requirements;
  - Describe what your final product will look like;
  - Present your findings to the class.

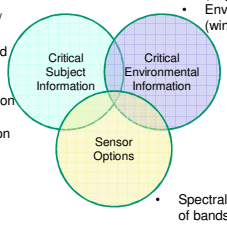
Student Choice – Geological Mapping



http://www.ga.gov.au/ausgeonews/ausgeonews200606/aster.jsp
http://www.nt.gov.au/d/Minerals_Energy/Geoscience/index.cfm?header=NT%20ASTER%20Mineral%20Maps

Problem Definition and Data Acquisition

- General location - accessibility
- Minimum size of feature
- Areal extent to cover
- Relevant times of the year / day
- 'Colour' – light reflection and absorption
- Temperature?
- Critical contextual information
- Accuracy requirements
- Existing data or classification schemes?



- Cloud cover
- Obscuring features (vegetation, water bodies)
- Environmental movement (wind, currents)

- Spectral resolution – number of bands, location, width
- Spatial detail
- Spatial extent
- Overpass frequency
- $$

Fault Mapping