translating**nature**into**knowledge**

Advancing quantitative techniques for the generation of acoustic variables to characterise seabed habitats.

International workshop on seabed mapping methods and technology, Trondheim 17th and 18th October 2012

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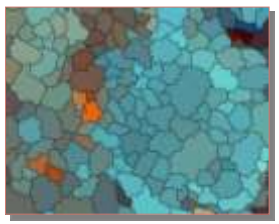

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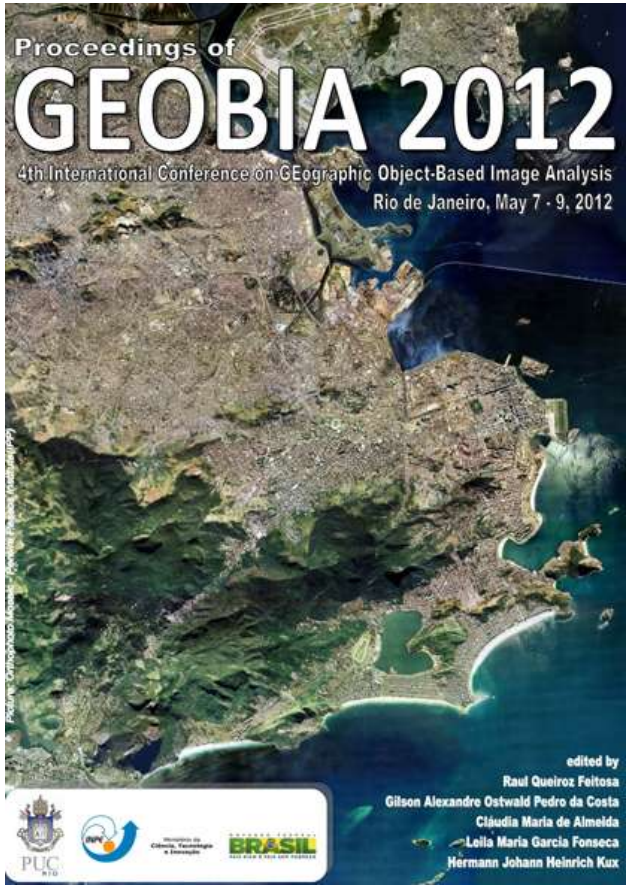
Presentation Outline

- What is GEOBIA ?
- GEOBIA Methods
  1. Image Segmentation
  2. Object Classification
  3. Product Output
     - Case Study
- Hot Topics in GEOBIA
- Software
- GEOBIA Summary

What is GEOBIA?

GEOgraphic (GEOspatial) Object Based Image Analysis



- a methodological framework for machine-based interpretation of complex classes, defined by spectral, textural, spatial and topological as well as hierarchical properties

- intervention is possible to implement expert knowledge

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Objects and spatial resolution

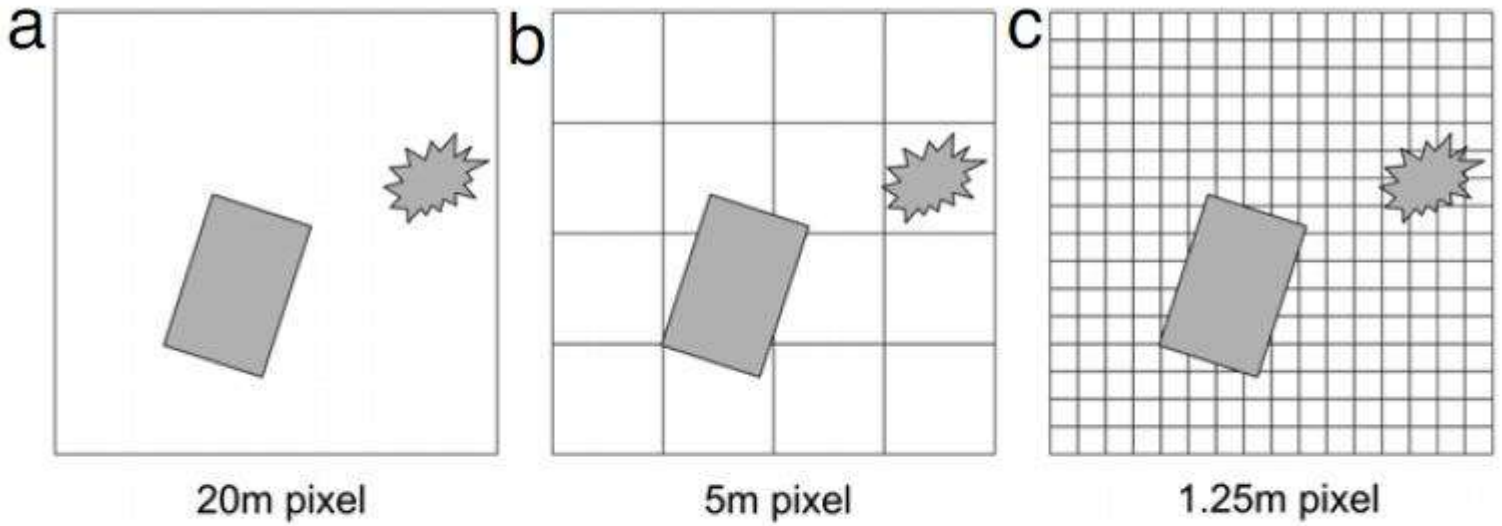


Fig. 1. Relationship between objects under consideration and spatial resolution: (a) low resolution: pixels significantly larger than objects, sub-pixel techniques needed. (b) medium resolution: pixel and objects sizes are of the same order, pixel-by-pixel techniques are appropriate. (c) high resolution: pixels are significantly smaller than object, regionalisation of pixels into groups of pixels and finally objects is needed.

Blaschke, 2010

Image analysis and the human perception

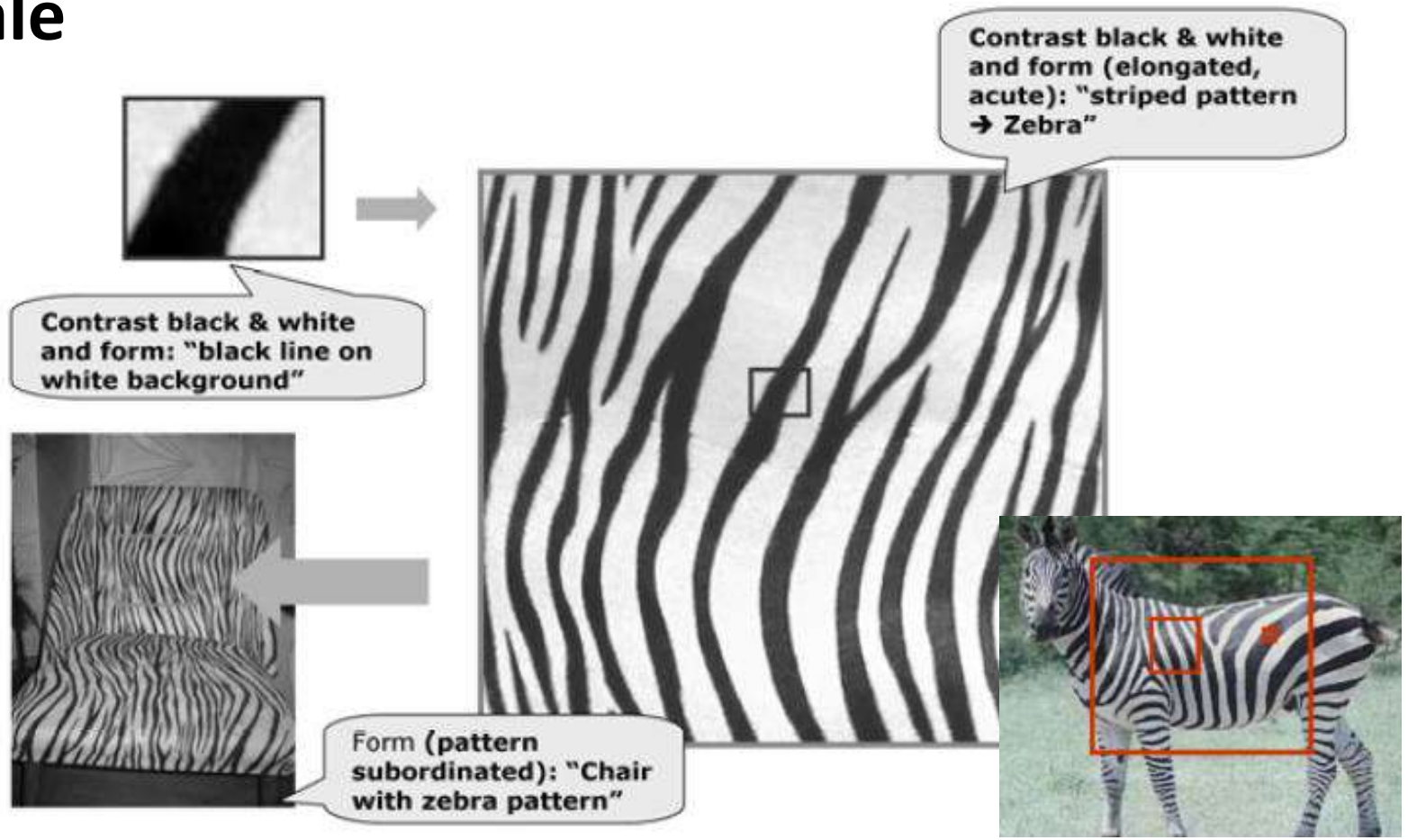
- Looks at objects, their colour, shape, size as well as their context and relationships in multi-scale environment and not at pixels
- Considers the environment and neighbourhood relations
- Uses other “background“ knowledge to identify features
- The finer the detail, the better the recognition of objects
- An image object or segment is the result of identifying contiguous homogenous pixels.

Analogy of context based approach

- What is this?

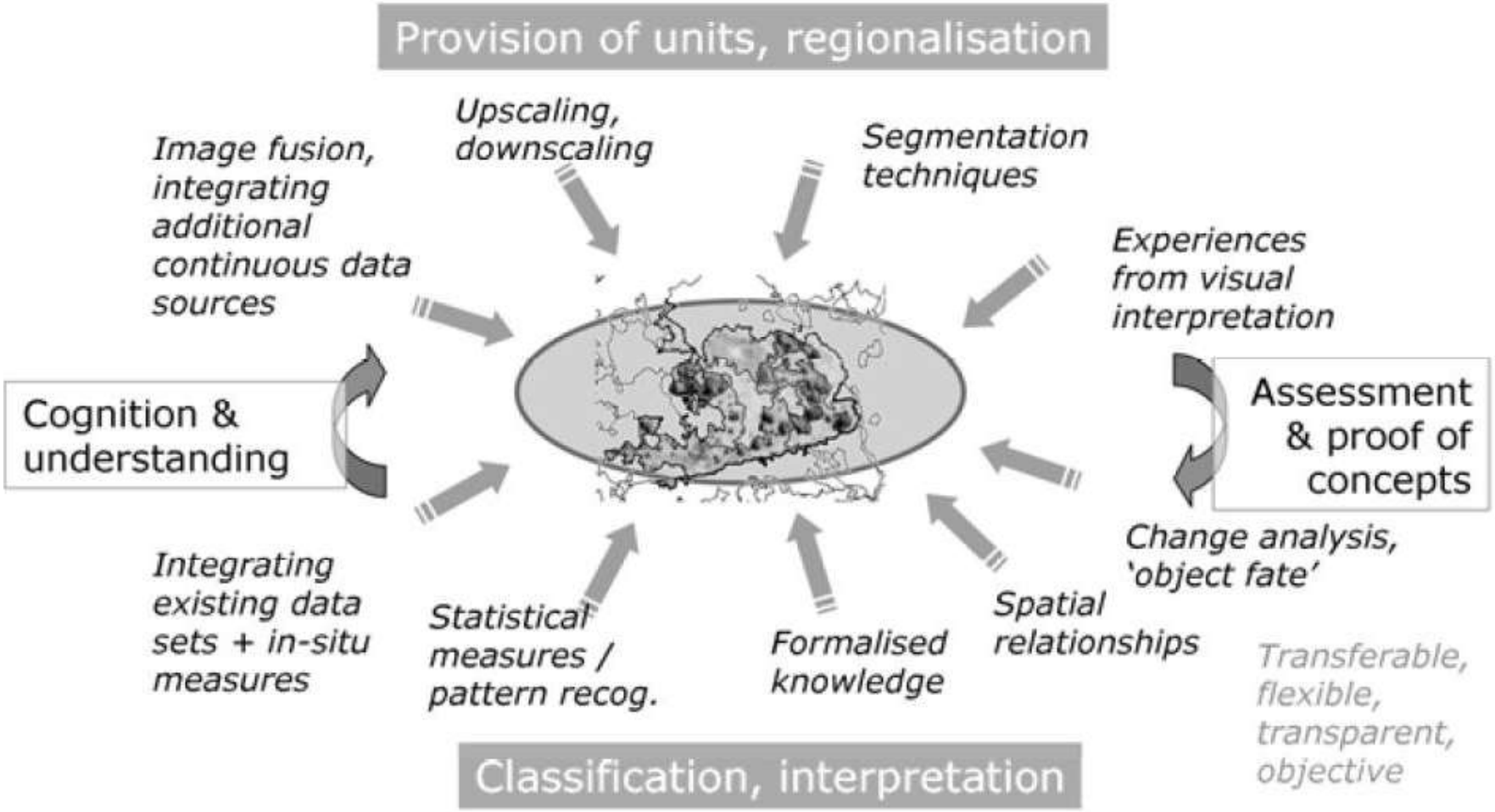
Philosophy of GEOBIA

Scale



Colour, form and arrangement evoke certain parts of our knowledge and experience Regardless of scale (from *Lang, 2005*)

Philosophy of GEOBIA



GEOBIA as an integrated approach *Lang, 2005*

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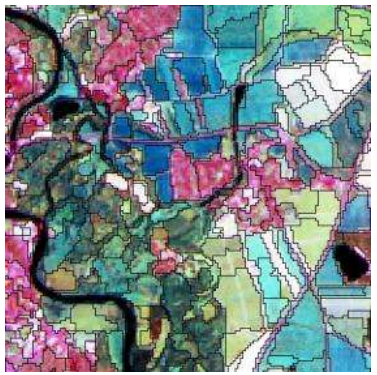
Object-based image analysis

Parameters available for pixel and object based methods:

	Pixel	Object
Colour	X	X
Colour statistics	-*	X
Size	-	X
Shape	-	X
Neighbours	-	X
Hierarchy	-	X
Sensor specific**	~	X

Pixel



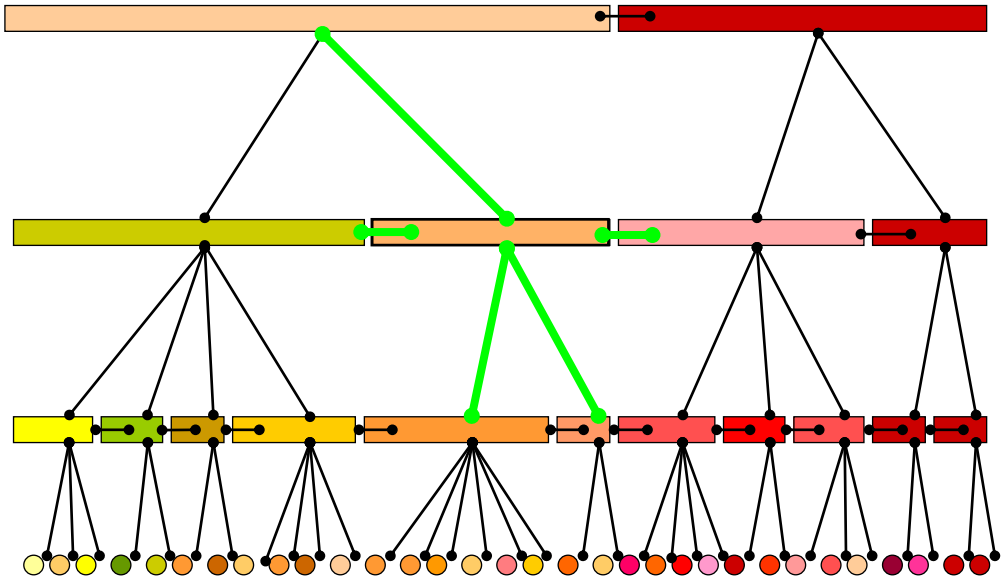
Objects

*Limited with texture: ** e.g.: polarimetric, entropy, etc

Source: Daniel L. Civco, University of Connecticut

Multiresolution Segmentation: Extraction of Image Objects

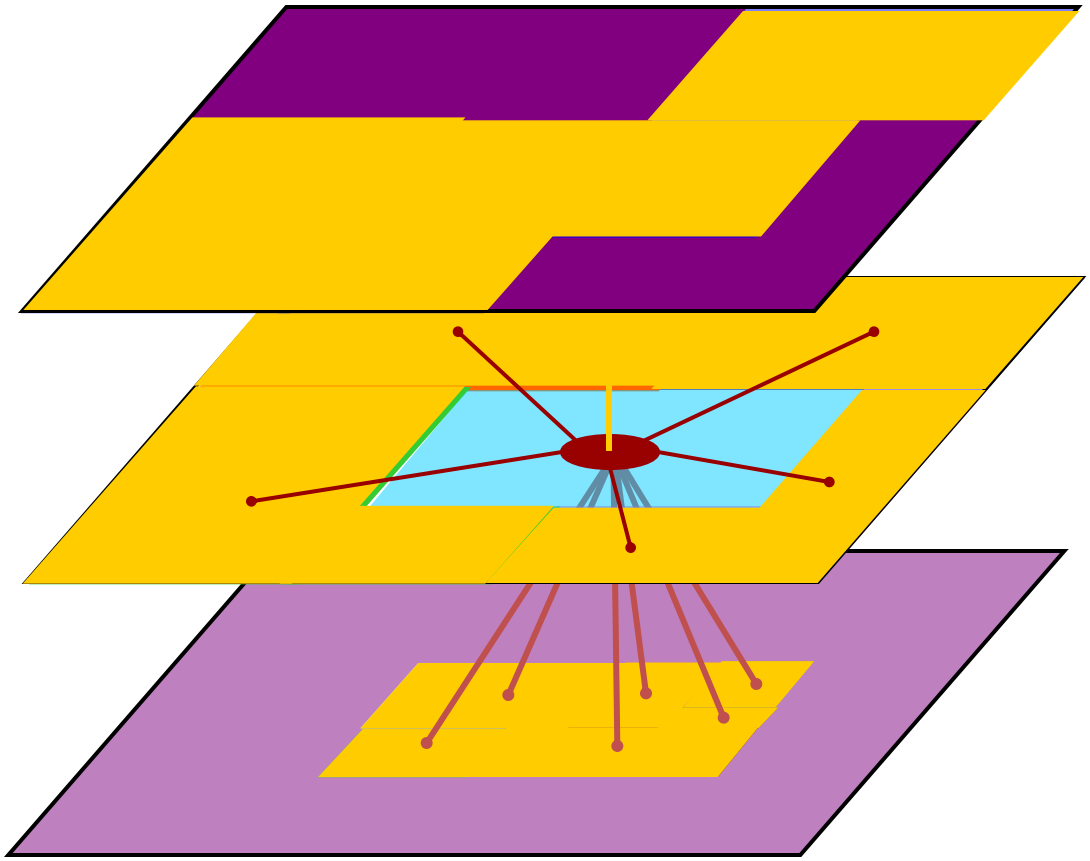
Hierarchical network of image objects



- Provides a framework for investigating objects at a range of scales
- Identifies relationships between objects and their super- and sub-objects

The Image Object Hierarchy

Each object knows its ...

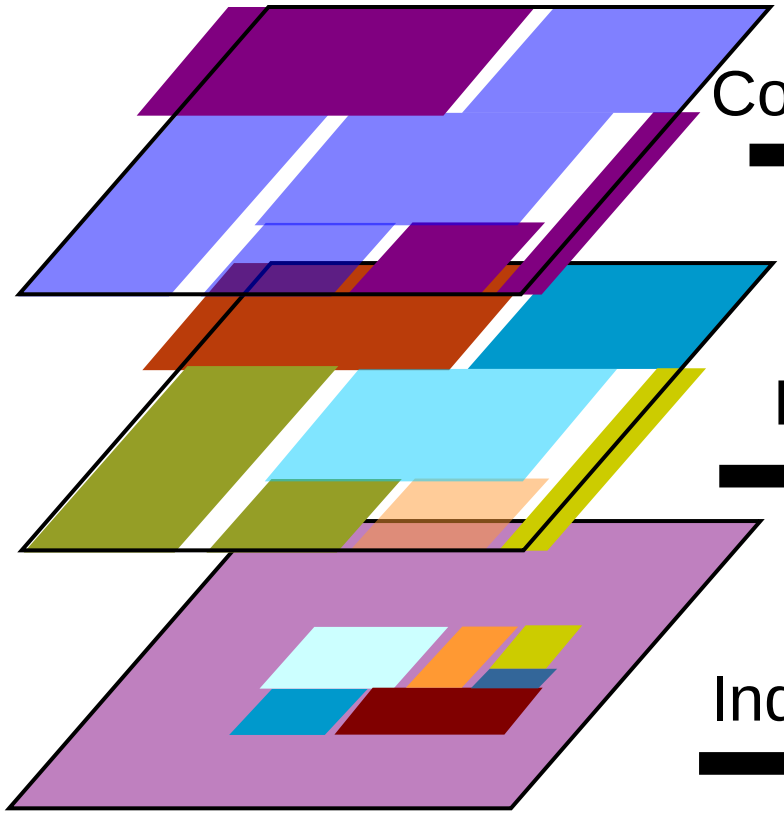


super object

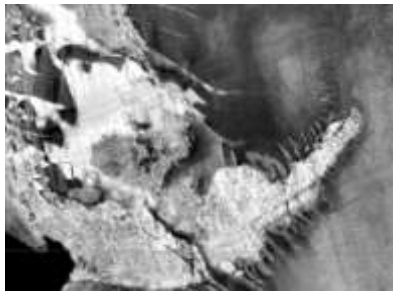
neighbor objects

sub objects

Using the Image Object Hierarchy

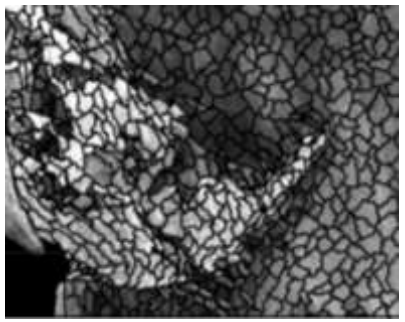


Consolidated Habitat

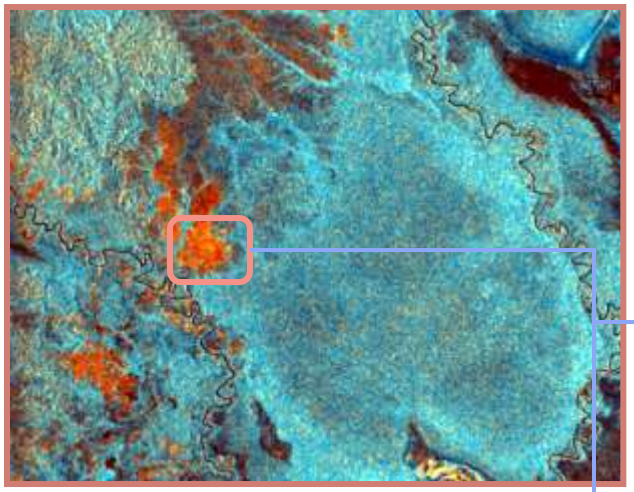


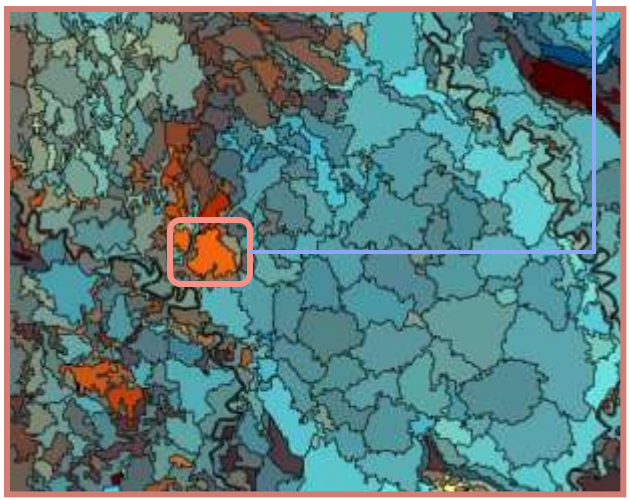
Reef Systems

Individual Rocks



GEOBIA Methods

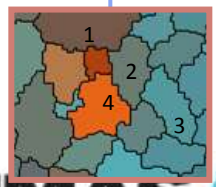




1. Image Segmentation into "image objects"

2. Object Classification

3. Product Output



POLY1 adjacent to POLY2, surrounded by objects of POLY 3

Image Segmentation

1. Image Segmentation

Segments are formed based on:

- Shape
- Size
- Colour
- Texture
- Form

How to define “homogeneity”?

Based on which properties?

- Mean/ StDev reflectance of a region
- (Co)Variance matrix of the GLCM region
- Shape of a region (boundary)

Multiresolution Image Segmentation

Object generation on multiple scales to adress differently scaled classification task within one project

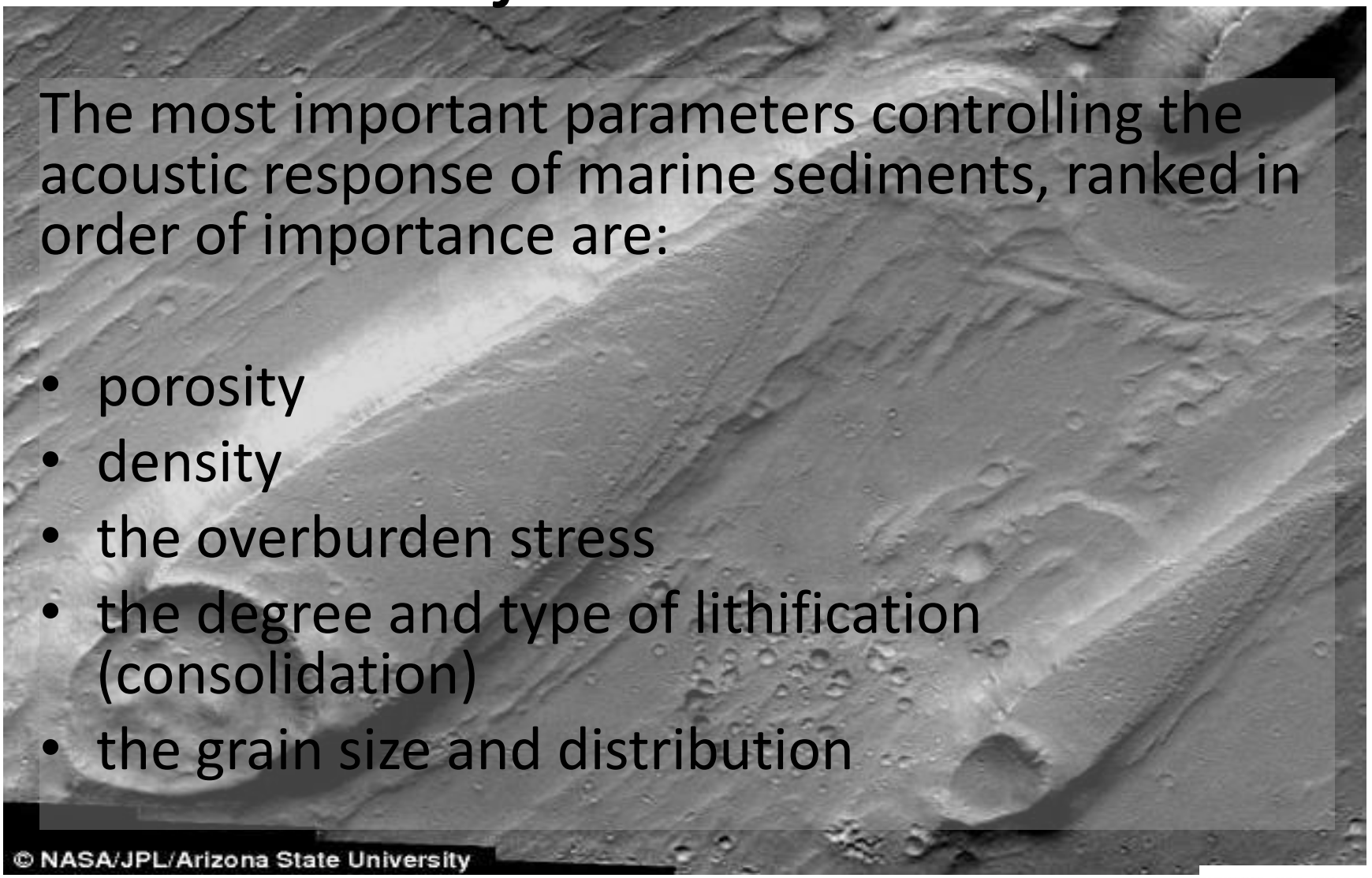
Build up a hierarchical network of image objects, which allows the representation of the image information content at different resolutions (scales) simultaneously.

Classification of image objects

2. Object Classification

- Multibeam backscatter data appropriate for GEOBIA application
- Transformation of acoustic backscatter images into marine habitat maps
- Interpretation in made on reflectivity, texture, pattern and context
- How do we build up the ‘rule set’ in GEOBIA for acoustic backscatter data?

2. Object Classification



The most important parameters controlling the acoustic response of marine sediments, ranked in order of importance are:

- porosity
- density
- the overburden stress
- the degree and type of lithification (consolidation)
- the grain size and distribution

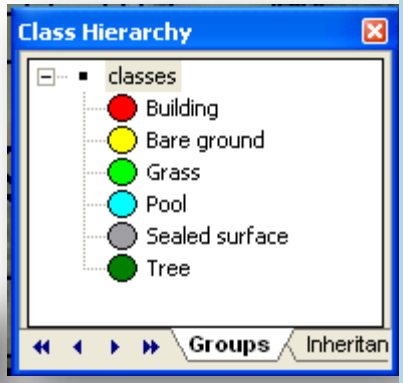
© NASA/JPL/Arizona State University

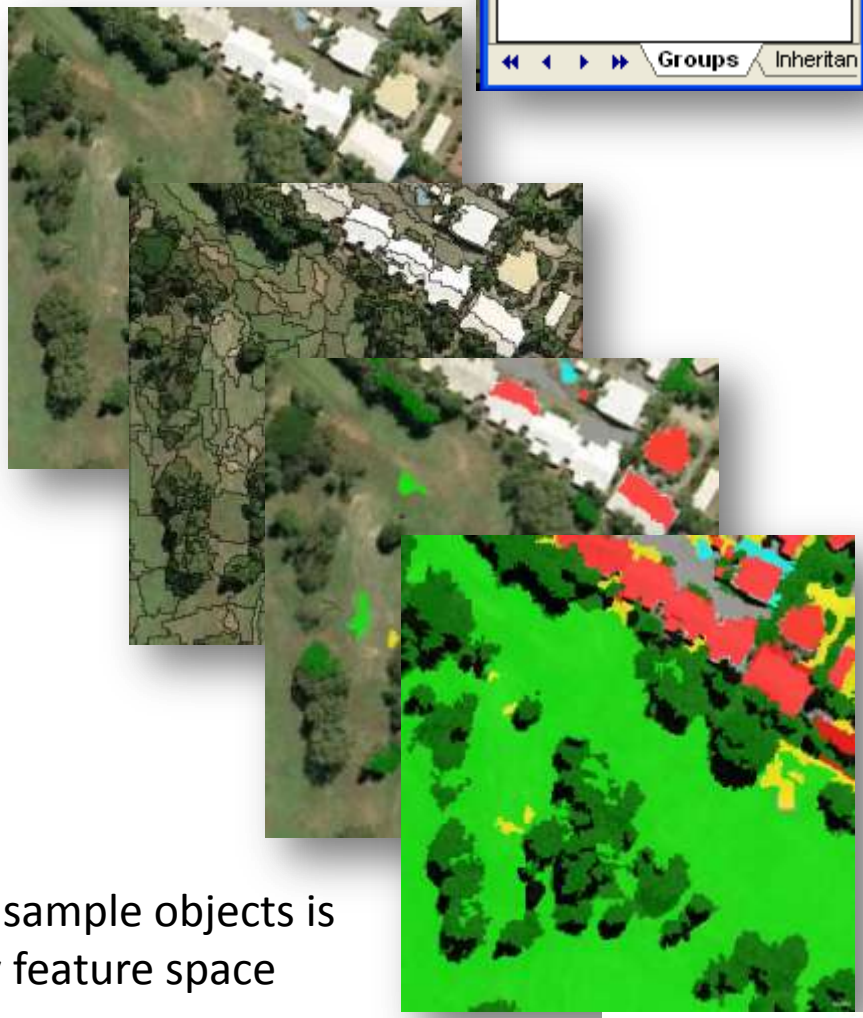
Object-based classification

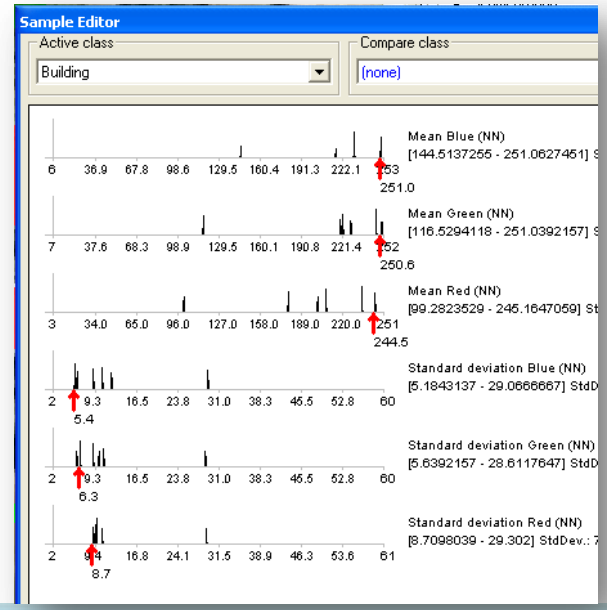
1. Sample based supervised nearest neighbour
   - Requires training objects
   - Often used as the first round of classification
2. Rule-based classification (threshold or fuzzy)
   - Requires fuzzy membership functions
   - Based on expert knowledge
   - Allows refinement of nearest neighbour classification

1. Sample-based

- Segmentation
- Select classes
- Select input spectral information
- Select or import training samples
- Classify







Selection of sample objects is driven by feature space

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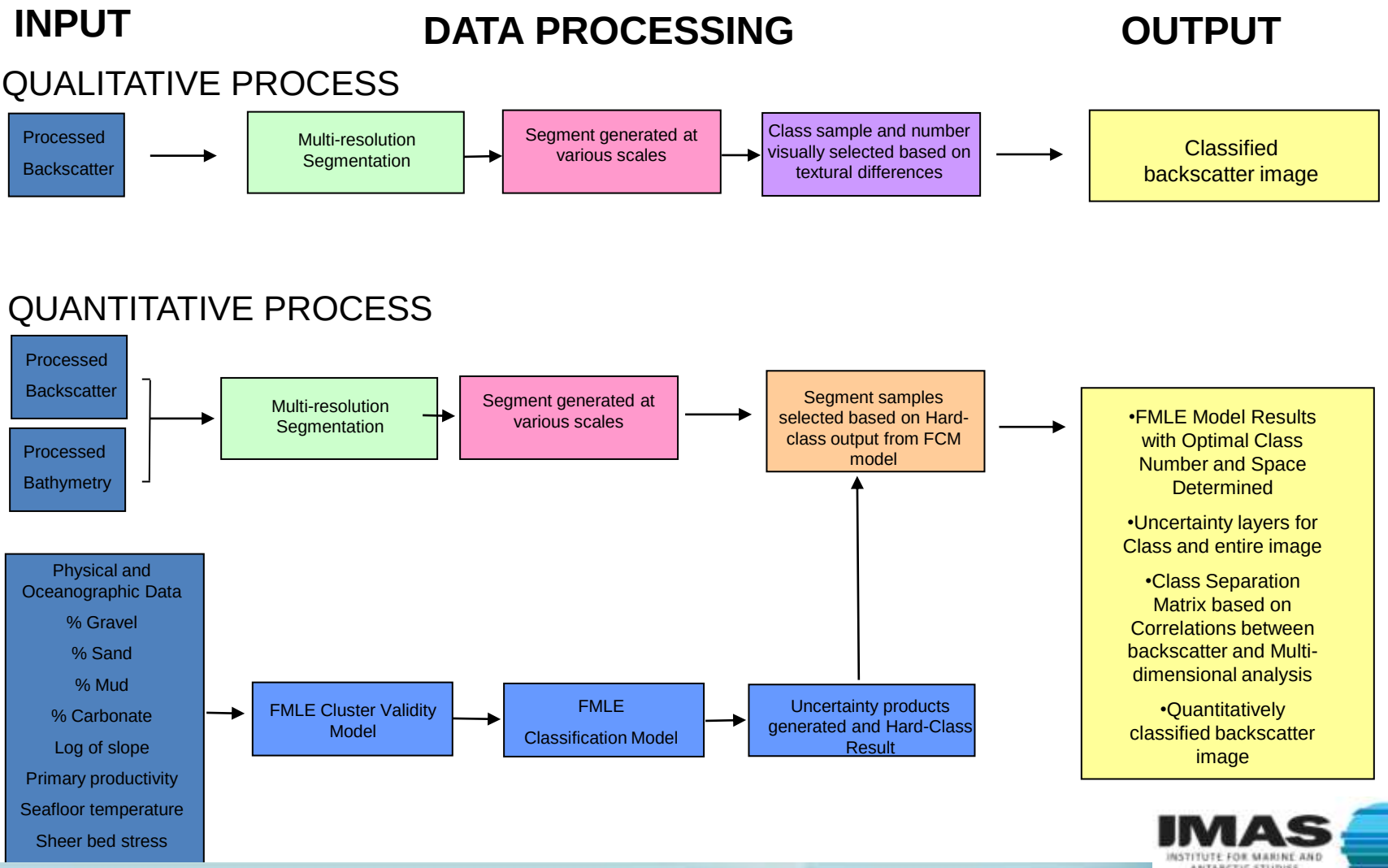
2. Rule Based Classification

Threshold or Fuzzy Classification

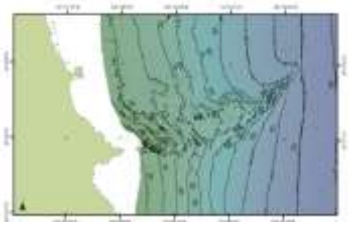
- *Fuzziness* refers to *vagueness* and uncertainty, in particular to the vagueness related to human language and thinking.
- Fuzzy classification(Sorties Paradox)

2. Object Classification

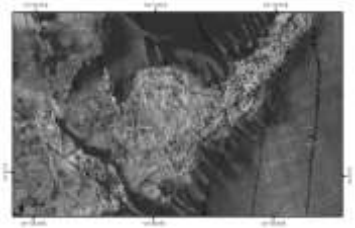


3. Product Output

Data Analysis- Predicting Substratum



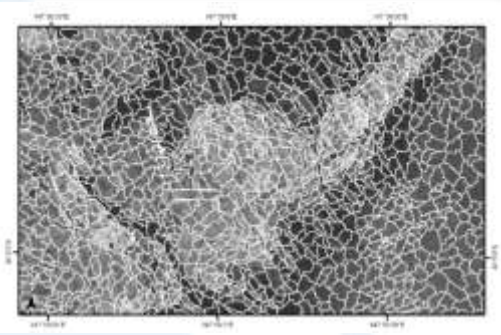
Bathymetry



Backscatter

OBIA

Segmentation



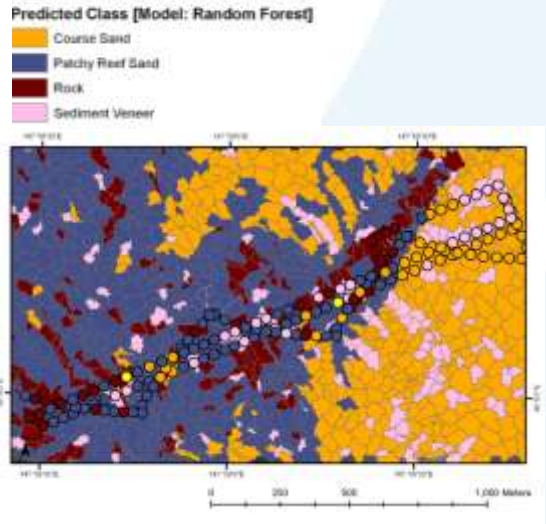
Extract Segment Statistics

1) Topographic
2) Textural

AUV Substratum Category

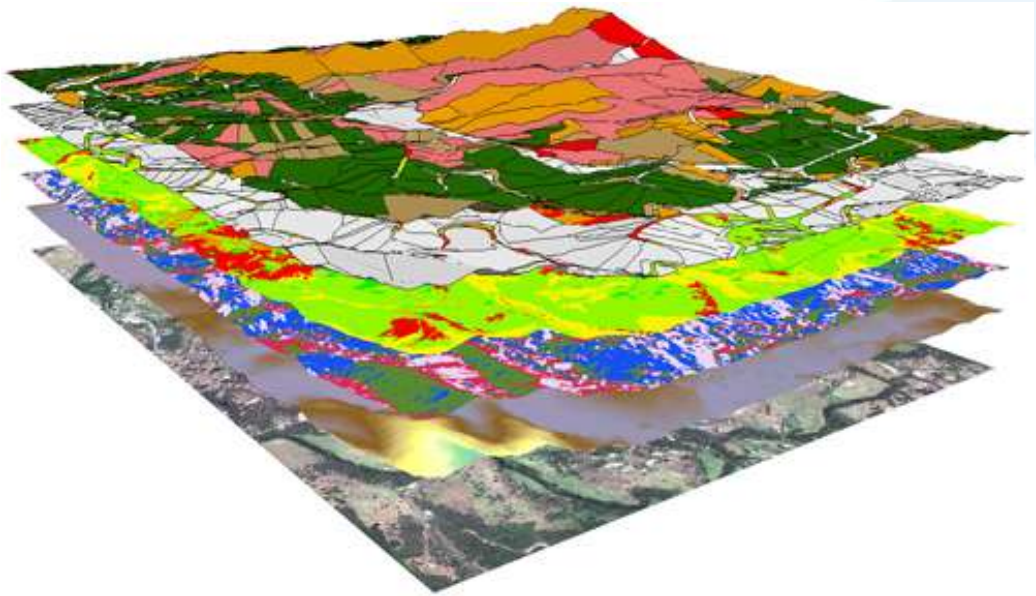
Train Classification Model (e.g. RF)

Optimal model



Predicted Substratum

OBIA Attributes



Object related statistics:

Mean, standard deviation and higher order statistics are indicative of acoustic impedance changes and interface roughness.

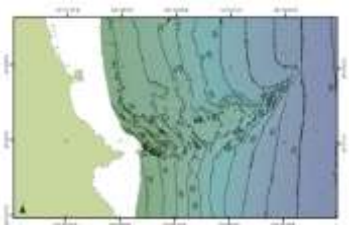
Texture related statistics:

Grey-level co-occurrence matrices: GLCMs describe amplitude changes over selected distances and directions in the image patch and are widely used to assess texture

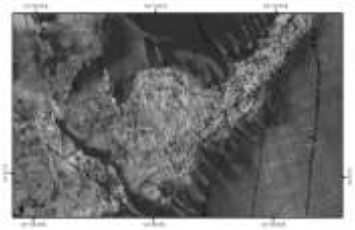
Feature Space Optimization:

Function offers a method to mathematically calculate the best combination of features that produce the largest average minimum distance between the samples of the different classes, in conjunction with a nearest neighbour classifier.

Data Analysis- Predicting Substratum



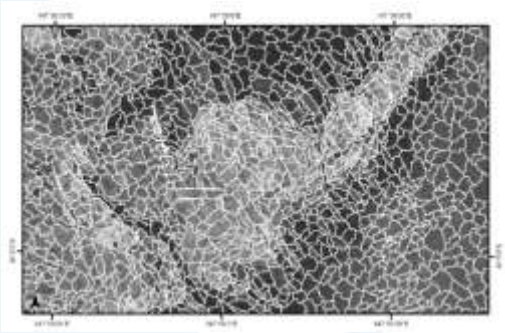
Bathymetry



Backscatter

OBIA

Segmentation



Extract Segment Statistics

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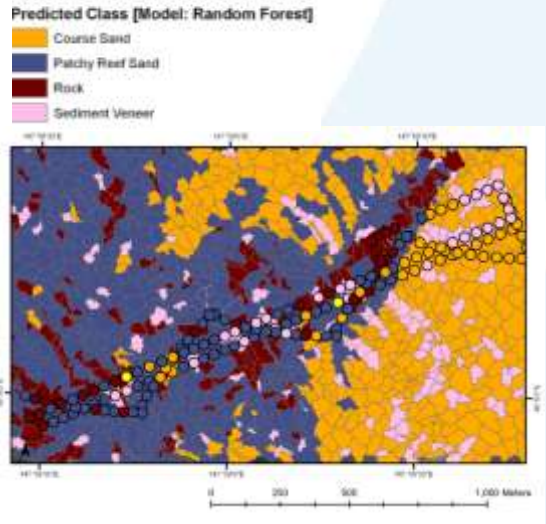
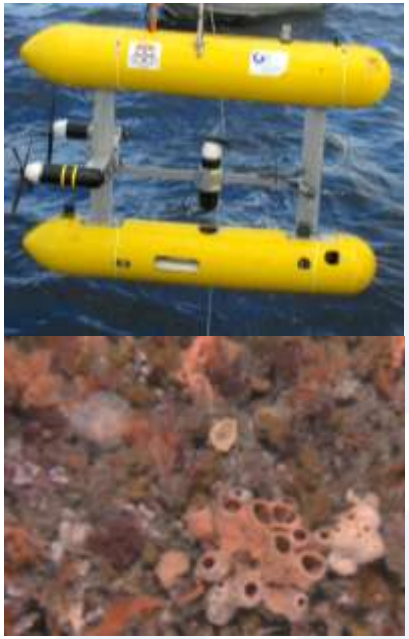
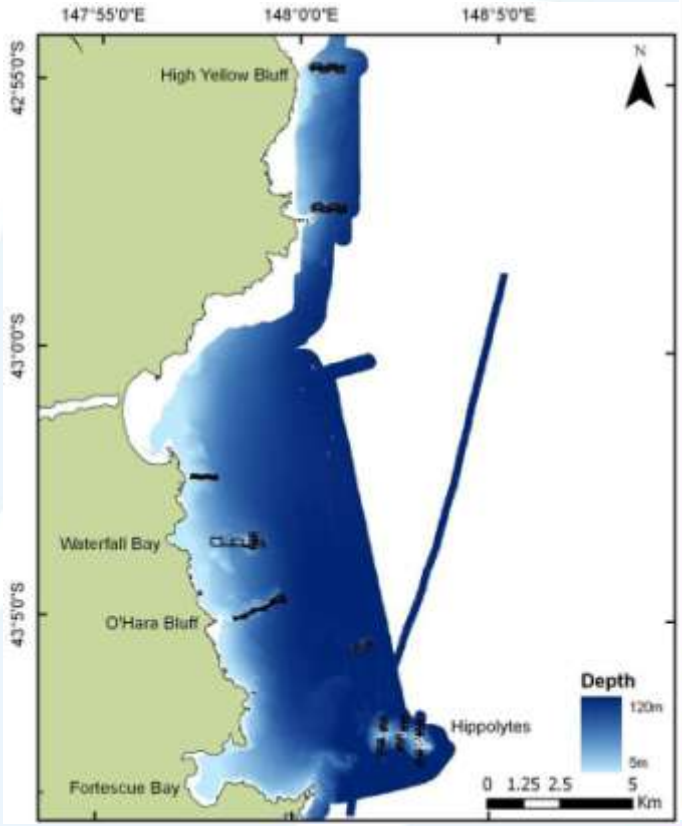


Predicted Substratum

7 areas surveyed by AUV from 2008-2011in conjunction with MBES (8101) and towed video





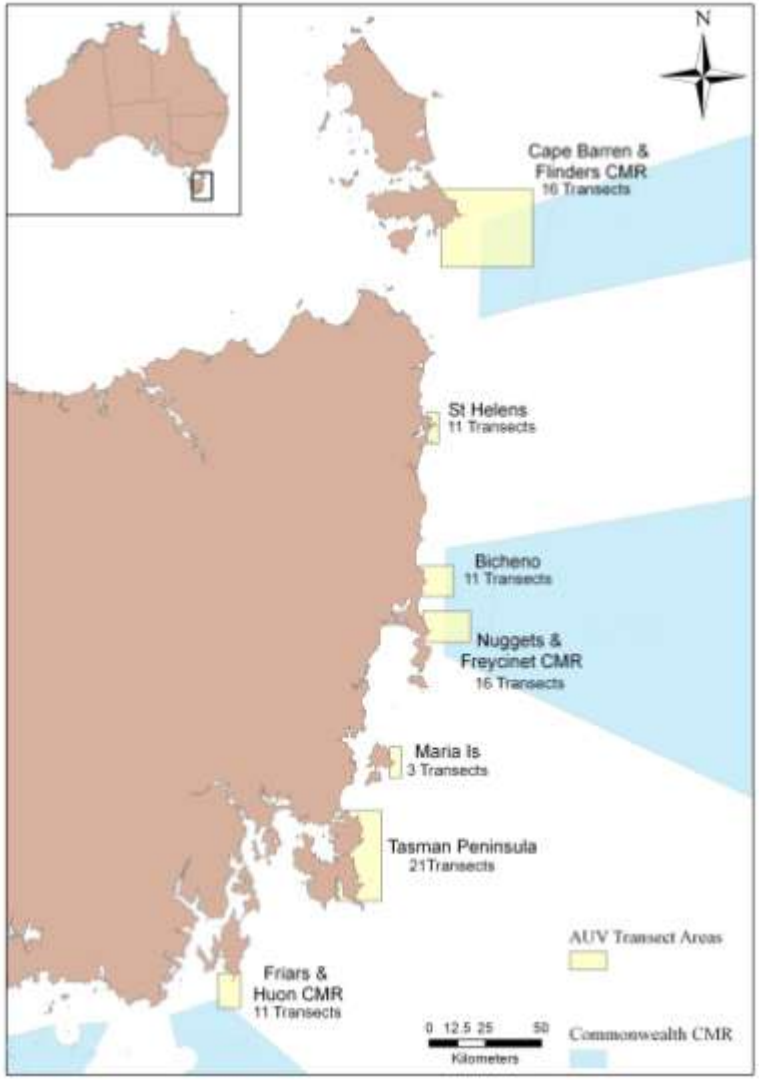


Image Scoring- Attributes

Substratum

- Mud
- Sand
- Gravel
- Cobble
- Boulder
- Patchy reef
- Contiguous reef
- Sediment veneer
- Screwshell

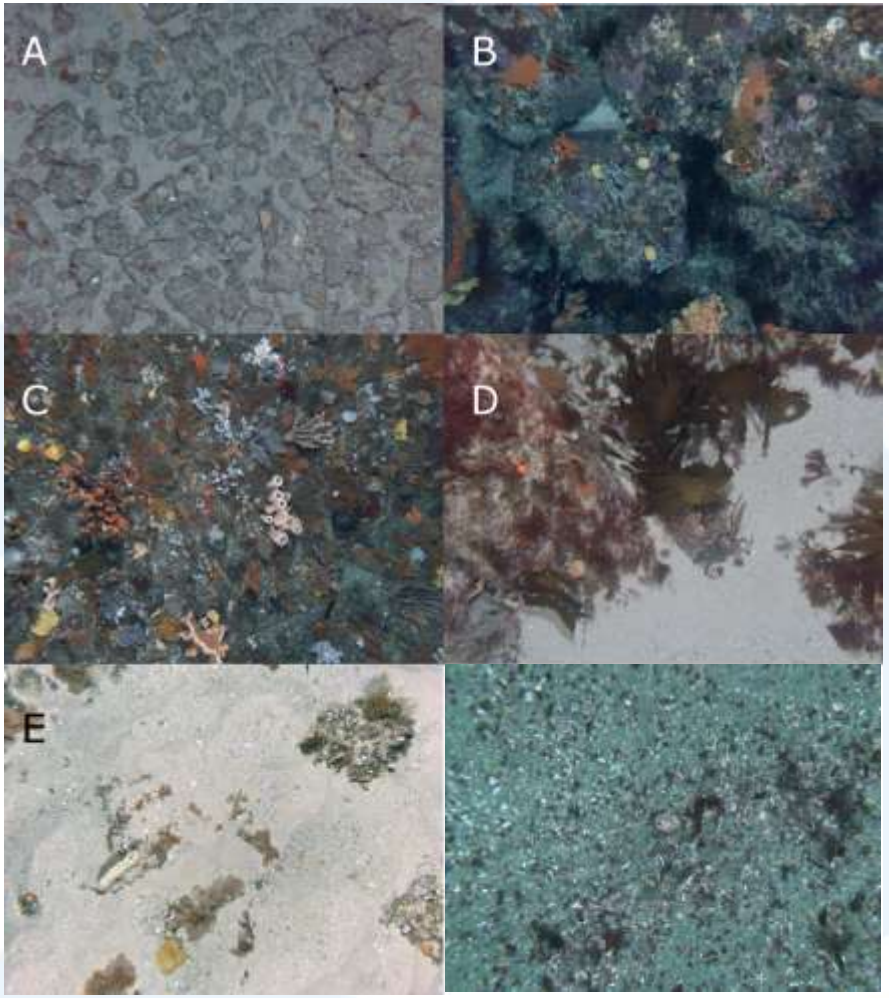


Image Scoring- Attributes

Slope/Form

- Flat
- Moderate slope
- Steep slope
- Sand waves
- Sand ripples
- Mounds and Pits

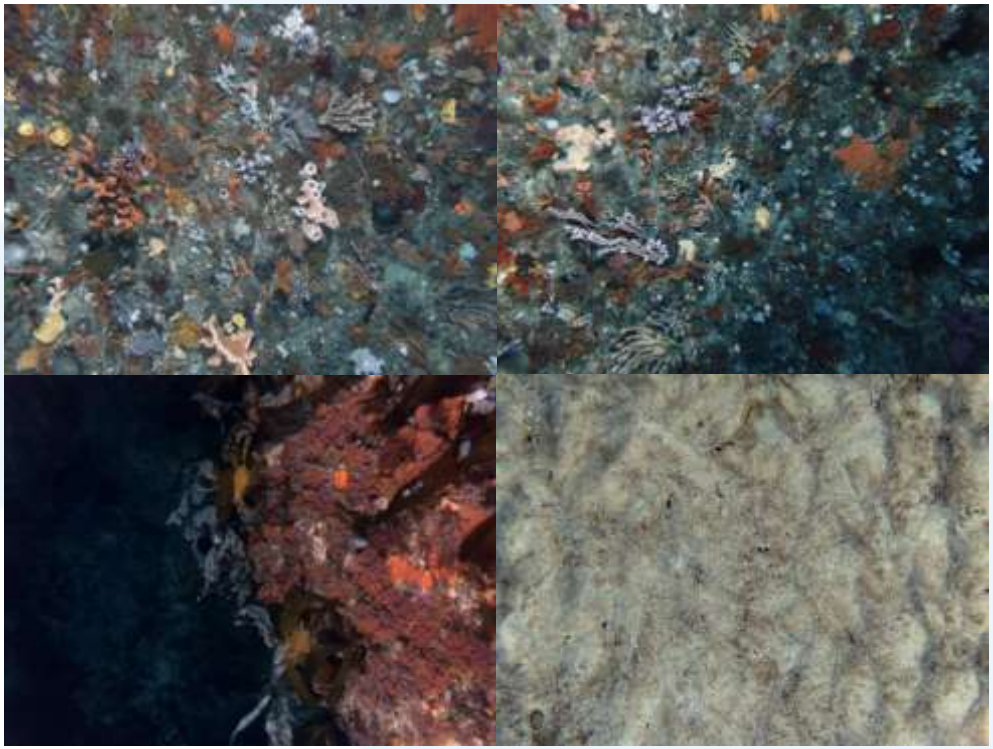
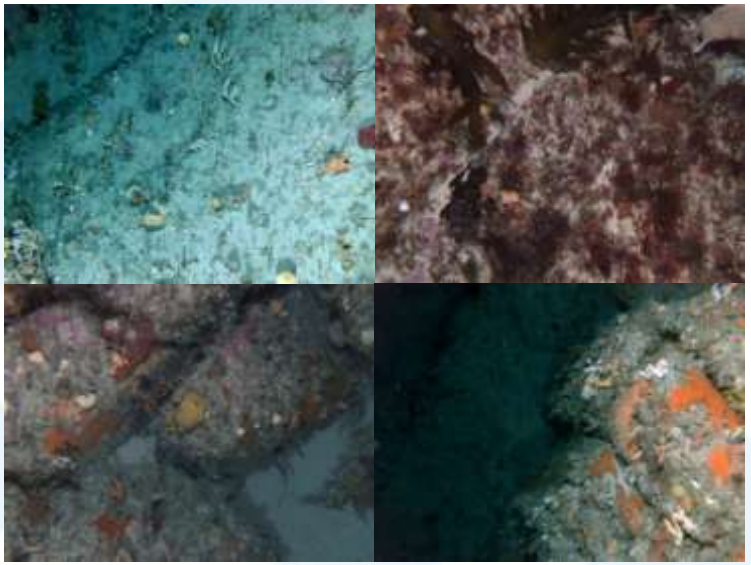


Image Scoring- Attributes

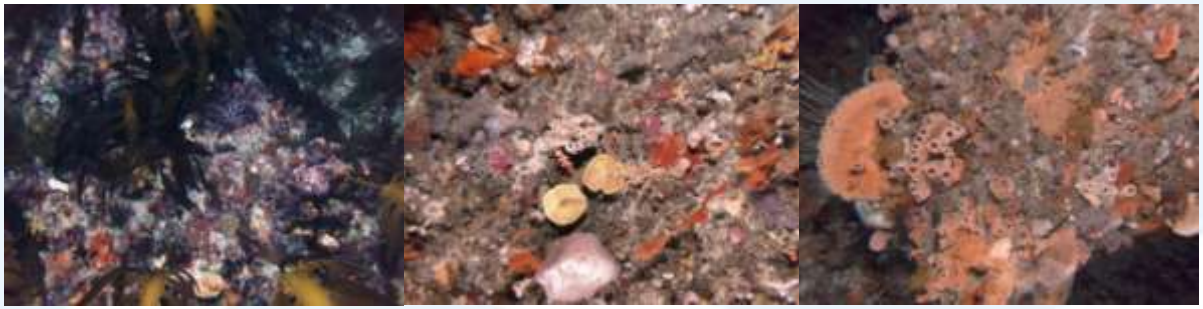
Apparent Rugosity

- Flat
- Low
- Moderate
- High

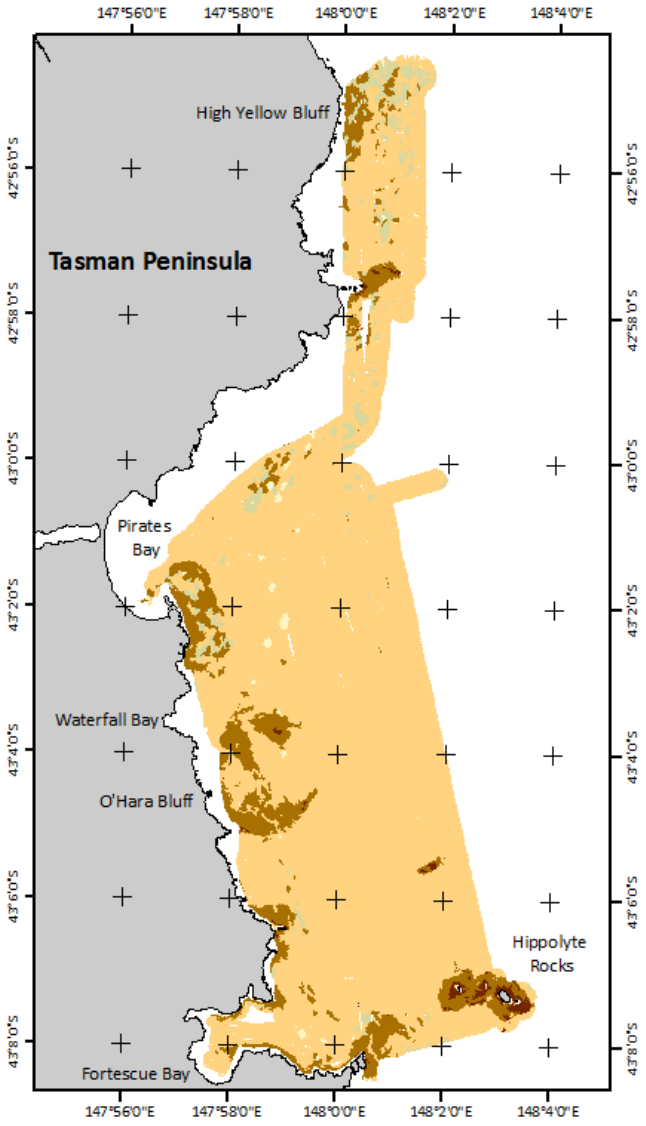


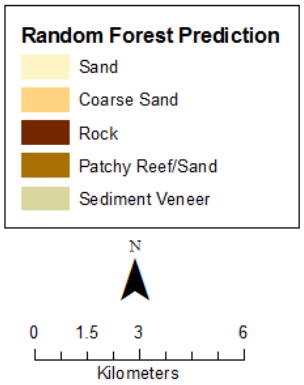
Sponge Structure

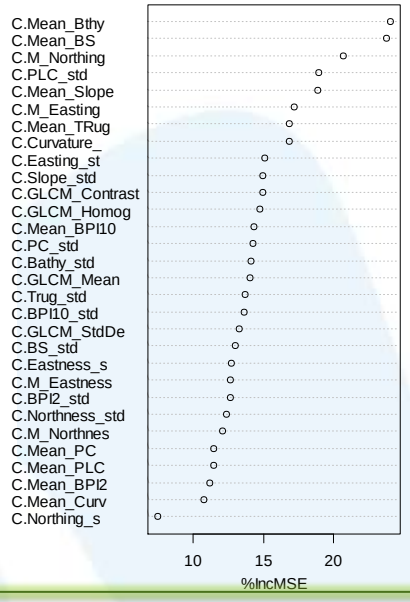
- None
- Low profile
- Moderate profile
- High profile

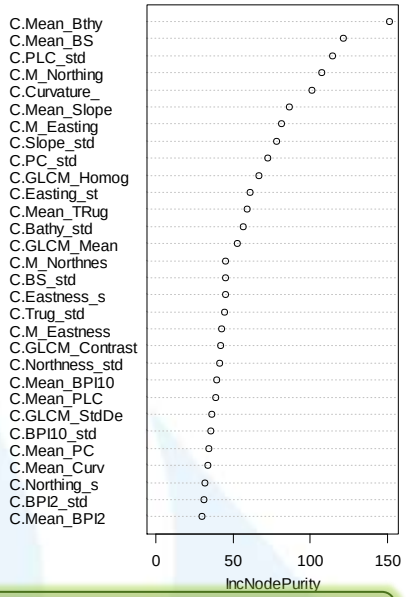


Predicted Substrate using Random Forest Model









Overall accuracy of 64% for 7 classes [Kappa 0.358]

Class	Sand	Course Sand	Cobble	Rock	Boulders	Patchy Reef	Sediment Veneer	Total	User's accuracy
Sand	0	3	0	0	0	0	1	4	0
Coarse Sand	0	149	0	1	0	48	10	208	71.65
4	0	1	0	0	0	0	0	1	0
Rock	0	7	0	52	0	63	0	122	42.7
6	0	4	0	0	0	18	0	22	0
Patchy Reef	0	26	0	19	0	125	5	175	71.43
Sediment Veneer	0	51	0	0	0	30	12	93	12.9
Total	0	241	0	72	0	284	28	625	
Producer's accuracy	0	61.83	0	72.22	0	44.01	42.86		K=0.358

Case Study Summary

- Example of how emerging technologies (AUV and MBES) and statistical advances can be used together to identify physical surrogates to characterise seabed habitats
- Multibeam variables used in supervised analysis capable of modelling substrates with high degrees of accuracy
- Bathymetry, texture measures, slope and rugosity most important variables for substrate prediction

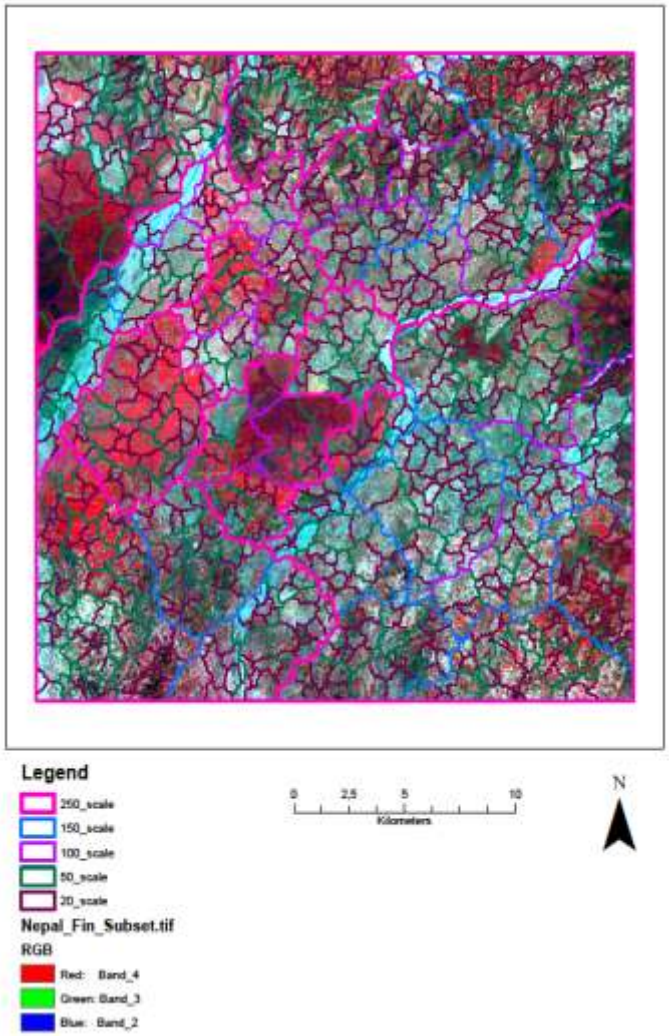
‘Hot’ topics in GEOBIA

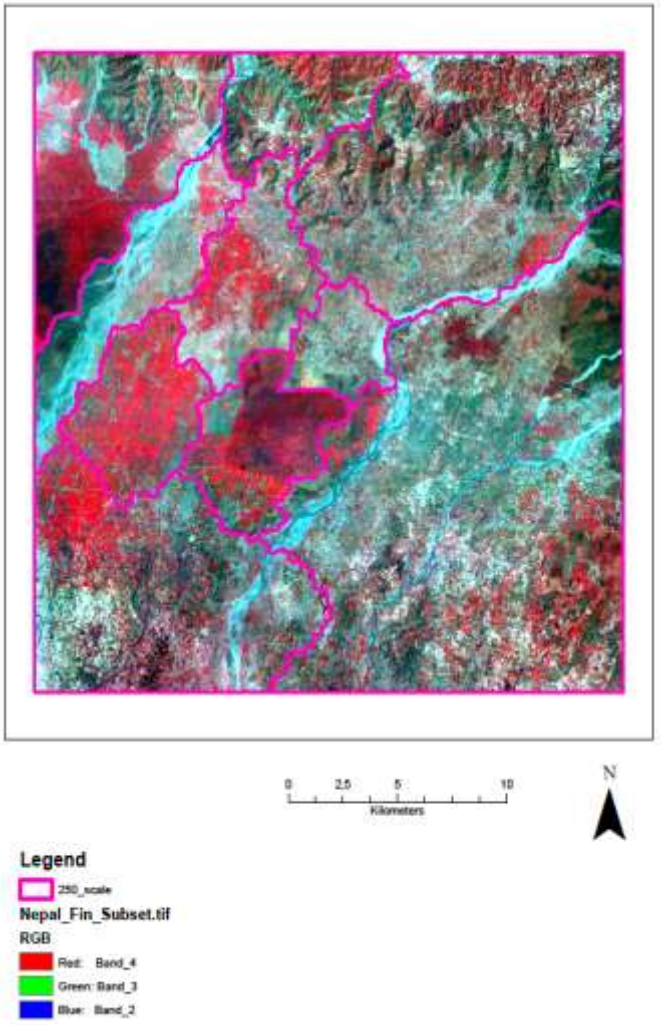
- GEOBIA Hierarchy and scale concepts
- New algorithms for segmentation
- GEOBIA and change detection
- Optimisation of segmentation procedure
- GEOBIA and angular profile correction

Local pertinent scale using algorithmic approach

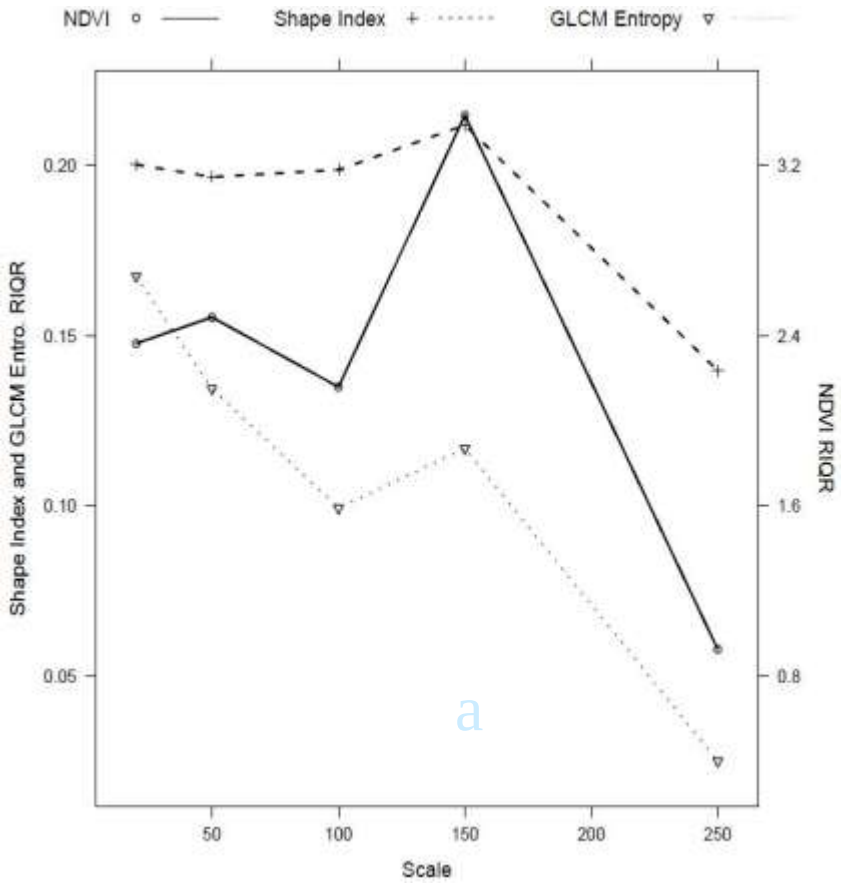
- Observe each patch at the suitable global scale and every finer scale in a top down approach
- When a patch is not disaggregated from the suitable scale to the next scale, keep the global scale as the local suitable scale for the patch
- If the patch keeps disaggregating then select as the local suitable scale at which the patches created from the disaggregation

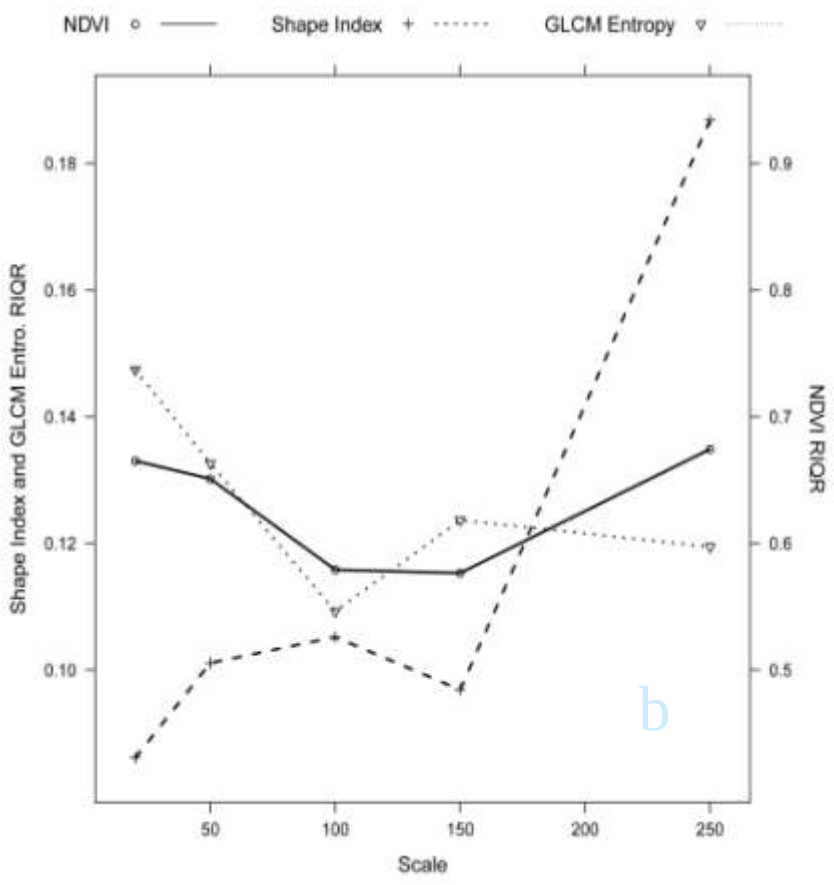
Aggregation Vs Disaggregation





Variability measure for appropriate scale





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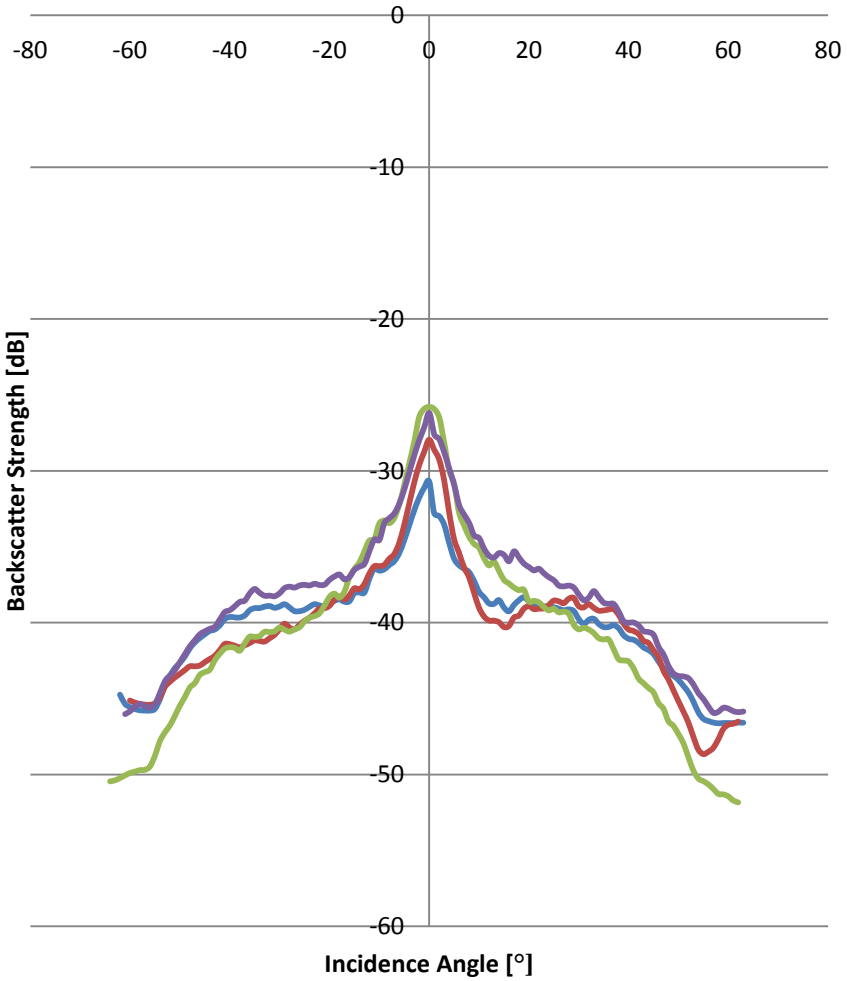
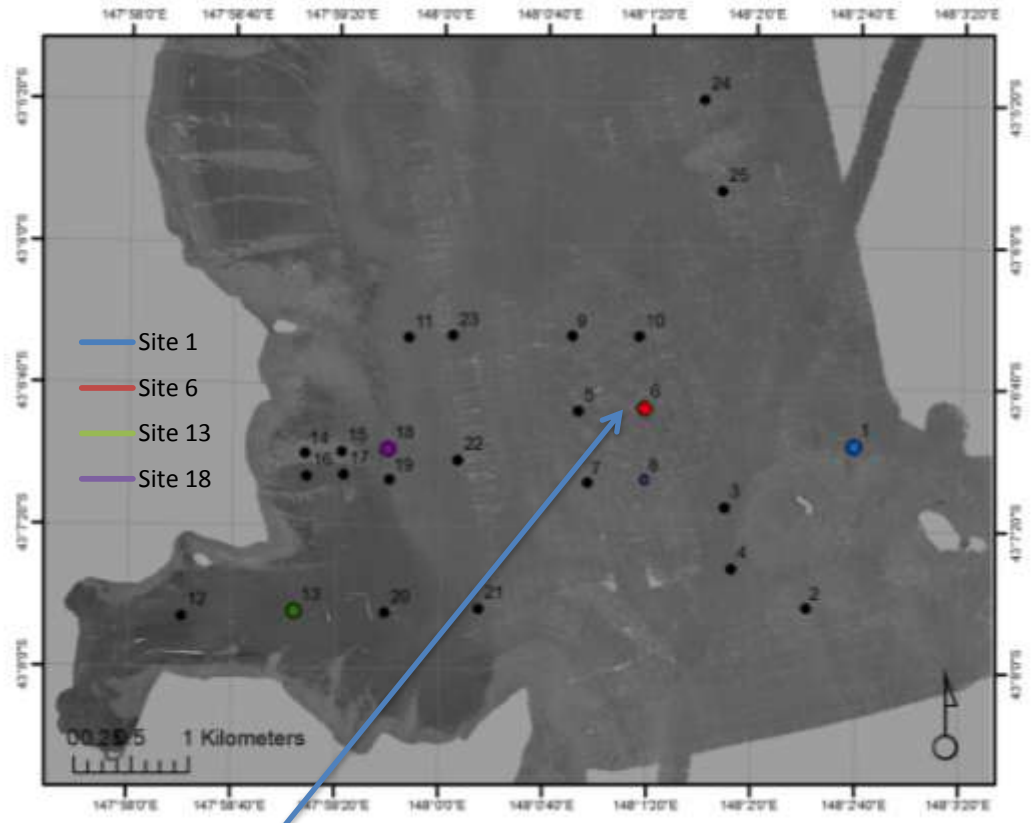
OBIA and angular profile correction





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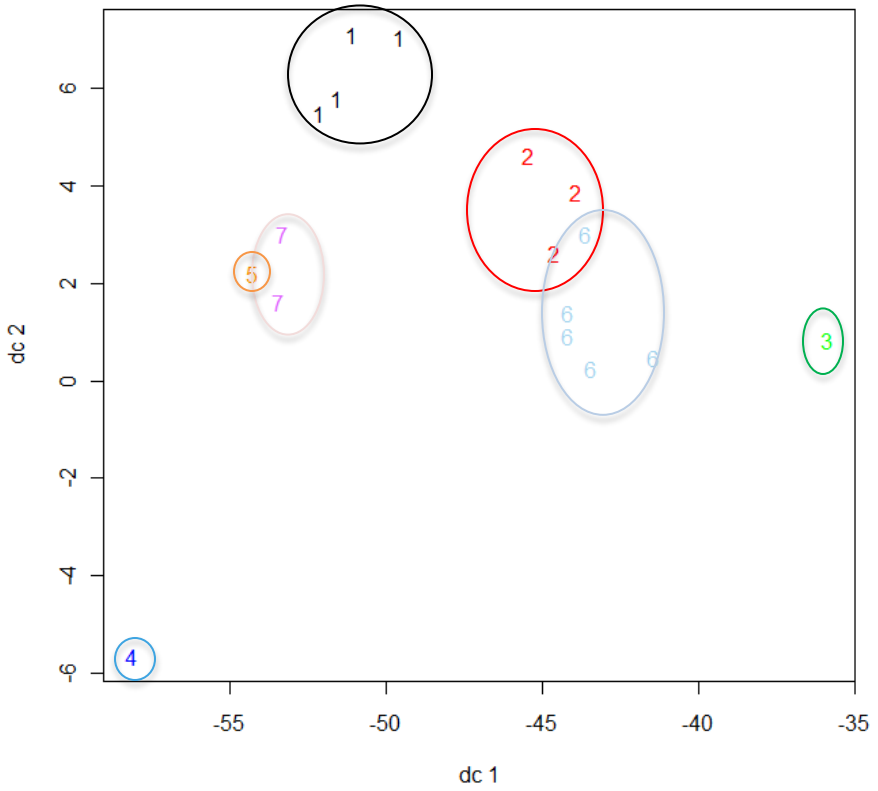
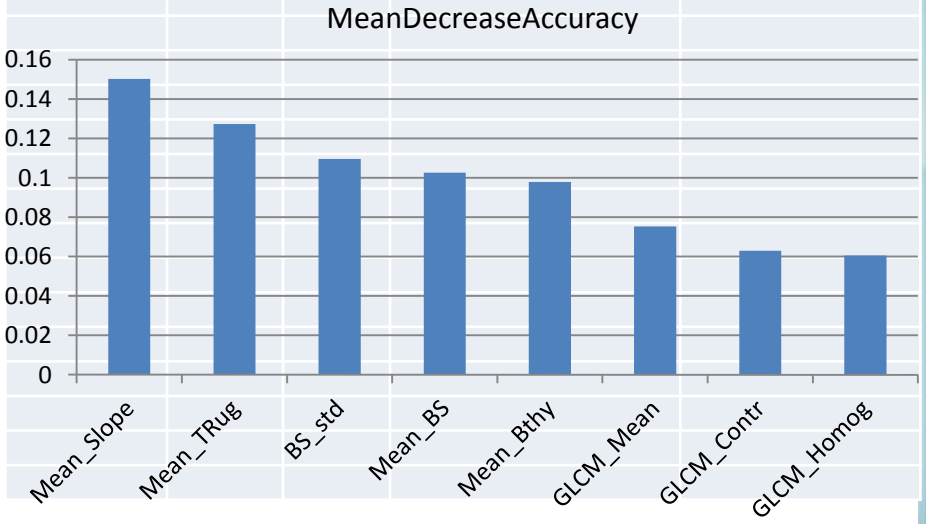
GEOBIA and angular profile correction

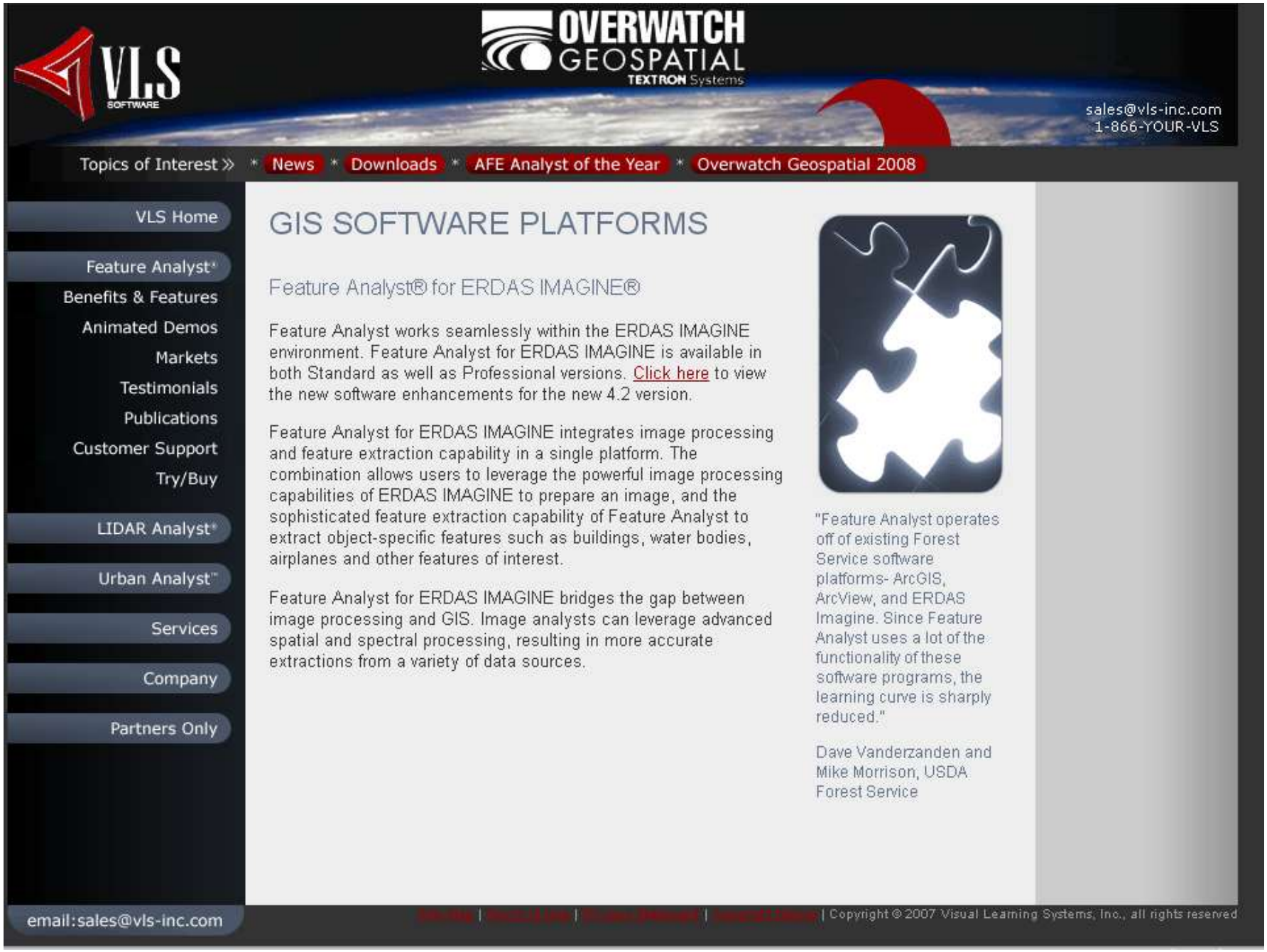


VARIABLE IMPORTANCE	1	2	MeanDecreaseAccuracy	MeanDecreaseGini
Mean_Slope	0.299975	0.00063	0.15028971	458.9735
Mean_TRug	0.25463	-6.3E-05	0.12727398	438.7625
BS_std	0.219396	-0.00017	0.10960758	355.8983
Mean_BS	0.205307	-3.3E-05	0.10262963	351.9455
Mean_Bthy	0.195745	0.000209	0.09797141	319.9718
GLCM_Mean	0.150823	-0.00021	0.0753024	288.1287
GLCM_Contr	0.126148	-0.00018	0.06298185	274.9907
GLCM_Hom	0.121486	-0.00034	0.0605709	261.8292



Mean Decrease in Accuracy 0.069= 7% Error OR 93% Accurate

Software



http://www.featureanalyst.com/feature_analyst/platforms/erdas_imagine.htm

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IMAGINE Objective

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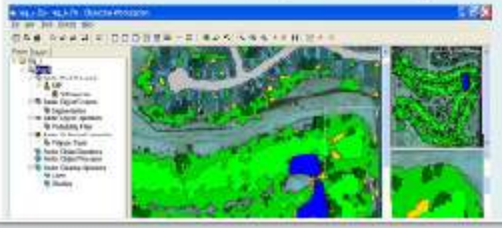
The Future of Feature Extraction, Image Classification and Change Mapping

IMAGINE Objective includes an innovative set of tools, enabling geospatial data layers to be created and maintained using remotely sensed imagery. Combining inferential learning with expert knowledge in a true object-oriented feature extraction environment, IMAGINE Objective emulates human visual processing. IMAGINE Objective also encapsulates vector processing operators to produce GIS-ready data with minimal post processing.

Classification of Vegetation Types from a High-Resolution QuickBird Image



IMAGINE Objective can also classify high resolution imagery for tasks such as vegetation mapping and delineation. Here the area of a golf course has been analyzed for variations in grass health and to map other associated land cover classes.

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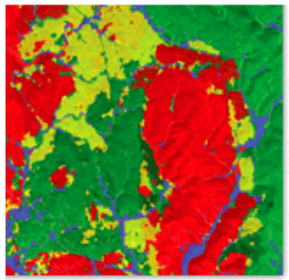
ENVI Feature Extraction Module

Quickly and easily extract features from imagery with this object-based tool.

Today you need to find and identify features of interest within geospatial imagery. But, the process of manually locating and digitizing these features can be complex and time consuming, and spectral content is often limited, reducing the accuracy of standard classification methods.

The new ENVI Feature Extraction Module allows you to quickly, easily and accurately extract features from high resolution imagery. This add-on module to ENVI uses object-based image analysis technology so you can extract features from readily available pan and multi-spectral imagery and data.



New Features with ENVI Fx 4.5

Programmatic Batch Capability
Extract features from multiple images automatically.

Vector Smoothing
Extracted features will now be smoothed by default.

Statistics and Results Summary
Get a summary of statistics and results from an extraction.

Save and Restore of Training Data
Save the training data from a workflow as a shapefile.

Vector Export Capability
Vector results can be exported to a shapefile.

Fast & Repeatable

Save time over traditional feature extraction methods:

Accurate

Get the accurate results you need:

Unlike traditional pixel-based approaches to

Quick Links

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ENVI FX Module Resources

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- Pricing
- Information Packet

ENVI Resources

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http://www.ittvis.com/ProductServices/ENVI/ENVIModules/ENVIFeatureExtractionModule.aspx

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  - Infrastructure Planning
  - Natural Resource Management
  - Security and Emergency Response
- Life Sciences
- Medical Imaging

Automated feature extraction form IKONOS imagery and metadata for rapidly updateable multi-scale mobility maps...

IKONOS satellite imagery with road center lines

Image Analysis in Earth Sciences

Every day, remote sensing provides thousands of images from a huge variety of sensors – from simple black and white photographs to hyperspectral imagery with hundreds of channels. The images range in scale from hundreds of square miles for monitoring large areas of land and sea to high resolution images of individual objects.

Standardized image analysis and information extraction are essential to compare results across geographic areas and support political directives like the Kyoto Protocol, sustainable management of natural resources and future-proof infrastructure planning. Similarly, in natural disasters and other emergencies, image analysis can rapidly provide maps of remote territory to assist emergency operations, save lives, reduce costs and support insurance and reinsurance services.

Further Links

- Customer references
- Case studies
- Products
- Definiens Technology
- Partners
- Overview Brochure
- Further readings

Attempts to **automate image analysis** and information extraction have been continuing for decades. But despite increases in computational power and imaging capabilities, fundamental advances in **automated image analysis** have been limited. Looking at a satellite image, it is easy, even for an untrained eye, to distinguish a river from a lake. But traditional automated image classification tools often fail to recognize features that are obvious to any person because they only use information contained within individual pixels and their immediate neighbors.

From the perspective of an image analyst, there is so much more to an image than the color and intensity of pixels. There is shape, texture, area, scale and the relationships of the objects, all attributes which analysts use to understand the content of an image and data set.

Image analysis in Infrastructure Planning

Accurate mapping and **change detection** are essential tools in the sustainable planning of urban infrastructure and traffic corridors. They are vital in reducing the cost of constructing and operating new oil and gas pipelines or telecoms infrastructure. They support urban planning should be supported by helping to ensure that land is used appropriately and that quality of life is enhanced by reducing noise and pollution.

Image analysis in Natural Resource Management

An accurate and up-to-date picture of land cover and of the surface of the ocean is vital for assessing the health of the planet. It is used to measure the impact of climate change, assess biodiversity in natural habitats, and support sustainable farming and forest management. It is also invaluable in finding and exploiting natural resources like oil

http://www.definiens.com

Software Architecture

- **eCognition Developer**

  The original development environment for object based image analysis

- **eCognition Server**

  The processing environment for the batch execution of image analysis jobs

- **eCognition Architect**

  Made for non-technical professionals to leverage eCognition rulesets

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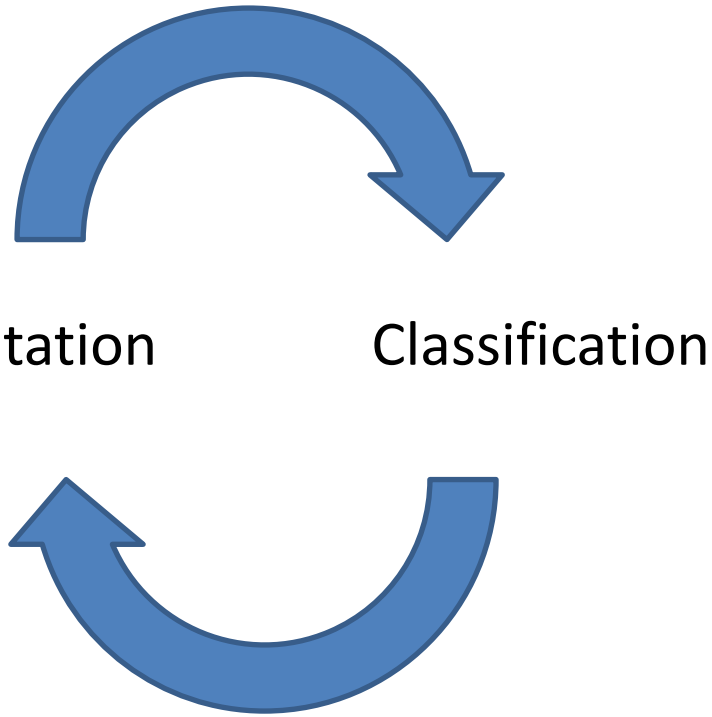
Understanding Images

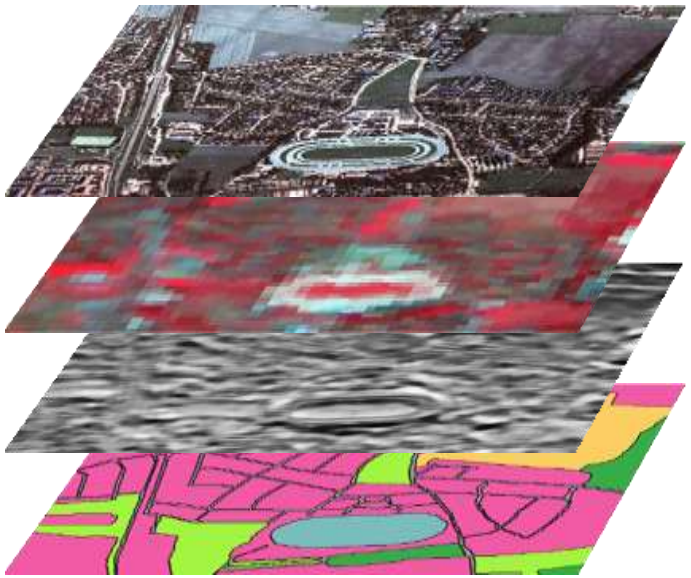
GEOBIA is iterative



GEOBIA Summary

Think differently…

- Forget click and classify or (un)supervised classification for a minute.
- Think about using all available information:
  - » image data of different scales
  - » Depth information
  - » Thematic data
- And above all:
  - » **Think about the reason why we as human beings are able to perceive an object for what it is!**
  - » **Use your own experience to describe the objects you are looking for!**



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The information in this presentation was generated by the Marine Biodiversity Hub and its partners for the purpose of consultation and collaboration with marine stakeholders in improving the evidence-base for decision making for marine biodiversity management. The Marine Biodiversity Hub is supported through funding from the Australian Government's National Environmental Research Program. The results should not be used or taken as final and are not for circulation outside of this audience without prior permission.

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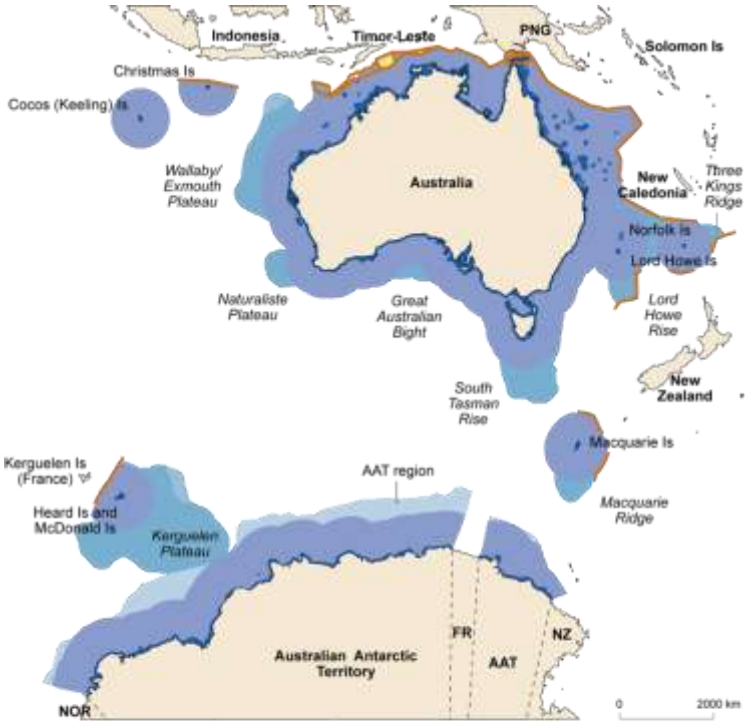
Presentation Outline



Territorial sea and internal waters

Australia's exclusive economic zone as defined by the United Nations Convention on the Law of the Sea and certain treaties (not all in force)

Australia's extended continental shelf (ECS) beyond 200 nautical miles as confirmed by the Commission on the Limits of the Continental Shelf and as defined by certain treaties (not all in force)

Australia's ECS considered by the commission and yet to be resolved

Australia's ECS off Antarctica as submitted on 15 November 2004 to the commission that Australia requested not be considered for the time being

Joint Petroleum Development Area as defined in the Timor Sea Treaty between Australia and Timor-Leste

Treaty boundary with opposite or adjacent state

AAT = Australian Antarctic Territory; FR = France; NOR = Norway; NZ = New Zealand; PNG = Papua New Guinea

Source: Symonds et al.[1]