Classification of Intertidal Sediments Based on Biophysical Characteristics Obtained by Imaging Spectroscopy

By

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Introduction

- Characterization of main intertidal sediment habitat types
- Study areas: intertidal flats at the North Sea (De IJzermonding) Westerschelde (Molenplaat)

Study Area: IJzermonding

Study Area: Molenplaat

Remote sensing AHS data

Image characteristics

- Spatial resolution = 3.4m
- Spectral resolution =

  VIS: 20 bands (30nm wide)
  SWIR-1: 1 band (200nm wide)
  ~~SWIR-2: 42 bands (13nm wide)~~
  ~~Mid IR: 7 bands (300nm wide)~~
  ~~thermal IR: 10 bands~~

Image acquisition

- IJzermonding - 17th of June 2005 at low tide
- Molenplaat – 20th of June 2005 at partly flooded conditions
- Molenplaat – 23rd of June 2005, one image at low tide and one image at partly flooded conditions

Remote Sensing AHS quicklooks

IJzermonding

Molenplaat

Molenplaat, low tide

Molenplaat, 3hrs after low tide

Field data

IJzermonding:

- 28 sites, three replicates (3m apart) ?
- 4 days before overflight
- sediments analyzed for grain size, organic matter content, moisture content, chlorophyll-a content
- digital photograph, ASD spectrum, GPS measurement

Molenplaat:

- 18 sites, three replicates at the day of overflight (20th of June)
- 4 sites, three replicates, 6 days later (26th of June)
- sediment analysed for grain size, chlorophyll a content
- digital photograph, ASD spectrum, GPS measurement

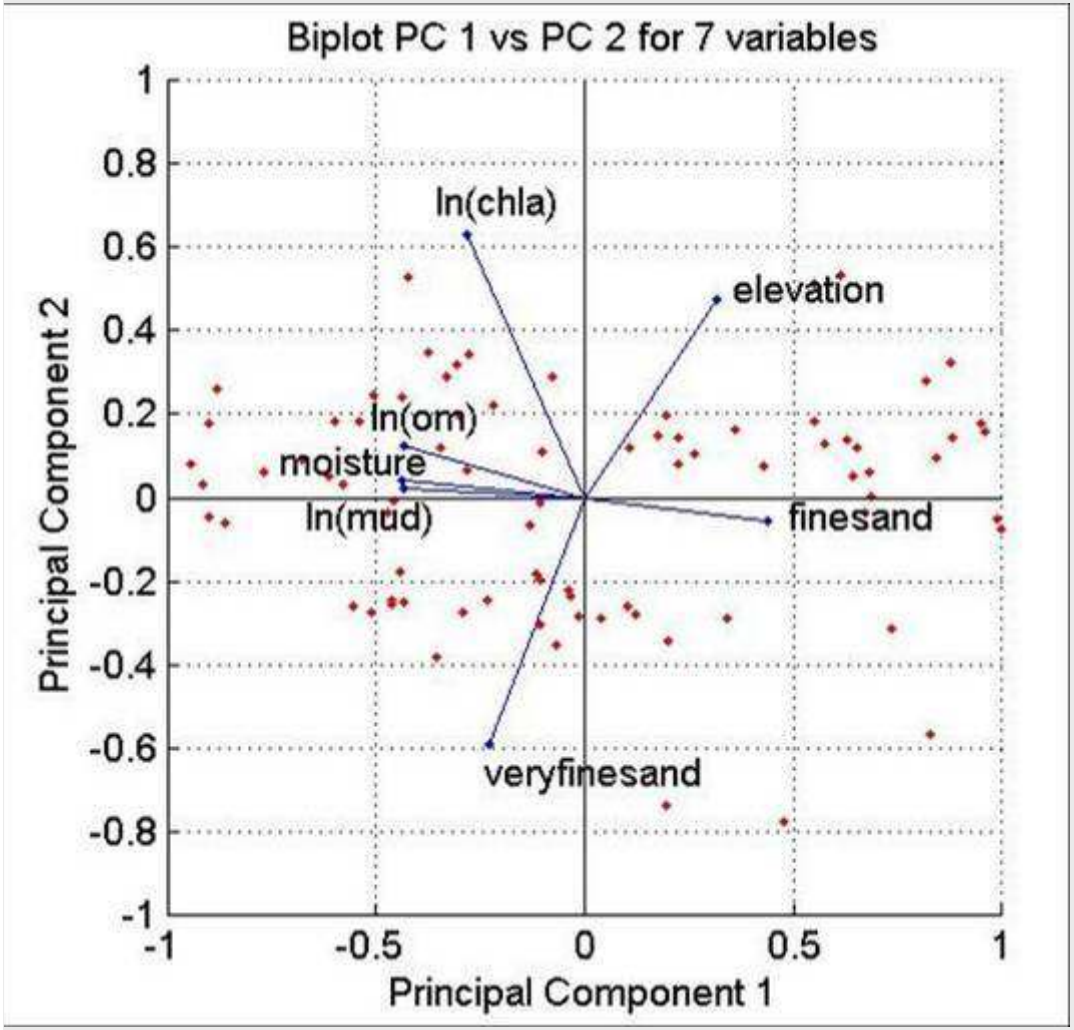
Sediment data - IJzermonding

Sediment variables highly correlated ($p<0.001$)

Correlation R^2	elevation	moisture	ln(om)	ln(mud)	very fine sand	fine sand	ln(chl a)
elevation	1.0						
moisture	**0.4440**	1.0					
ln(om)	**0.3230**	**0.7800**	1.0				
ln(mud)	**0.2860**	**0.6710**	**0.683**	1.0			
very fine sand	**0.1500**	0.0973	0.1260	**0.2620**	1.0		
fine sand	**0.3380**	**0.8290**	**0.769**	**0.7980**	**0.1340**	1.0	
ln(chl a)	0.0100	**0.2580**	**0.361**	**0.3390**	0.0108	**0.2690**	1.0

- Moisture, organic matter, mud fraction highly correlated
- Fine sand negatively correlated with moisture, organic matter and mud fraction

Sediment data - IJzermonding



Principal component analysis on sediment variables

- PC1 explains more than 80% of the variation in the dataset
- Organic matter, moisture content and mud fraction are highly correlated
- Fine sand, mud fraction, organic matter content, moisture content are important to describe the variability in sediment

Supervised Classification: Approach

1. **Feature selection procedure : sequential floating forward selection (SFFS)**

Principle: search for the best subset of features to obtain the highest classification accuracy

- Search for the one, best feature
- Add a second feature to obtain highest acc.
- With this subset adding third feature but also removing least significant feature as long as cost function increases (= floating aspect)
- Search stops if accuracy decreases when adding new features

# bands	Weighted accuracy Moisture content	Weighted accuracy Organic matter
1	89	75
2	89	79
3	89	75
4	96	
5	93	

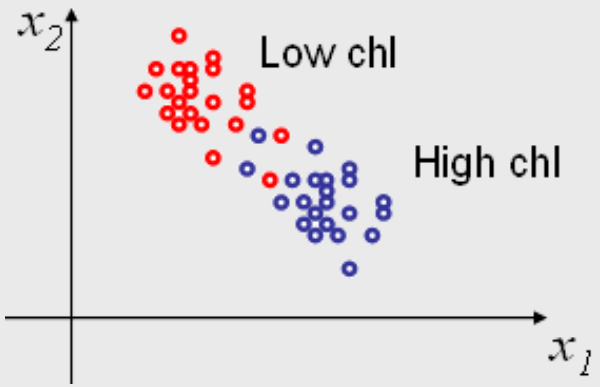
Supervised Classification: Approach

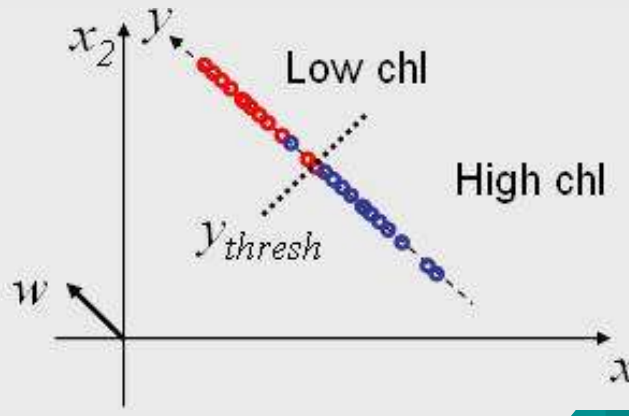
2. Fisher linear discriminant analysis

Principle

- Make a new linear function y=wtx for which ratio "between class scatter" to "within class scatter" is maximized > max class separability!
- 2-class problem: projection to 1-dimension (*y*)
- 3-class problem: projection to 2-dimensions

Threshold *ythresh* discriminates two classes





Supervised Classification: Classes

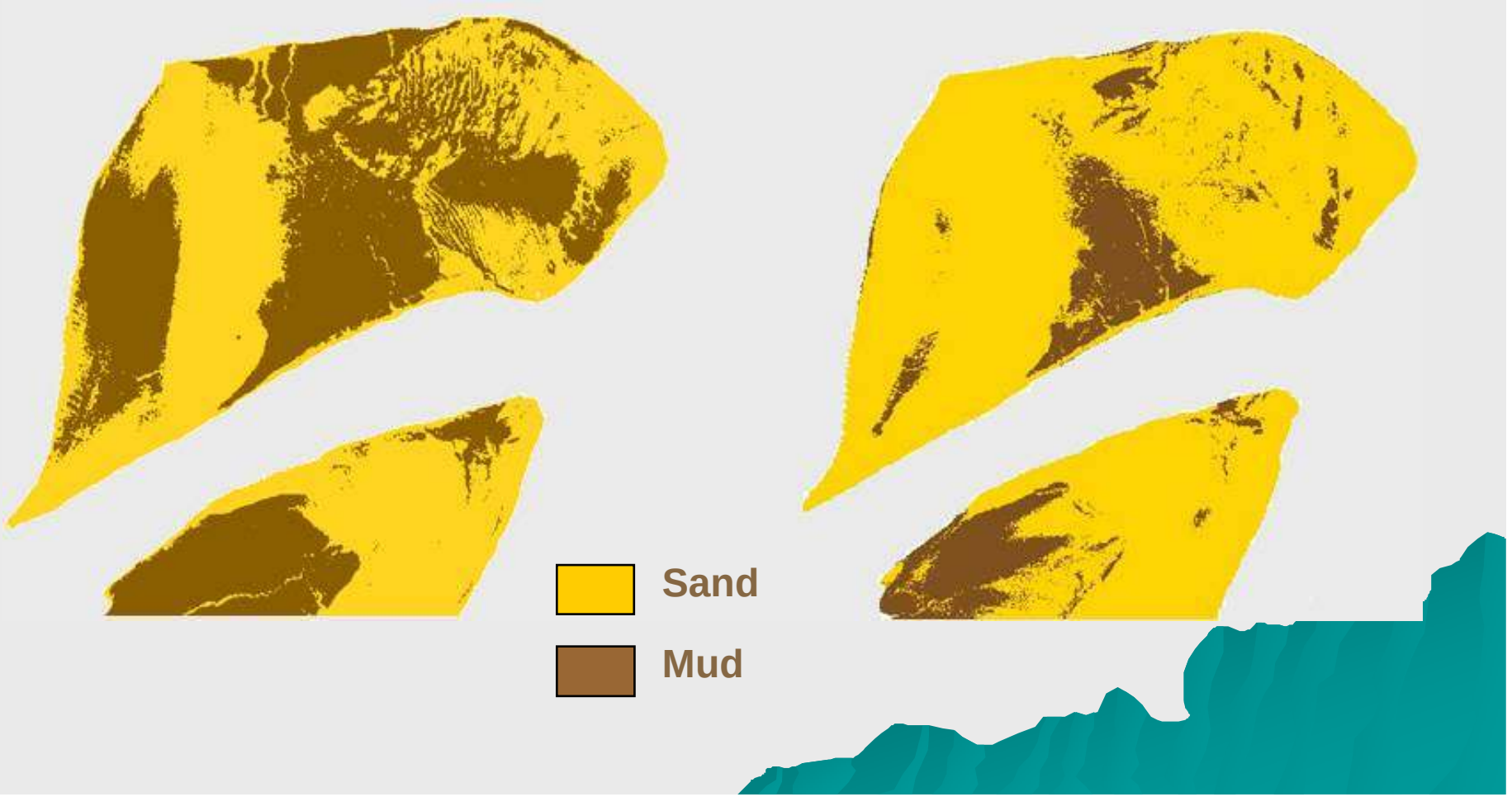
	Threshold	Class name	# samples
Water content*	0-30 %	Dry	10
	> 30 %	Wet	18
Chlorophyll-a	0- 40 mg/m²	Low chl-a	19
	> 40 mg/m	High chl-a	32
Grain size	Clay & silt > 30%	mud	33
	Clay & silt < 30%	sand	18
Organic matter*	0 - 3 %	low org.	7
	3 - 6 %	Medium org	9
	> 6 %	High org	12

* No in-situ data for Molenplaat

Supervised Classification: Grain Size, Molenplaat

HyMap 2004

AHS 2005

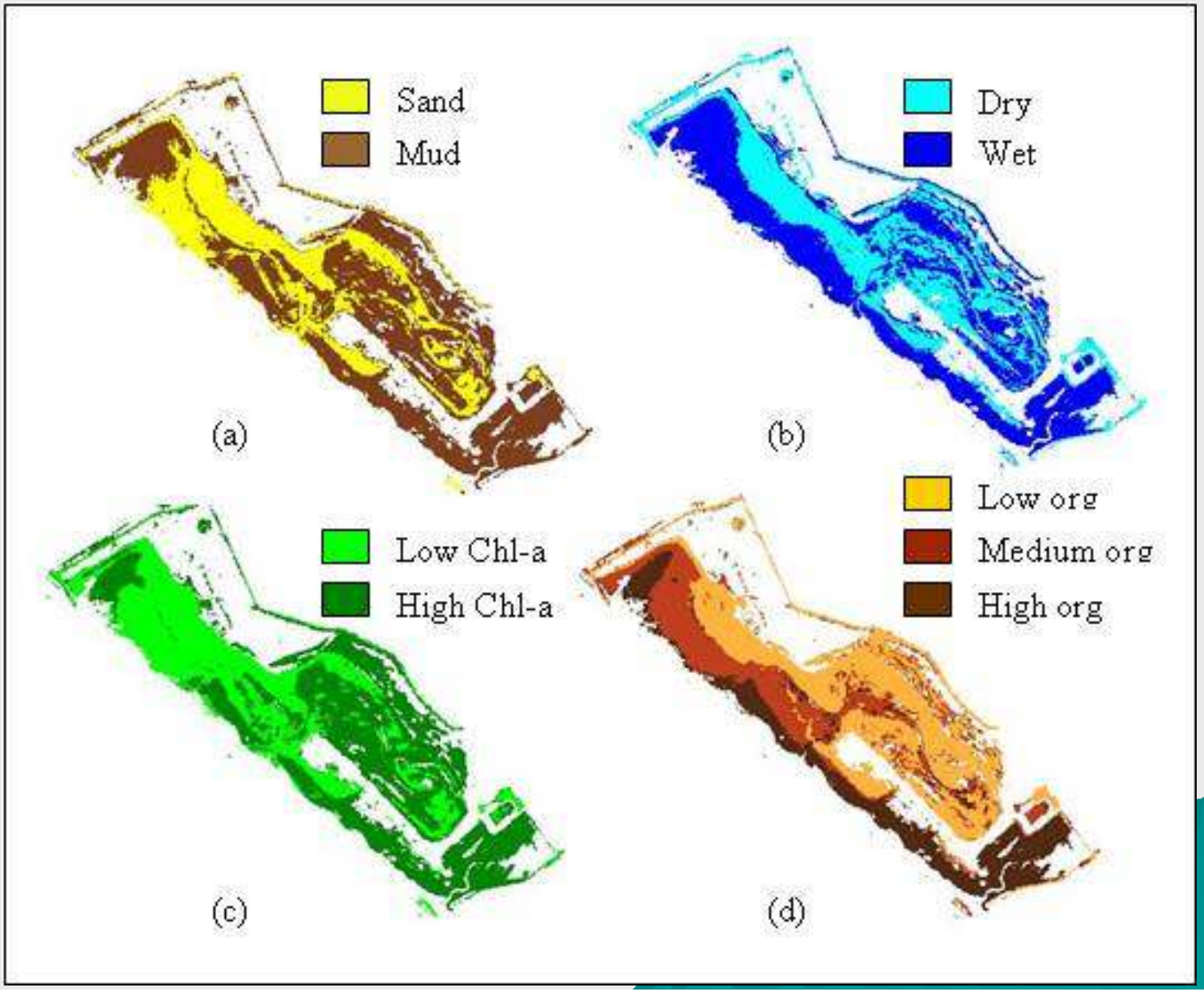


Supervised Classification: Chl-a, Molenplaat

HyMap

AHS 2005

Supervised Classification: IJzermonding



Unsupervised Classification: Approach

- Principal Component Analysis (PCA):
  - reduces redundancies in spectral bands

- Clustering:
  - "is the process of organizing objects into groups whose members are similar in some way"
  - deals with finding a structure in a collection of unlabeled data

Unsupervised Classification: AIM

AIM…Why?

1- For this presentation:

- To derive different areas where no field data exists

2- In general:

- For an efficient field sampling campaign
- Fast preliminary classification in case of lack of field data
- Classification of inaccessible areas

Unsupervised Classification: Clustering

- Exclusive Clustering (hard)
- Overlapping Clustering (Fuzzy)
- Probabilistic Clustering (Mixture models)

A completely probabilistic approach

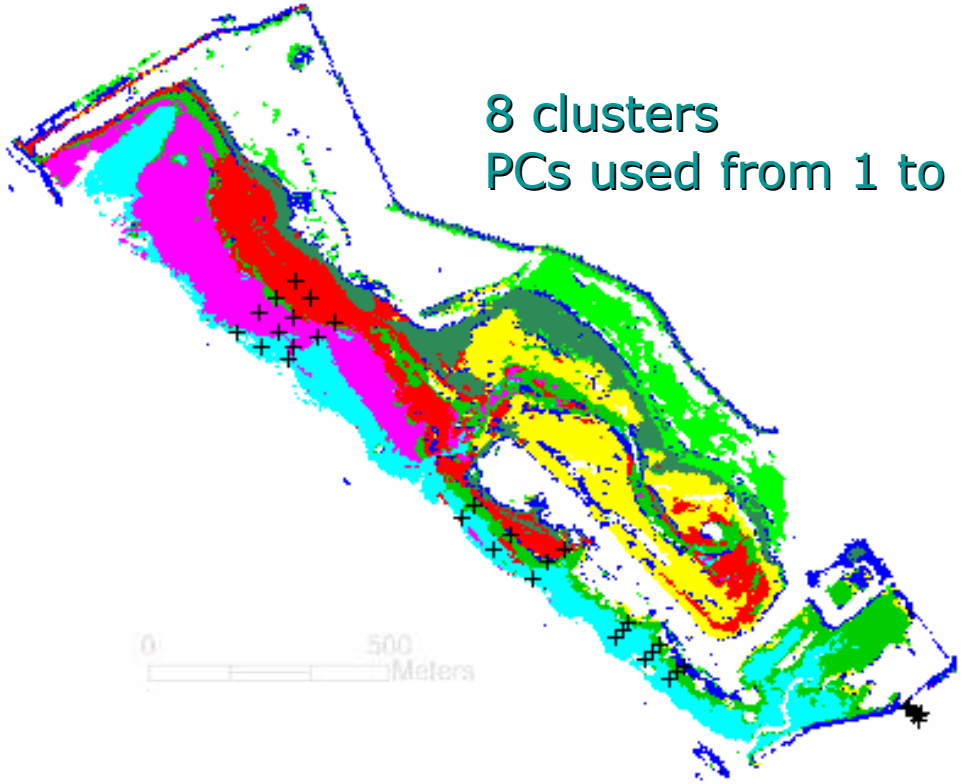
- Mixture of Gaussians: where clusters are considered as a Gaussian distributions centred on their barycentres

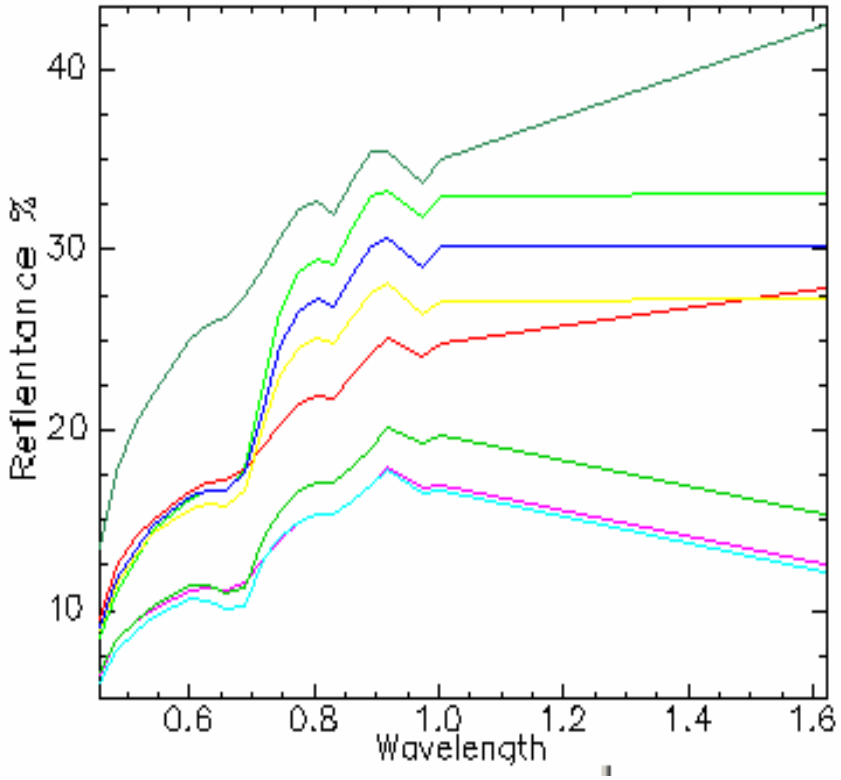
According to Covariance structure:

- Spherical models
- Diagonal Models
- General Models

"MixMod"

Unsupervised Classification: IJzermonding





- Clay, wet, intermOM, interm-highChla *
- Sand, dry, low-intermOM, low-intermChla *
- MixedSediments, wet-sat, highOM, highChla *
- Clay, sat, highOM, highChla *
- Sand, semidry-wet, sparseVegetation **
- Sand, dry, sparseVegetation **
- Sand, dry, lowChla **
- Border **

* Based on Field Data

** Based on literature review and expert knowledge

Conclusions

- Supervised Classification

  Features were successfully and efficiently identified according to requested properties of moisture content, grain size, chlorophyll-a content, and organic matter content

- Unsupervised Classification

  Different features can be classified though not obvious in the field data

Future Work

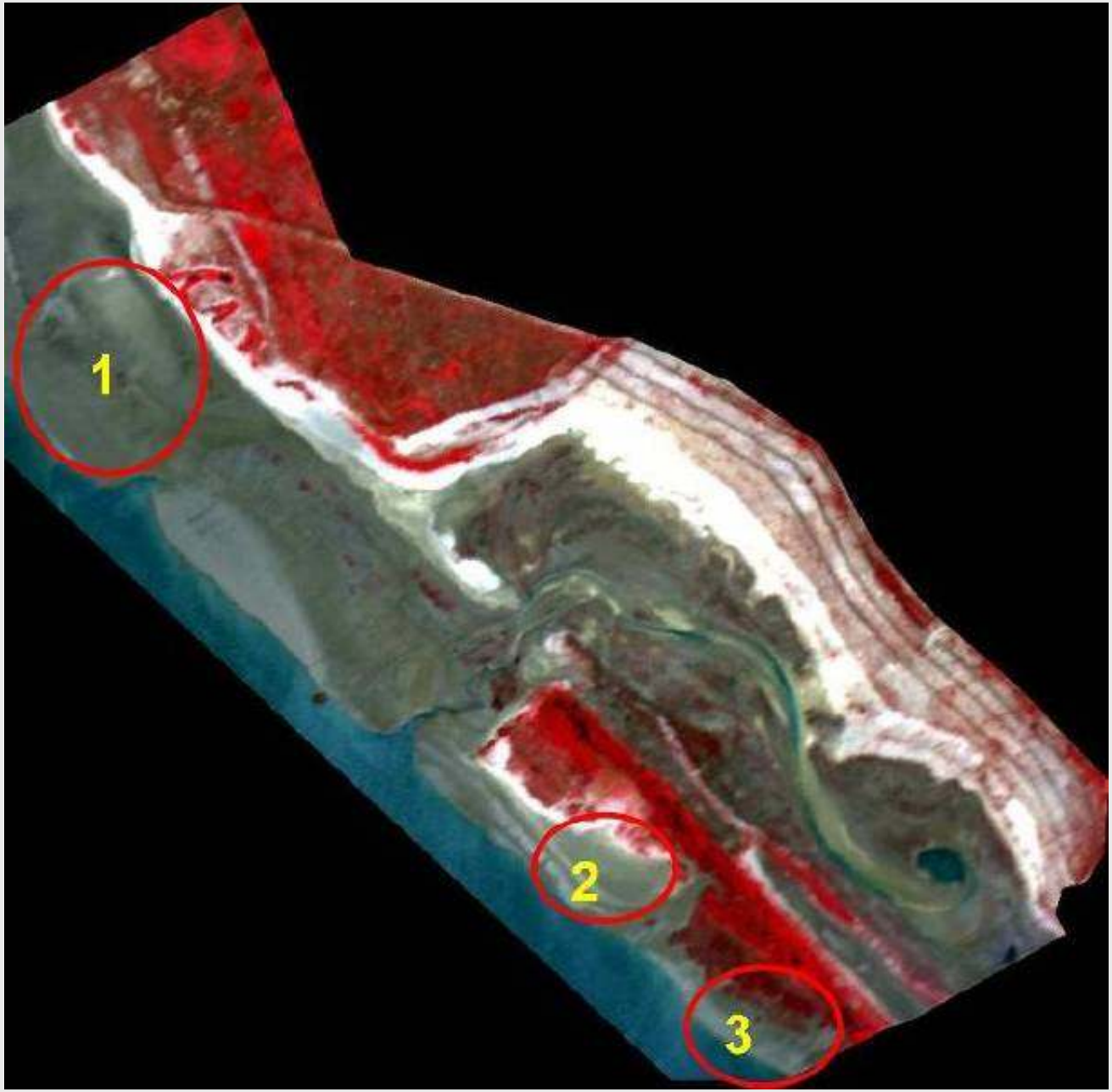
- More work on unsupervised classification is needed
- Detailed Temporal Analysis
- Low tide and high tide case analyses
- Laboratory experiments to find the influence of sediment parameters on reflectance

References

- Deronde, P. Kempeneers and R.M. Forster, 2006. Imaging spectroscopy as a tool to study sediment characteristics on a tidal sandbank in the Westerschelde. Estuarine. Coastal and Shelf Science, 69:580-590.

- MIXMOD software developed jointly by Inria, Laboratory of Mathematics of Besançon, Laboratory of Mathematics of Lille and Laboratory Heudiasyc (Compiègne) in France

- MONAY project report: Monitoring Nature Restoration IJzermonding: July 2001- June 2004.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