Sediment characterization in 'De IJzermonding' using an empirical orthogonal function: application to CASI

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Study area: nature reserve ‘De IJzermonding’

- situated near Nieuwpoort at the outlet of the IJzer in the North Sea
- ~100ha of dunes and mudflats
- very high biodiversity due to the many gradients (salt-fresh; silt-sand; wet-dry)
- the erodability of sediments is dependent on
  - air exposure/dehydration
  - physical factors
  - biological factors (macrofauna, microphytobenthos, higher plants)

Problem statement and objectives

- An improved quantification of the role of biological and physical factors in hydro- and sediment dynamics is required to develop models for understanding and predicting changes in mudflat morphology
- These questions are difficult to address by direct experiments or field studies. Mudflats are difficult and often dangerous to access
- Hyperspectral airborne remote sensors are promising: high spatial and spectral resolution, and operational flexibility

Problem statement and objectives

Extraction and interpretation of the information of hyperspectral images using:

- method using endmember extraction and spectral angle mapper (SAM)
- method using empirical orthogonal functions (Principal Component Analysis)

Focus on classification of sand and silt

Data Availability

	CASI 2001	CASI 2003
Date	08-24-2001	06-16-2003
Moment of overflight	low tide, after a considerable time of air exposure	two hours after low tide
Spatial resolution	2m pixel size	2m pixel size
Spectral range	430-971nm	408-944nm
Spectral resolution	96 bands	48 bands
Radiometric resolution	8-bit	8-bit
Quality	Good	good
Spatial coverage	IJzermonding not complete; only 1 flight line	IJzermonding complete, but partly flooded, due to late overpass of airplane

Methodology

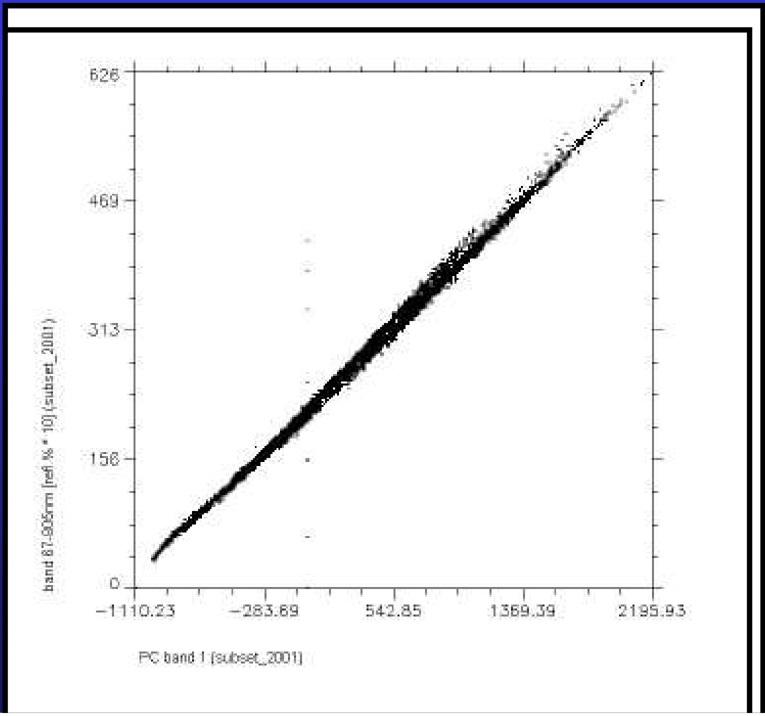
1. image preparation:
   - exclusion of bad bands
   - spatial subsetting (watermask)

2. classification method using principal component analysis (PCA)

3. classification method using endmember extraction and spectral angle mapper (SAM)

PCA classification method

- Calculation of a new set of orthogonal axes that have their origin at the data mean and that are rotated so the data variance is maximized
- First 2 PC's explain more than 99.2% of the data variability for both images (reduction of dimensionality)
- Knowledge about terrain, image --> PC 1 and PC 2 catch variation in NIR and VIS (red absorption) respectively



- sand: high NIR reflectance no red absorption
- vegetation: high NIR reflectance red absorption
- silt with algae: low NIR reflectance red absorption feature
- mixed sediment: low NIR reflectance no red absorption

Classification method using endmember extraction and spectral angle mapper

Minimum Noise Fraction Transformation (MNF)

↓

Pixel Purity Index calculation (PPI)

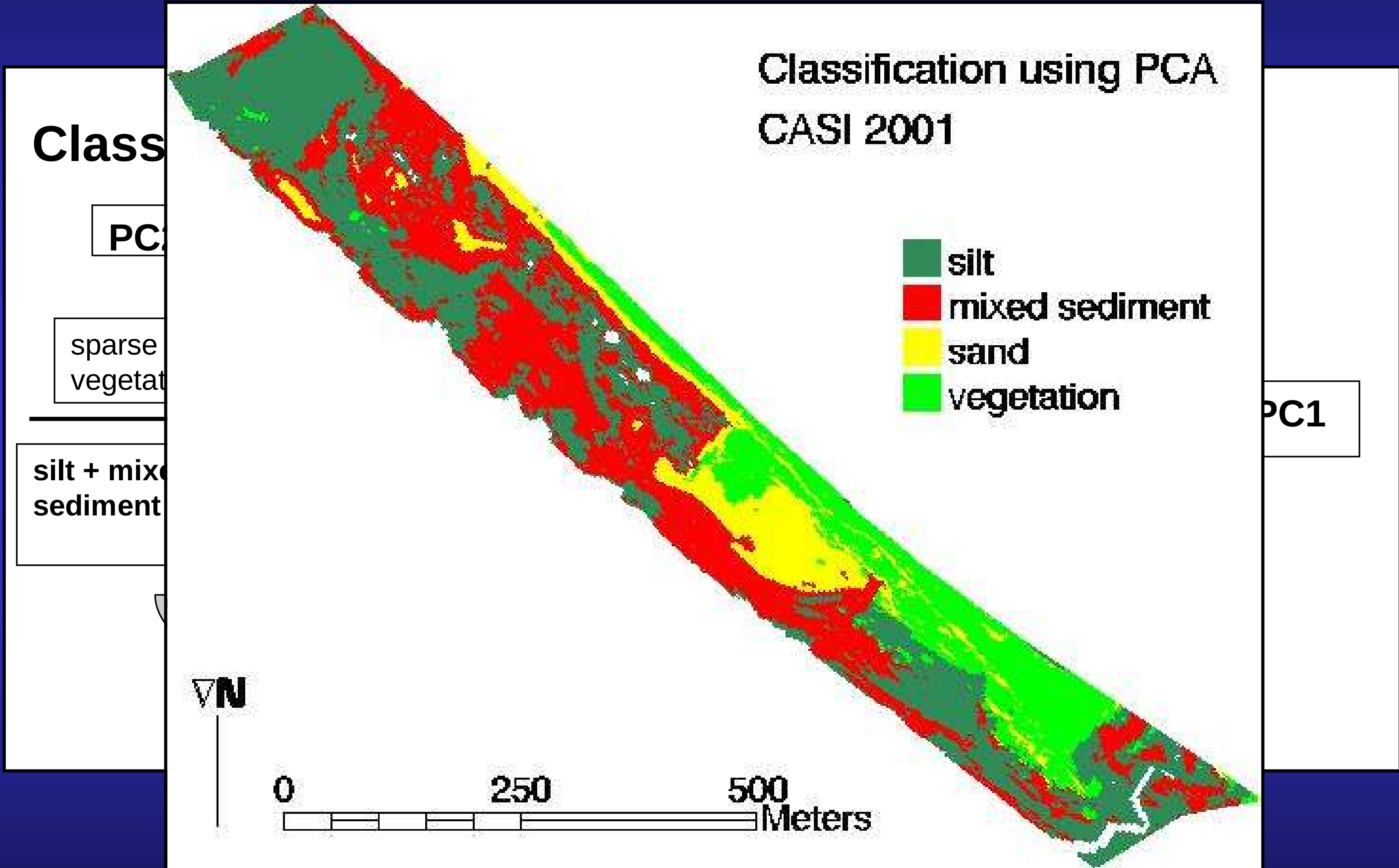
↓

n-Dimensional visualization of pure pixels and collection of endmembers

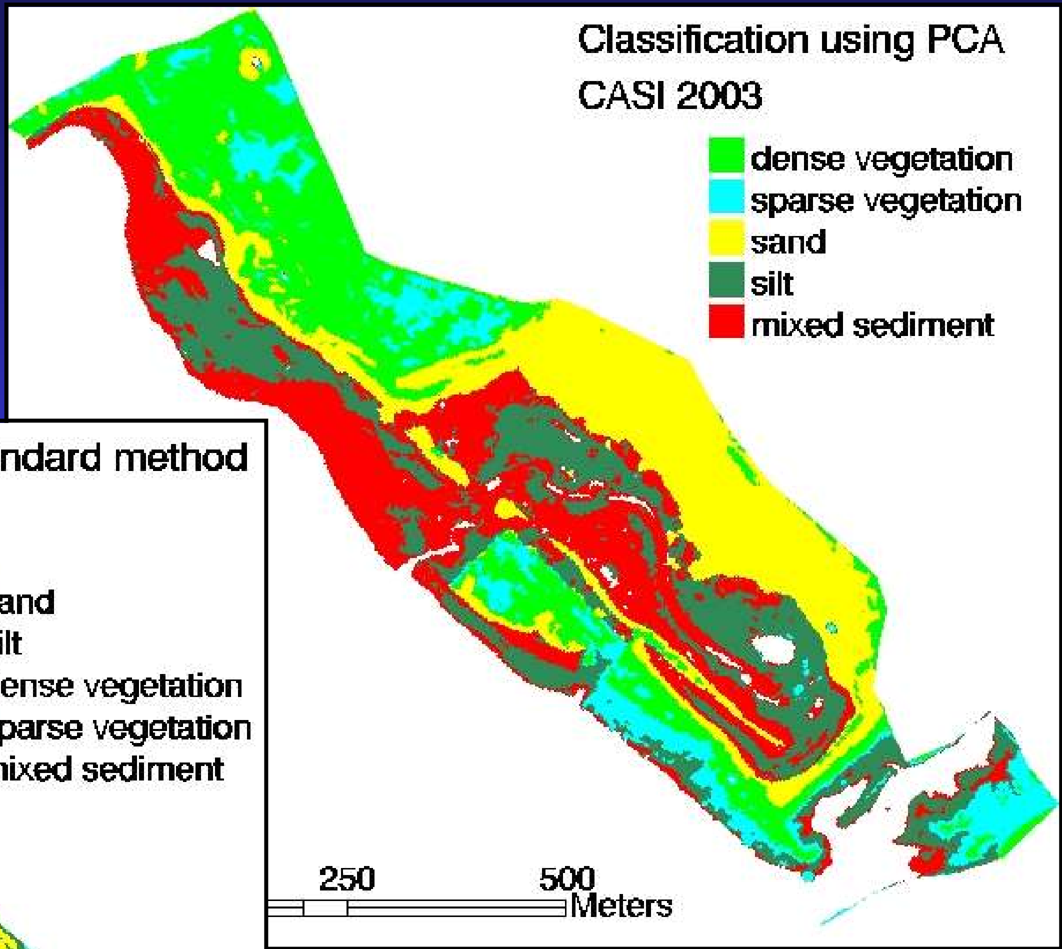
↓

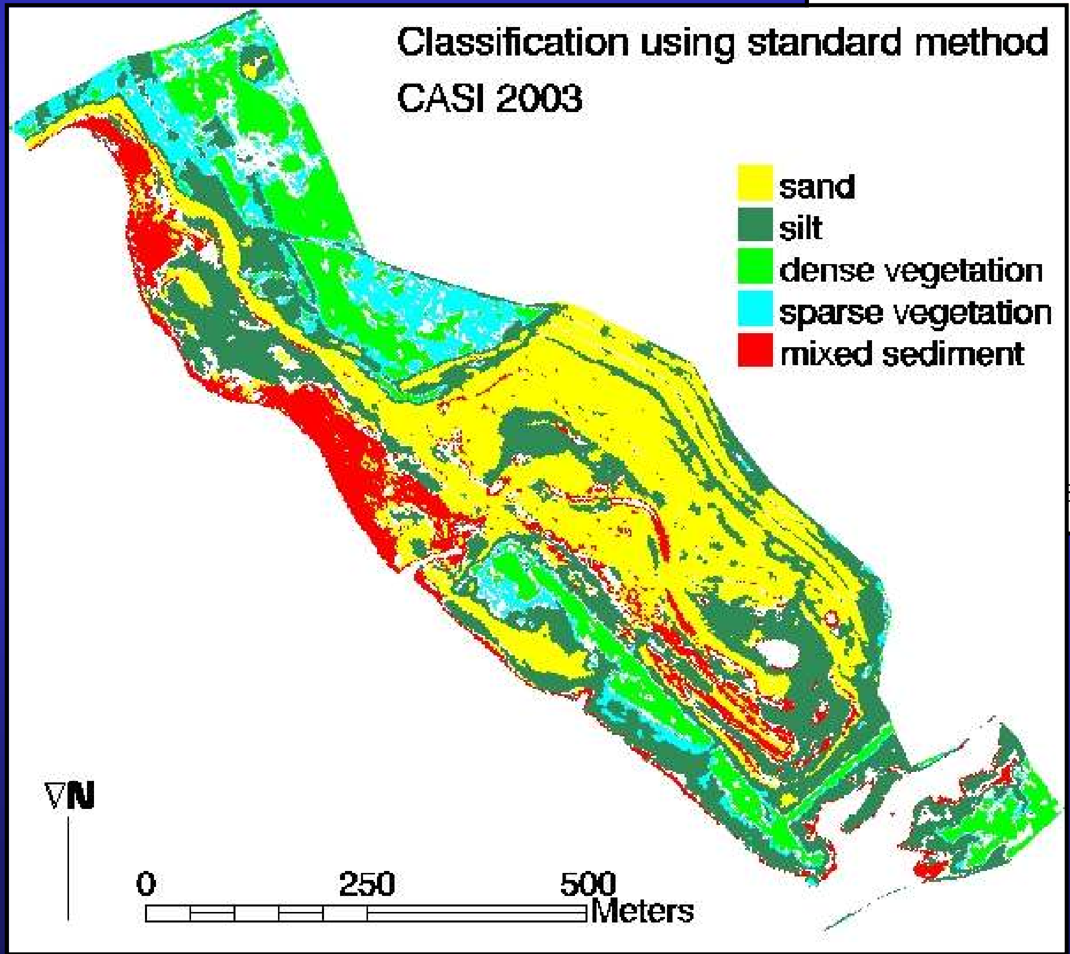
Spectral Angle Mapper (SAM) classification

Results: PCA classification method



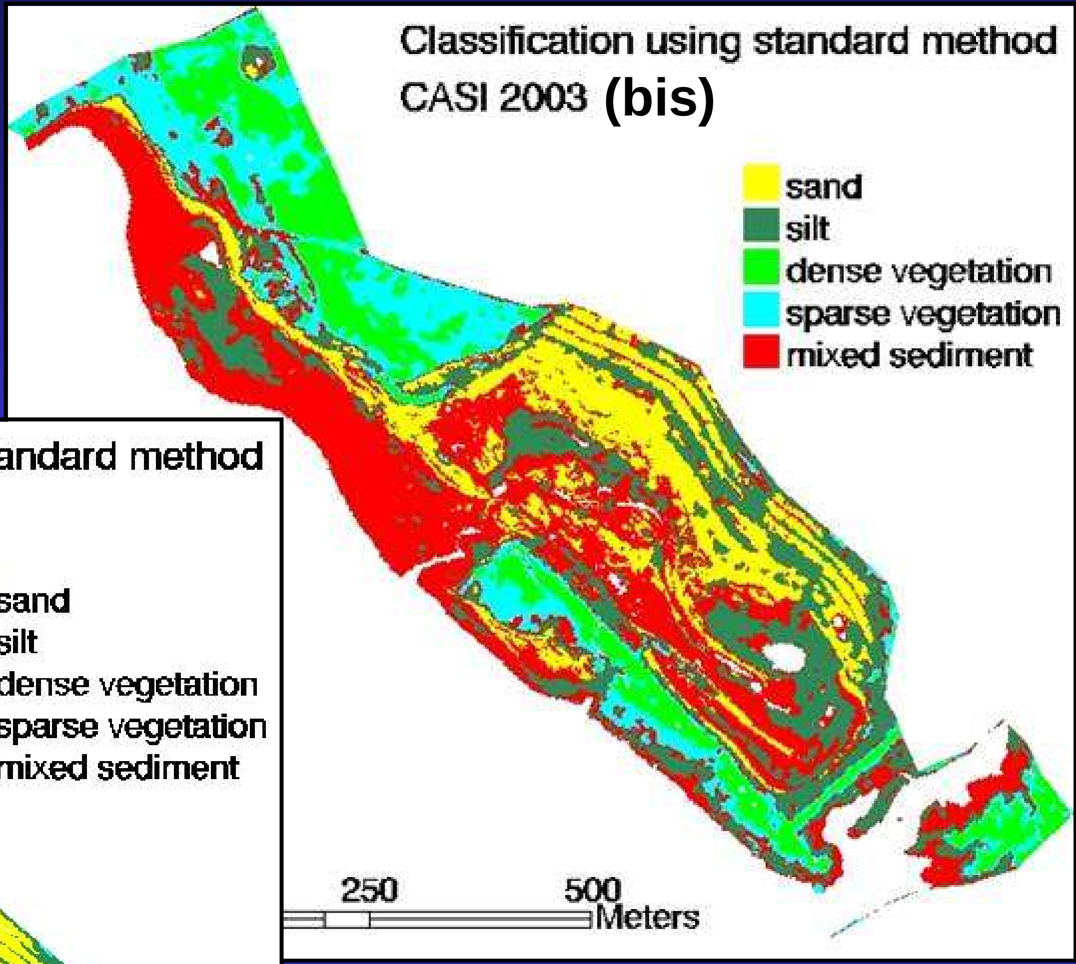
Comparison of classification results of both methods

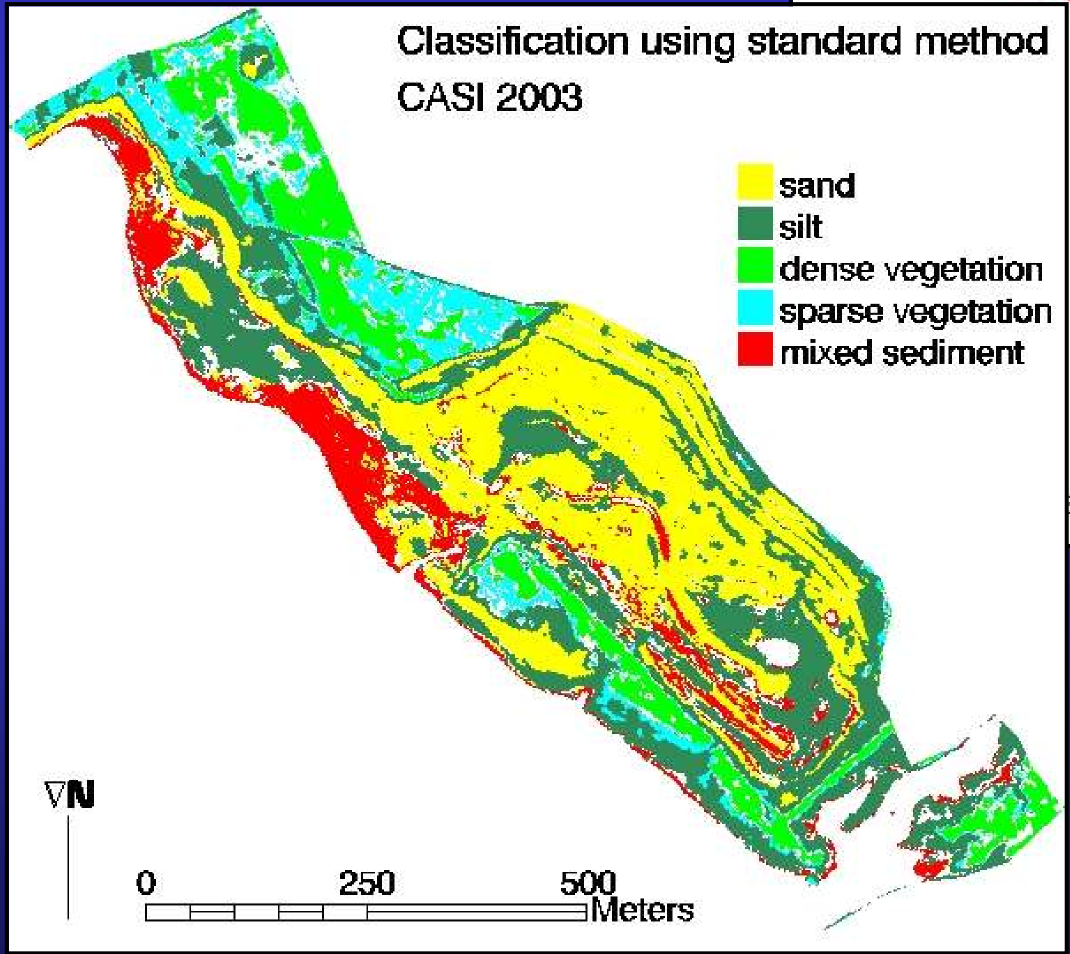




Overall similarity: 61%

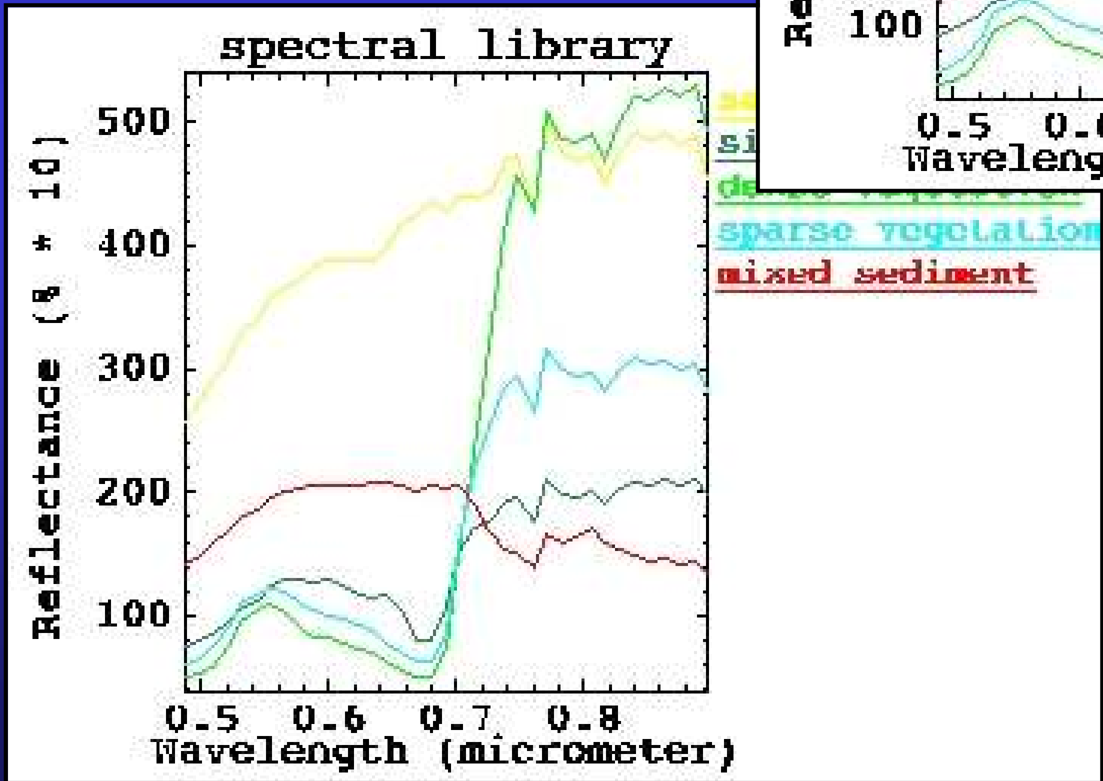
Comparison of classification results of two different runs of standard method

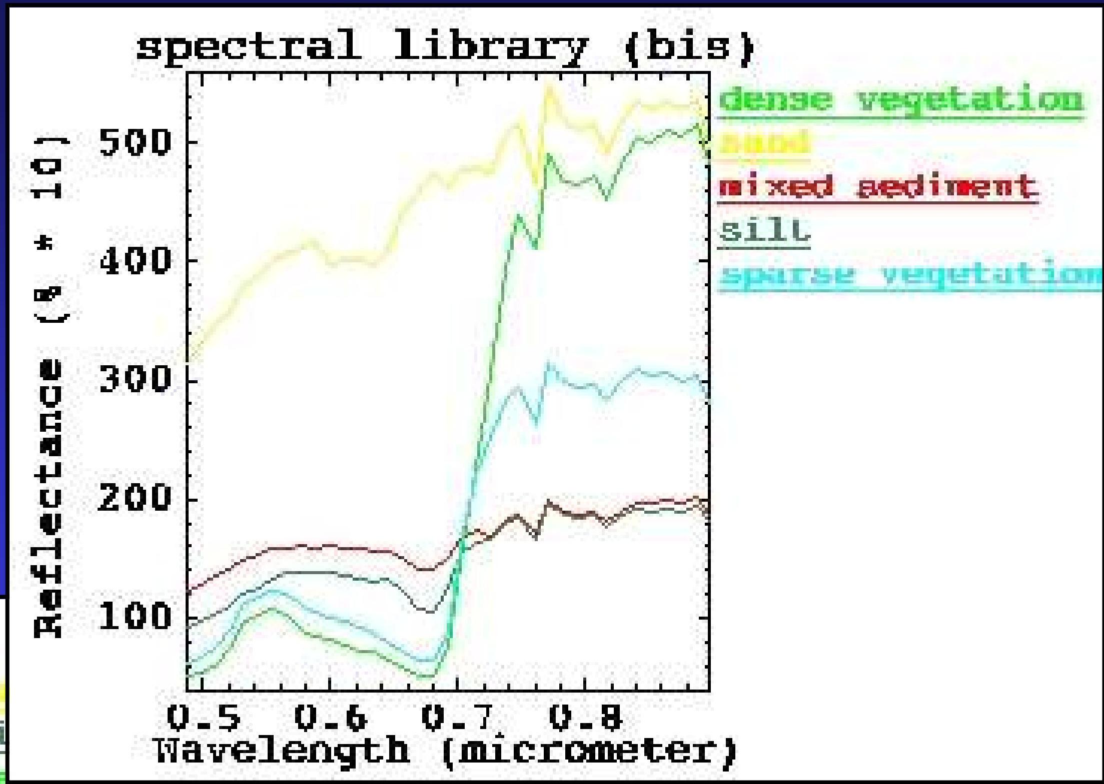




Overall similarity: 72%

Comparison of spectral libraries of two different runs of standard method





Conclusions

- Hyperspectral images offer the possibility to identify some important sediment characteristics
- The proposed method using PCA:
  - fast, easy and robust (no interference of expert necessary). The method can be automated and performed in few steps
  - the results are interpretable and reproducible
  - some previous knowledge about the number of classes present in the image is necessary.
- A classification method based on PCA is superior of the method of endmember extraction and spectral angle mapper with regard to user-friendliness, repeatability and physical interpretability
- An accuracy assessment of both methods should be made, but was not possible due to lack of ground truth data

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