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

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

Classification using PCA
CASI 2001

- silt
- mixed sediment
- sand
- vegetation

PC1 – NIR reflectance
PC2 – red absorption

Classification method:
- Sparse vegetation
- Dense vegetation
- Silt + mixed sediment
- Sand
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
Acknowledgements

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- AMINAL