Monitoring the evolution of the tidal estuary of the Scheldt river and its upstream river network based on LiDAR and airborne imaging spectroscopy

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Introduction

River Scheldt
- Main river: 350 km
- Drainage basin: 22000 km²
- Total population: 7 million
- Fresh – Brackish – Salt water
- Economical function
  - Port of Antwerp
  - National transport
- Ecological function
  - Wetland, Marches and intertidal plates
  - Rich variety of water species in all trophic levels

Ref: www.scheldenet.nl
Introduction

Our study area

Total Estuary length: 35 km
Total area: 300 km²

Total river-network Length: 220 km
Total Area: 200km²
Monitoring the Tidal Estuary

» Ecological monitoring program of the Westerscheldt
» Hyperspectral data for support
» Yearly flight campaign from 2005 to 2008

<table>
<thead>
<tr>
<th>Overview</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>AHS160 (80 bands)</td>
<td>CASI3 (18 bands)</td>
<td>AISA (16 bands)</td>
<td>CASI3 (18 bands)</td>
</tr>
<tr>
<td>Number of flight lines</td>
<td>3</td>
<td>4</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Number of tidal plates and shores</td>
<td>2</td>
<td>1</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>4 m</td>
<td>1 m</td>
<td>1 m</td>
<td>2 m</td>
</tr>
<tr>
<td>Date</td>
<td>June</td>
<td>June</td>
<td>August</td>
<td>August</td>
</tr>
</tbody>
</table>
Monitoring the tidal estuary

- Processing in Central Data Processing Centre (CDPC) @ VITO
- Radiometric/geometric/atmospheric correction

Smile correction
Before & After

Intertrack reflectance calibration
Before & After
Monitoring the tidal estuary

» Processing in Central Data Processing Centre (CDPC) @ VITO
   » Radiometric/geometric/atmospheric correction
   » Mosaic/partitioning flightlines into tidal plates and shores
Monitoring the tidal estuary

» Processing in Central Data Processing Centre (CDPC) @ VITO
  » Radiometric/geometric/atmospheric correction
  » Mosaic/partitioning into tidal plates and shores
  » Building water, land and cloud masks
Monitoring the tidal estuary

» Processing in Central Data Processing Centre (CDPC) @ VITO
  » Radiometric/geometric/atmospheric correction
  » Partitioning/mosaic into tidal plates and shores
  » Building water, land and cloud masks
  » Simple unsupervised classification algorithm for sediment, saltmarsh vegetation and microphytobenthos (MFB) with the aid of field measurements
Monitoring the tidal estuary

Results
Monitoring the tidal estuary

Results: intercomparison

Sediment - Ecotop Klassen
- Water very light sediment
- Not suitable for sand
- Sand
- Green: moderate concentration MFB
- Yellow: high concentration MFB
- Red: very high concentration MFB
- Brown: silt

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Mapping the upstream river network

Overview

Total length of river network mapped: 220km
57 hyperspectral flightlines
and
68 LiDAR flightlines
Mapping the upstream river network

Flightplanning

Schelde 2007
Hyper spectral survey
Flight planning
(All times in UTC)

Flightline 18 & 19 can be flown on 13/07/07 between 12:29 & 13:44

Flightline 11 & 12 can be flown on 13/07/07 between 08:45 & 09:24

Low waters in Antwerp
13/07/07
[1]-(08:29 UTC)
[2]-(20:58 UTC)
Mapping the upstream river network

<table>
<thead>
<tr>
<th>Hyperspectral</th>
<th>LiDAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AISA Eagle</strong></td>
<td><strong>Riegl LMS Q560</strong></td>
</tr>
<tr>
<td>Field-of-View (FOV)</td>
<td>Laser pulse rate</td>
</tr>
<tr>
<td>Instantaneous FOV (IFOV)</td>
<td>Scan Angle (FOV)</td>
</tr>
<tr>
<td>Pixel number</td>
<td>Max scan incidence</td>
</tr>
<tr>
<td>Flight altitude</td>
<td>Flight altitude</td>
</tr>
<tr>
<td>Swath width</td>
<td>swath width</td>
</tr>
<tr>
<td>Across/Along track GSD</td>
<td>Laser beam footprint diameter</td>
</tr>
<tr>
<td>Wavelength</td>
<td>Scan frequency</td>
</tr>
<tr>
<td>FWHM (bands 1-4, 5-28, 29-32)</td>
<td>Flight speed</td>
</tr>
<tr>
<td>Number of bands</td>
<td>Point density</td>
</tr>
<tr>
<td>Overlapping</td>
<td>Overlapping</td>
</tr>
<tr>
<td>Line spacing</td>
<td>Line spacing</td>
</tr>
<tr>
<td><strong>Data volume</strong></td>
<td><strong>Data volume (filtered DTM)</strong></td>
</tr>
</tbody>
</table>

⇒ Mapping sediments, tidal marshs and bank vegetation

⇒ Detailed topographic mapping
Mapping the upstream river network

» Data preprocessing @ CDPC

What to do if no DGPS information is available??
Mapping the upstream river network

Data preprocessing: Interactive geo-correction tool

Making use of georeferenced orthophotos.
Select scanlines every 100 line
Move select scanlines to correct position with the aid of the reference orthos
Interpret and apply the correction for all scanlines
Mapping the upstream river network

» Data preprocessing: geometrical corrections
Mapping the upstream river network

1. Detection of water bodies (591 & 835nm)
2. Detection of shadow above water bodies (835nm)
3. Separation vegetation <-> non-vegetation (NDVI=0.45)
4. Detection of microphytobenthos on mud flats
   - Low: \[ 0.2 = \text{NDVI} < 0.25 \]
   - Medium: \[ 0.25 = \text{NDVI} < 0.32 \]
   - High: \[ 0.32 = \text{NDVI} < 0.45 \]
5. Detection of sediment types: wet mud containing sand; sand; water saturated (ISODATA with 30 classes, 20 iterations)
Mapping the upstream river network

» Mapping the sediments and vegetation – expert system
  1. Detection of water bodies (591 & 835nm)
  2. Detection of shadow above water bodies (found in slides..)
  3. Separation vegetation <-> non-vegetation (NDVI=0.45)
  4. Detection of microphytobenthos on mud flats
     \[ \text{Low} \] \( 0.2 = \text{NDVI} < 0 \)
     \[ \text{Medium} \] \( 0.25 = \text{NDVI} < 0.32 \)
     \[ \text{High} \] \( 0.32 = \text{NDVI} \)
  5. Detection of sediment types: wet mud containing sand; sand; water saturated (ISODATA with 30 classes)

» Mapping the tidal marshes and bank vegetation - LDA
  6. Training based on 248 ground reference points
     » 6 Brackish water veg. species
     » 6 Fresh water veg. species
     » 4 Bank vegetation veg. species
  7. Linear Discriminant analysis
Mapping the upstream river network

» Detailed topographic mapping (LIDAR)

• Use DEM to identify bend lines
• Field work for interpretation
Mapping the upstream river network

» Result: classical cartography → vector layer
Mapping the upstream river network

» Result: Automated mapping for the follow-up of the river banks and salt marshes of the river Scheldt by multiple RS techniques
Conclusions

» River Scheldt, giving access to the port of Antwerp with unique ecological value.
» Repeated hyperspectral monitoring of the Westerschelde for
  » Stability of tidal plates
  » Investigate alternative dumping of dredging material
» Combination of hyperspectral and LIDAR RS techniques to map the river network
  » Practical issues to handle the vast amount of data
  » Situated within the European Union Water Framework Directive (WFD), this approach will be executed every 3/6 years.
» Allow decision makers to visualize the ecological importance of the river Scheldt during discussion around the accessibility of the port of Antwerp
THANK YOU...