PROGRAMMATORISCHE FEDERALE OVERHEIDSDIENST
*WETENSCHAPSBELEID*

RESEARCH PROGRAMME FOR EARTH OBSERVATION "STEREO"
Partnerships between Industry and Research

ONDERZOEKSCONTRACT
CONTRAT DE RECHERCHE
**SR/67/36**

155398

PROJECT

Operational Remote sensing Mapping of Estuarine suspended Sediment
concentrations (ORMES)

Operationele kartering van suspensiesedimentconcentraties in estuaria
door middel van aardobservatie (ORMES)

**THE PARTNERSHIP**

SCIENTIFIC PARTNER
Vlaamse Instelling voor Technologisch Onderzoek (VITO)

PRIVATE PARTNER
International and Marine Dredging Consultants (IMDC)

PROGRESS REPORT #2
Covering the period from 15/06/2005 to 15/01/2006

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# 1. Activity report for the partnership

## 1.1    Summary

This activity report of the ORMES project describes the scientific progress made during the a six month period and the scientific plans for the next six months. The status of the work packages and corresponding deliverables is illustrated in Table 1

### Table 1: *ORMES deliverable status*

| | 2005 1-3 | 2005 3-6 | 2005 7-12 | 2006 |
|---|---|---|---|---|
| **WP 0 Project management** | | | | |
| 0.1 Coordination | C | C | C | C |
| 0.2 Organization meetings | C | C | C | C |
| 0.3 Diffusion valorization | C | C | C | C |
| 0.4 Reports | | D | | |
| **WP 1 Reviewing** | D | D | | |
| **WP 2 Campaign preparation** | | | | |
| 2.1 Specifications | | D | | |
| 2.2 Subcontracting flight agency | D | D | | |
| 2.3 Deployment spectrometers | | D | | |
| 2.4 Transport model optimizing | | | D | P |
| **WP 3 Campaign** | | | | |
| 3.1 Atmospheric measurements | | D | | |
| 3.2 Reflectance measurements | | D | | |
| 3.3 Turbidity measurements | | D | | |
| 3.4 Water samples | | D | | |
| **WP 4 Processing field data** | | | | |
| 4.1 Laboratory analysis | | D | D | |
| 4.2 Conversion turbidity | | D | D | |
| **WP 5 Processing image data** | | | | |
| 5.1 pre-processing | | | D | |
| 5.2 Applying algorithms | | | B | P |
| 5.3 Accuracy assessment | | | | P |
| 5.4 determination min. sample size | | | | P |
| **WP6 exporting methodology** | | | | P |
| **WP 7 Validation** | | | | P |
| **WP 8 Implementation** | | | | |
| 8.1 Specification software | | | | P |
| 8.2 Development of software | | | | P |
| 8.3 Implementation | | | | P |

D: Delivered, B: Busy as planned, P: Planned delivery, C: Continuous activity

## 1.2 Scientific progress, activities and results

### 1.2.1 Work Package 0 - Project Management

- On October 7th the ORMES project has been presented by a poster presentation on the Bruges hyperspectral workshop.
- An abstract has been submitted for the International Hydrographic Conference 2006 in Antwerp

### 1.2.2 Work package 3 – Campaign

On June 23, reflectance measurements were done on 5 targets surrounding the Scheldt using an ASD spectrometer. These targets can help in the atmospheric correction of the AHS images. The location of these targets is illustrated in Figure 1.

### 1.2.3 Work Package 4 – Processing field data

All water samples taken during the field campaign have been analyzed at VITO to obtain suspended sediment concentrations and determine chlorophyll content (Table 2).

| Sample | CHL ng/l | CHL mg/m$^3$ | SPM mg/l = g/m$^3$ | NAP (~=SPM -0.07*CHL) g/m$^3$ |
|--------|----------|--------------|---------------------|-------------------------------|
| A55 | 5477 | 5.477 | 30 | 29.6 |
| A56 | 4647 | 4.647 | 65 | 64.6 |
| A57 | 6805 | 6.805 | 69 | 68.5 |
| B60 | 3209 | 3.209 | 36 | 35.7 |
| B62 | 3301 | 3.301 | 16 | 15.7 |
| B63 | 3320 | 3.32 | 21 | 20.7 |
| C49 | 11249 | 11.49 | 4 | 3.1 |
| C50 | 26925 | 26.92 | 12 | 10.11 |

Table 2: Chl, SPM and NAP concentrations obtained from water samples from boat A (A55, A56, A57), boat B (B60, B62, B63) and boat C (C49, C50)
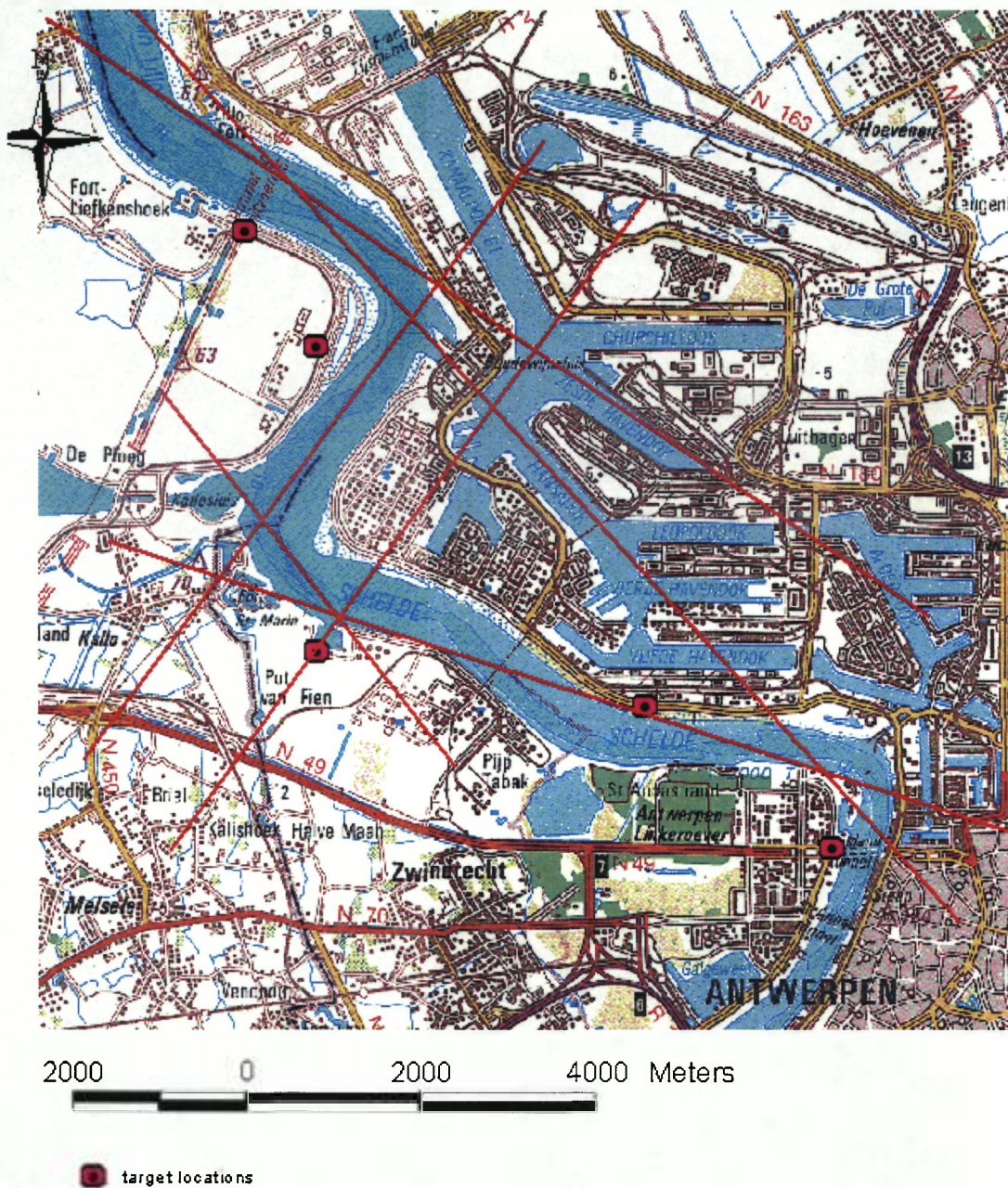
**target locations**

**Figure 1: Location of targets**

The spectral analysis of the water samples is finished and absorption and backscattering are derived according to methods described by Tassan and Ferrari (1995). Figures 2 till 5 show the specific absorption of particles, Chl , NAP and the specific backscatter coefficient of particles. Spectra's A55, A56 and A57 were sampled at boat A, spectra's B60, B62 and B63 were sampled at boat B and spectra's C49 and c50 were sampled at boat C.
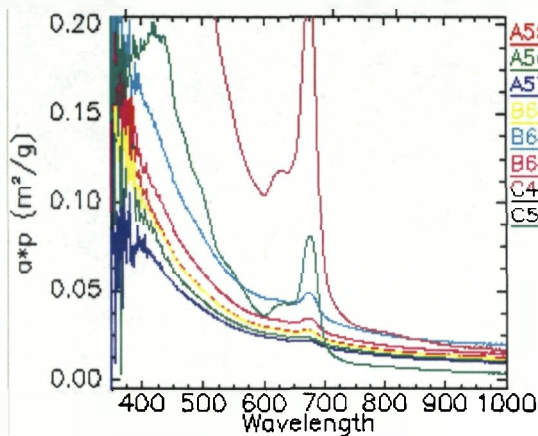


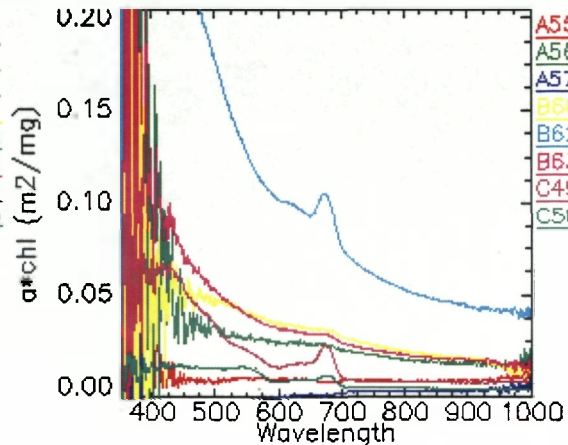Figure 2: Specific absorption particles
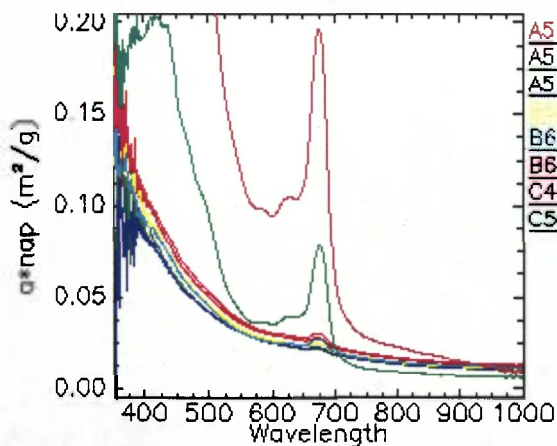


Figure 3: Specific absorption Chl (m2/mg)



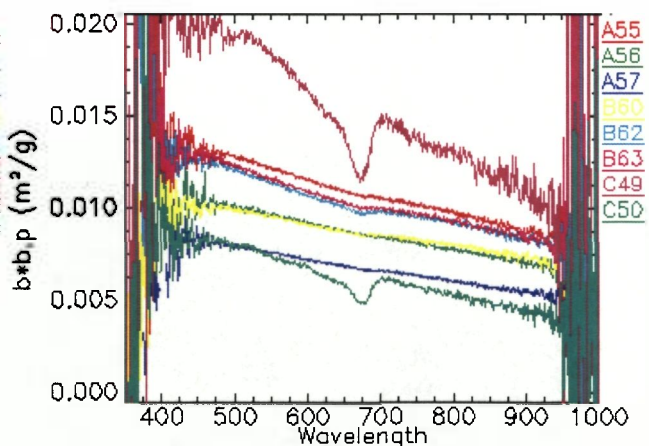Figure 4: Specific absorption nap (m2/g) (m2/g)



Figure 5: Specific backscattering particles

The grain size distribution was obtained from 3 samples, one from boat A, B and C. The results were not accurate since the signal to noise ratio of all samples was low (Figure 6,7,8).
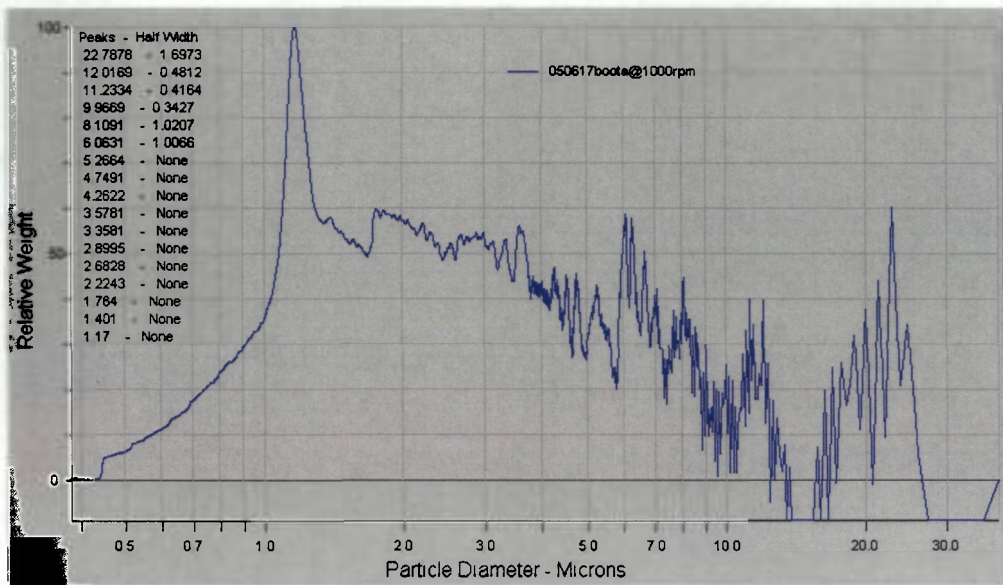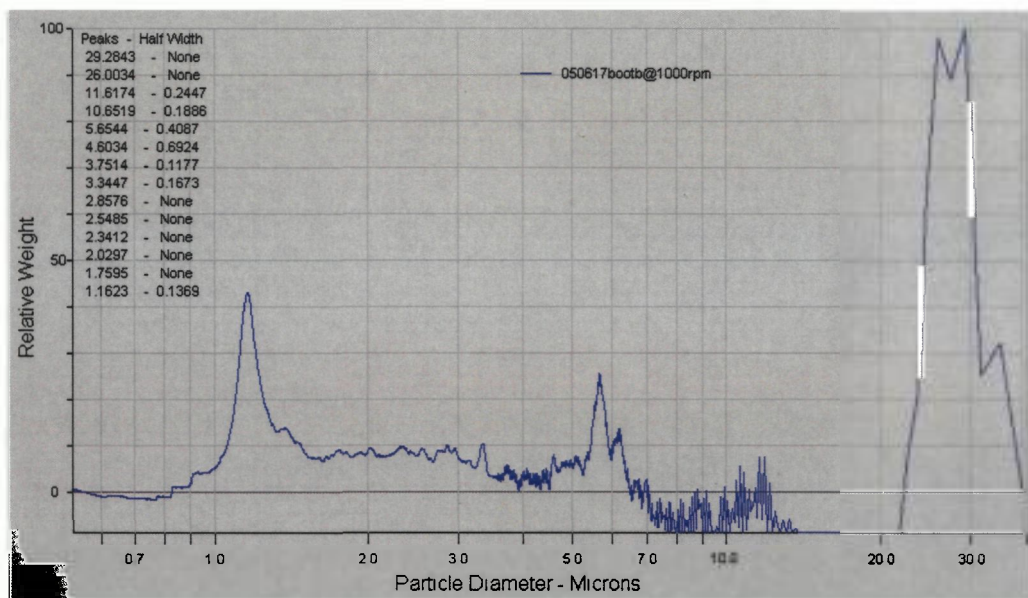
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**Figure 6: grain size distribution boat A**



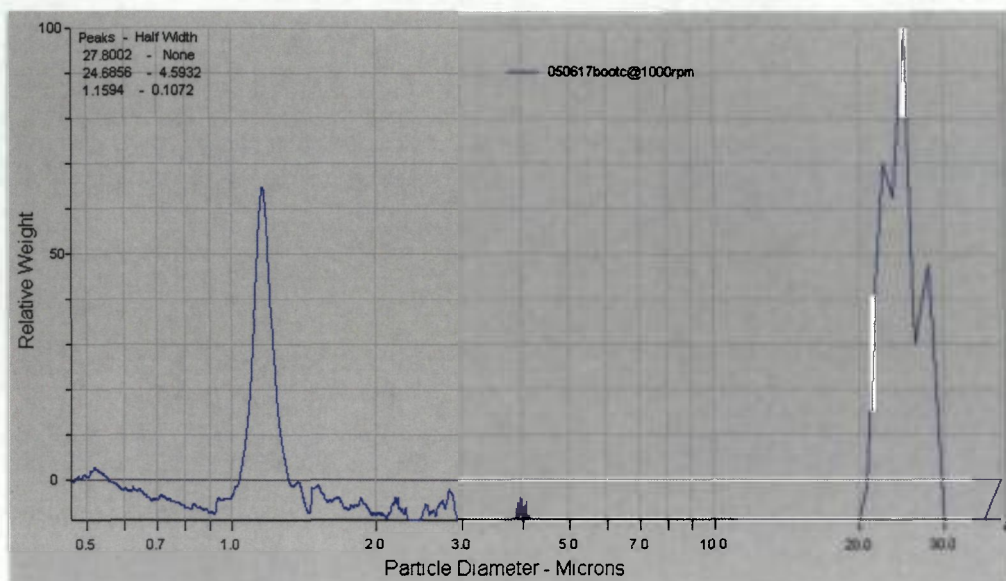**Figure 7: Grain size distribution boat B**

**Figure 8: Grain size distribution boat C**

Turbidity measurements were conducted simultaneously on all 3 boats at 1 m below the water surface. These instruments logged time, depth and turbidity every 14 seconds. Turbidity values were converted to suspended sediment concentration using the equation of the calibration curve.
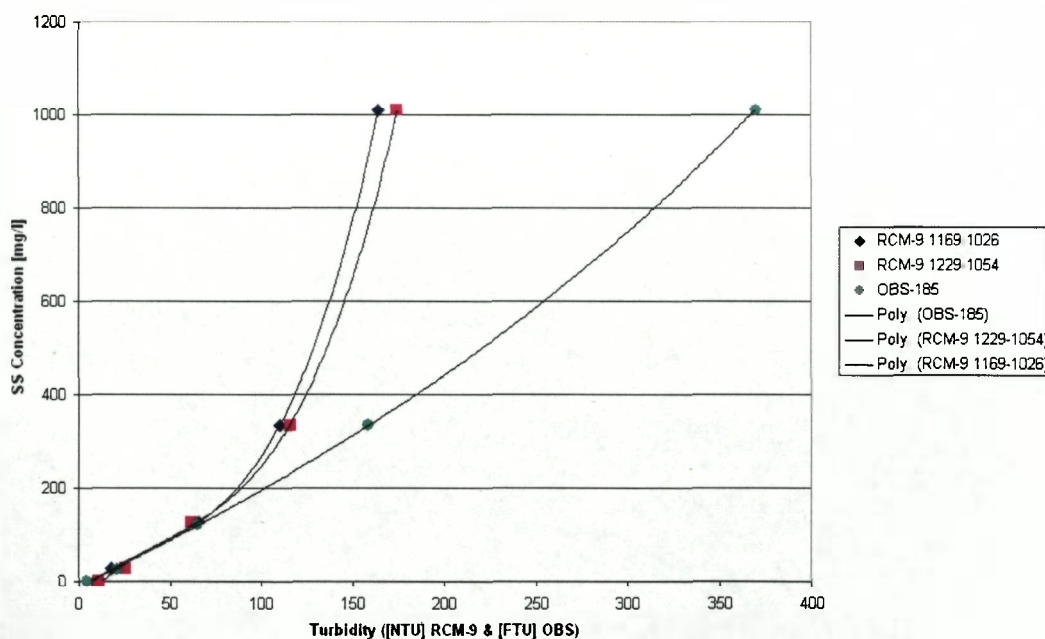


**Figure 9:Calibration Curves for RCM-9 (2) and OBS (1) sensors**

1 litre samples from the calibration mixture were filtered over a preweighed desiccated 0.45 micron filter, after which the filter was dried in an oven at 105°C, cooled and weighed to determine the suspended sediment concentration. The calibration curve for each instrument is shown in Figure 9.

Turbidity measurements were linked to GPS data using time and depth (secondary). Also depth profile measurements were conducted and processed to investigate vertical distribution of suspended sediment concentrations.

### 1.1.1 Work Package 5 – Processing image data

<u>Pre-processing</u>

The radiometrically calibrated AHS images from the ORMES campaign were delivered in August. The first images were taken under clear sky , the latter ones were covered with a thin cirrus cloud cover.

Subsequently a geometric, atmospheric and air-interface correction have been applied to the data using in-house software. As input to the atmospheric correction aerosol optical parameters were derived from the sun photometer data. After processing, these parameters could be adjusted iteratively by comparing the ASD reflectance and the image reflectance of the target.

For the last images, different cirrus models were included in Modtran. Figures 9 and 10 show an atmospherically corrected image using a clear sky and the two cirrus cloud models with a base altitude of 0.8 km over water and land respectively.
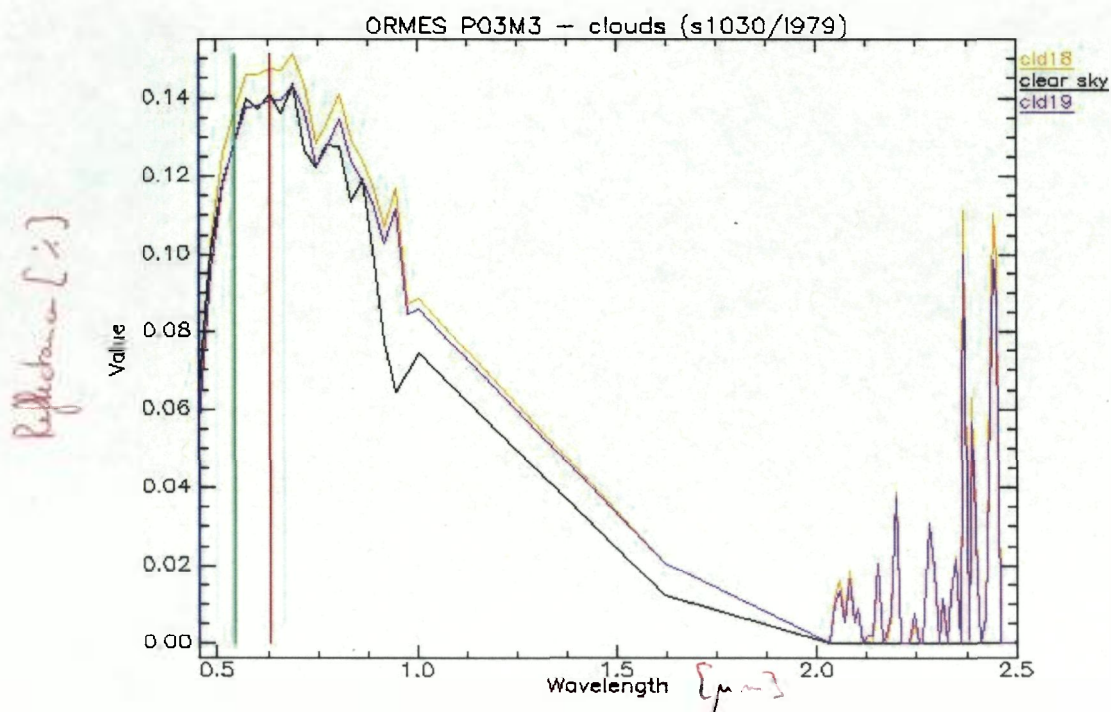
**Figure 10: waterleaving reflectance of image P03M3 (sample 1030-line 979)**

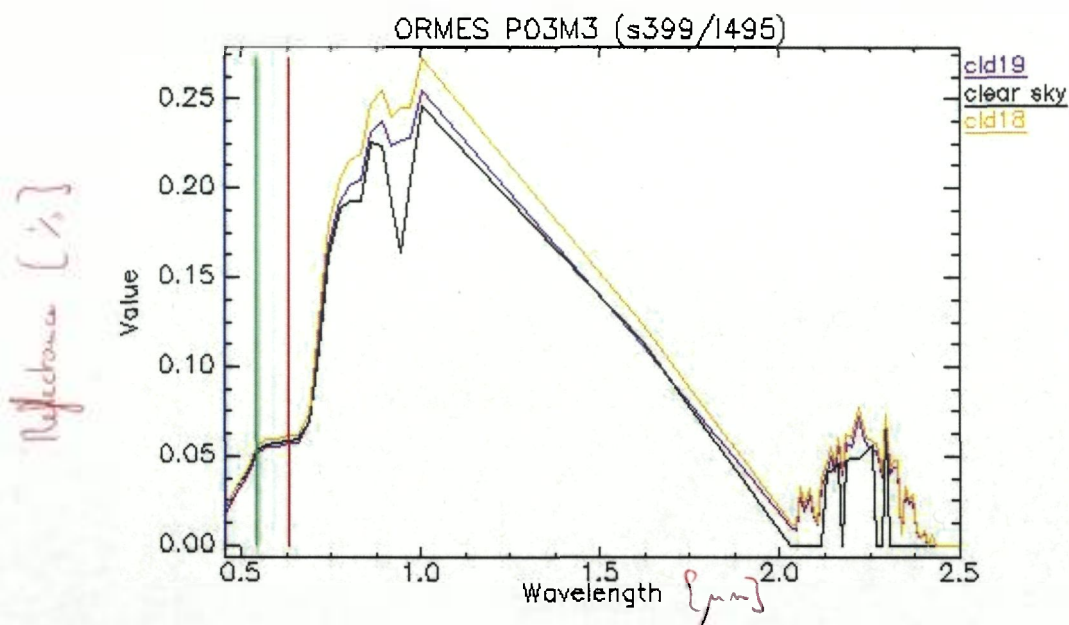cld 18 = standard cirrus model
cld 19 = sub-visual cirrus model



**Figure 11: Apparent reflectance of image p03M3 (sample 399-line 495)**

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? $R^2$ van 0,78 (met gevoeltje)
linker % betrouwbaarheidsinterval rond SS [mpk]

Applying algorithms

The retrieval of suspended sediment concentrations from the AHS data will be tested using:

1. the best algorithms from the literature.

Different empirical algorithms from the literature were tested using the in situ reflectance measurements, resampled to the AHS bands. These reflectance measurements were carried out on vessel A and vessel B, and not in the docks (vessel C) . The highest correlation coefficient (0.78) was obtained using the SPM algorithm of Matthews et al. (2001).
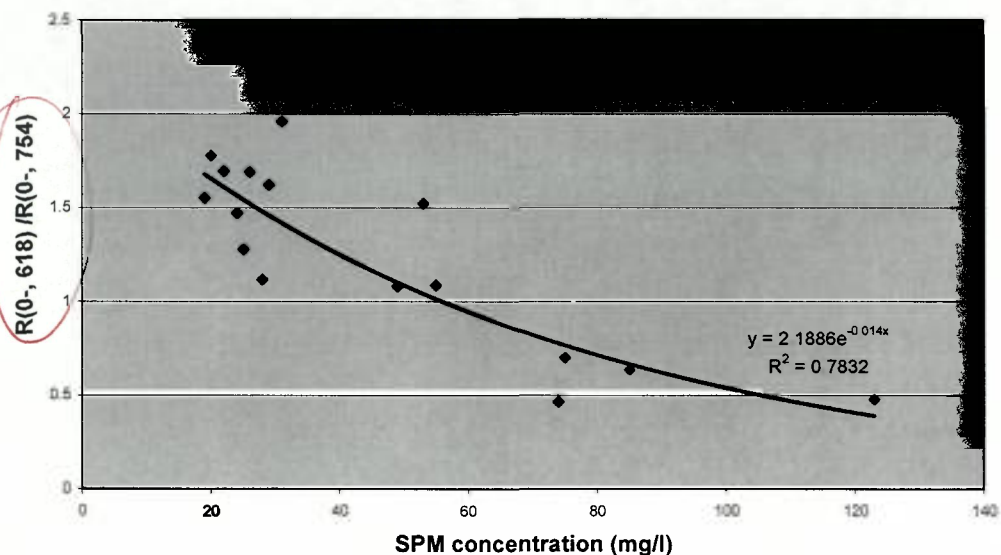


**Figure 12: R(0-) versus SPM concentration**

This algorithm was used to obtain a first suspended sediment map of the Scheldt. Figure 13 and 14 show the results for an image taken at 08:44 UTC time and 11:13 UTC time respectively.
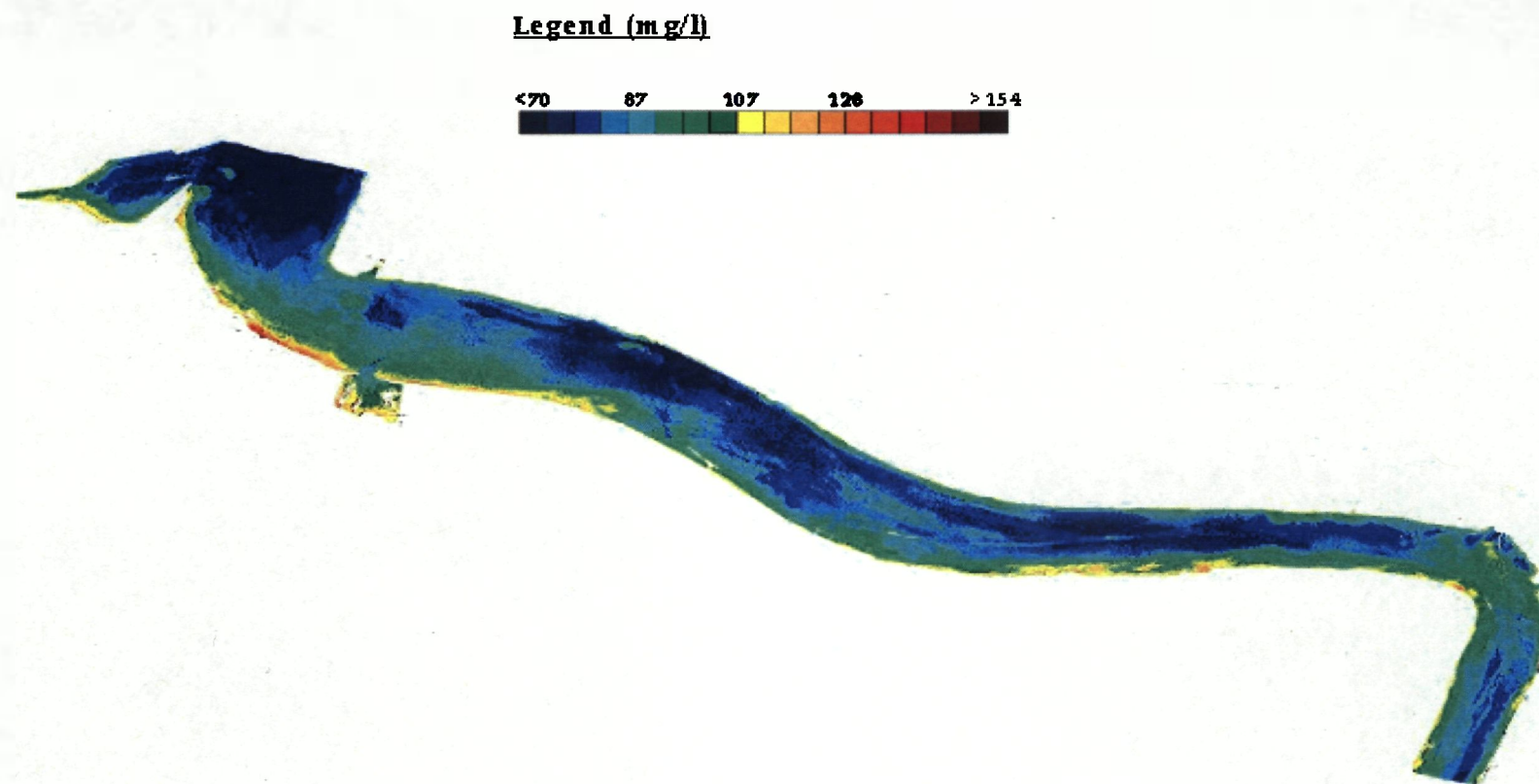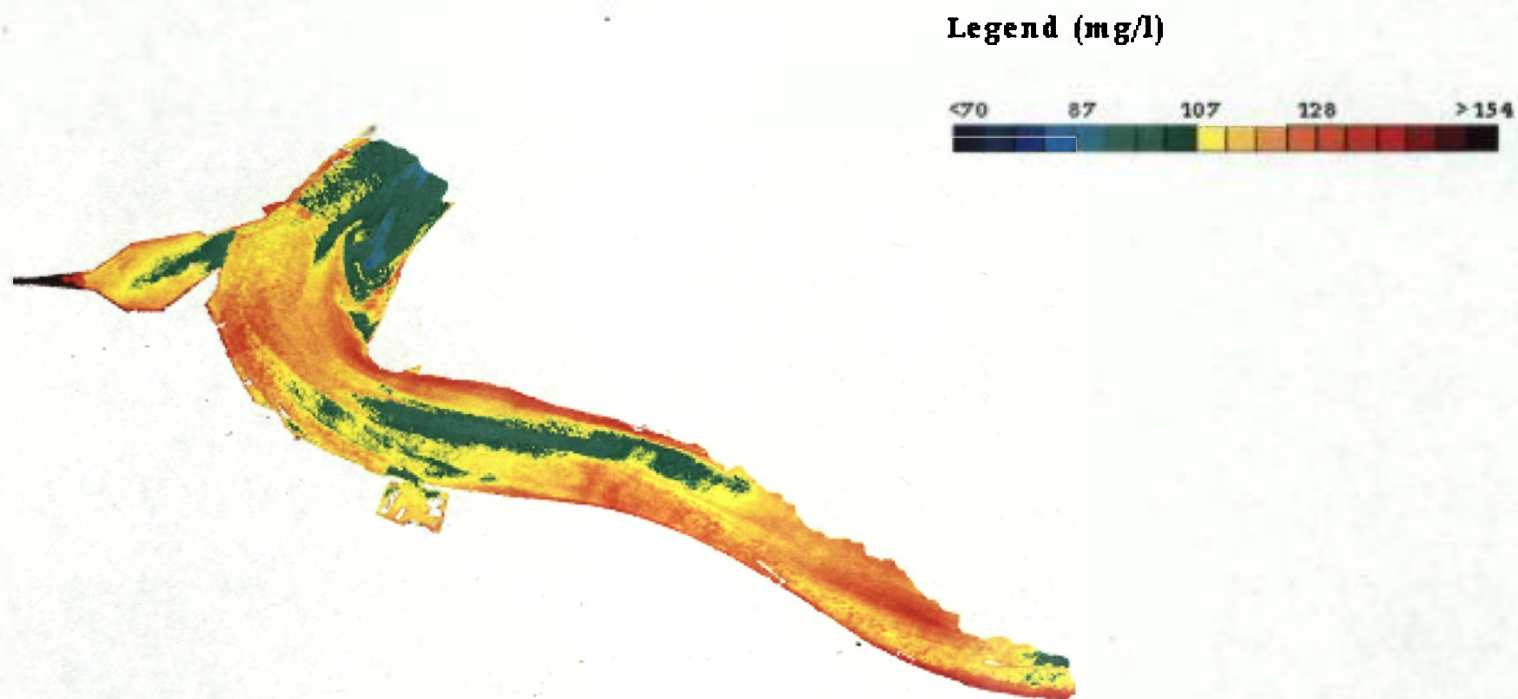
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Figure 13: SPM concentrations (mg/l) – Method 1 - 08 : 44u (UTC)

**Legend (mg/l)**

<70    87    107    128    >154

Figure 14: SPM concentrations (mg/l) – Method 1- 11 : 13u (UTC)

2. algorithms modified ourselves.

An IDL program was written to test linear and logarithmic relationships between in-situ SPM or turbidity measurements and image reflectance. Image reflectance can either be the reflectance in 1 band, a ratio of two spectral bands or a first derivative. Furthermore, a hydro-optical model is calibrated for this specific location and will be tested.

### 1.3 Problems encountered and solution adopted or proposed

The ORMES team has been looking for another validation site.

- Mugardos Spain: harbour measurements, but no sediment.
- Another cross-check will be done between historical measurement campaigns and satellite images available for that period: Umm Qassr measurements, Iraq.

### 1.4 Scientific activities planned for the next six months

The following tasks are planned in relation to work packages 4 and 5 :

- The accuracy of different suspended sediment retrieval algorithms will be tested on the AHS data

- determination minimum sample size

- exporting the methodology to satellite imagery

## 2. Administrative update to initial report

### 2.1 Steering Committee membership

The user partner, 'Waterbouwkundig Laboratorium en Hydrologisch onderzoek (WLH)' will be represented by Joris Vanlede and Eric Taverniers.

## Acknowledgement