Compact High Resolution Imaging Spectrometer (CHRIS): the future of hyperspectral satellite sensors

Imagery of Oostende coastal and inland waters

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OVERVIEW

- Introduction
- CHRIS/PROBA
- Traditional Ocean Colour satellite sensor vs. airborne imaging spectroscopy
- CHRIS potential
- CHRIS images from test site Oostende
  - Image processing
  - Sea
    - Comparison with other data sources
    - SPM & CHL
  - Inland: Spuikom
- Conclusion

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INTRODUCTION

- BELCOLOUR: creation of Suspended Particulate Matter (SPM) and chlorophyll maps
  - Airborne imagery: VITO
  - Satellite imagery: MUMM
    - SeaWiFS: Sea-viewing Wide Field of view Sensor
    - MERIS: MEdium Resolution Imaging Spectrometer Instrument
    - MODIS: Moderate Resolution Imaging Spectroradiometer
    - CHRIS: Compact High Resolution Imaging Spectrometer

- Why here?
  - Satellite sensor (CHRIS) has similar characteristics with airborne imaging spectroscopy

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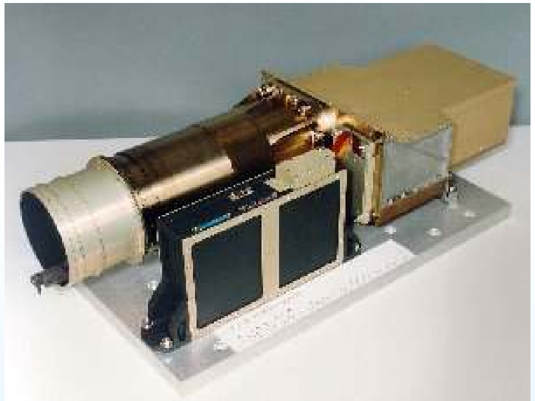
CHRIS

- Compact → < 15 kg
- High Resolution → 18 m
- Imaging Spectroscopy → "class of instruments which preserve the image field while also determining the spectrum"

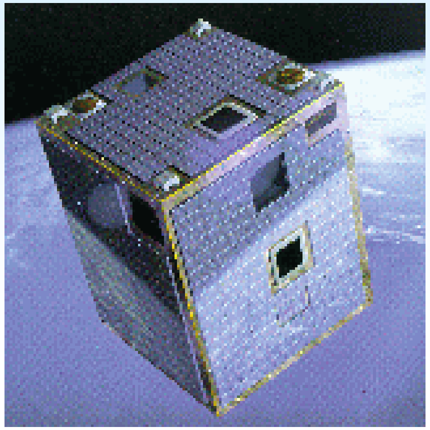


62 spectral bands
410nm-1050nm
1.3nm at 410nm
12nm at 1050nm

- developed by Sira Electro-Optics Ltd.

PROBA

- Project for on board autonomy
- Advanced small satellite
- Pointable
- High level of autonomy
- Created by Verhaert



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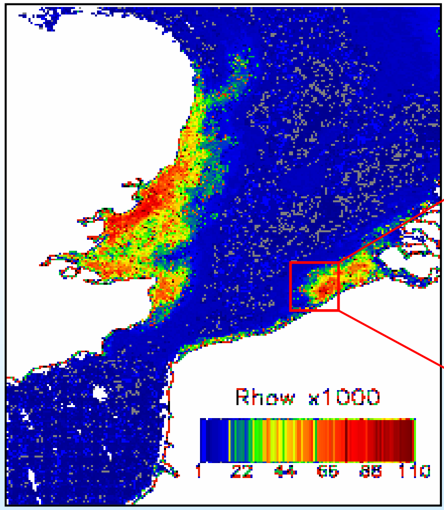
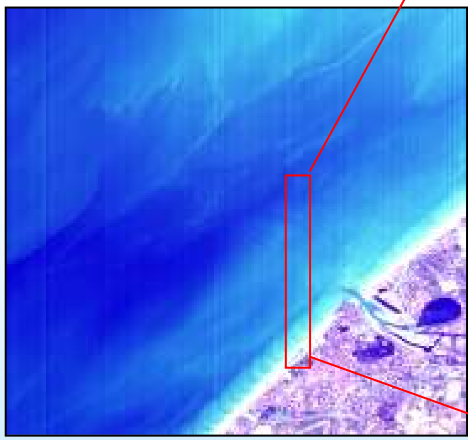
Traditional Ocean Colour satellite sensor vs. airborne imaging spectroscopy (1)

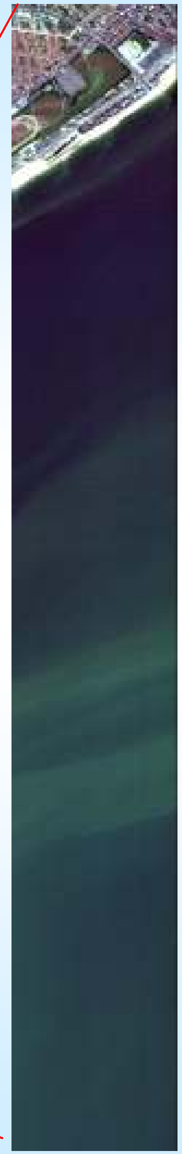
	satellite based IS	CHRIS/PROBA	Airborne IS
homogeneous data quality over a long time-frame	+	+	-
level of support	+	+/-	-
Entire earth is viewed with regular repetition	+	+/-	-
pointable	+/-	+	-
spatial resolution	-	+	+
geographical flexibility	-	+/-	+
spectral resolution	-	+	+
programmable spectral bands and pixel sizes	-	+/-	+

Traditional Ocean Colour satellite sensor vs. airborne imaging spectroscopy (2)

- **Unprocessed CASI image Oostende (16 June 2003) (R=643nm, G=551nm, B=461nm)**
- **Unprocessed CHRIS image (21 September 2003) (R=691nm, G=561nm, B=442nm)**
- **Unprocessed SeaWiFS image (5 August 2003) (670nm)**







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CHRIS potential

- Small low-cost
- > spectral resolution than current ocean colour sensors
- Pointability Atmospheric effects
- → same area, different angles
  - Air-sea interface effects
  - Special event
- Mapping small features

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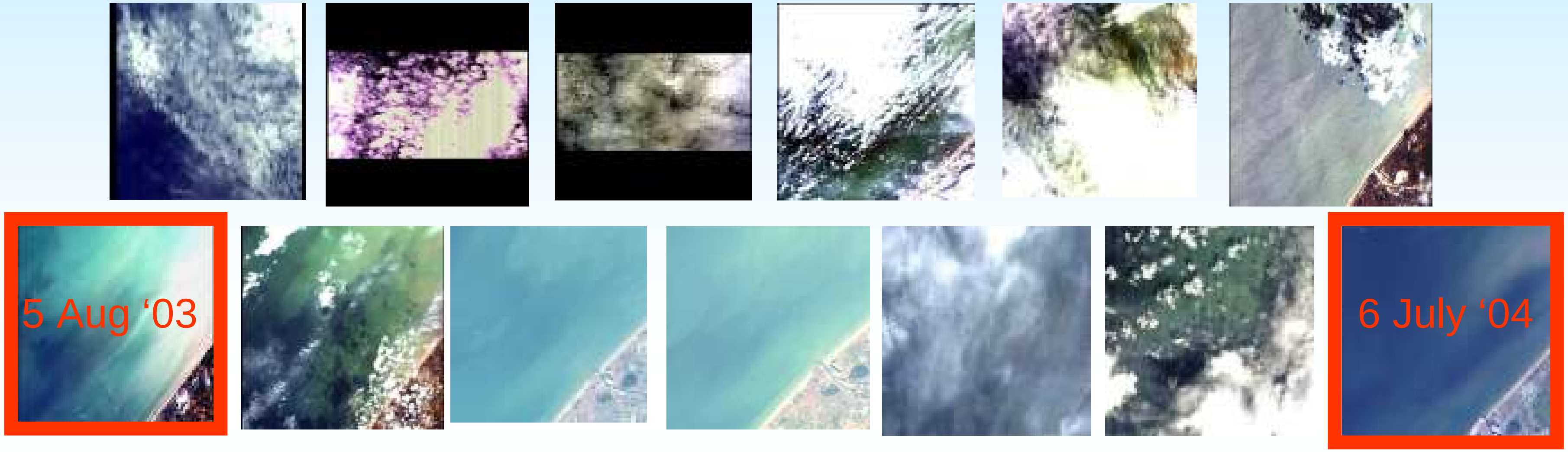
CHRIS images from test site Oostende



- **13 image sets, 4 cloud free**
- **9 with sea borne measurements…BUT only 2 cloud free image sets with sea borne measurements**
- **Mode 1: 62 spectral bands (411-997nm),**

  36 m² resolution

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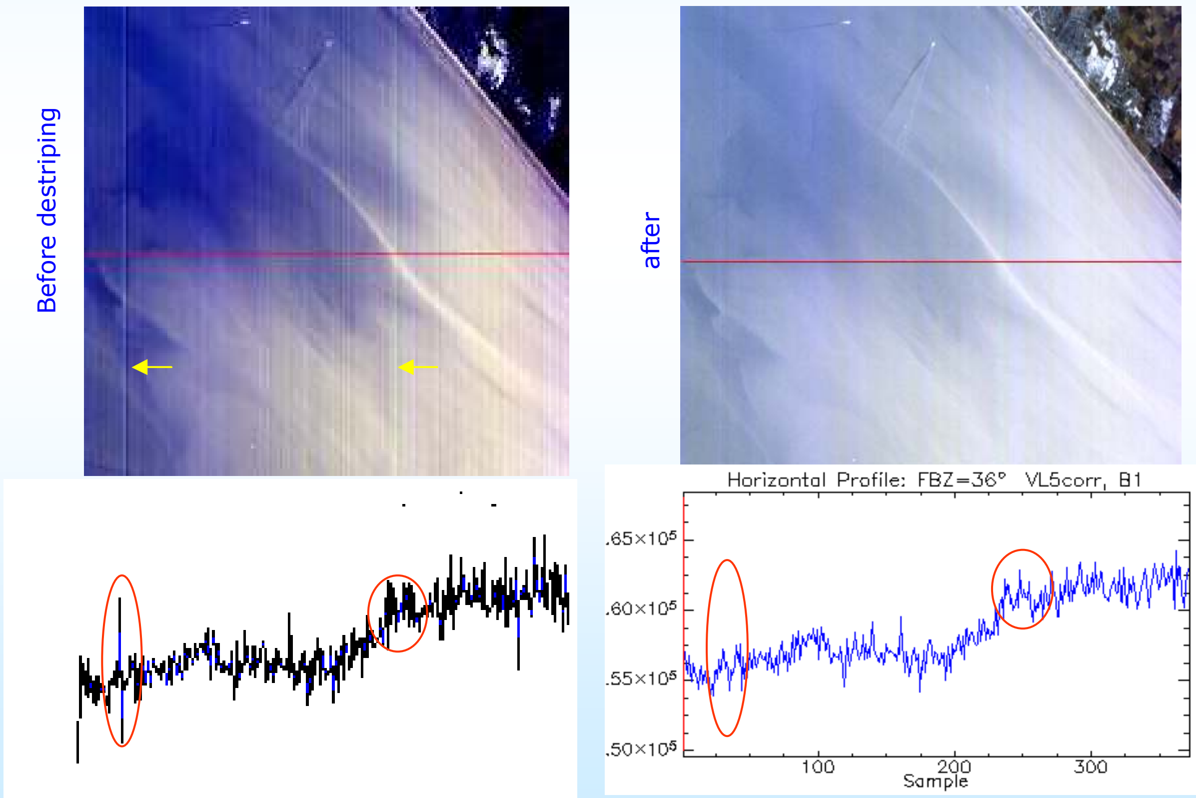
Image processing (1)

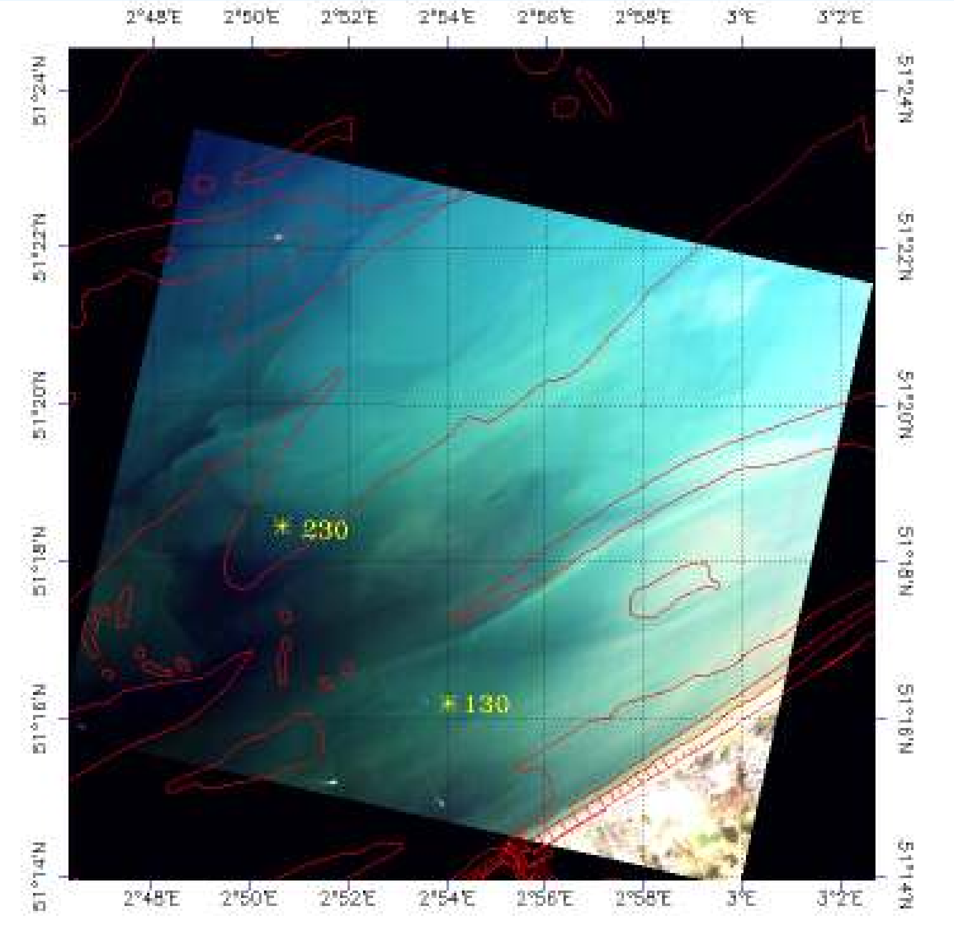
- Some problems: destriping, atmospheric correction and georeferencing
- Destriping
  - Correction factor based on a 5 column moving average



OPTICAL REMOTE SENSING OF COASTAL WATERS
BELCOLOUR PROJECT
http://www.mumm.ac.be/BELCOLOUR

Image processing (2)

- **Atmospheric correction**
  - Darkest pixel approach
- **Georeferencing**
  - GCP's on land
  - Problem: uncertainty is amplified considerably far from land



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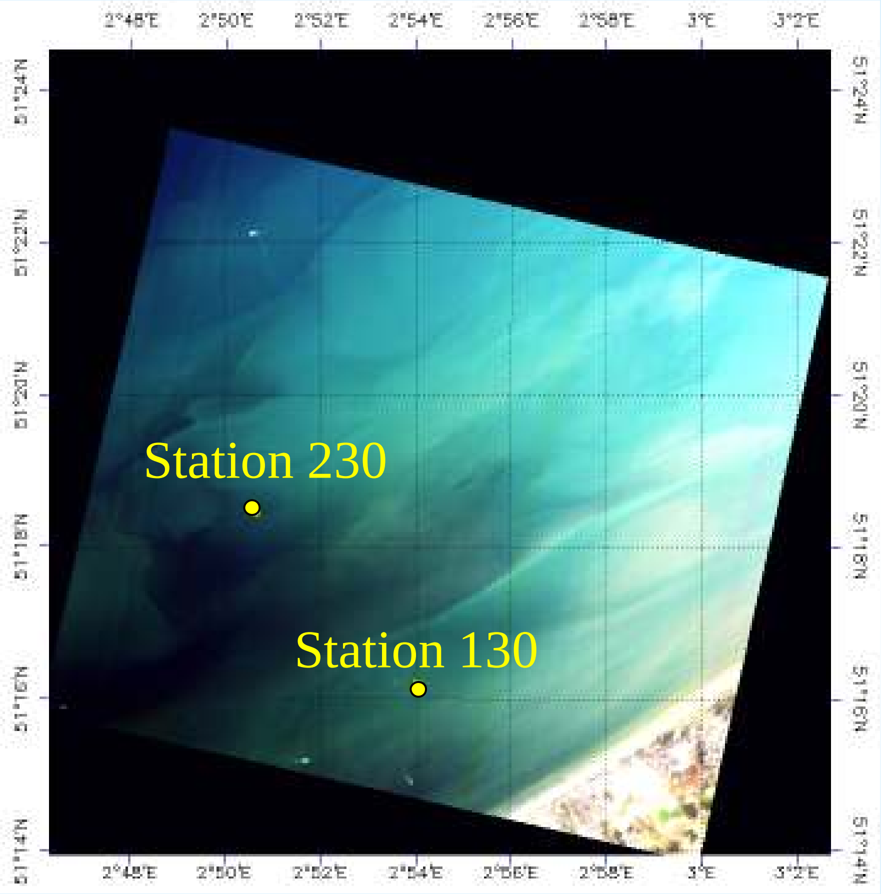
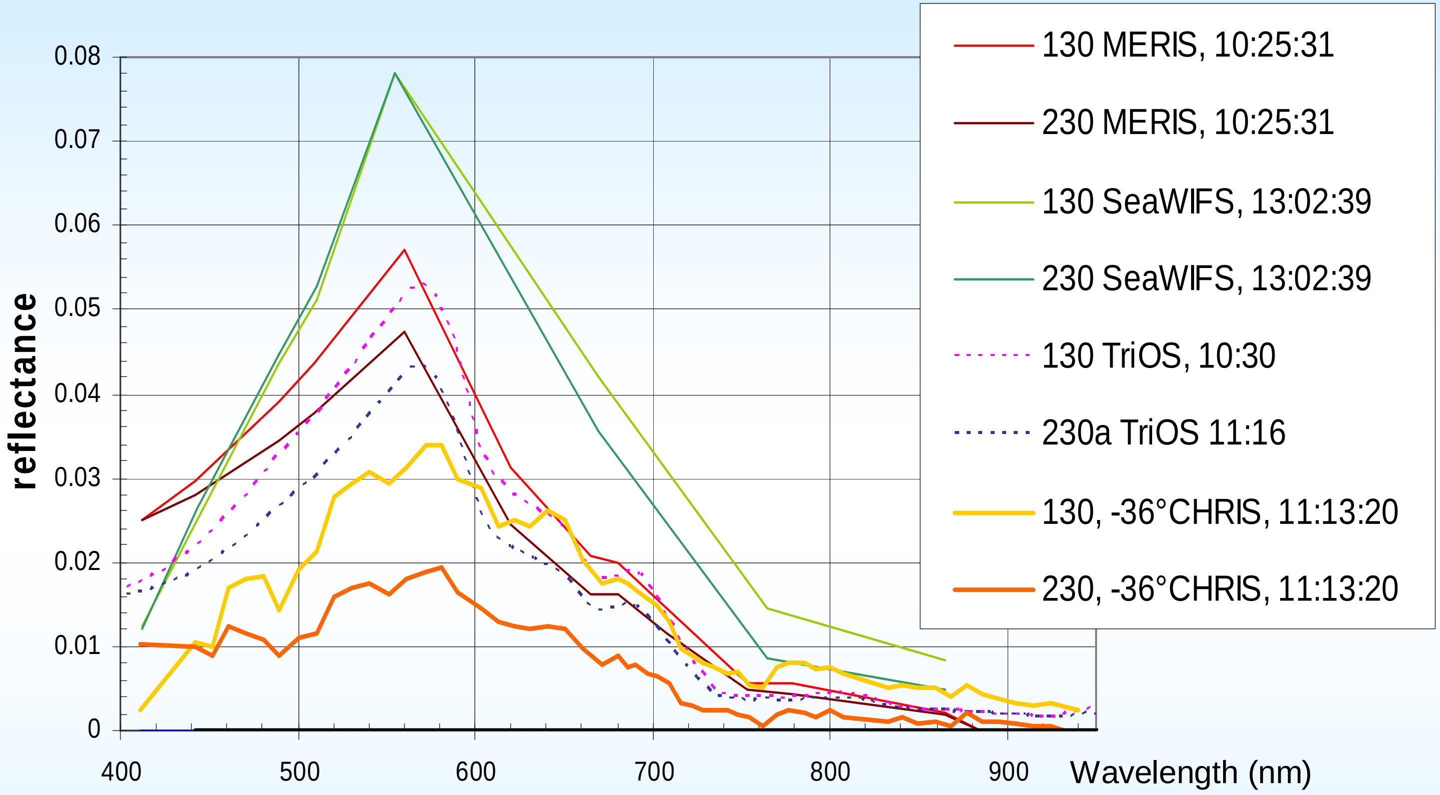
Comparison with other data sources of 2 points at sea
Images of 5 August 2003(1)



- TriOS, MERIS, SeaWiFS

Comparison with other data sources of 2 points at sea Images of 5 August 2003 (2)



- **All sensors show higher reflectance at station 130**
- **Differences in values: → Time**
  → Darkest pixel assumption

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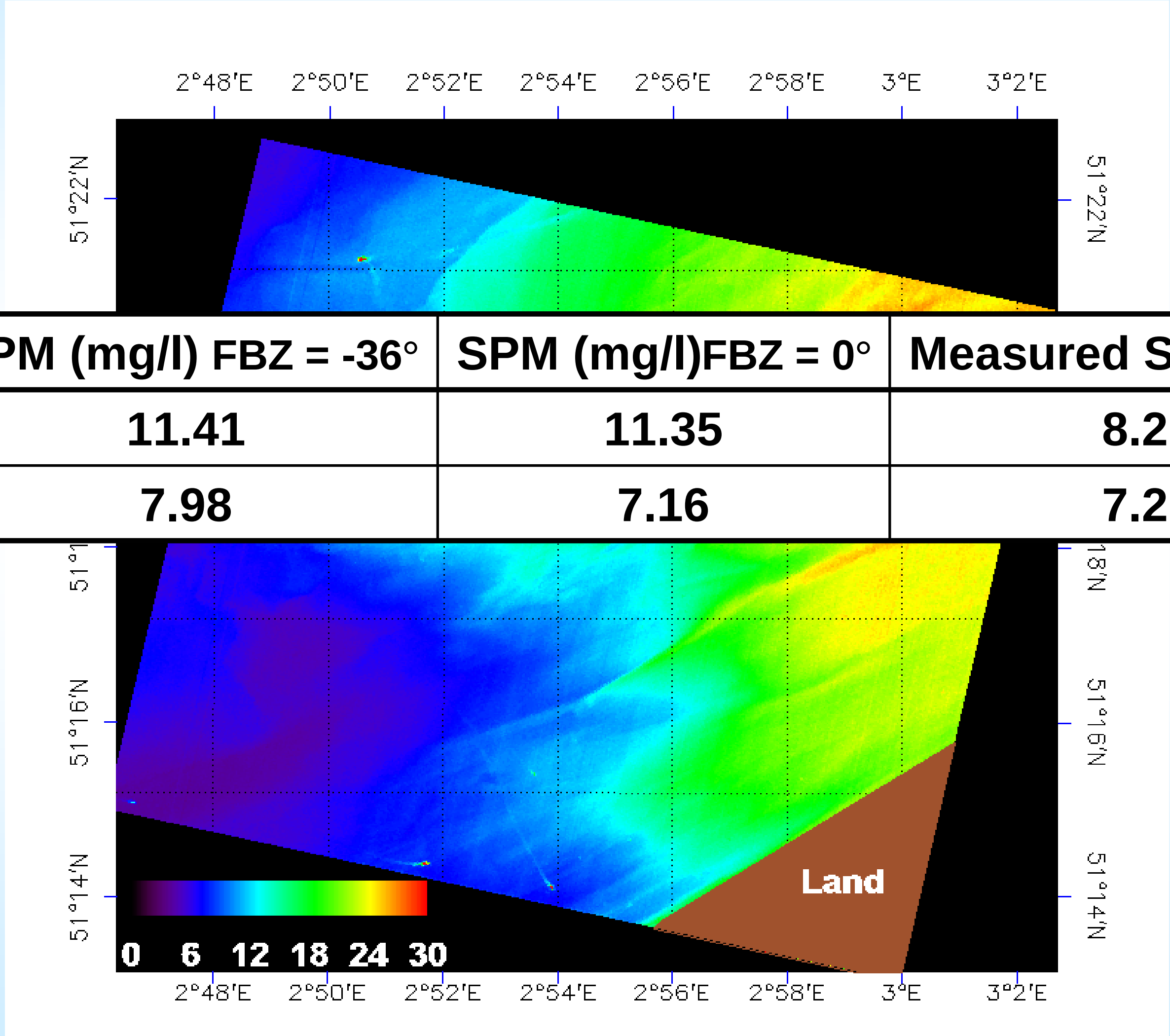
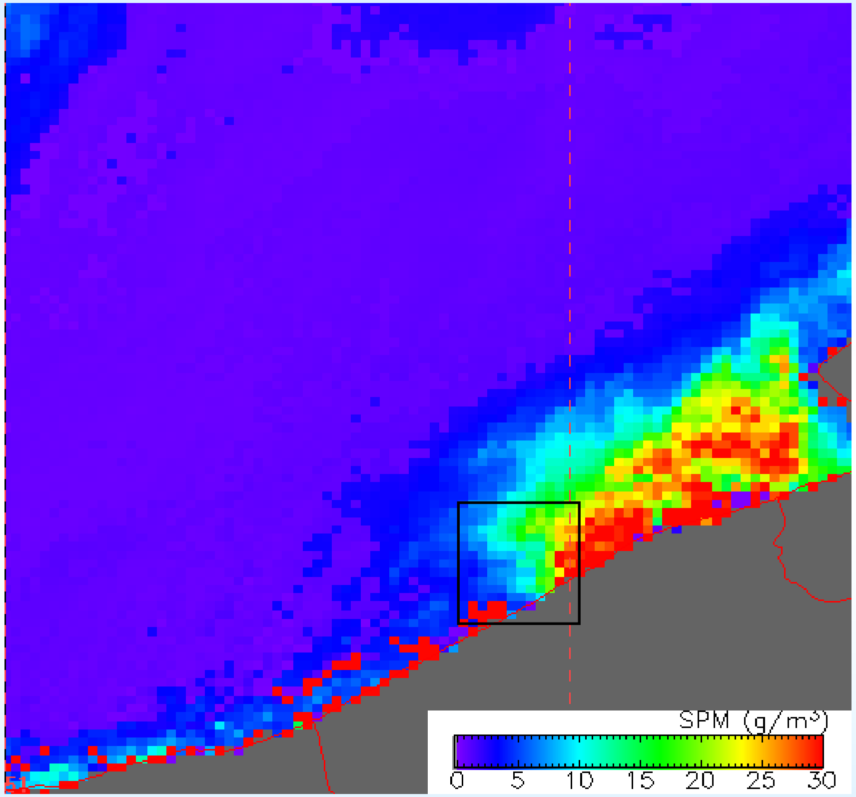
SPM maps (1)

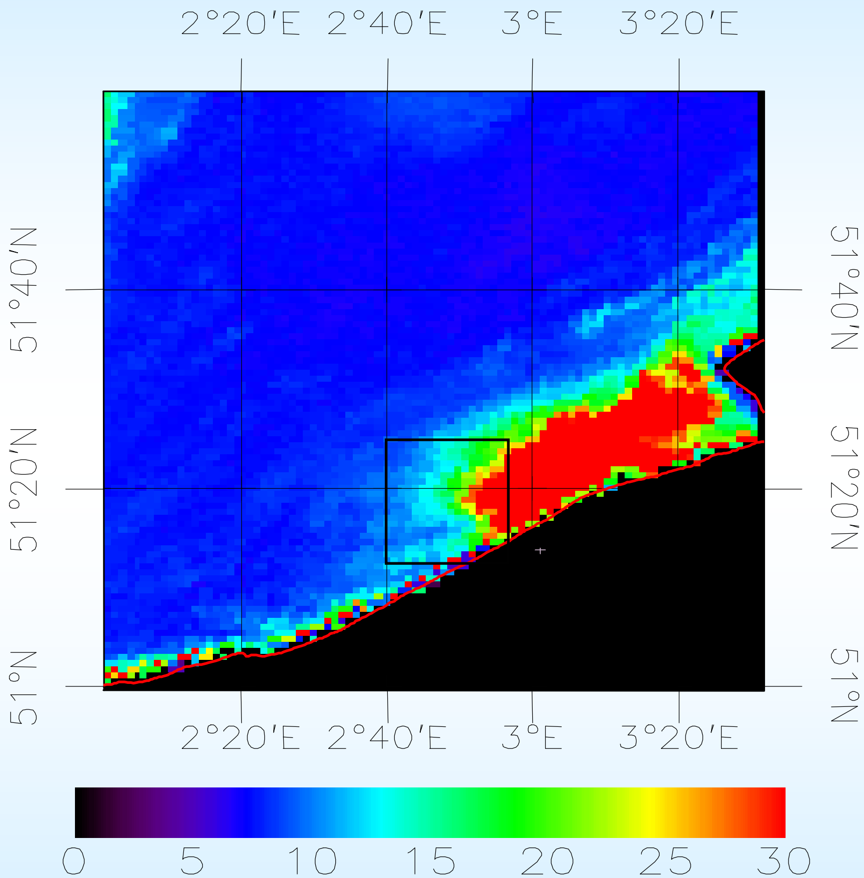


Station	SPM (mg/l) FBZ = -36°	SPM (mg/l)FBZ = 0°	Measured SPM (mg/l)
130	11.41	11.35	8.20
230	7.98	7.16	7.27

SPM maps (2)

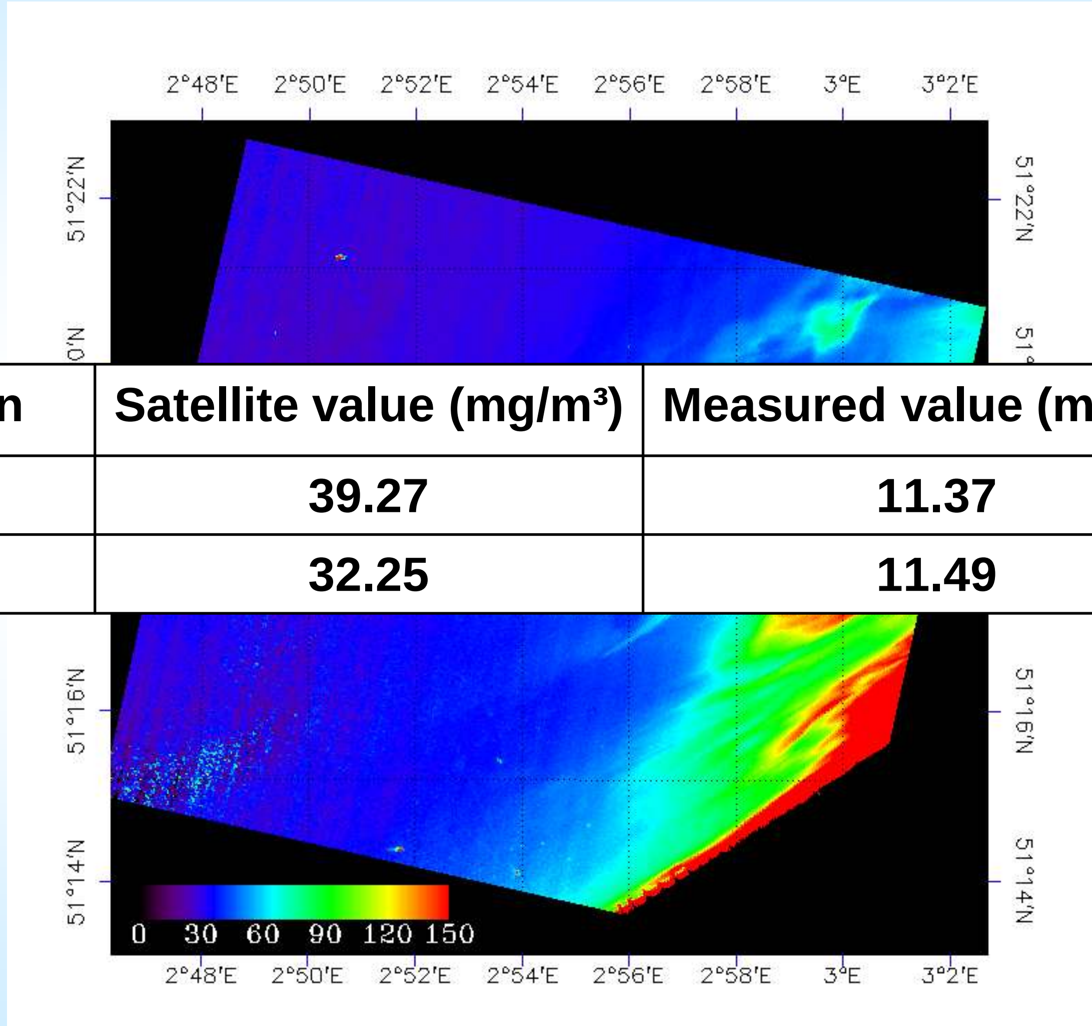


MERIS (5 August 2003, 10:25)



SeaWiFS (5 August 2003, 13:02)

chlorophyll maps



Station	Satellite value (mg/m³)	Measured value (mg/m³)
130	39.27	11.37
230	32.25	11.49

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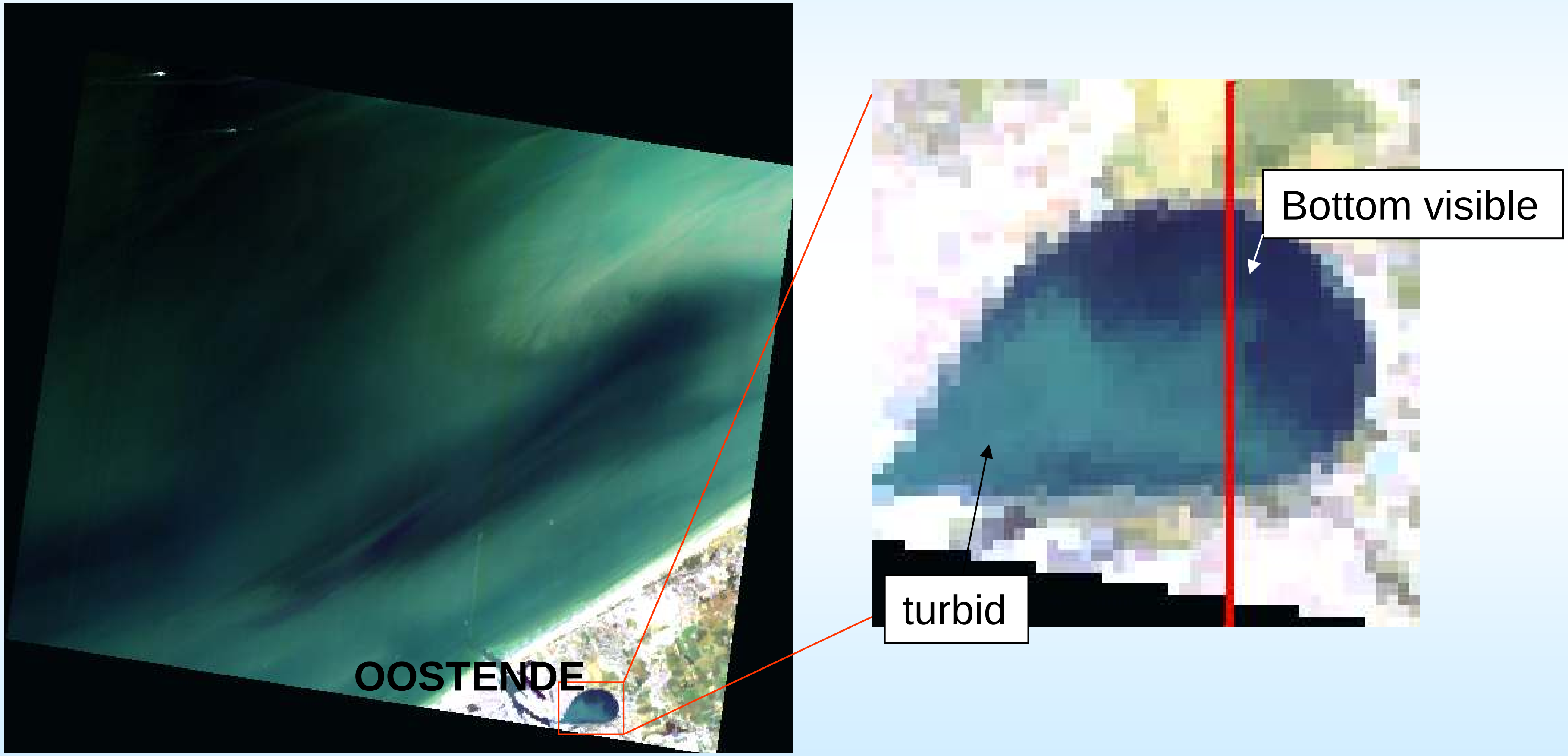
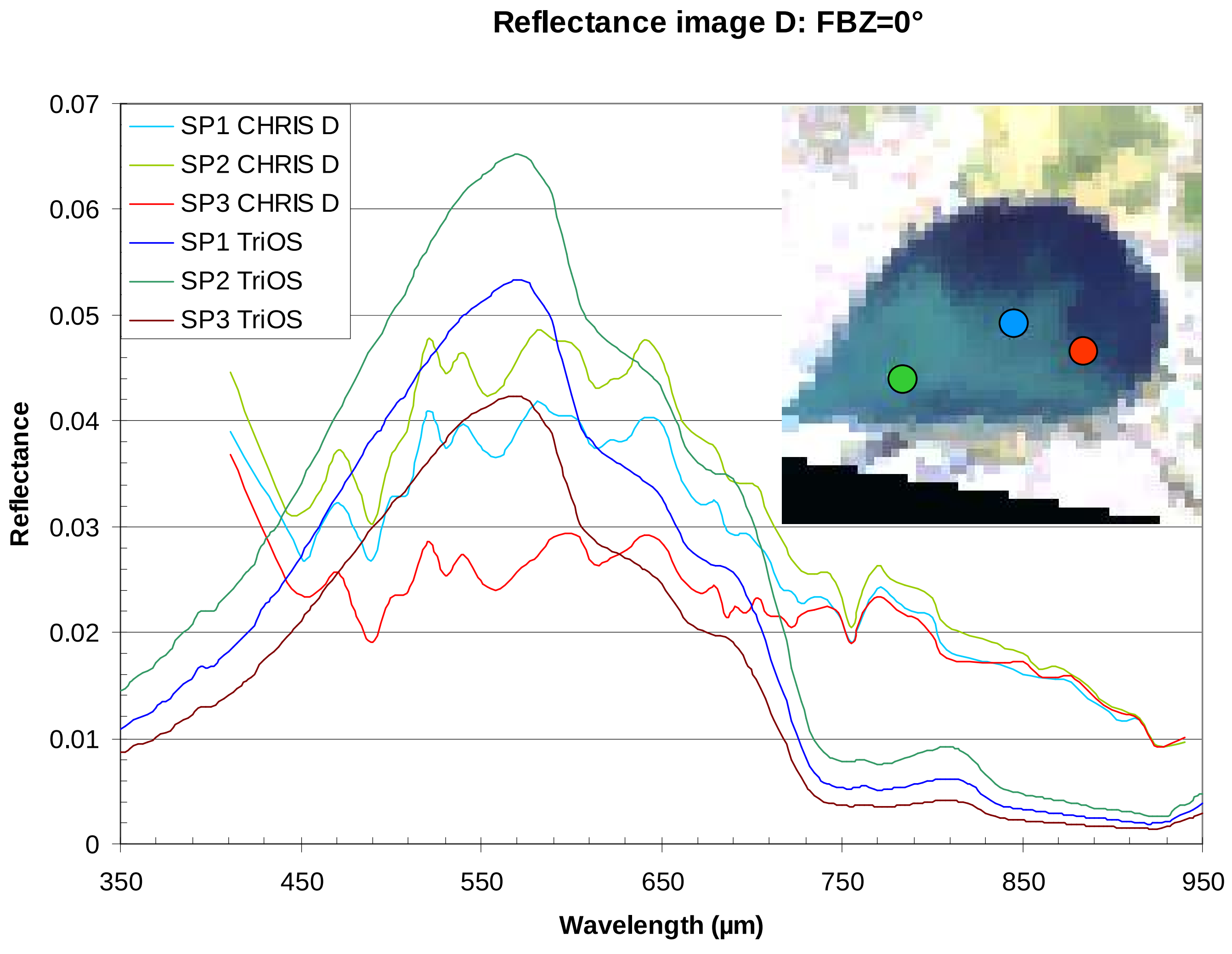
Inland waters: adjacency effects?
Images of 6 July 2004

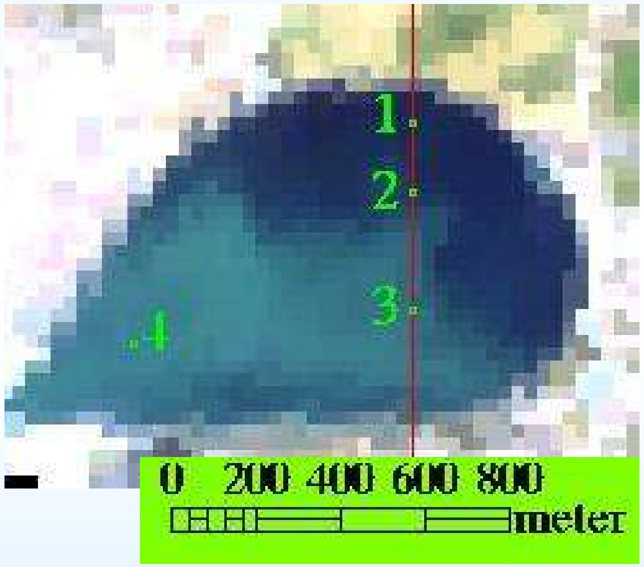
- **Only image with FBZ = 0°**

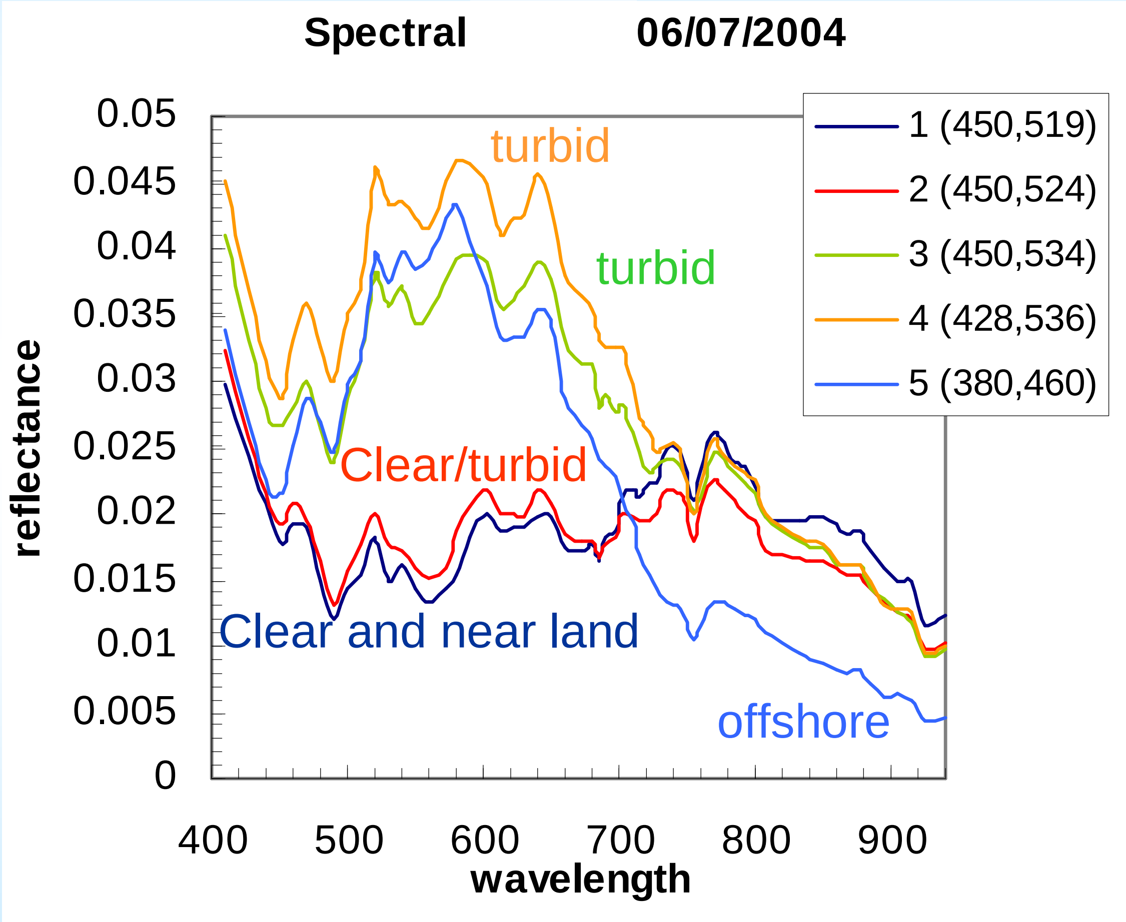


Inland waters: adjacency effects?
Images of the Spuikom on 6 July 2004



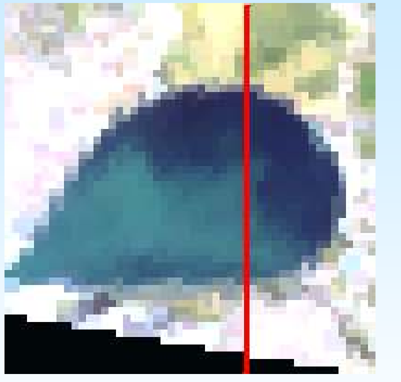
Inland waters: adjacency effects?
Some spectra



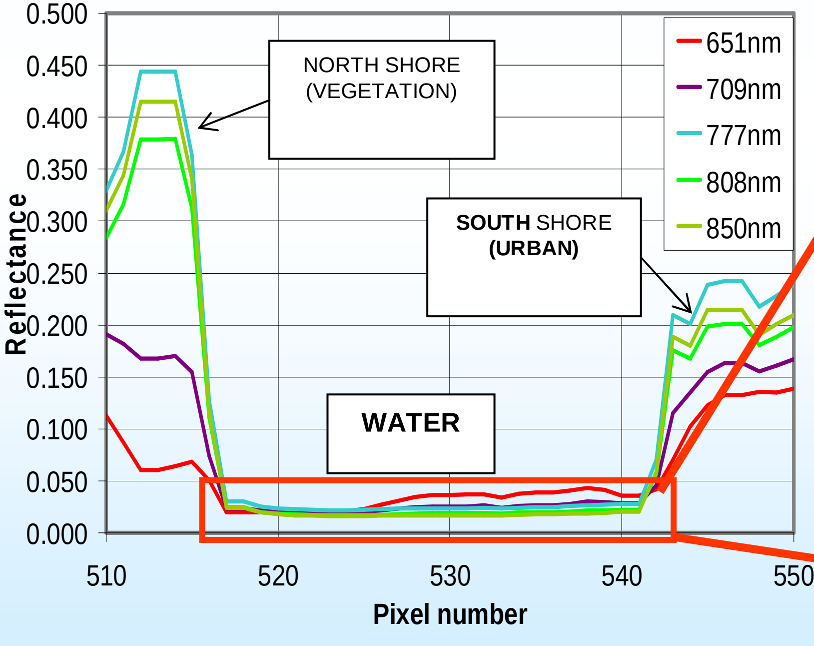


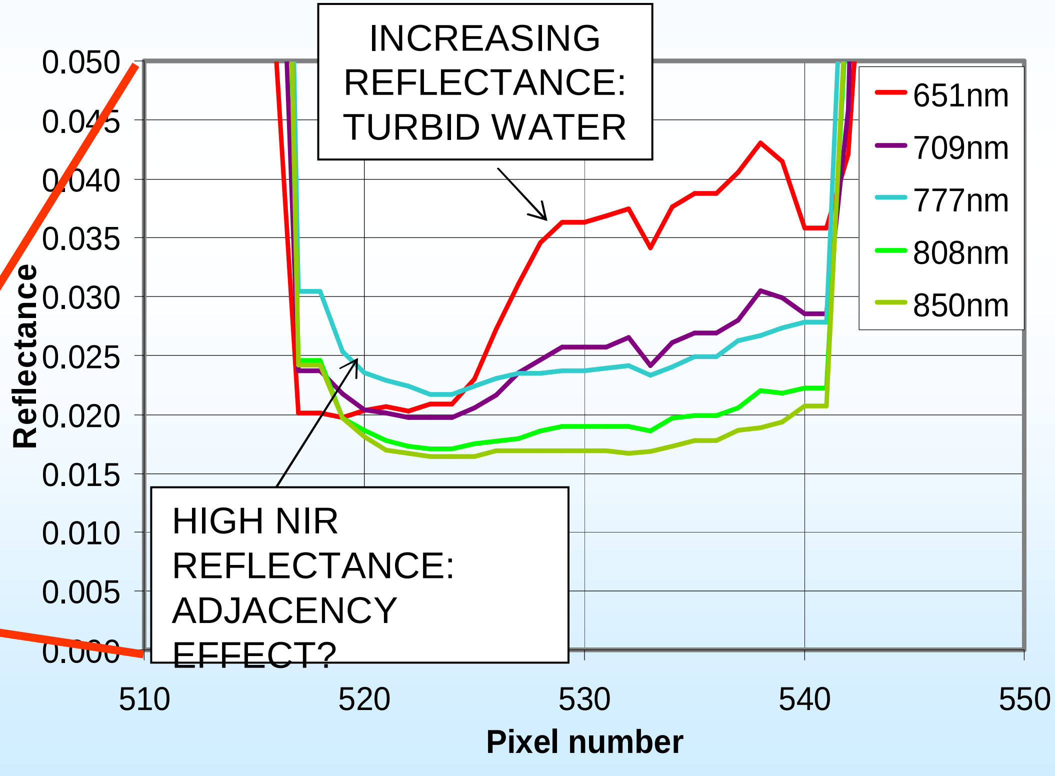
Inland waters: adjacency effects?

North-South transect Spuikom



- **NIR North shore (vegetation) > NIR South shore (urban)**
- **North: NIR reflectance > red reflectance**





Inland waters: adjacency effects?

- **Bottom reflection?**
  - Northern and Eastern parts: bottom visible

    BUT bottom reflectance become rapidly absorbed for red and NIR wavelengths

    e.g. clear water, 1m → surface signal of bottom reflectance attenuated to factor 0.45 and 0.015 or smaller at 709nm and 850nm respectively

- **Adjacency (environmental straylight)?**
  - Rapid decrease by going away from the North shore is consistent with ✵ atm. forward scattering
  - Higher reflectance at 777nm is consistent with a similar difference for the nearby vegetation
  - Turbid water in the South tends to hide the adjacency effect

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Conclusions

- Some problems in image quality
- Simple dark pixel atmospheric correction gives reasonable results
  good enough for suspended particulate matter
  BUT better atmospheric correction by radiative transfer modeling
- CHL detection ???
- CHRIS data for inland water body are contaminated in the NIR, especially for clear water pixels → adjacency effect
  Bottom reflection ?
- Great potential
  - Hyperspectral → more info for CHL detection
  - Spatial resolution → smaller features visible
- CHRIS/PROBA provides proof of the concept and advance warning of expected problems in future systems

Acknowledgement

- Tuimelaar crew
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- ESA & SIRA
- Peter Fletcher
- You……

….FOR YOUR ATTENTION