(BR)ADEX
(Bottom reflectance and) adjacency experiment

Barbara Van Mol, Kevin Ruddick, YoungJe Park, Bouchra Nechad

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of all water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Introduction

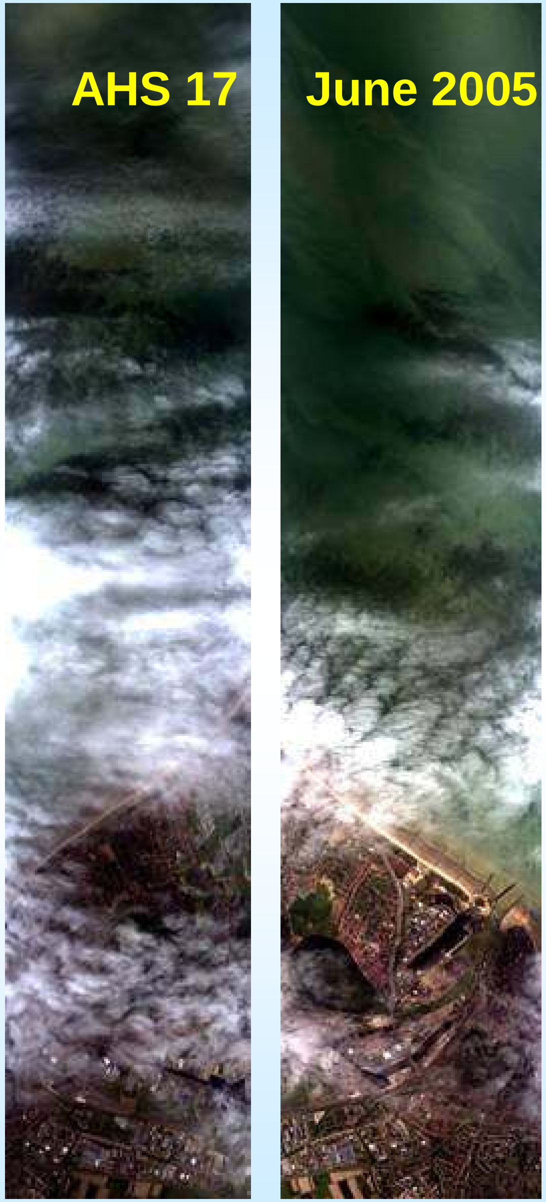
- **Motivation: very close to the shore and for small inland water bodies bottom reflectance and adjacency effects (AE) ↓ quality of optical remote sensing.**
- **Objective: collect benchmark dataset to develop and test detection and correction of AE in remote sensing imagery.**

Overview

- Introduction
- Overview measurements
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Day of measurements

- June – July 2004: HYMAP
  - Clouded during 1 month
  - Measurements postponed to 2005
- 17 June 2005: AHS
  - Full day of measurements
  - Clouded during overflight
- 23 June 2005: AHS
  - Full day of measurements
  - Variable cirrus (=high) clouds
  - THE DAY!!



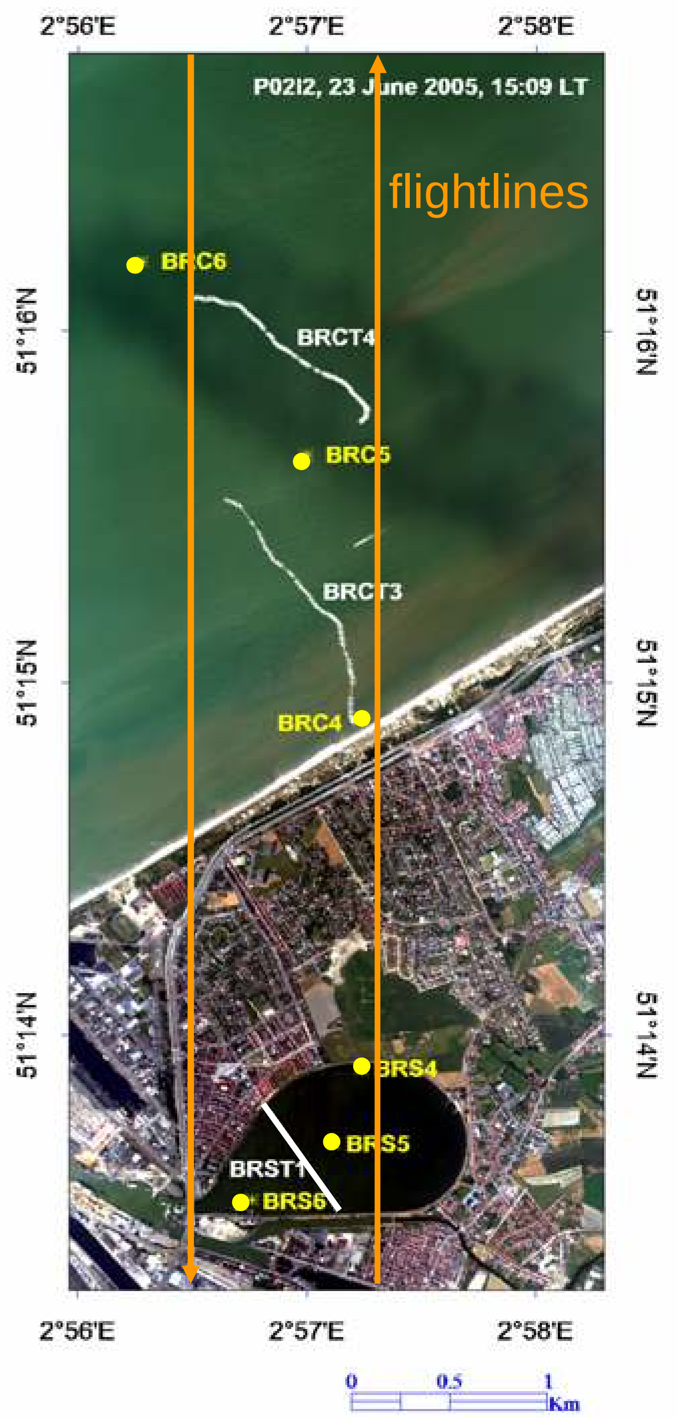
23 June 2005: **THE** day

Timing measurements

DATA	Time (local)
BRS4	10:42
BRS4	10:48 - 10:55
Spuikom	11:00 -12:50
BRS5	10:59
BRS5	11:03 - 11:08
BRS6	11:13
BRS6	11:15 - 11:19
Bredene beach	11:20 -12:30
BRST1	11:24 - 11:31
P01I1 (N->S)	11:50 - 11:54
P02I1 (S->N)	11:59 - 12:02
MERIS	12:14
CHRIS	13:22
herb Spuikom	13:30 - 13:40
water Spuikom	13:40 - 13:45
concrete Spuikom	13:45 - 13:50
BRC4	14:00

DATA	Time (local)
Spuikom	14:01 - 15:50
BRC4	14:03 - 14:13
BRCT3	14:14 - 14:30
MODIS aqua	14:15
BRC5	14:30
Bredene beach	14:32 -15:22
BRC5	14:33 - 14:43
BRCT4	14:44 - 14:54
P01I2 (N->S)	14:58 - 15:01
BRC6	15:00
BRC6	15:02 - 15:12
P02I2 (S->N)	15:07 - 15:10
intercalibration	17:27
ASD/TriOS	
wet sand	17:31 - 17:34
dry sand	17:36 - 17:39
Beach	17:45

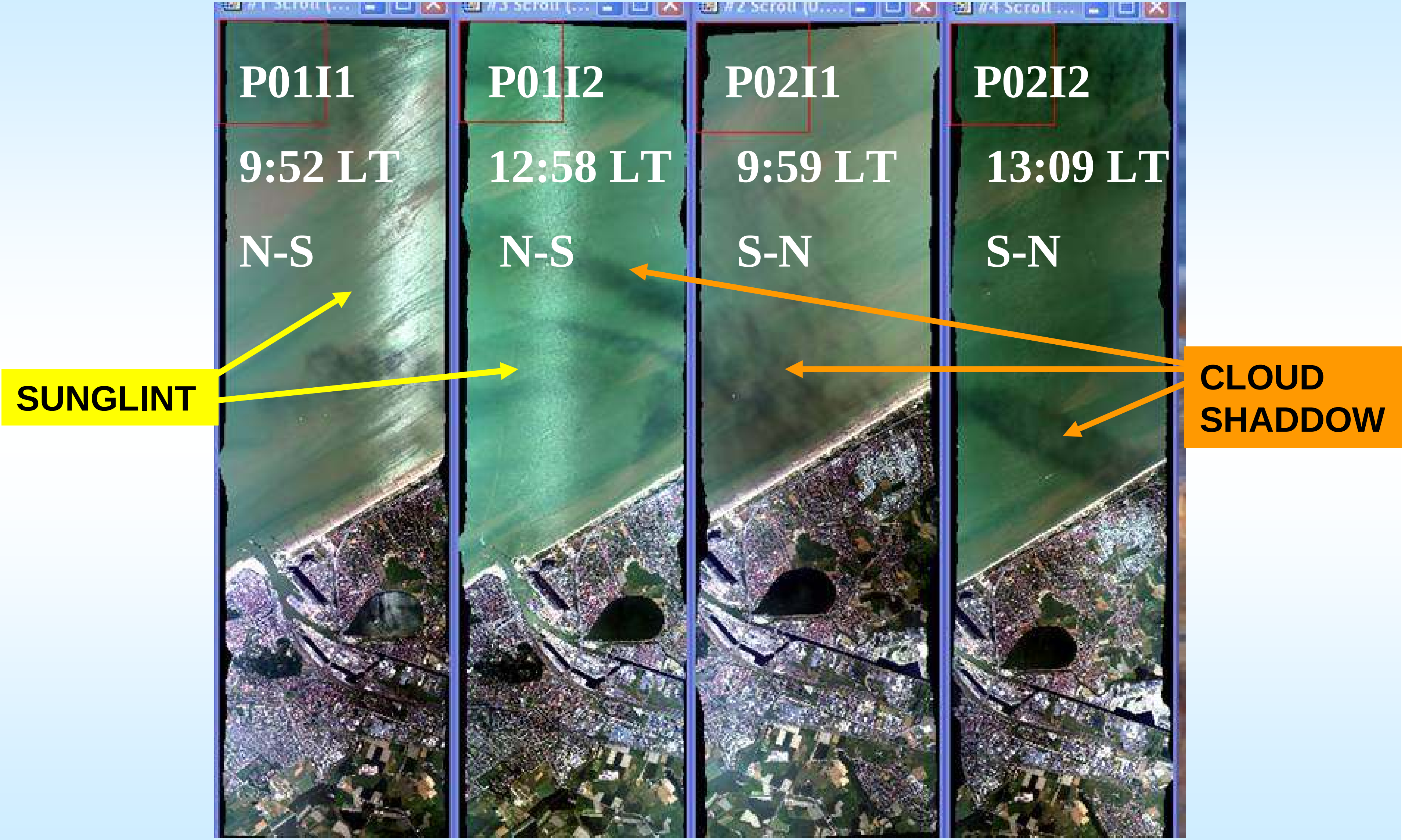
SPM and CHL water sample	AHS
TriOS reflectance	satellite
CIMEL	ASD reflectance



Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Airborne Hyperspectral System (AHS) images



Comparison in-situ (TriOS) with airborne (AHS) (1)

- South to North: avoid sunglint
- Spuikom different image then coast to reduce time difference
- Max. 1 hour time difference

Analyses AHS spectra

- Highest red reflectance in station closest to the coast. In agreement with the coastal-offshore gradient
- Ratio $\rho_w(\lambda_{720nm}):\rho_w(\lambda_{780nm})$ normally within 10% of 2.35. In AHS data respectively 1.23, 1.33 and 1.47 for stations BRC4, BRC5 and BRC6.

  Probably due to an atmospheric correction error (estimation of aerosol scattering difficult because of cirrus clouds)

  $\Rightarrow$ Try to correct

- Band 18 will not be taken into account
- Extreme high near infrared for the AHS data in the Spuikom due to adjacency.

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Correction AHS data (1)

- Shape of water-leaving reflectance spectra in turbid waters is nearly invariable between 700 and 900 nm

  $\Rightarrow$ similarity spectrum
- Fitting similarity spectrum to calculate the error ε

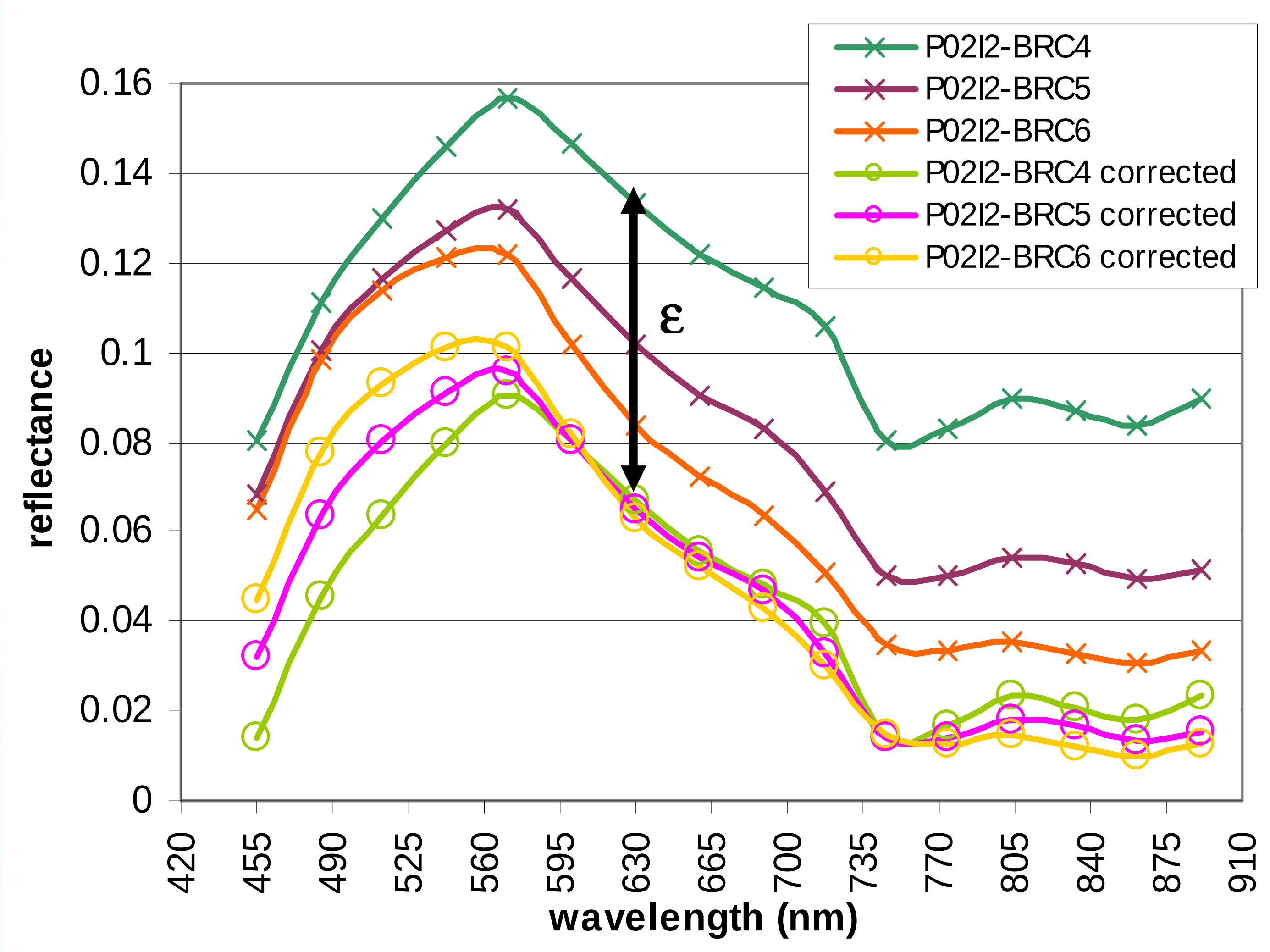
$$\varepsilon = \frac{\alpha_{1,2}\rho_w^m(\lambda_{720nm}) - \rho_w^m(\lambda_{780nm})}{\alpha_{1,2} - 1}$$

  $\alpha_{1,2}$ = 2.35 and ρ_w^m is the original AHS water-leaving reflectance for wavelength λ
- The corrected AHS water-leaving reflectance ($\rho_w(\lambda)$) is calculated by subtracting this offset ε.

$$\rho_w(\lambda) = \rho_w^m(\lambda) - \varepsilon$$

- [Ruddick et al., 2005*: Use of the near infrared similarity reflectance spectrum for the quality control of remote sensing data]*

Correction AHS data (2)

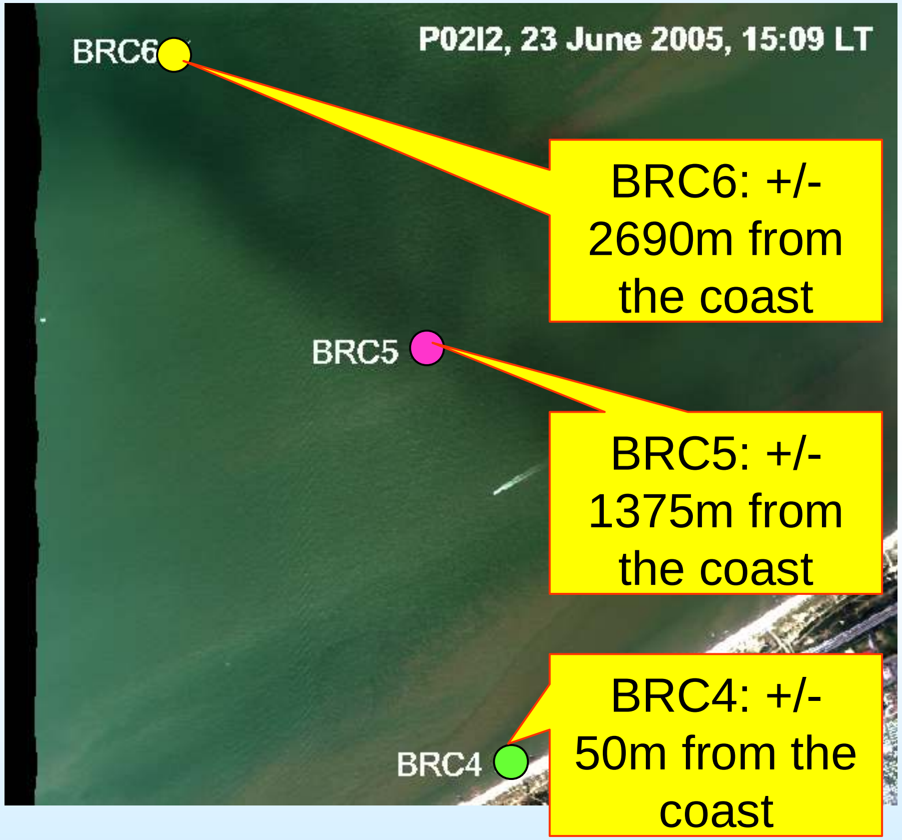


- **Results good if general shape corresponds to the similarity spectrum.**
- **Not valid if reflectance spectra affected by adjacency effect or sunglint.**

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Comparison water-leaving reflectance: BRC5 and BRC6



- **> distance from the coast, < difference btw the water-leaving reflectance data**
- **Reason:**
  - **Turbidity changes less in time**
  - **Higher quality: less affected by the land**

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Adjacency effects

- **Some high NIR reflectance from the adjacent land is scattered into the water leaving reflectance path of the water pixel and “read” as originating from the water.**
- **Clearly the case in the Spuikom, less at the coast**

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

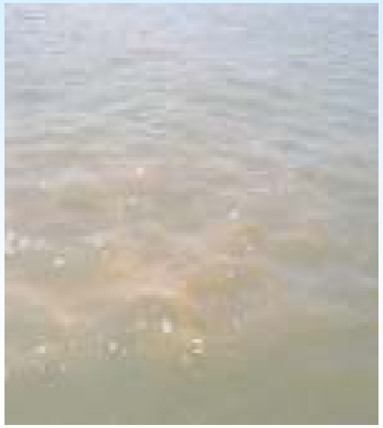
Noctiluca

- Bloom forming heterotrophic dinoflagellate
- Bloom period in Belgium waters: end of June
- Reddish discoloration of the water
- Patches ⇒ not detectable by low spatial resolution images

EXAMPLE OF HEAVY *NOCTICULA* BLOOM

Noctiluca: AHS spectra and *in situ*

- **23 June 2005**
- **AHS**



- **29 June 2005**
- **TriOS**

- **AHS and TriOS reflectance spectra measured in a *Noctiluca* patch are similar**

Noctiluca

- Detection of *Noctiluca* is possible in hyperspectral images with high spatial resolution
- These data can be used to design a *Noctiluca* detection algorithm

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Conclusion (1)

- Benchmark dataset of simultaneous measurements of Oostende coastal and inland waters with radiometric data from seaborne (TriOS), airborne (AHS) and satellite (MERIS, MODIS, CHRIS) sensors as well as atmospheric measurements (fixed and portable CIMEL sunphotometers)

  ⇒ one of the most detailed datasets available for investigation of adjacency effects
- AHS data relatively white offset in comparison with the seaborne data.

  Correction of this white offset using NIR similarity theory provided some improvement but further work on the atmospheric correction algorithm is required.
- Adjacency effects significant in the AHS data for the Spuikom.

Conclusion (2)

- A preliminary algorithm for detection of adjacency effects
  - detect successfully severe adjacency effects
  - refinements required to detect weaker adjacency effects and to distinguish between adjacency effects and other phenomena
- *Noctiluca* bloom observed in the airborne data.
- The lack of spectral resolution around 670nm in AHS data
  - crucial for chlorophyll *a* quantification in turbid waters.
- only a first exploitation of the BRADEX dataset
- primarily focused on the aquatic radiometric data

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Future perspectives

- This dataset will be further exploited over the coming years as a benchmark dataset for development and testing of algorithms for detection and correction of adjacency effects.
- The preliminary detection algorithm will be further refined.
- The atmospheric measurements will be used with atmospheric radiative transfer simulations (in progress at ULCO) to validate a new adjacency effects correction for MERIS imagery, to be incorporated in the standard MERIS processor used by the European Space Agency.

Overview

- Introduction
- Overview measurements
- Comparison AHS -TriOS water-leaving reflectance
- Correction AHS data
- Comparison of water-leaving reflectance
- Adjacency effects
- *Noctiluca* detection
- Conclusion
- Future perspectives
- Acknowledgment

Acknowledgement

- STEREO program for funding
- INTA and VITO for image acquisition and processing
- Jan Haelters, Machteld Price and Dietrich Van Tuyckom, Andre Cattrijsse, Ann Deiteren, Tony, ULCO, Jean-Piere De Blauwe, Marc Knockaert for logistical and practical help concerning the the in-situ measurements
- Richard Santer
- You…for listening