Deriving inland water quality from APEX imagery
Challenges and opportunities

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Monitoring Inland and Coastal waters with the APEX sensor – MICAS

BruHYP 2012, Brugge

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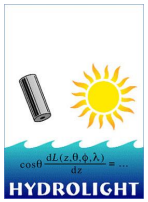
REMOTE SENSING LABORATORIES RSL

IVM Institute for Environmental Studies

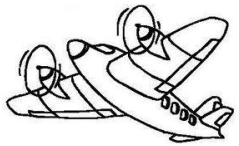
Overview

- Our test sites
- Challenges
- A typical spectrum – simulations



- ASD spectra

- APEX - opportunities for inland water monitoring



Our test sites

Scheldt

Lake Constance

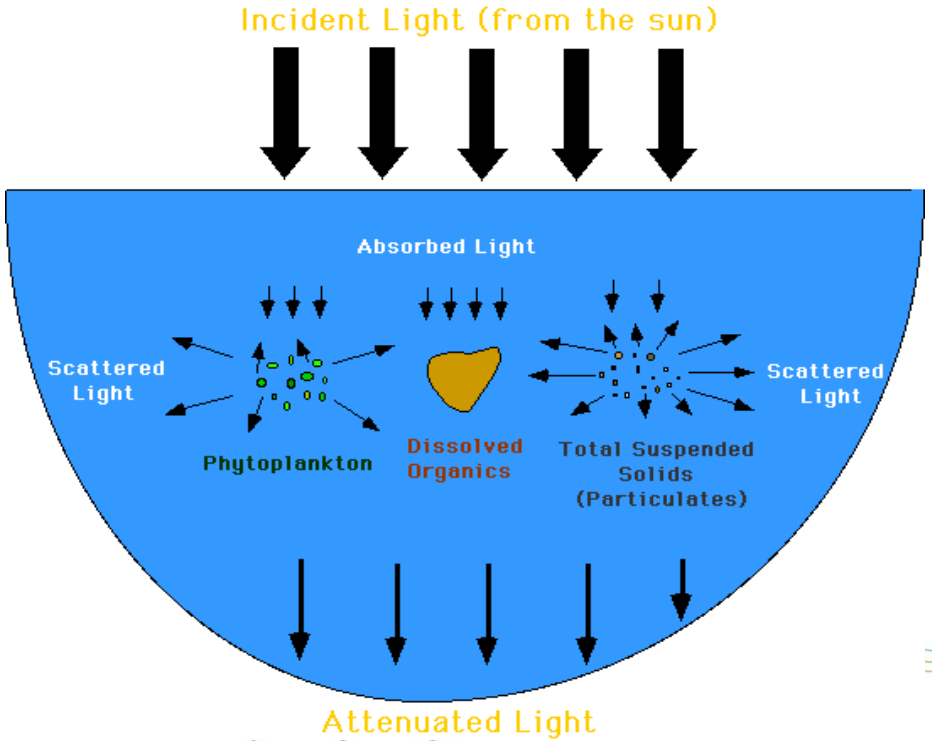
Wadden Sea

Gironde

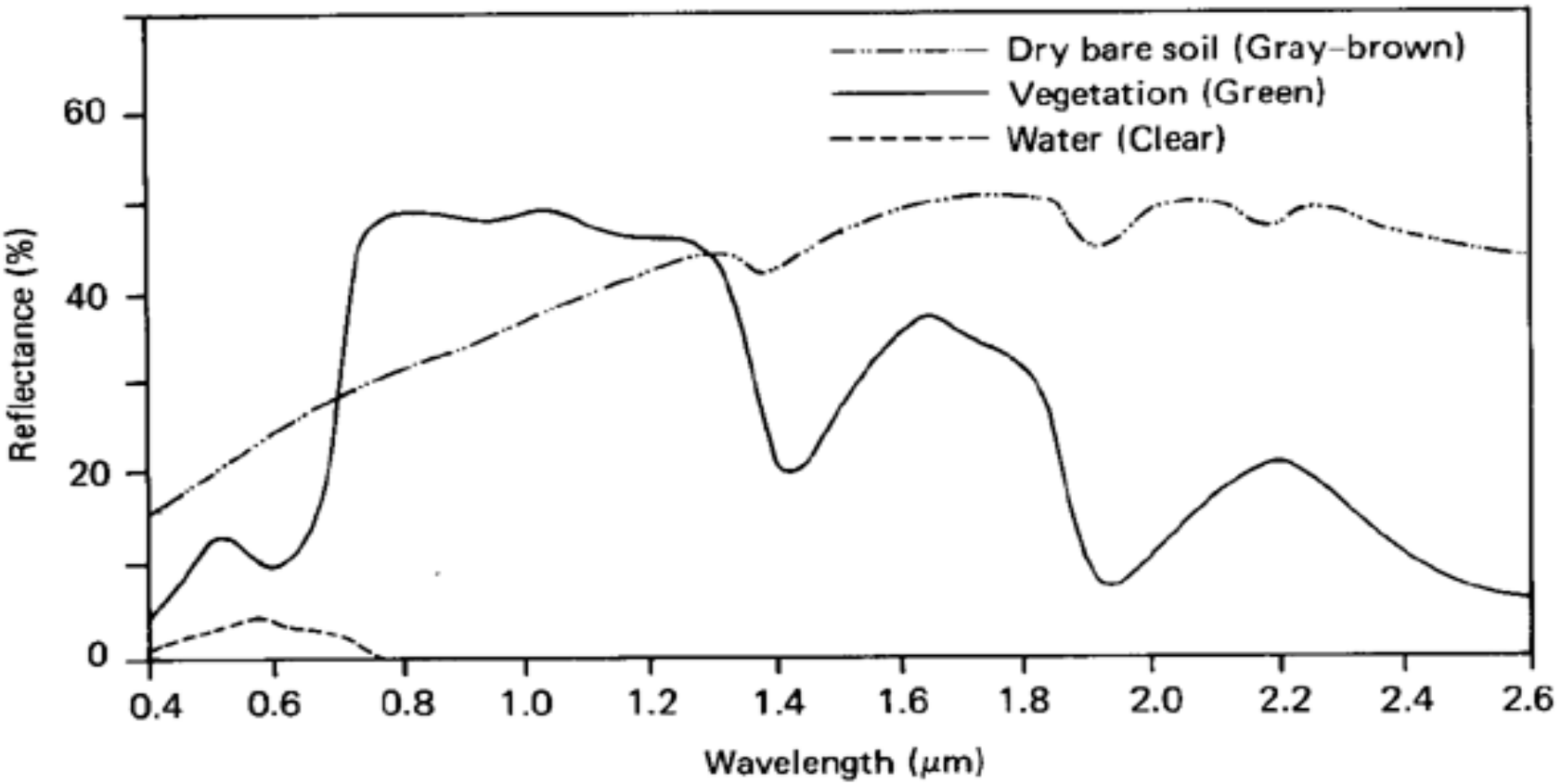
•macrotidal estuary suspended sediments delivered by the Garonne and Dordogne rivers and trapped within the maximum turbidity zone of the estuary.
•TSM from ten to four thousands mg L-1 (Doxaran et al. 2002a, 2002b, 2006, 2009)

Challenges - Complex waters

- Water Quality Estimations for CASE-II water systems
  - Algae [CHL]
  - Total Suspended Material [TSM]
  - Colored Dissolved Organinc material [CDOM]



Challenges - A low signal



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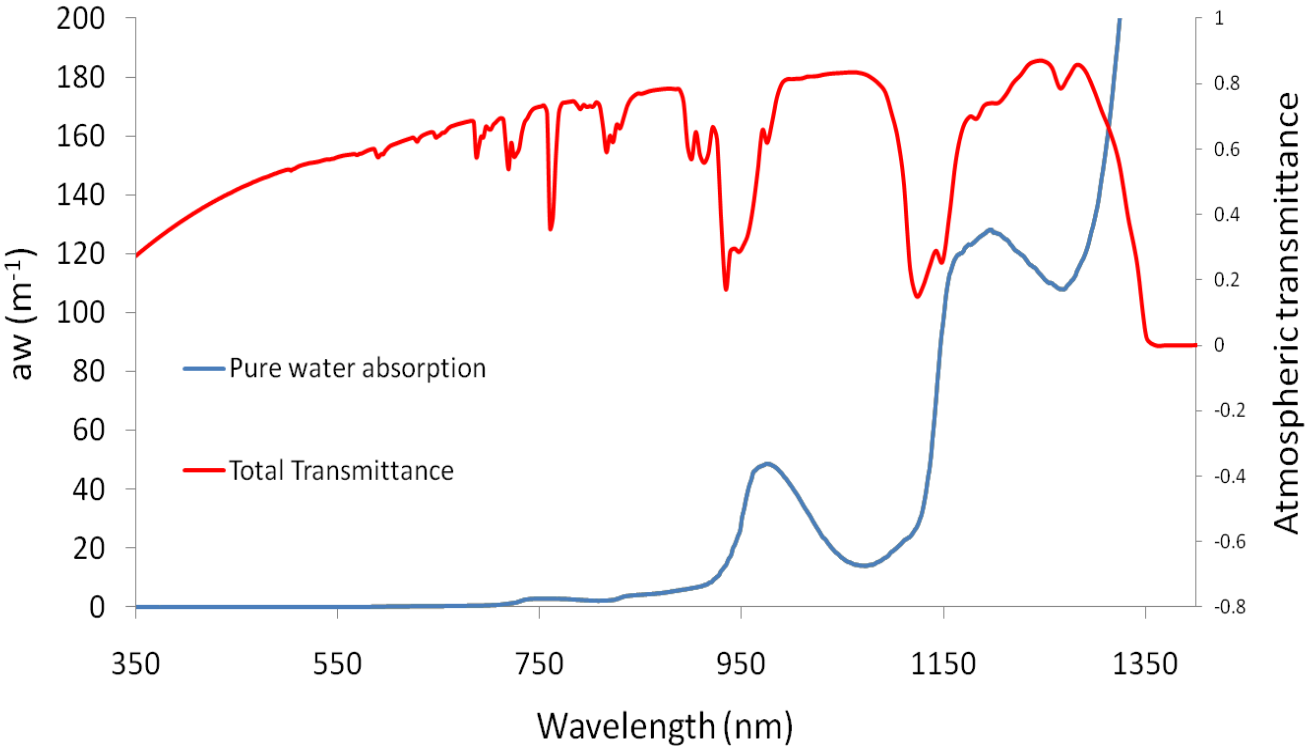
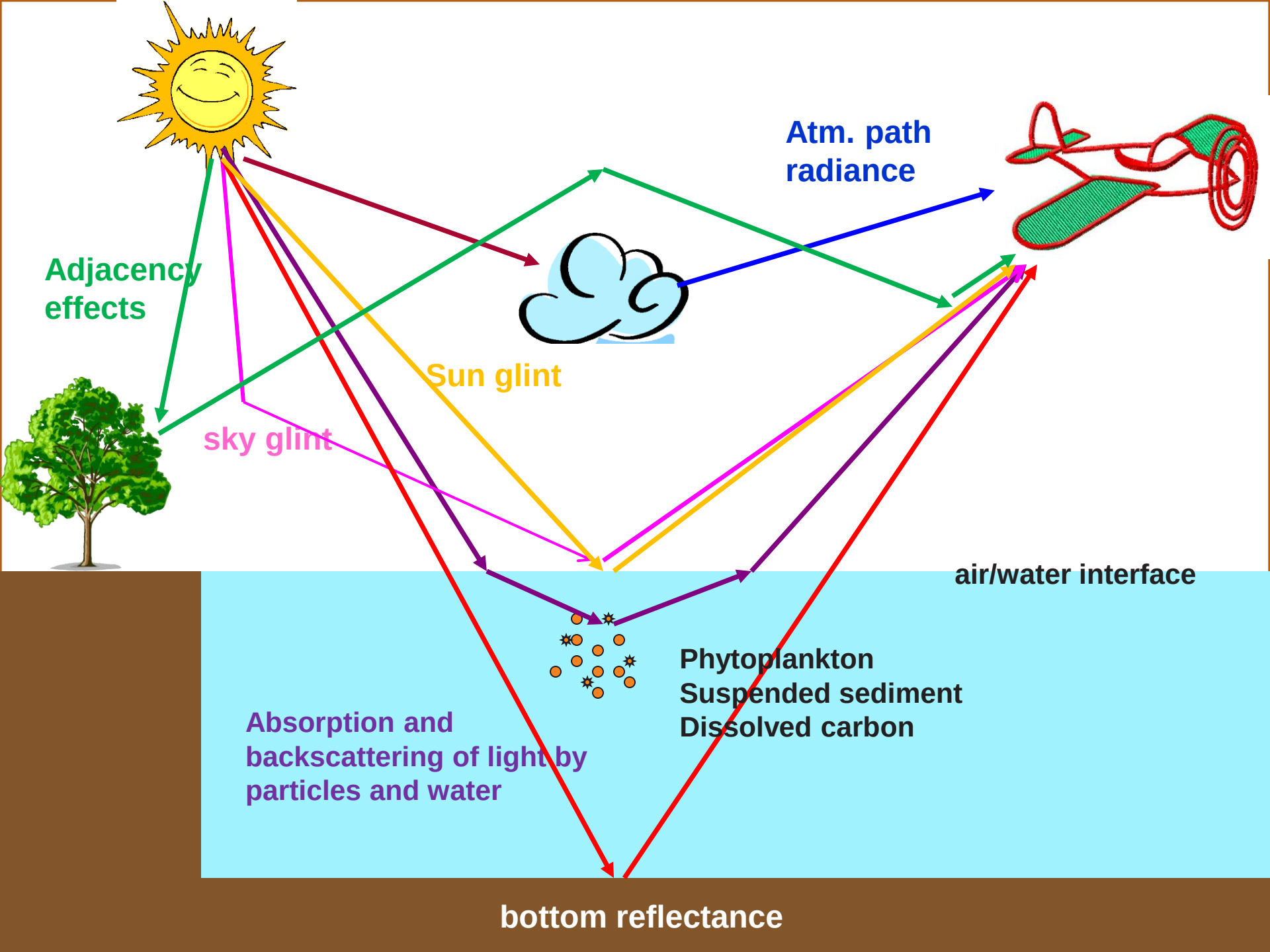
Challenges - A low signal

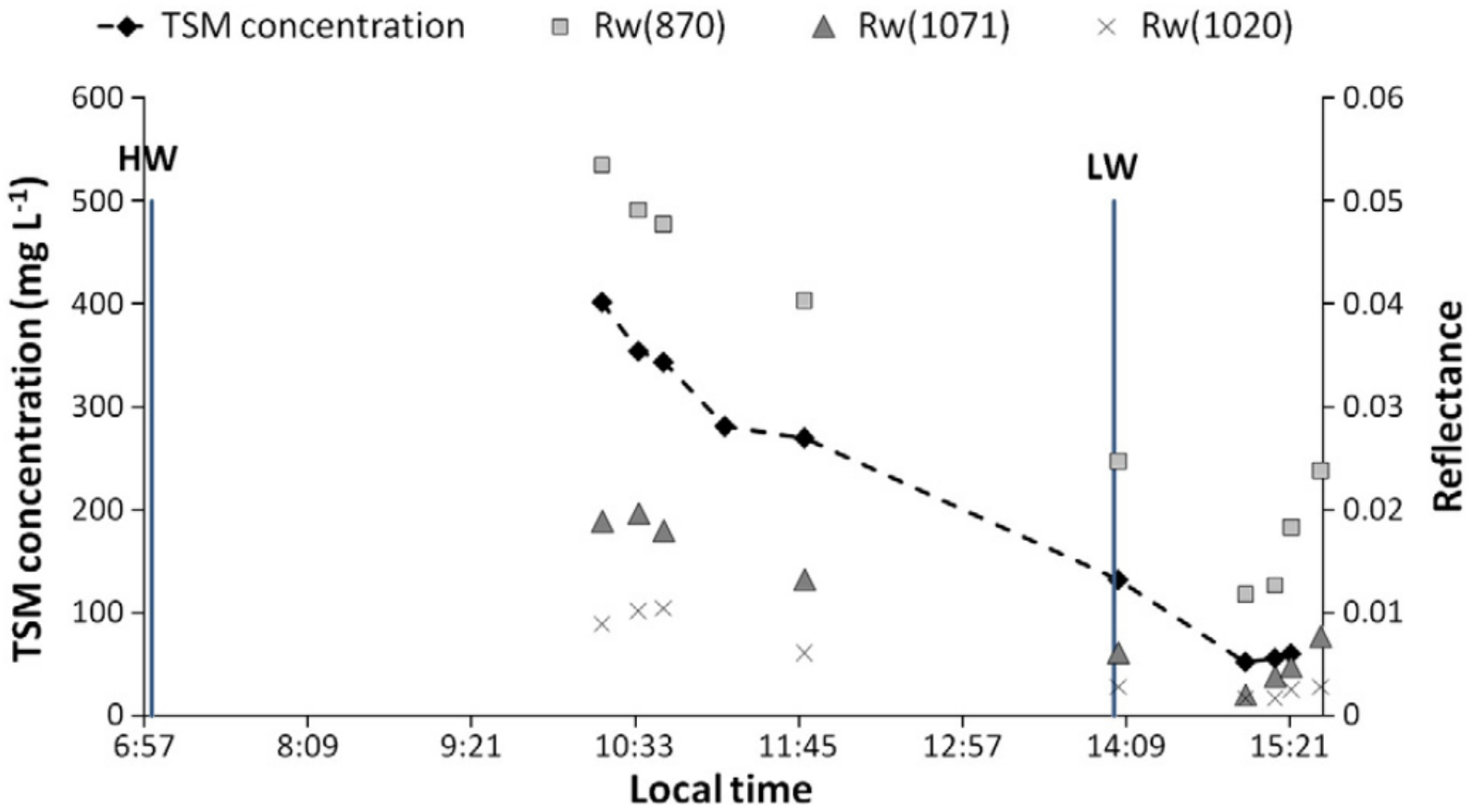
Pure water absorption coefficient (Kou et al., 1993; Pope & Fry, 1997) and total atmospheric transmittance



High SNR required
Good atmospheric correction


Atm. path
radiance
Adjacency
effects
Sun glint
sky glint
air/water interface
Phytoplankton
Suspended sediment
Dissolved carbon
Absorption and
backscattering of light by
particles and water
bottom reflectance

Challenges - Dynamic environment



→ **Match up difficulties**
Need for detailed campaign planning

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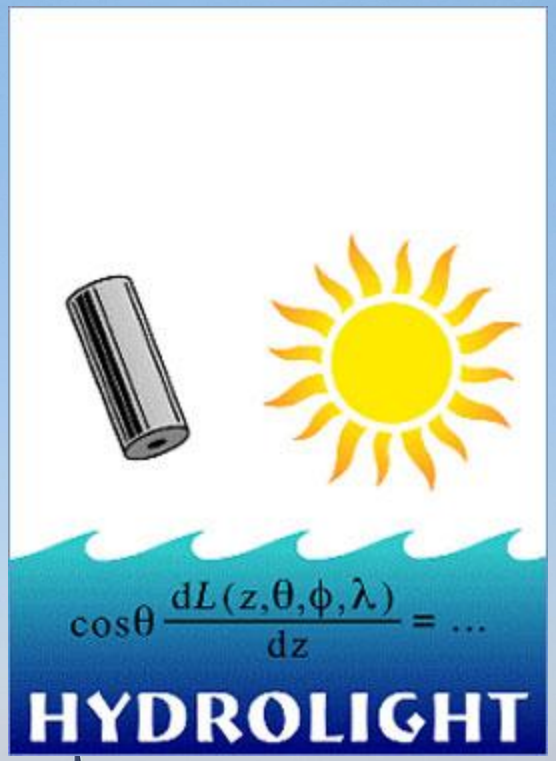
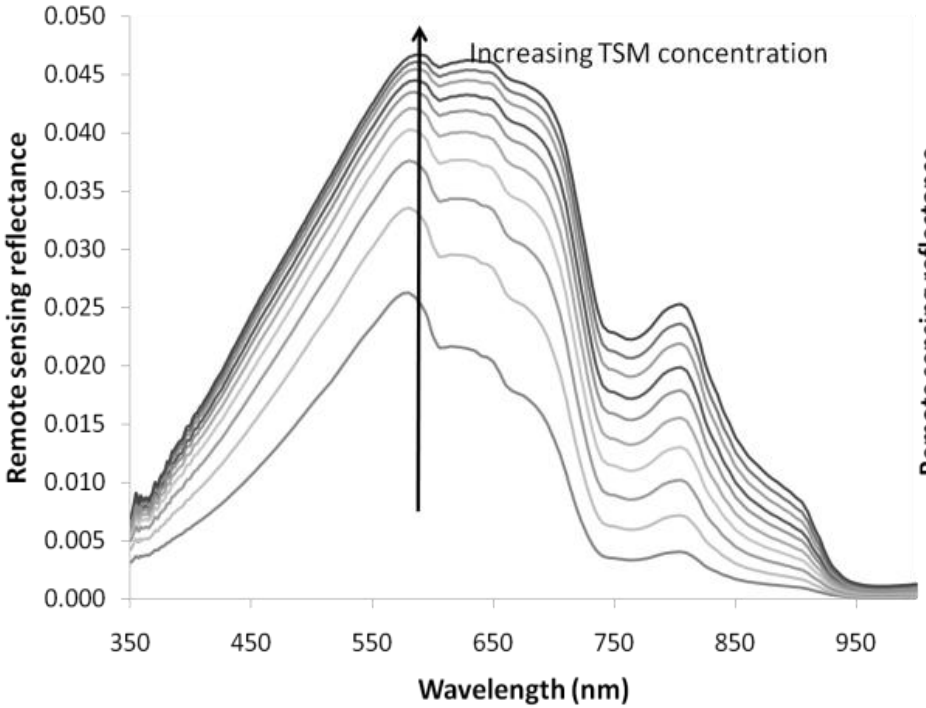
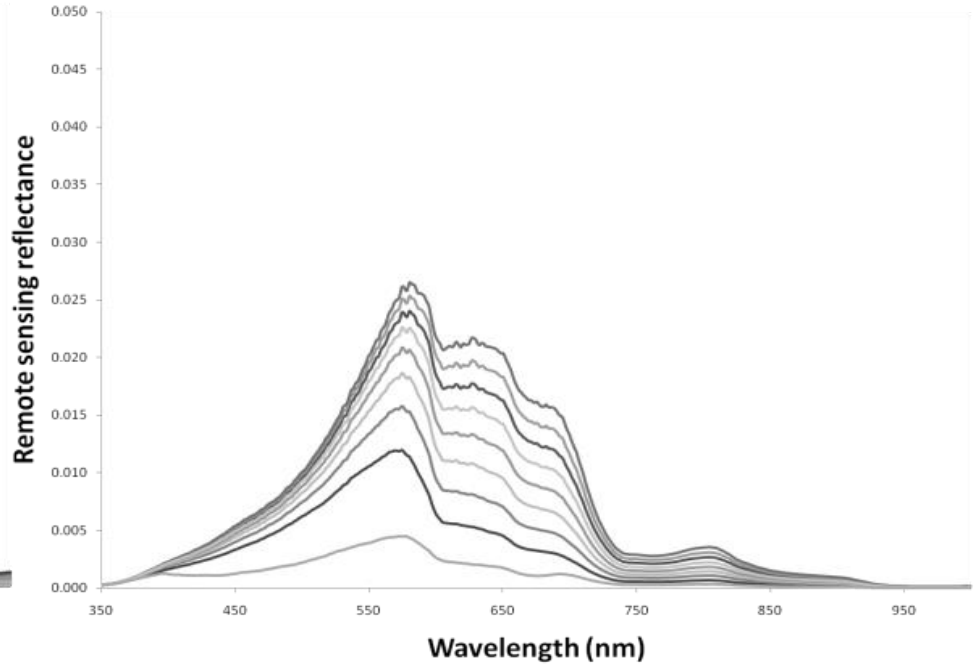
A typical water spectrum – simulation



Simulated Hydrolight spectra

Effect of concentration on the simulated spectra

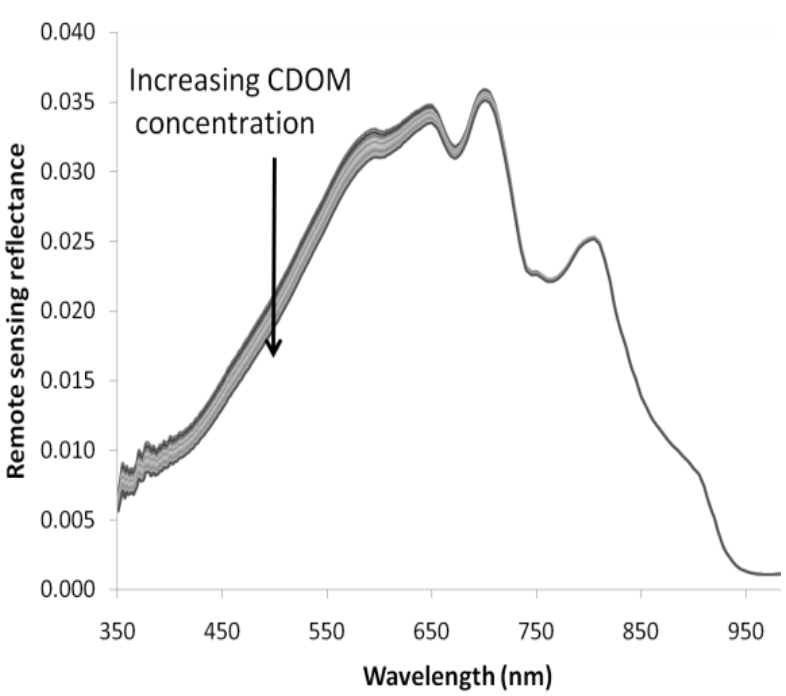


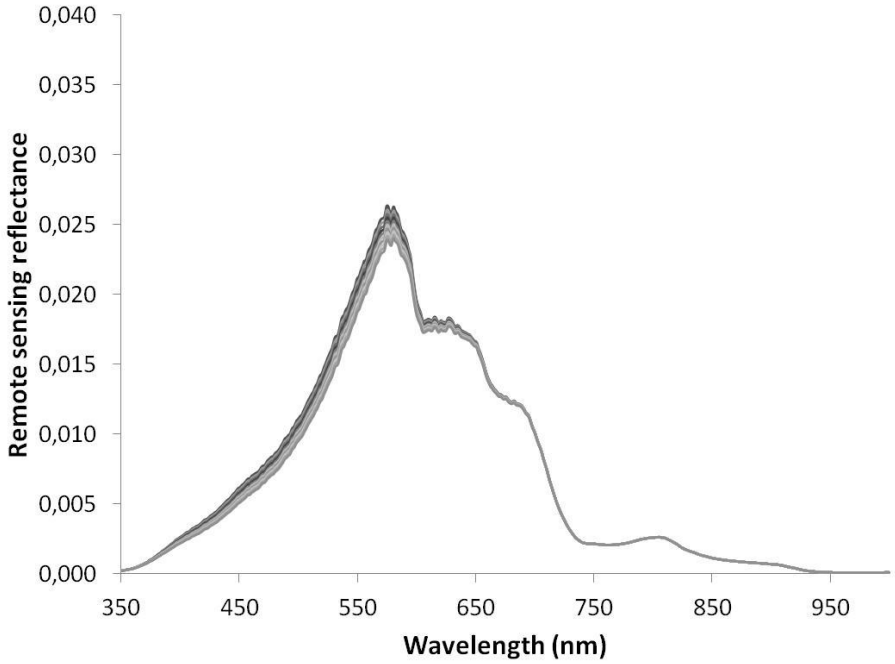


Variation in TSM concentration
Left: Scheldt
Right: Lake Constance

Simulated Hydrolight spectra

Effect of concentration on the simulated spectra

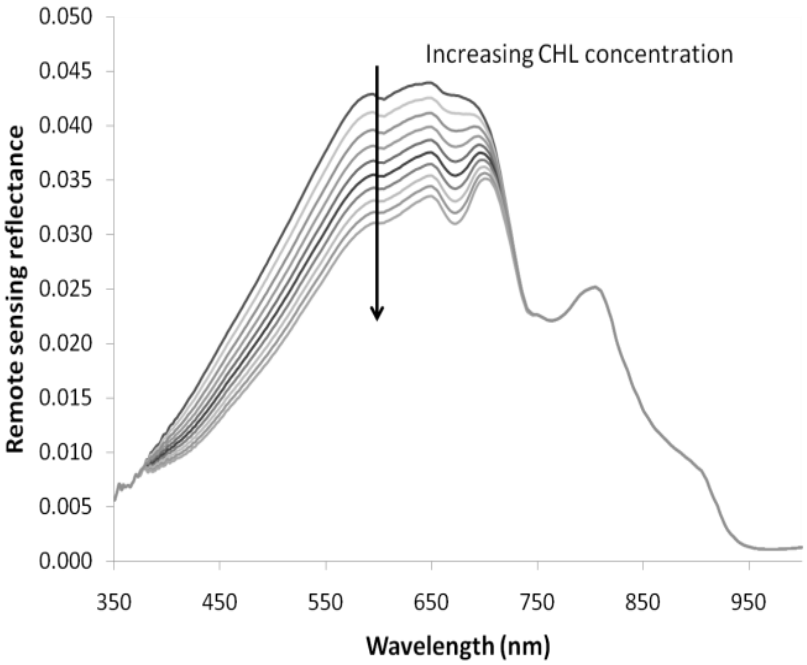


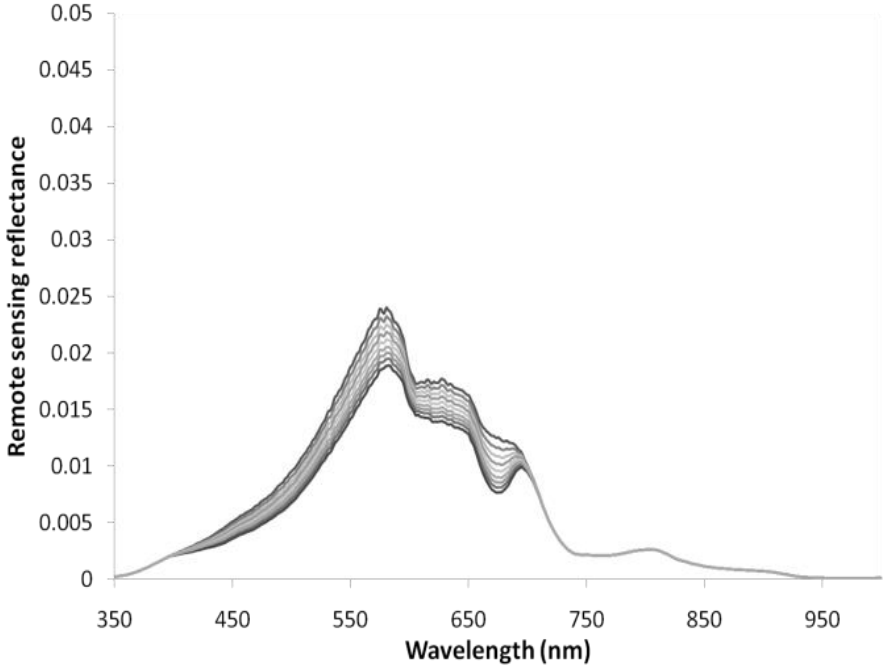


Variation in CDOM concentration
Left: Scheldt
Right: Lake Constance

Simulated Hydrolight spectra

Effect of concentration on the simulated spectra





Variation in CHL concentration
Left: Scheldt
Right: Lake Constance

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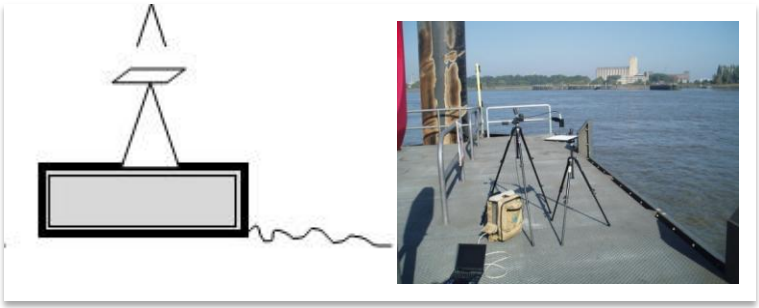
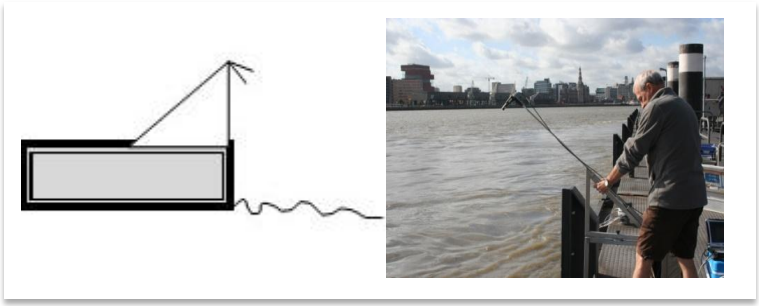
ASD spectra

water reflectance using an ASD FieldSpec FR spectrometer

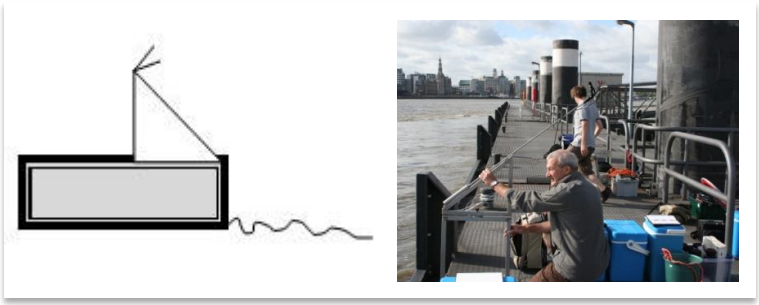
$E_d(0+)$:
downwelling irradiance
above the surface.



$L_u(a)$
total upwelling radiance
from the water



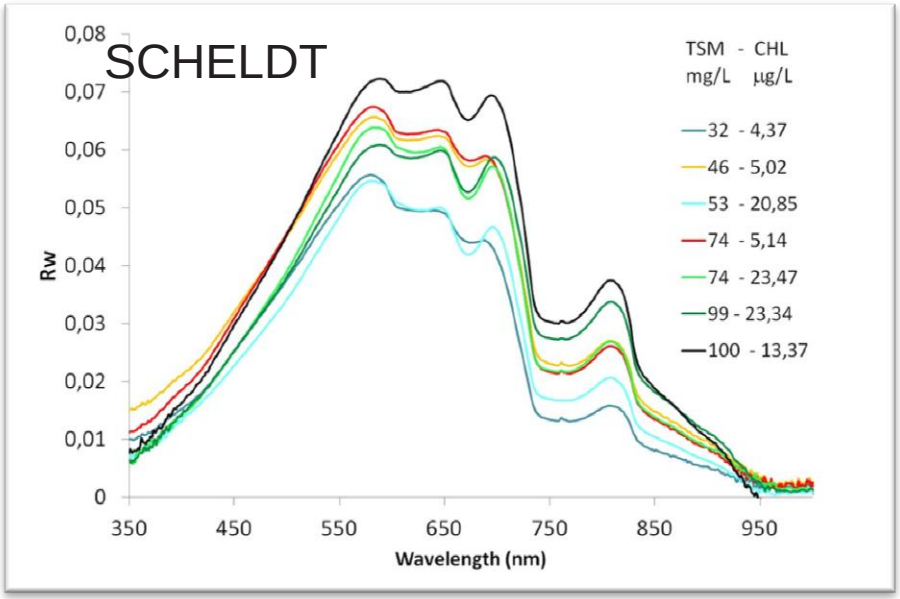
$L_{sky}(a)$
Downwelling sky radiance

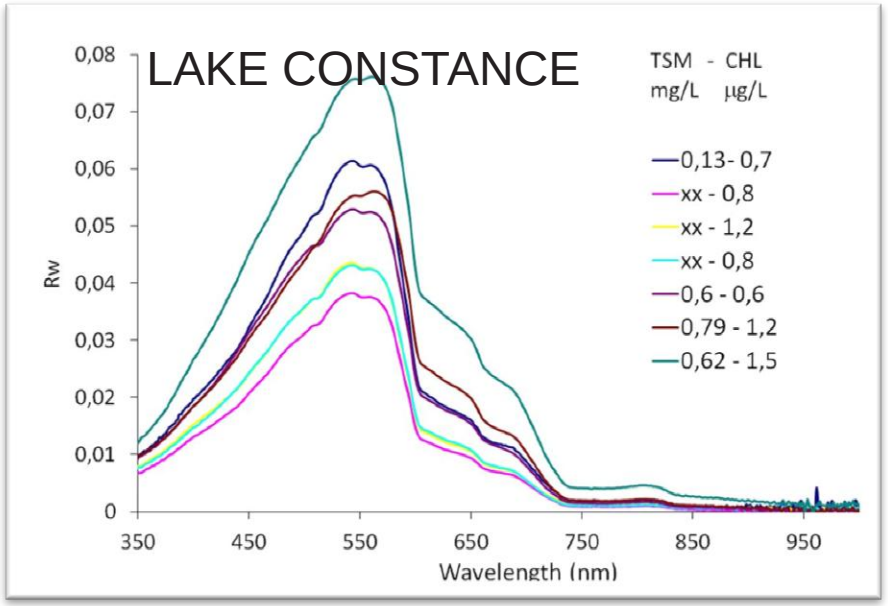


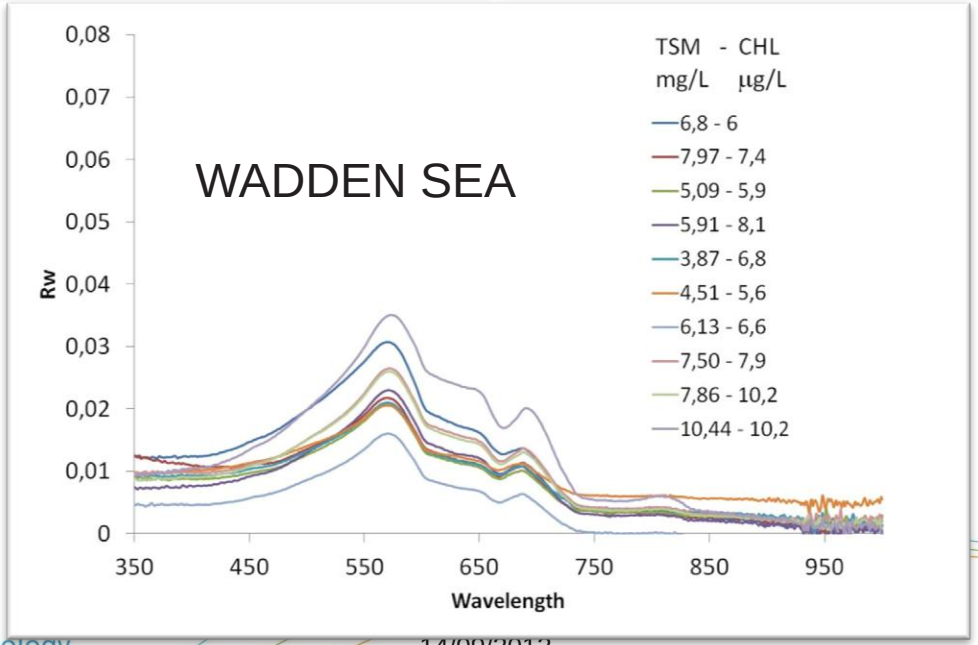
The water-leaving reflectance (Rw) was calculated using the following equation (Mobley, 1999):

$$Rw = (Lw(a) - \rho as * Lsky(a)) / Ed(a)$$

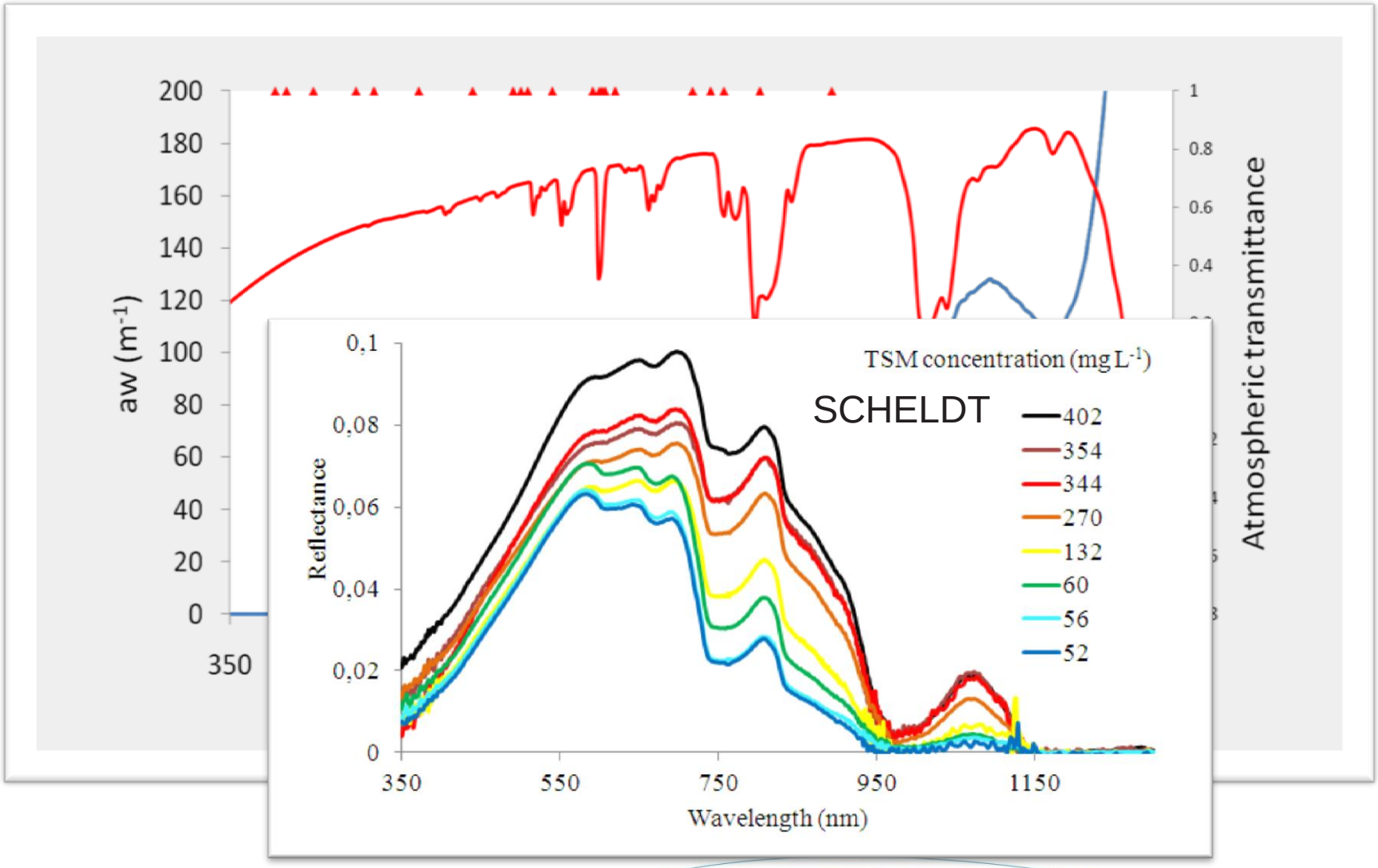
ASD water leaving reflectance





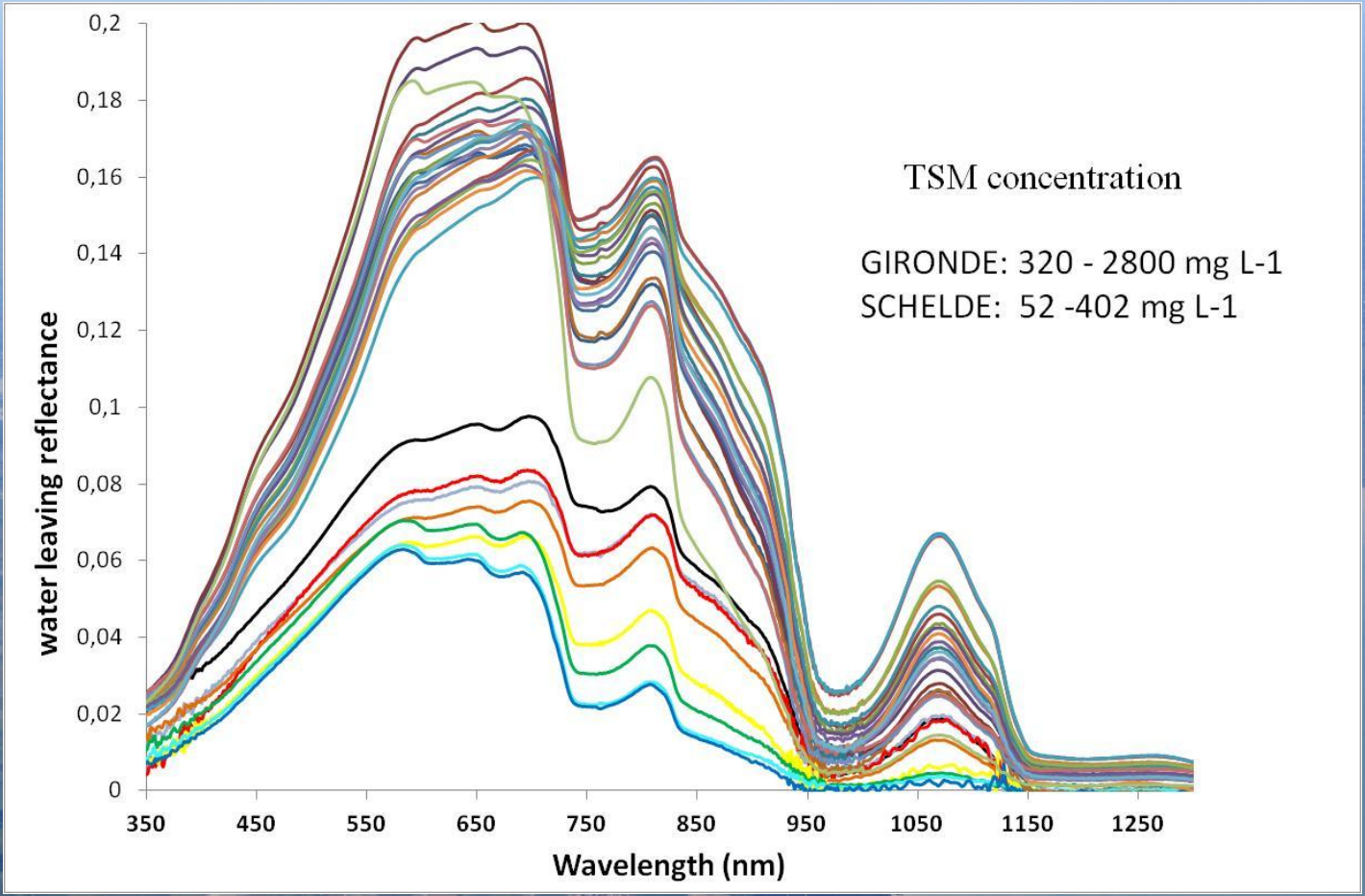


ASD water leaving reflectance – SWIR?

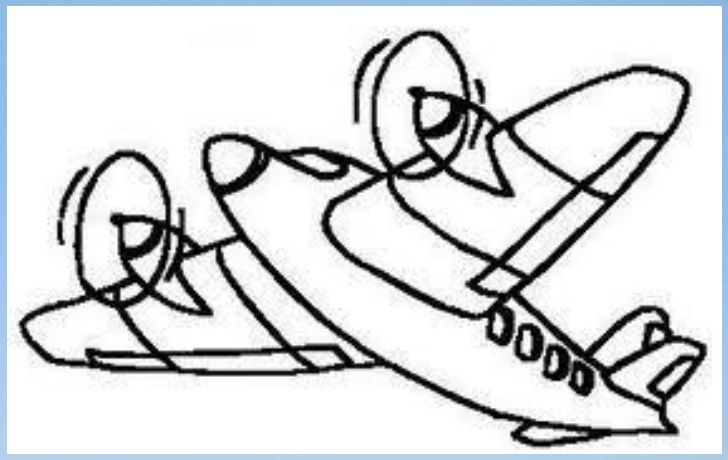


Knaeps, E. et al., Remote Sensing of Environment 120 (2012) 133-144

ASD water leaving reflectance – SWIR?

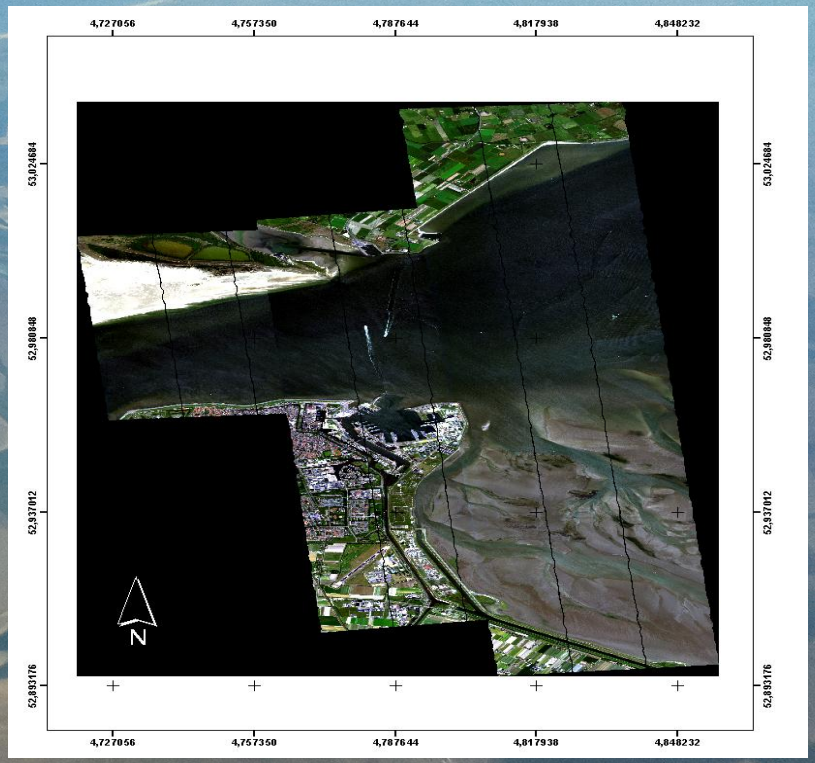


APEX - some results



APEX campaign: 06/2011 - Wadden Sea

- Cooperation with INPLACE project
- Logistics (boat, lab, ..)



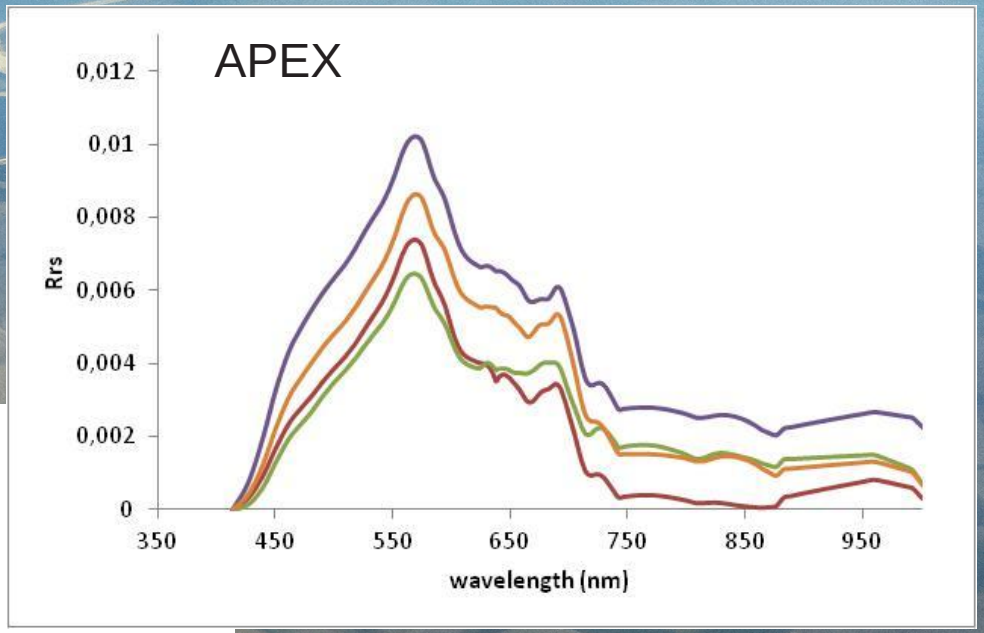
Zeevonk

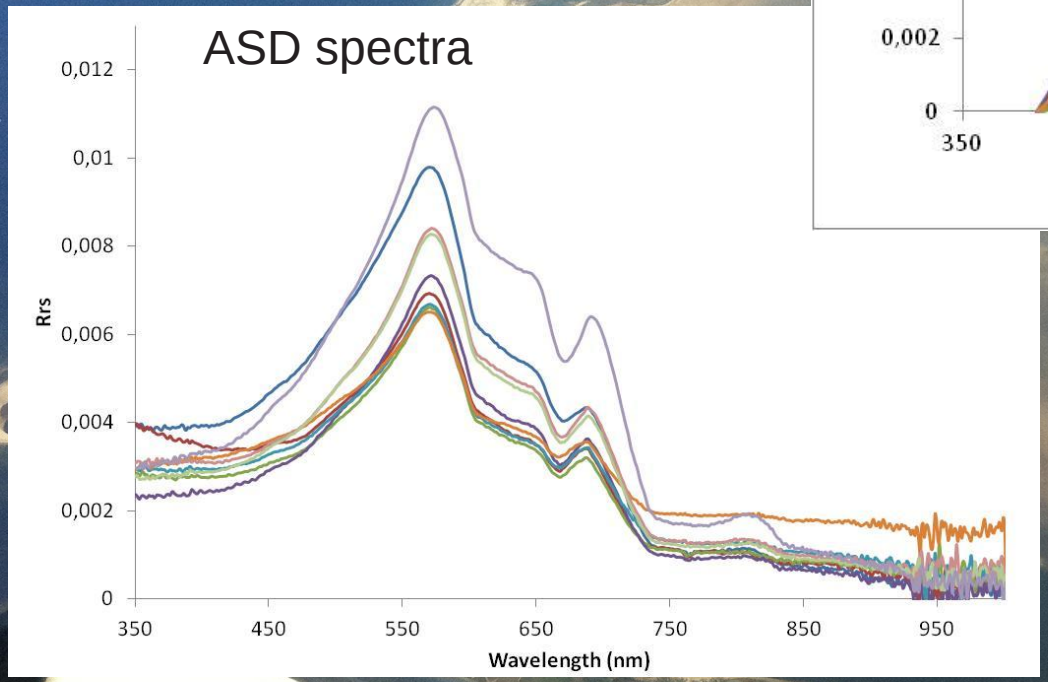
TESO (ferry)

NIOZ - pontoon

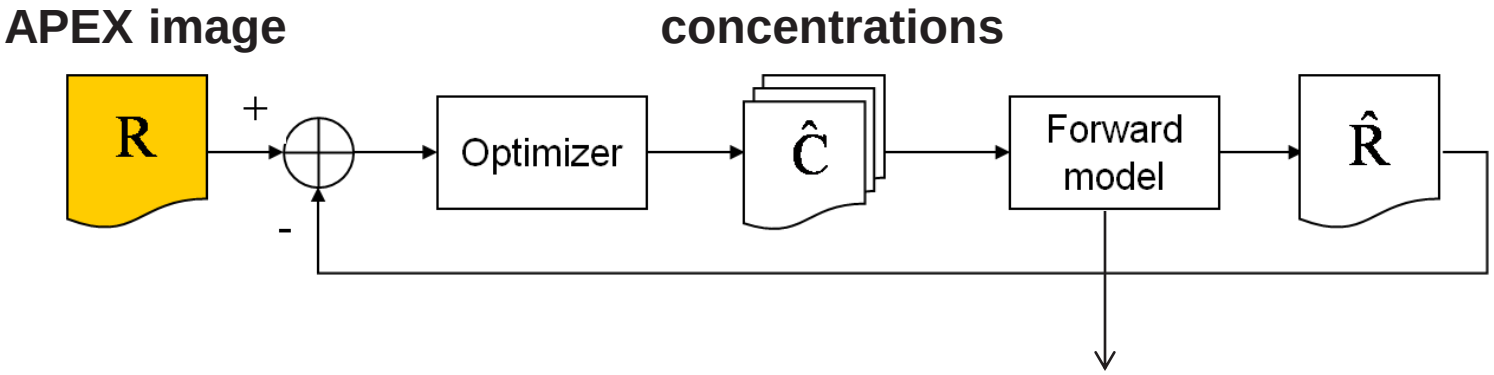
INPLACE pole

APEX campaign: 06/2011 - Wadden Sea





Wavelet based curve fitting algorithm



Bio-optical model of Albert and Mobley (2003)

$$R(0-,\lambda) = p_1(1 + p_2 x + p_3 x^2 + p_4 x^3)(1 + p_5 \frac{1}{Cos\theta_s})(1 + p_6 u)x$$

$$x = \frac{b_b(\lambda)}{a(\lambda) + b_b(\lambda)}$$

Objective: develop algorithm less sensitive to noise in atmospheric correction and sensor noise

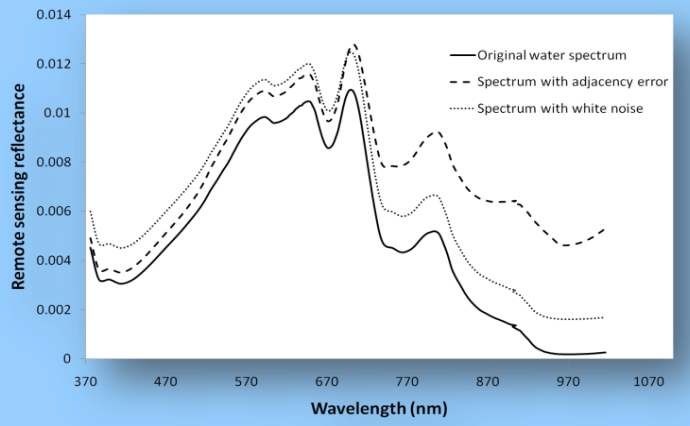
Study area: Scheldt

Reference = Hydrolight with known concentrations, resampled to APEX wavelengths

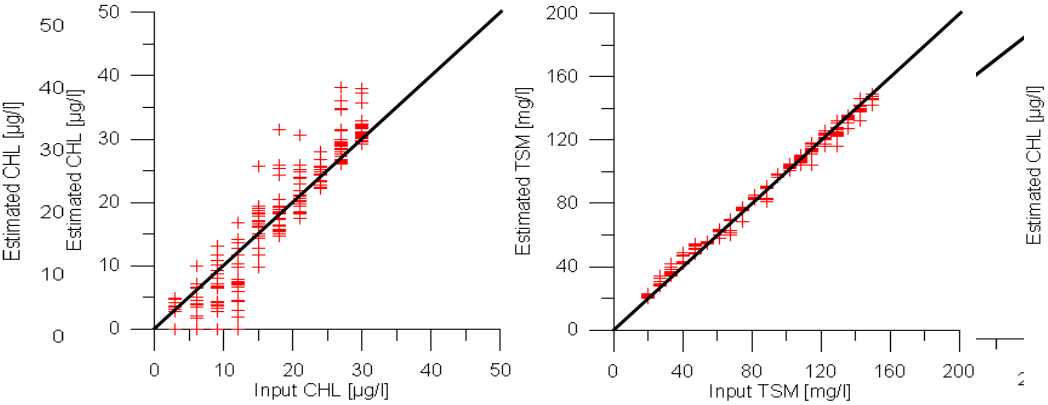
Noise: adjacency

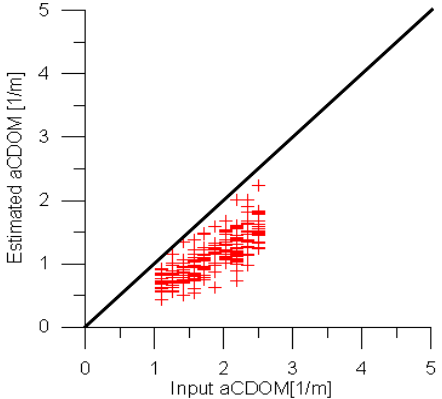
Noise: adjacency, with wavelets

Figure: Synthetic remote sensing reflectance spectra with white noise and adjacency error

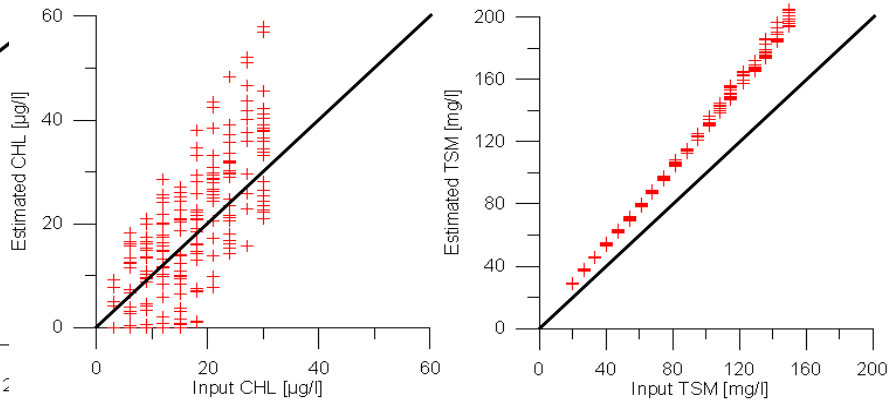


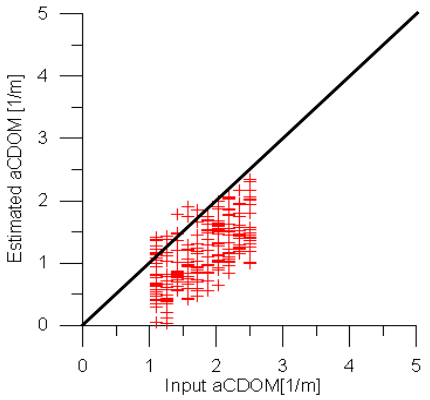
Water Quality Estimations: Scheldt
Noise: Adjacency effect
Optimalisation: Wavelet combination



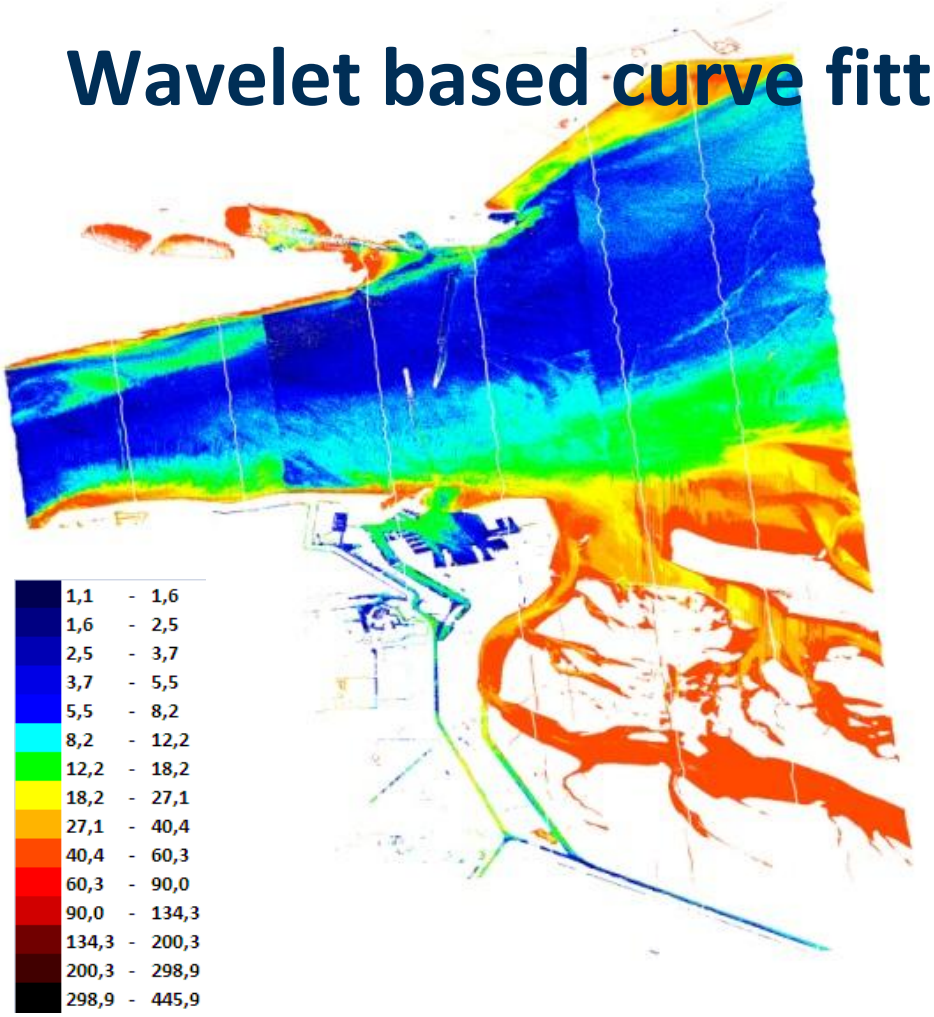


Water Quality Estimations: Scheldt
Noise: Adjacency effect
Optimalisation: RMSE

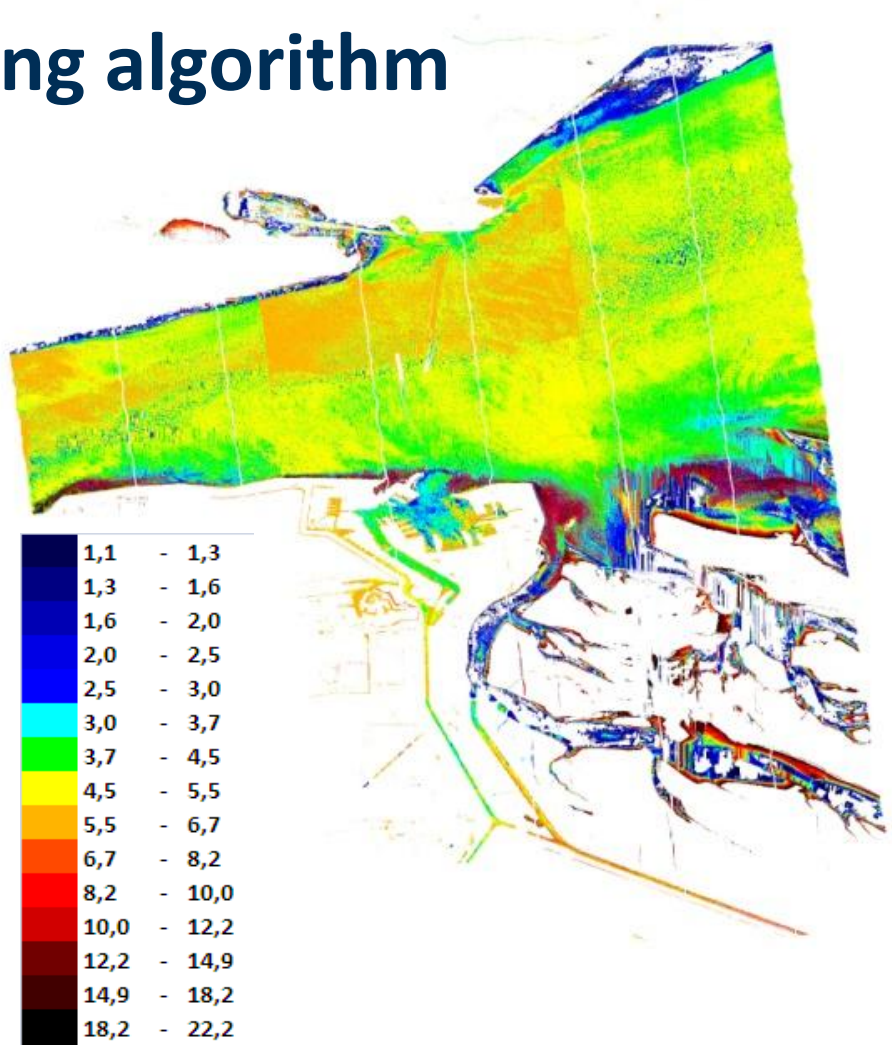




Wavelet based curve fitting algorithm



TSM concentrations in the Wadden Sea (in mg L^{-1}), mosaic of flight line 1, 2 and 3



CHL concentrations in the Wadden Sea (in mg L^{-1}), mosaic of flight line 1, 2 and 3

Scheldt – APEX flight

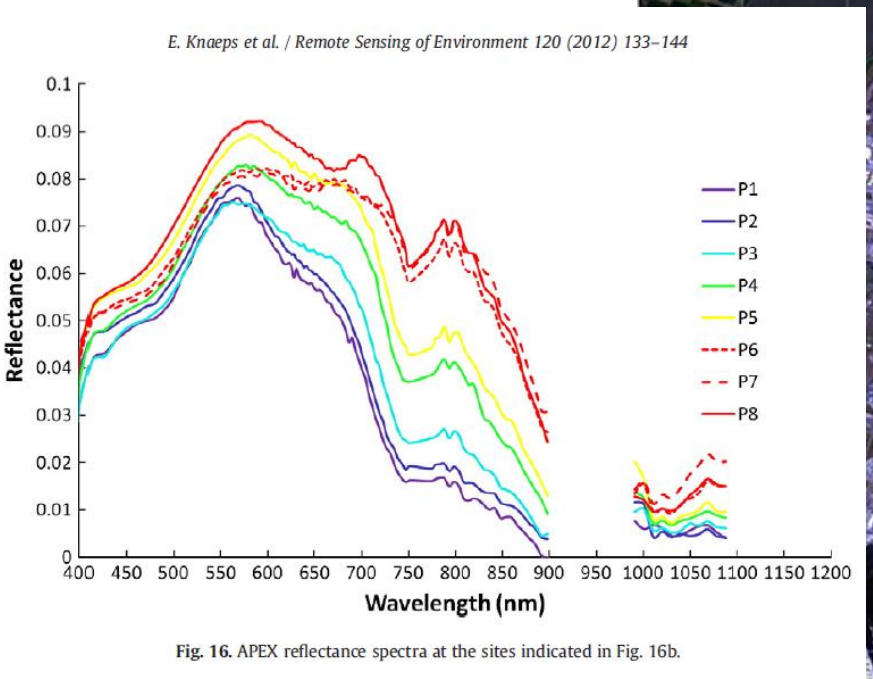
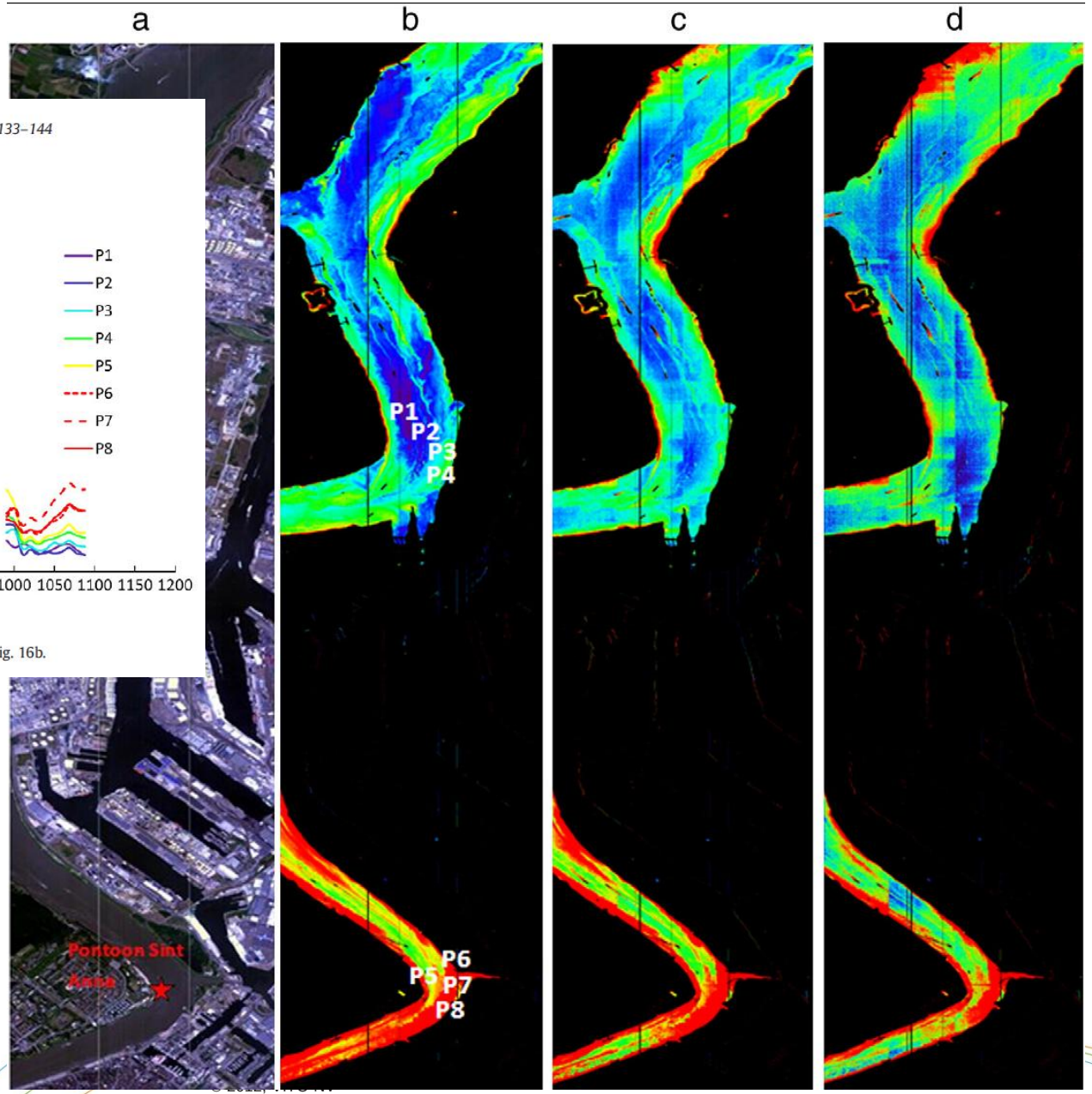


Fig. 16. APEX reflectance spectra at the sites indicated in Fig. 16b.



(a) RBG APEX image of the Scheldt
(b) map of Rw711/Rw597
(c) map of Rw1069
(d) map of Rw1020.

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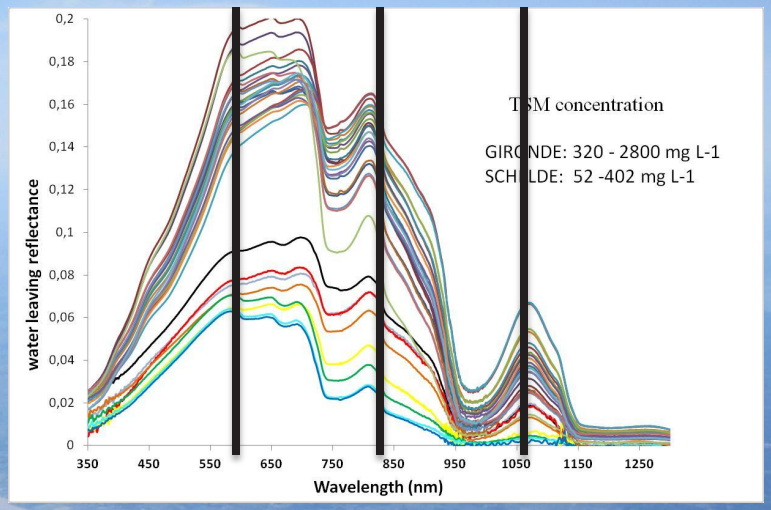
GIRONDE – APEX flight



Conclusion and way forward

- Complex waters (dynamic, small, atm. Cor,…)
  - -> Currently no suitable spaceborne sensor
  - -> airborne Hyperspectral
  - -> simulator for future spaceborne missions
- APEX SWIR potentially interesting for TSM retrieval


THANK YOU
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