SEASWIR: Remote sensing of extremely turbid waters: an evaluation of the SWIR spectral region

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BEO day 2014

Landsat 8 image - Gironde estuary

Motivation

Usefullness of SWIR = matter of debate

- Only use of SWIR is in atmospheric correction of MODIS for highly and extremely turbid waters (assumption SWIR = black)
- Suggested that SWIR could be of interest to derive concentrations of TSM in these waters! (<-> saturation in NIR!)
- Almost no information on SWIR water optical properties
- Additional SWIR = expensive. Should be well motivated!

- Describe variability of the water reflectance in SWIR
- Develop SWIR TSM algorithm
- Give recommendations to the space agencies

How?

- Field campaign in extremely turbid waters

  -> Instrumentation (ASD, Hydroscat, CIMEL)
- Image analysis (airborne - APEX, satellite - MODIS)
- Theoretical model

Main results of the project

- SWIR reflectance, SWIR TSM algorithm, TSM limits
- Demonstration that water-leaving radiance can be measured by the CIMEL SeaPRISM (basis of the AERONET-OC network) for the 1019nm SWIR wavelength.
- Performance of existing NIR Turbidity algorithms
- A new correction method for the Hydroscat
- Theoretical model and the SWIR similarity spectrum
- Validity and limitations of the SWIR atmospheric correction algorithm in extremely turbid waters

Publications

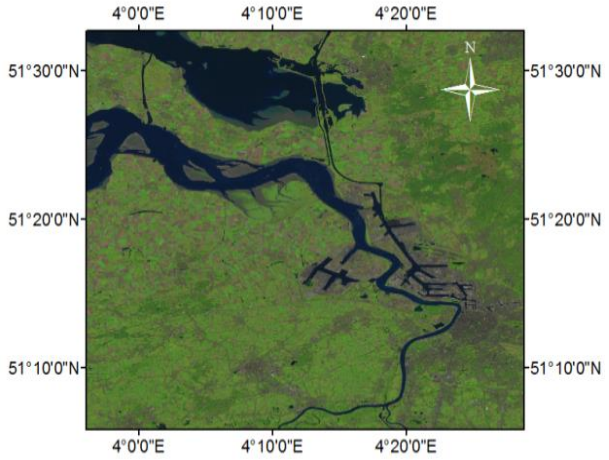
- Knaeps, E. , Ruddick, K.G., Doxaran, D., Dogliotti, A.I., Nechad, B., Raymaekers, D., Sterckx, S. SWIR spectral signature of highly turbid waters (submitted to RSE)
- Doxaran D., Leymarie E., Nechad B., Dogliotti A., Ruddick K., Gernez P. and E. Knaeps. An improved correction method for field measurements of particulate light backscattering in turbid waters . (to be submitted to Optics Express within two months)
- Dogliotti, A. I., Ruddick, K. G., Nechad, B., Doxaran, D., Knaeps, E. *Can a single algorithm be used to retrieve turbidity from remotely-sensed data in all coastal and estuarine waters?* Paper submitted to Remote Sensing of Environment. Accepted
- An additional paper will be written on the SWIR similarity spectrum, including both theoretical model and analysis of in situ ASD measurements.

Extremely turbid waters?

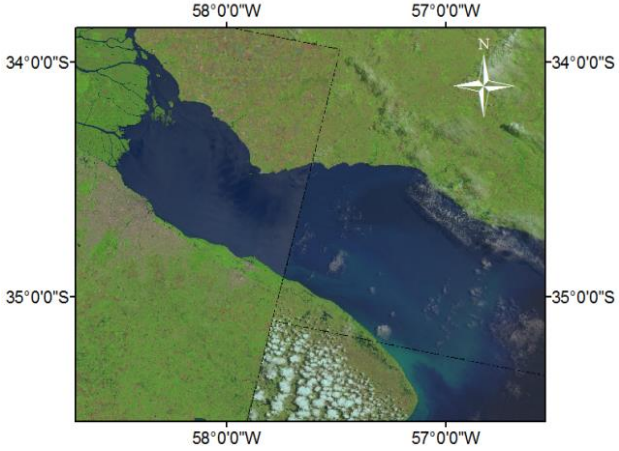
> 100 mg L-1

Study areas – extremely turbid waters

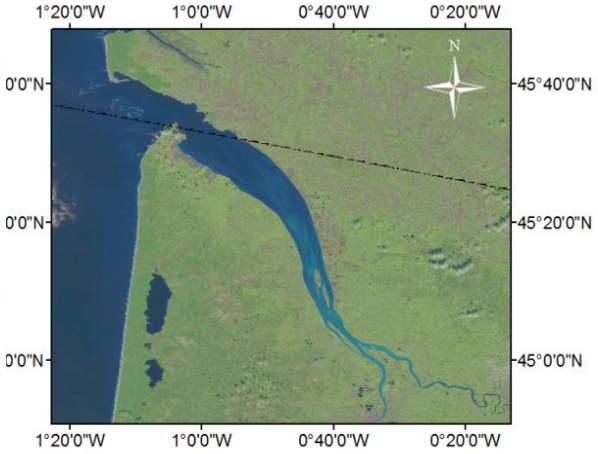
Scheldt



La Plata

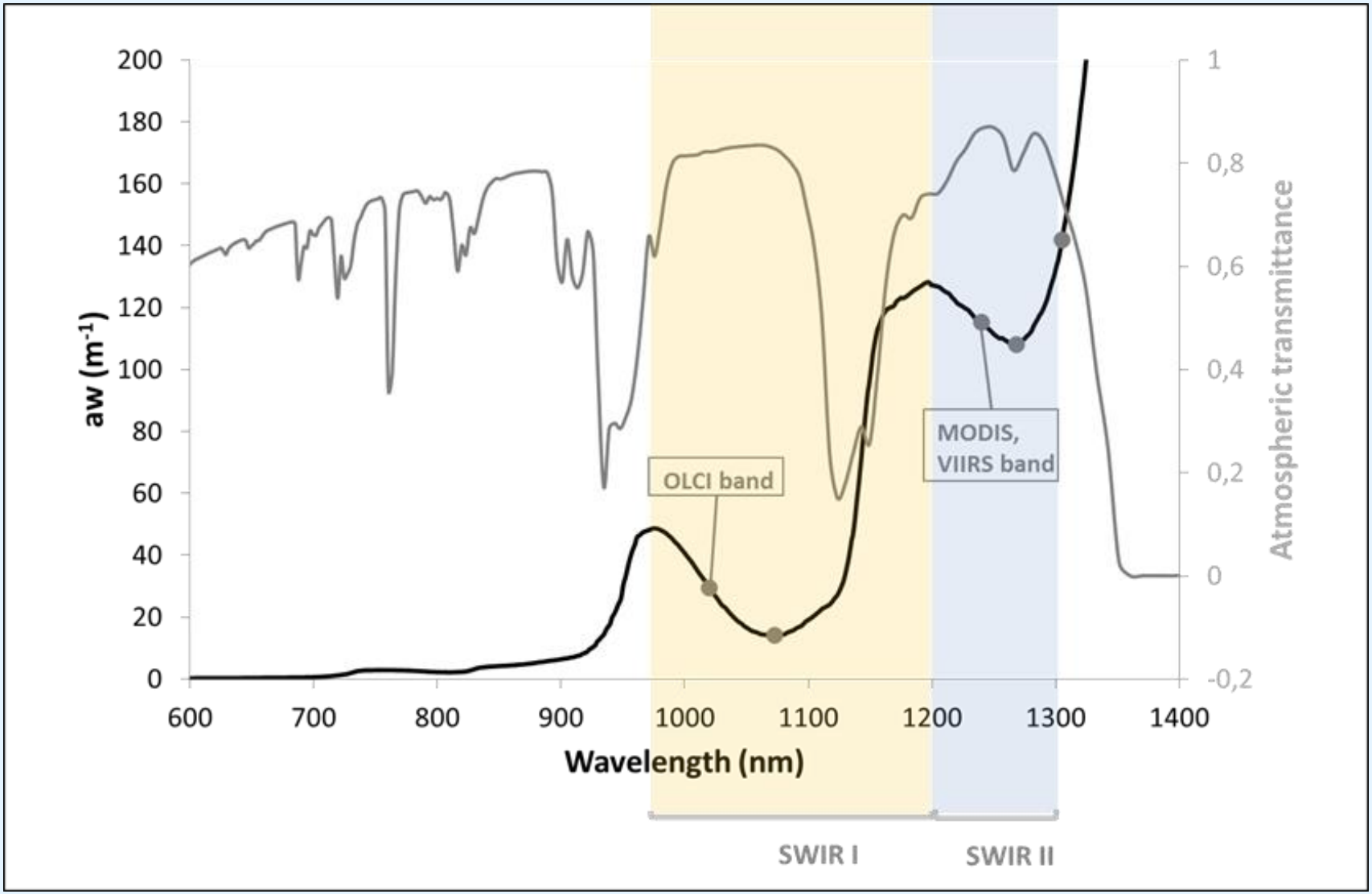


Gironde

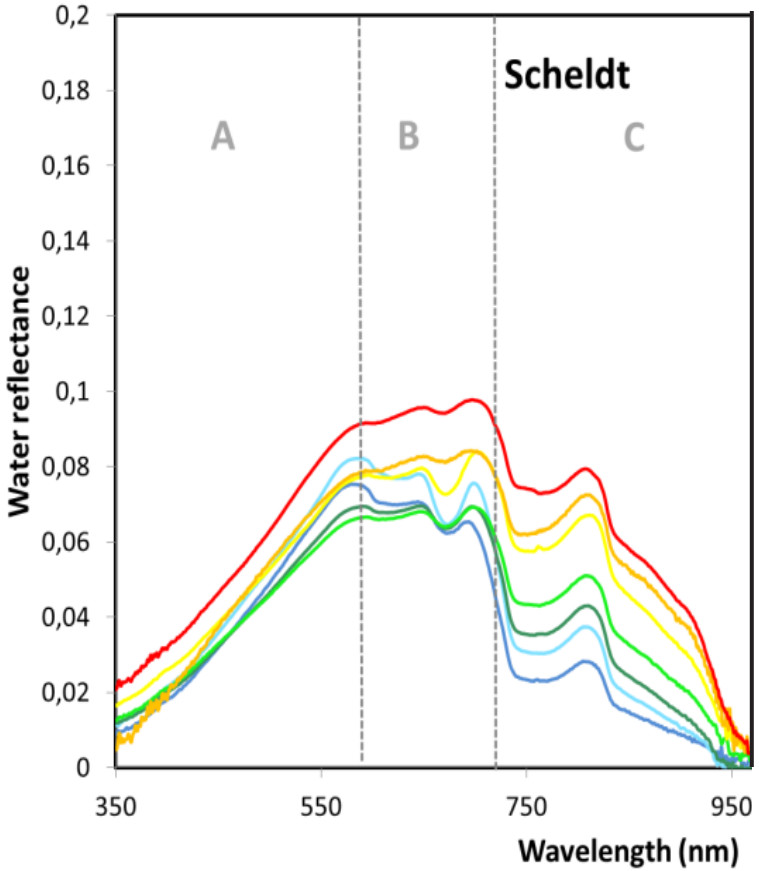


Study area	TSM (mg L-1)	Turbidity (FNU)	Chla (µg L-1)	Salinity (psu)	Temperature (°C)
Scheldt2010	15-402	54-283	/	2,7-10,4	23,5-23,8
Scheldt2012	49-365	48- 371	16-71	1,1 – 6,4	18,5 – 19,7
Gironde2012	56-1400	256-1919	0,9-4,2	0,1-20,8	18,4-21
La Plata	30-160	60-186	/	0,15-0,19	23-26,9
Gironde2013	68-1875	41 - 2697	/	1,7 – 7,5	21,3 - 26

SWIR?


aw (m-1)
200
180
160
140
120
100
80
60
40
20
0
600
700
800
900
1000
1100
1200
1300
1400
Wavelength (nm)
1
0,8
0,6
0,4
0,2
0
-0,2
Atmospheric transmittance
OLCI band
MODIS, VIIRS band
SWIR I
SWIR II

Typical water reflectance spectra for Scheldt, La Plata and Gironde



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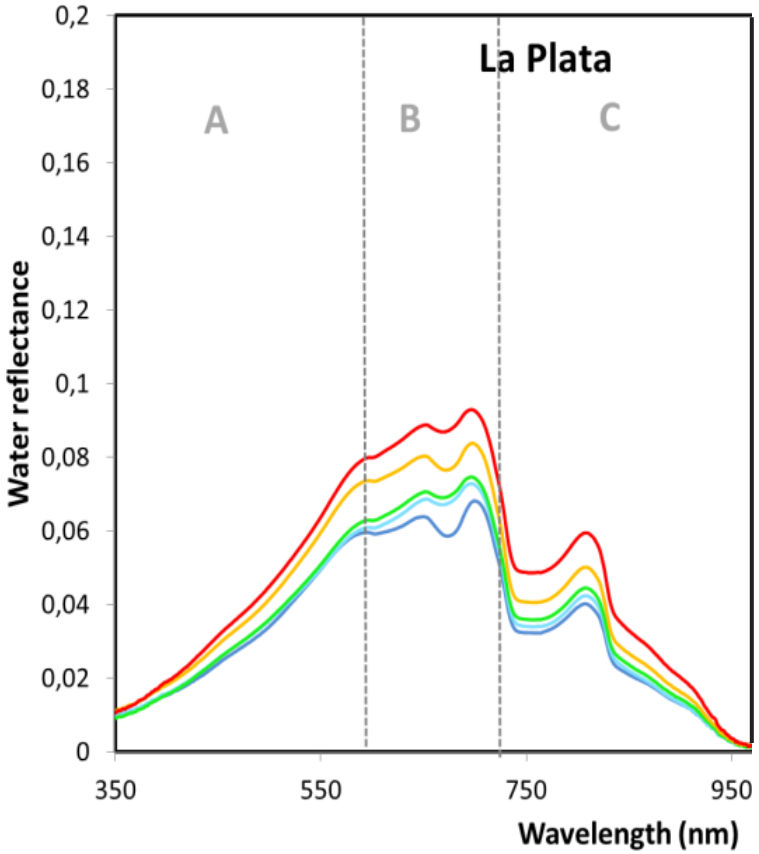
Typical water reflectance spectra for Scheldt, La Plata and Gironde



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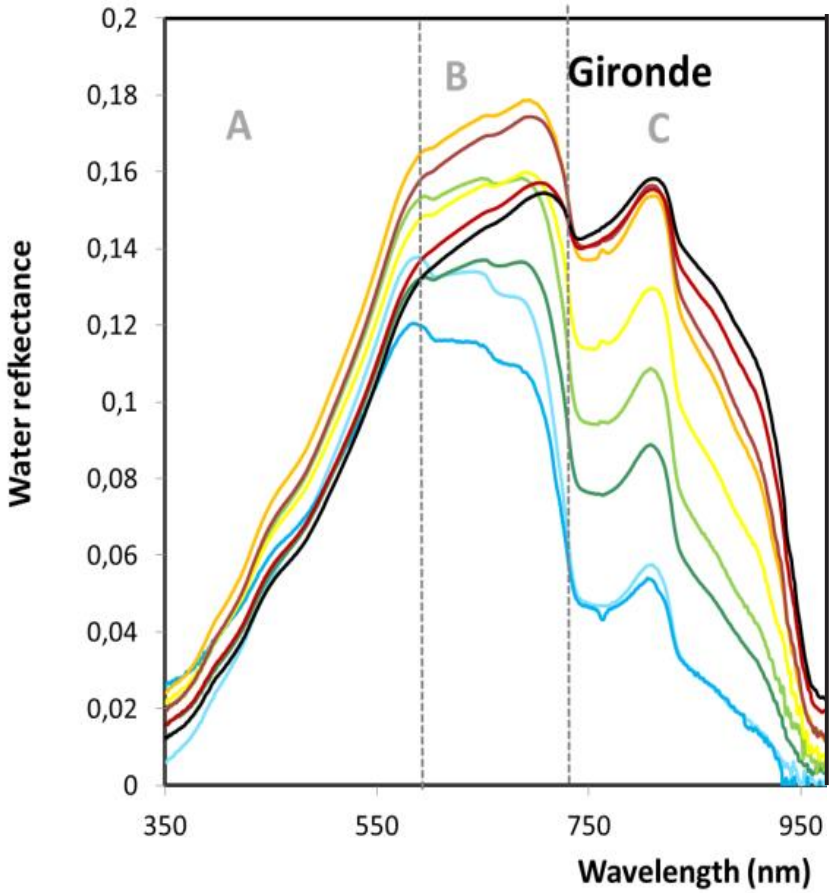
Typical water reflectance spectra for Scheldt, La Plata and Gironde



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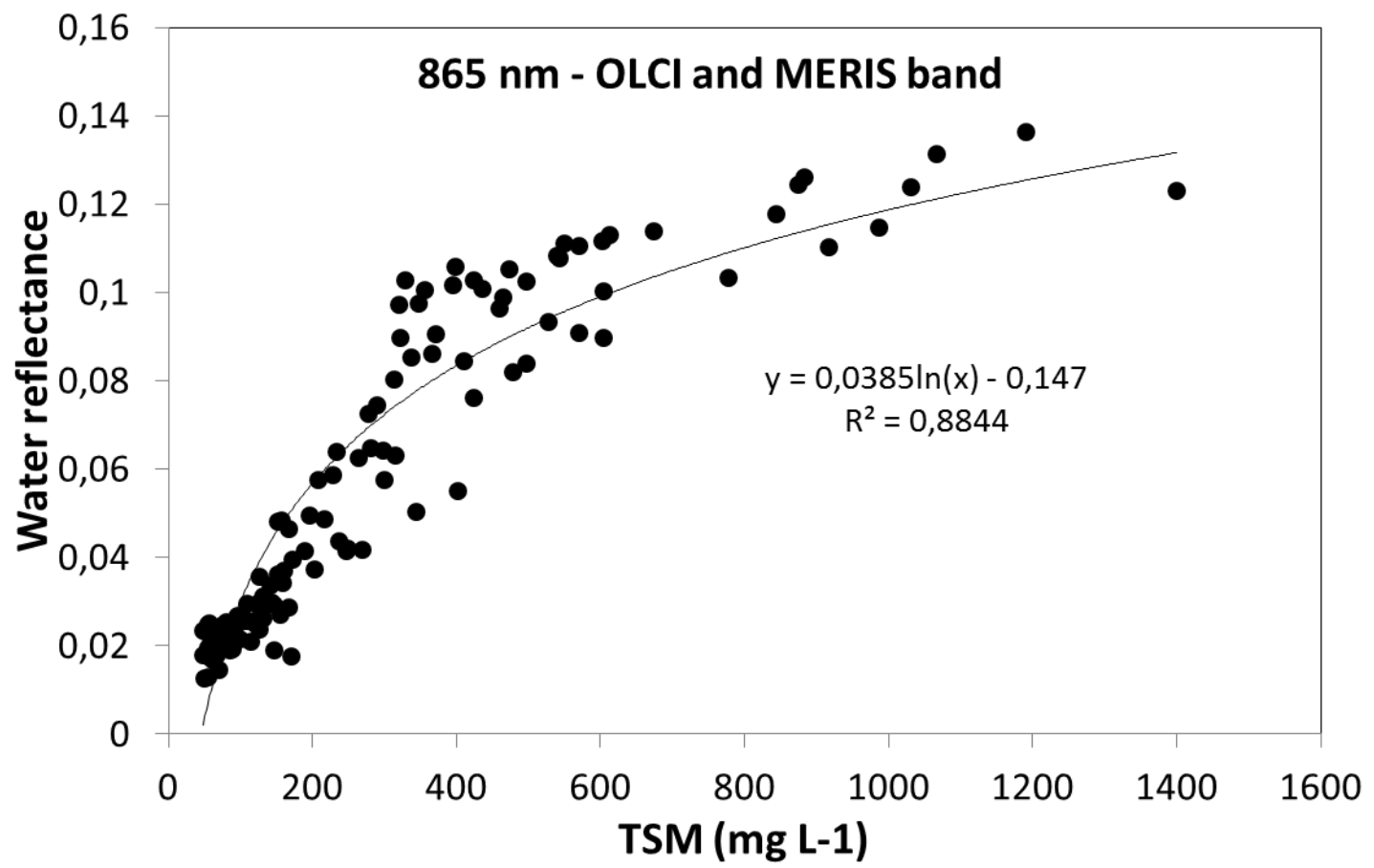
Relationship with TSM concentration

- In general, ↑ TSM → ↑ backscattering coefficient. In the SWIR ↑ water reflectance
- Knaeps et al. (2012) : linear relationship between reflectance at 1071 and 1020 nm and TSM concentration for a TSM range between 15 and 402 mg L-1.

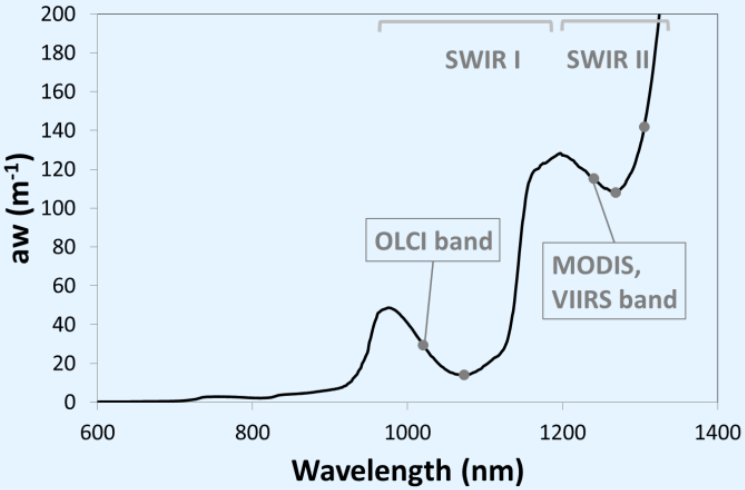
- **We expect:** when moving to more turbid waters, the relationship between reflectance and TSM will become non-linear, but this will occur at much higher TSM concentrations than for the NIR because of the higher pure water absorption.

Relationship with TSM concentration - NIR



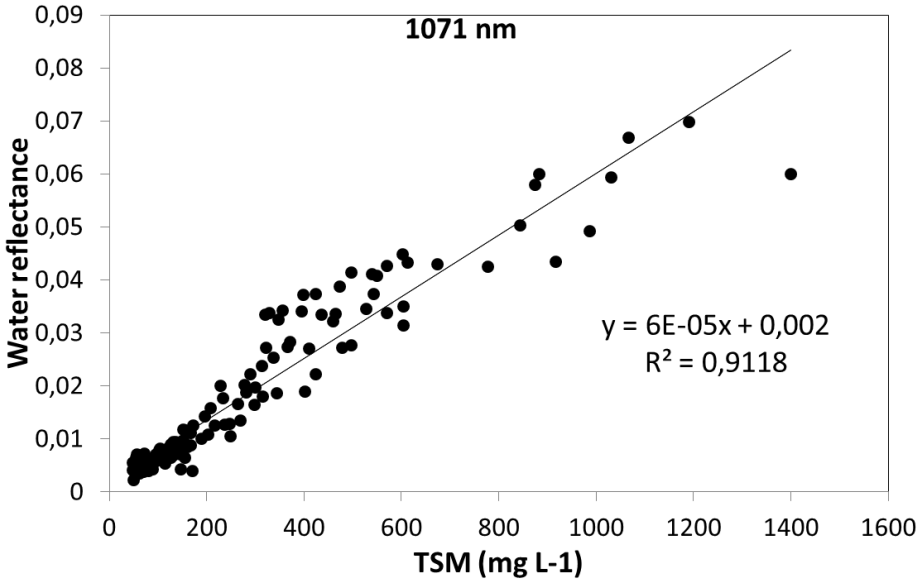
Rw > 0,08 -> lower sensitivity -> switch to longer wavelength

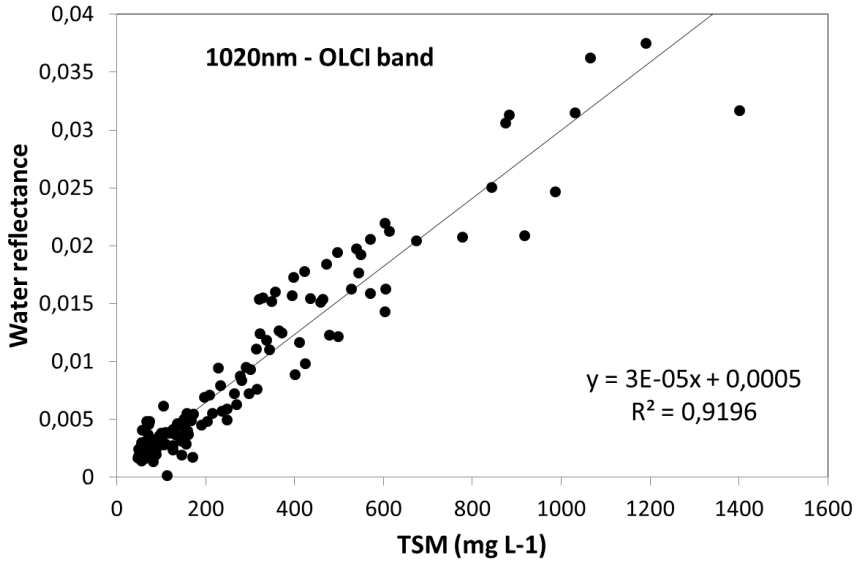
Relationship with TSM concentration – SWIR I



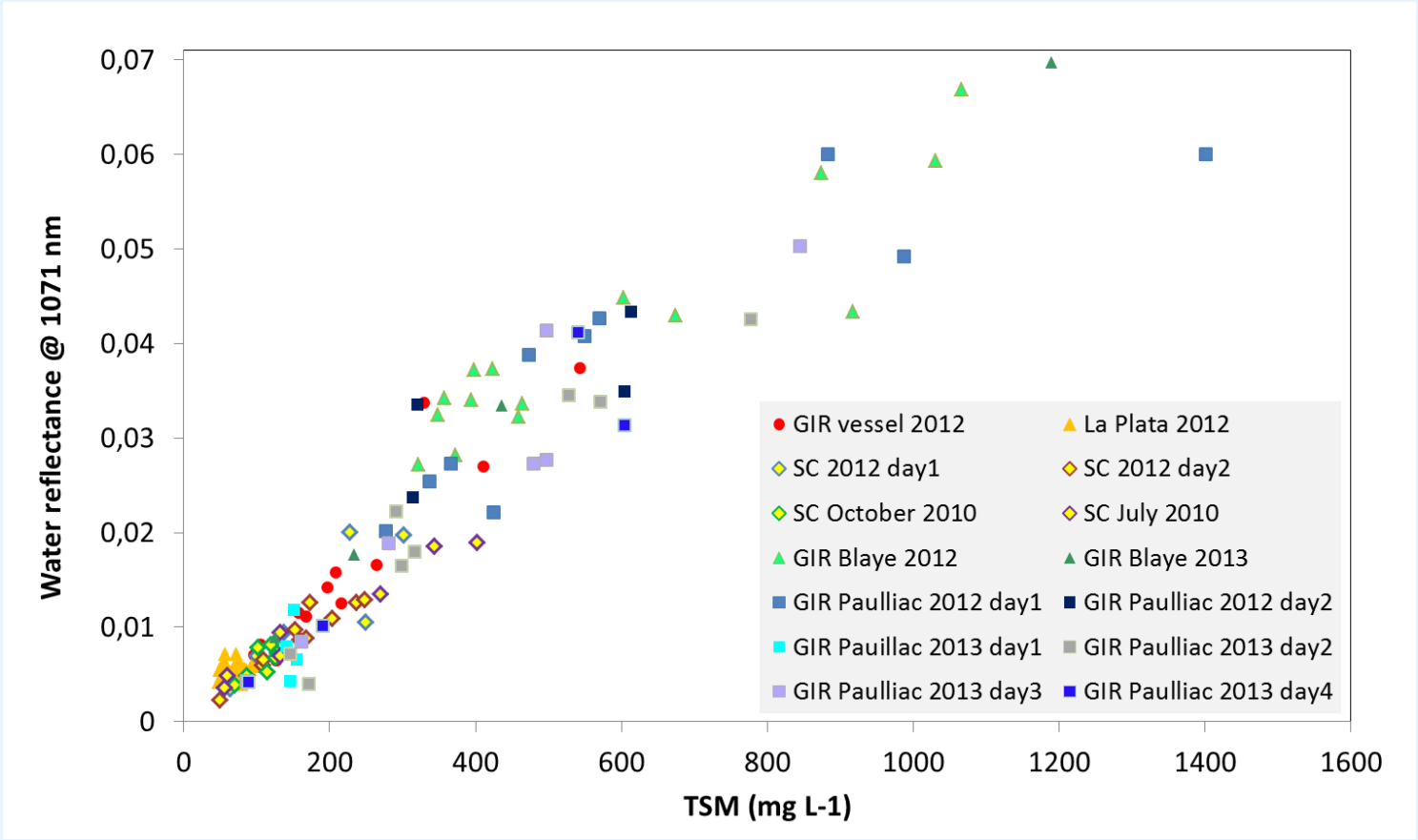
Linear ! No decrease in sensitivity

MAE = 26,6 %(1020nm) and 26,2% (1071nm)



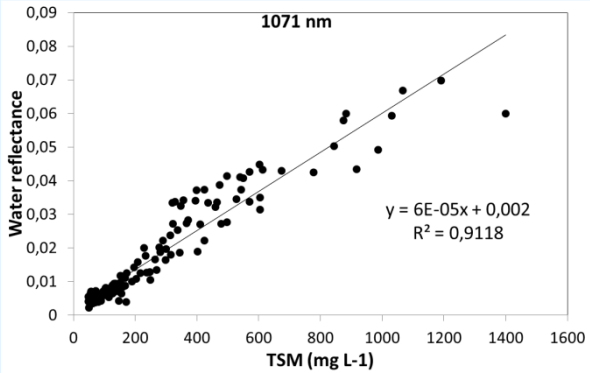


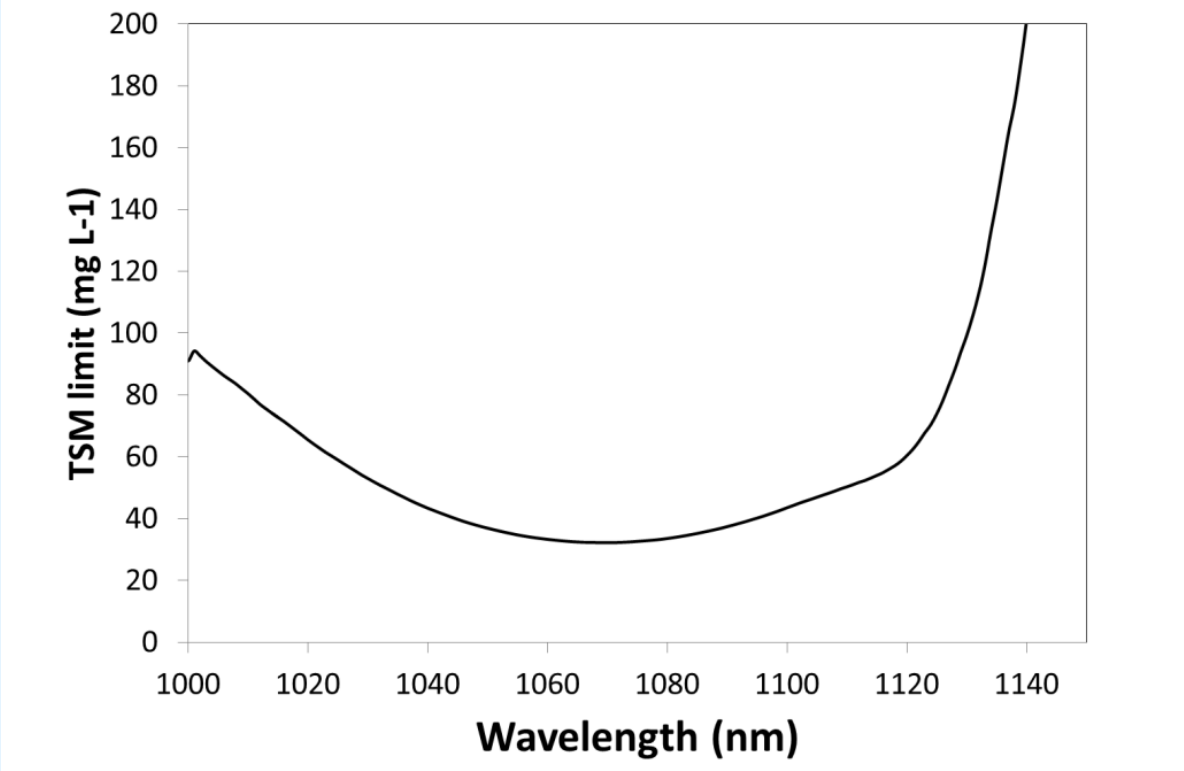
Regionality



TSM limits for SWIR I

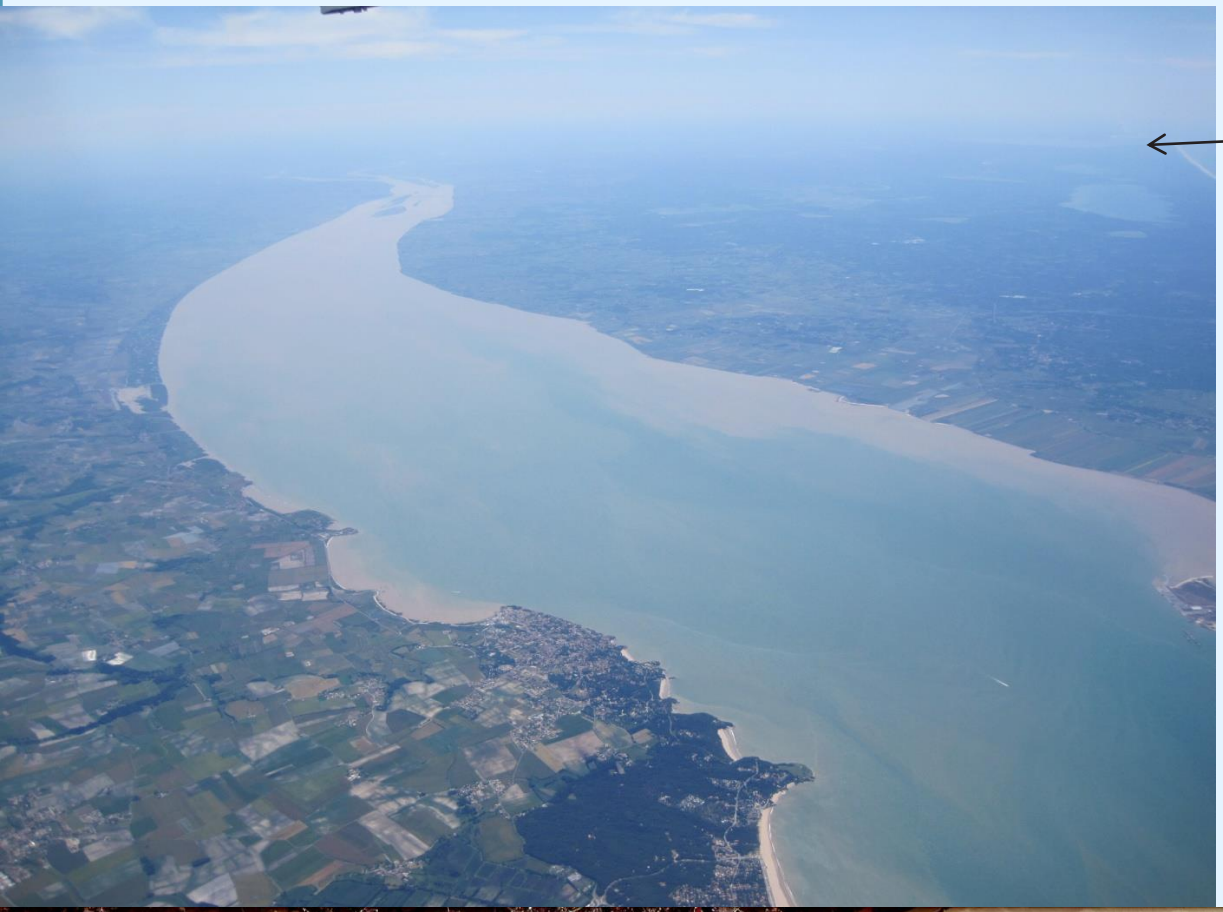
TSM limit (1071 nm) = 32 mg L-1
TSM limit (1020 nm) = 65 mg L-1





reflectance threshold of 0.002

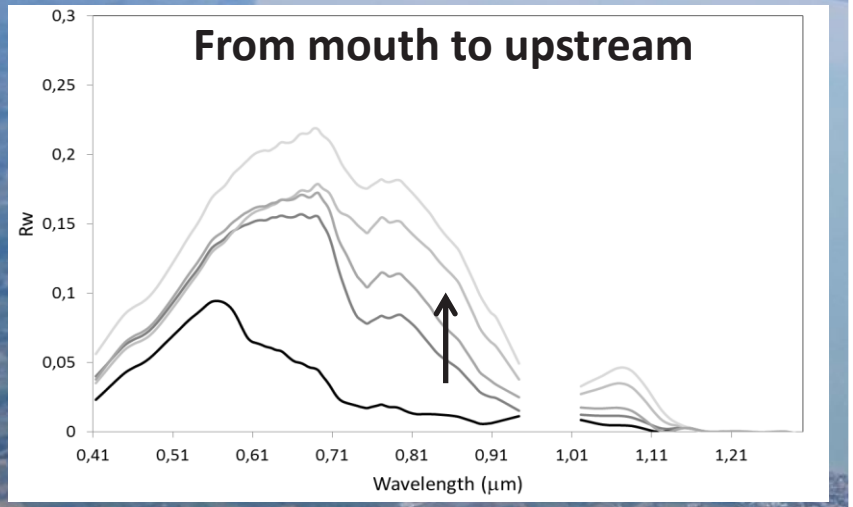
SWIR water reflectance from APEX

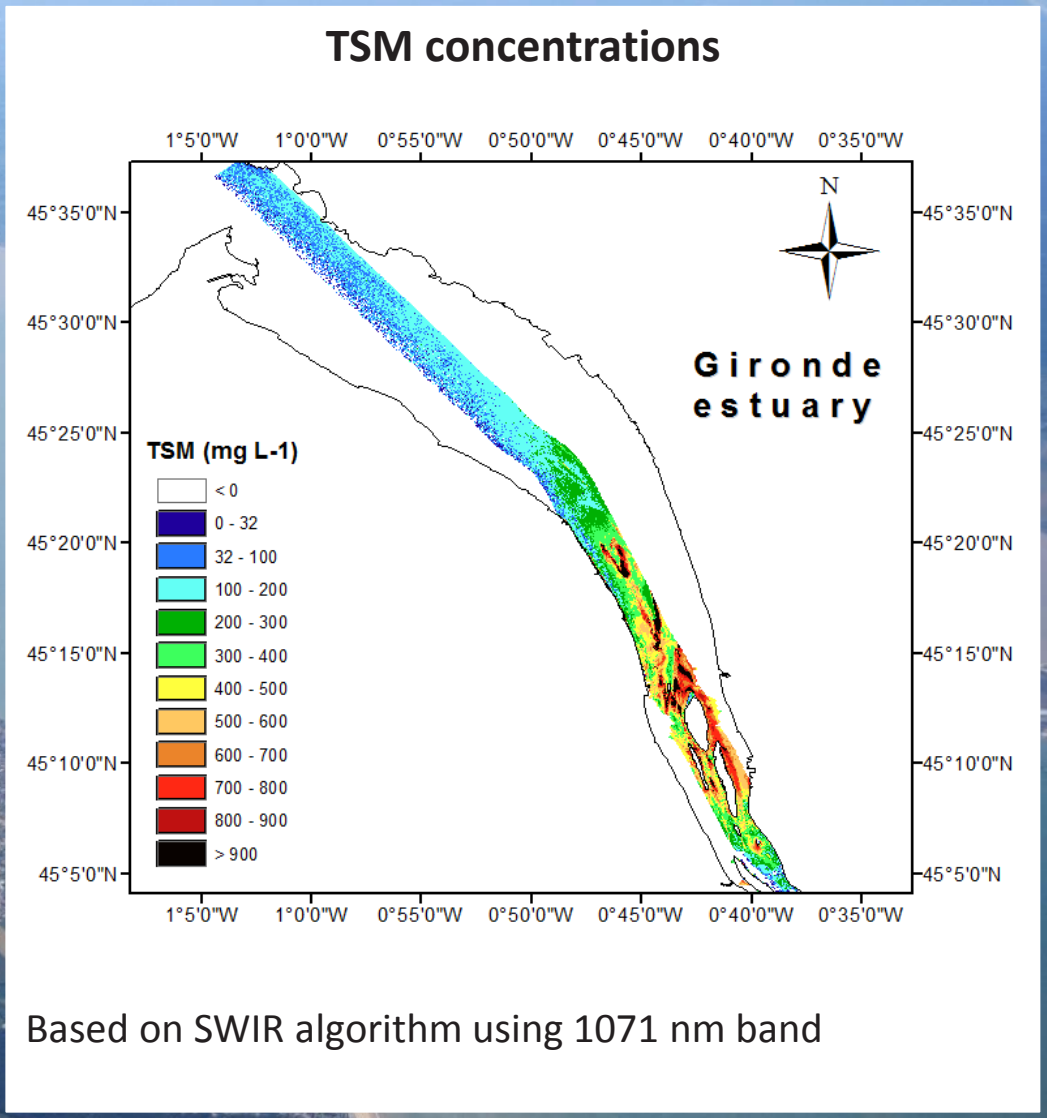


Picture taken by
APEX operator

APEX quicklook

SWIR water reflectance from APEX





Based on SWIR algorithm using 1071 nm band

Conclusions and recommendations

- **SWIR black pixel assumption.** be careful when assuming a black pixel in turbid waters in the SWIR I. TSM limits !
- **SWIR TSM algorithm**. SeaSWIR has shown the existence of one single relationship between TSM and reflectance for the Scheldt and Gironde dataset based on the 1071 spectral band
- **Sensitivity of spectral reflectance to increases in TSM.** Above a TSM concentration of 500 mg L-1 or a reflectance threshold of 0,09, a decrease of sensitivity was observed for the 865 nm band. It is suggested to switch the longer wavelengths above these thresholds. No sensitivity decrease was observed for the SWIR I bands.
- **Inclusion of SWIR detectors on future ocean colour sensors** to enhance performance for extremely turbid waters such as the world's major river plumes and the many extremely turbid estuaries and inland waters.
- **More extensive in situ measurement** of water-leaving radiance reflectance in the SWIR-1 synchronous with satellite acquisitions for validation purposes.

THANK YOU

Ongoing work:

http://www.copernicus-inform.eu/

http://www.highroc.eu/

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Funded by

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