An improved correction method for field measurements of particulate light backscattering in turbid waters

D. Doxaran[1], E. Leymarie[1], B. Nechad[2], K.G. Ruddick[2], A.I. Dogliotti[3], E. Knaeps[4]

[1] Laboratoire d'Océanographie de Villefranche, CNRS-UPMC, France
doxaran@obs-vlfr.fr
[2] Royal Belgian Institutefor Natural Sciences (RBINS), Brussels, Belgium
[3] Instituto de Astronomía y Física del Espacio (IAFE), CONICET/UBA, Argentina
[4] Flemish Institute for Technological Research (VITO), Belgium

CoastColour and SeaSWIR User Consultation Meeting

9-10 May 2013, Darmstadt, Germany

Interests

The the **seawater reflectance** signal (Rrs, sr^{-1}), is function of two inherent optical properties (IOPs): the **absorption** (a, m^{-1}) and **backscattering** (b_b, m^{-1}) coefficients (Gordon et al. 1975; Morel and Prieur 1977)

$$Rrs = Lu\,(0-) / Ed\,(0-) = f/Q \times b_b / (a + b_b)$$

Where: Lu (0−) and Ed (0−) are the upwelling radiance and downwelling irradiance just below the sea surface; f/Q is the proportionality factor

State of the Art

No (very few?) field measurement of b_{bp} in turbid coastal/estuarine waters(!) as sensors designed and used in marine optics either:

• Saturate in highly scattering waters (**ECO-BB, Wetlabs**)[1]

• Do not have proper correction for light attenuation (**Hydroscat, Hobilabs**)[2]

[1]

measures light backscattered at 117°

Fixed gain / sensitivity for open ocean

[2]

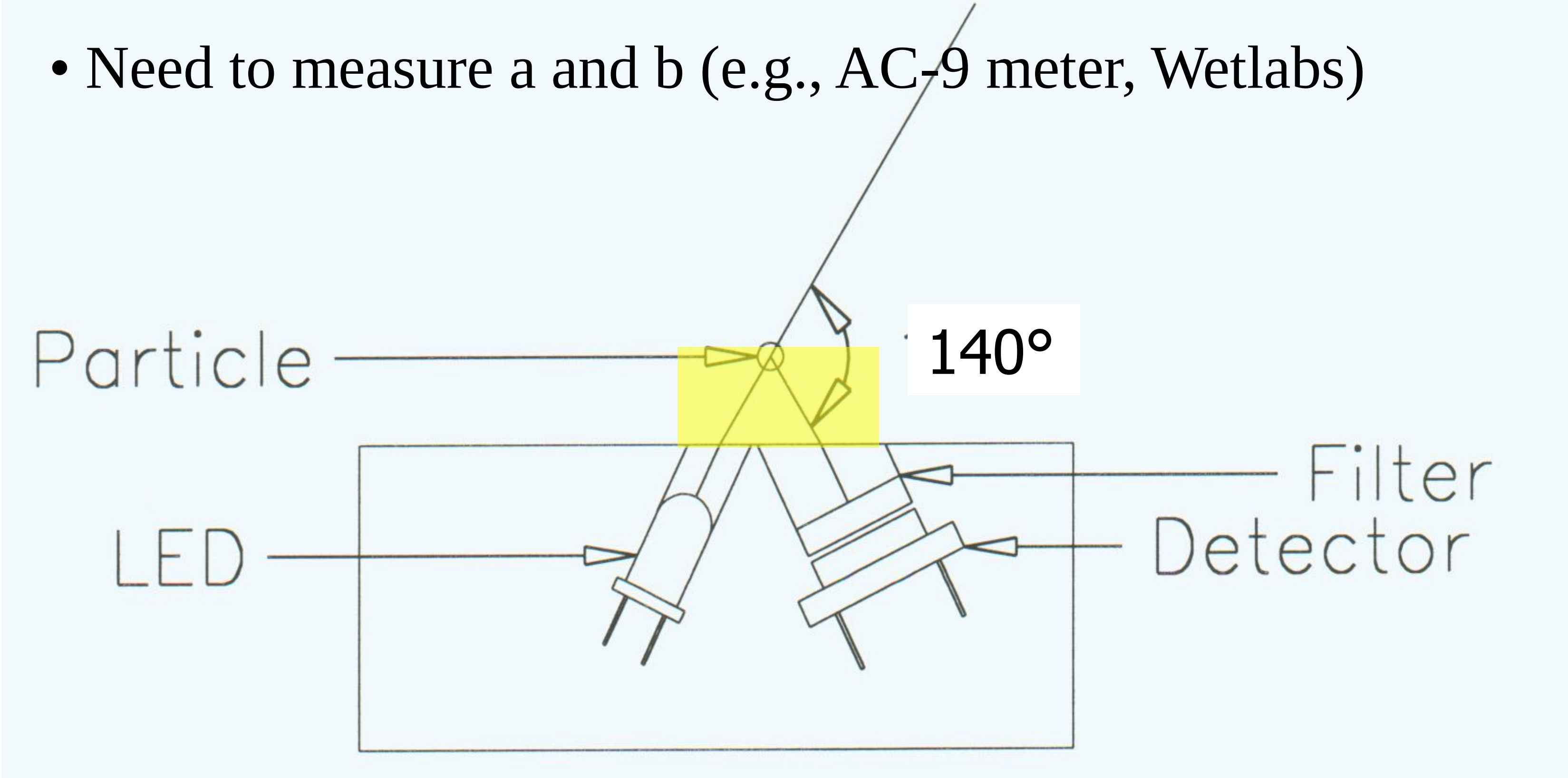
measures light backscattered at 140°

Adaptative gain: clear to turbid waters

State of the Art

➔ Use of Hydroscat in turbid estuarine waters (SeaSWIR)

- Each sensor is calibrated in pure water
- Need to correct for other absorption and scattering losses
- Need to measure a and b (e.g., AC-9 meter, Wetlabs)



State of the Art

➔ The sigma-correction (Hydroscat)

$$\beta = \sigma(K_{bb}) \cdot \beta_u$$

$$\sigma(K_{bb}) = \exp(k_{\exp} K_{bb})$$

$$K_{bb} = a + 0.4b$$

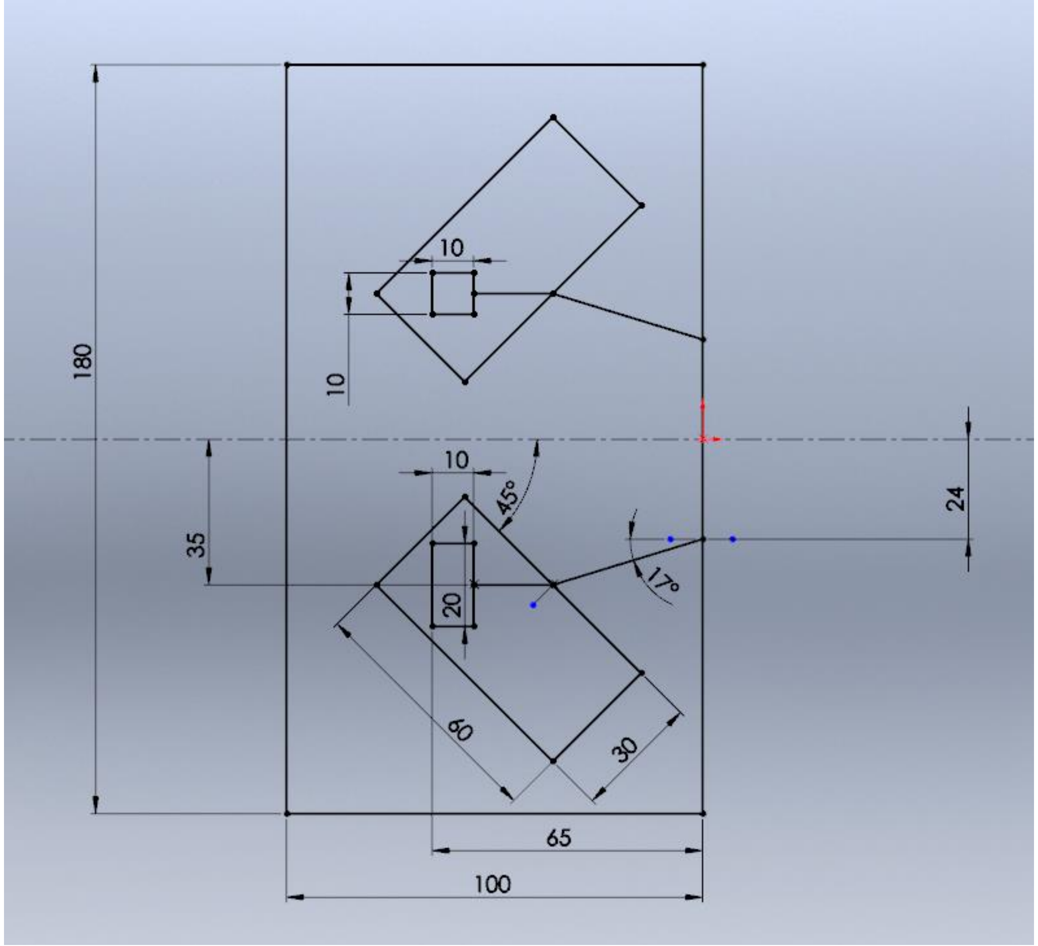
With 0.4 coming from …???

Objectives

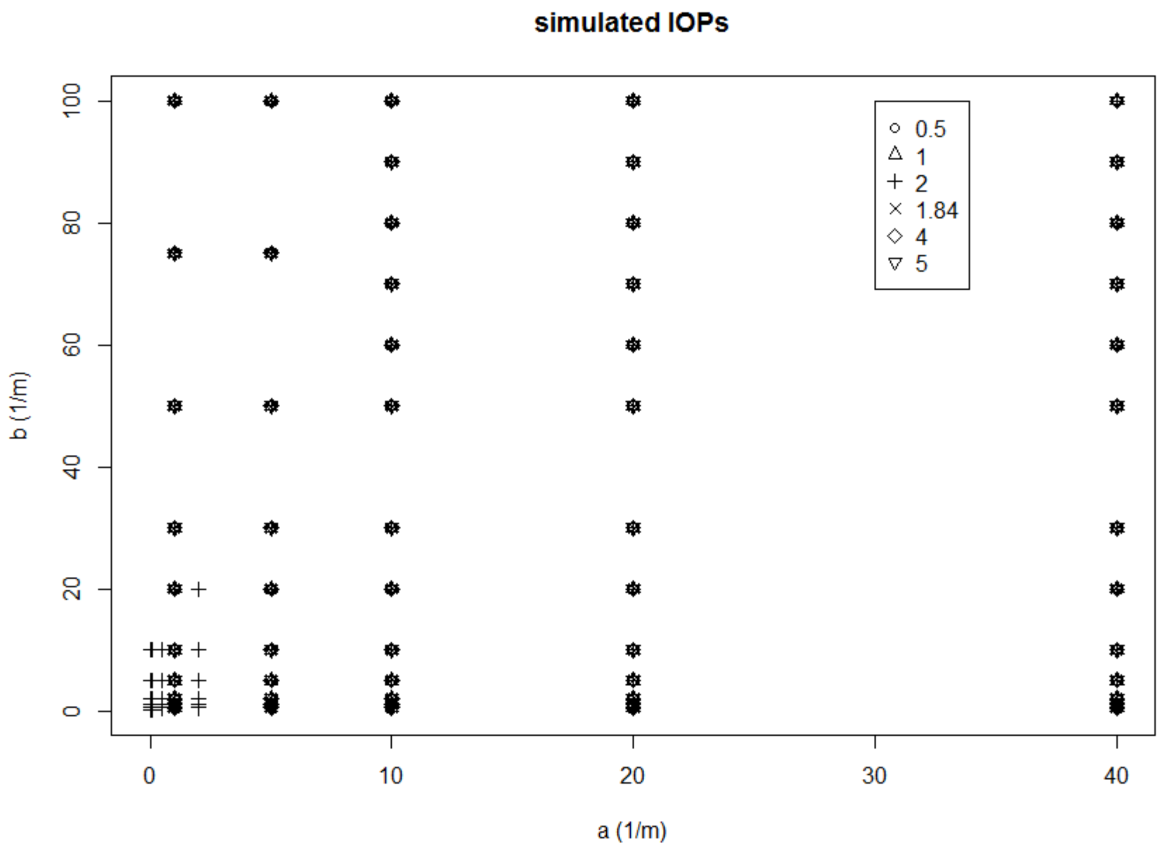
- Check the validity of the sigma correction
- Improve/modify the correction method in the case of highly-turbid and scattering waters
- Test it on a representative dataset
- Validate the new method

Methods

The SimulO 3D Monte Carlo code (Leymarie et al. 2010) is used to reproduce the design of the Hydroscat sensor and compare true and 'measured' β signals.

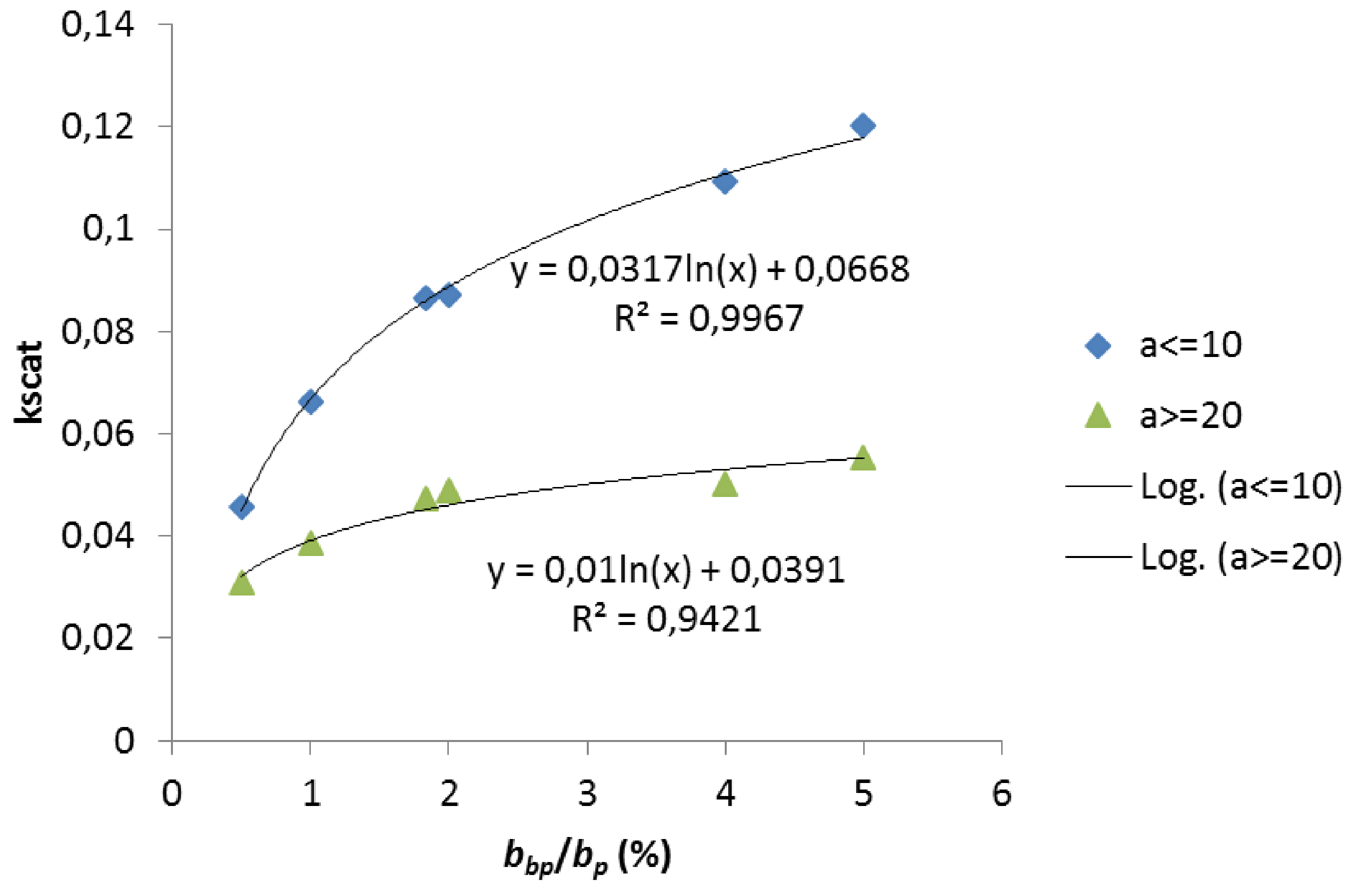


Methods



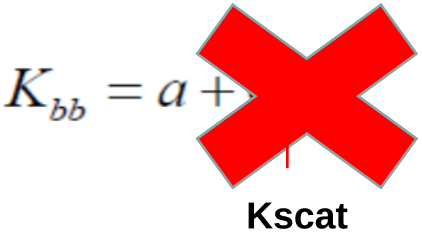
Particulate VSF: Petzold, Fournier-Forand (b_{bp}/b_p = 0.5, 1, 2, 3, 4, 5%)

Results



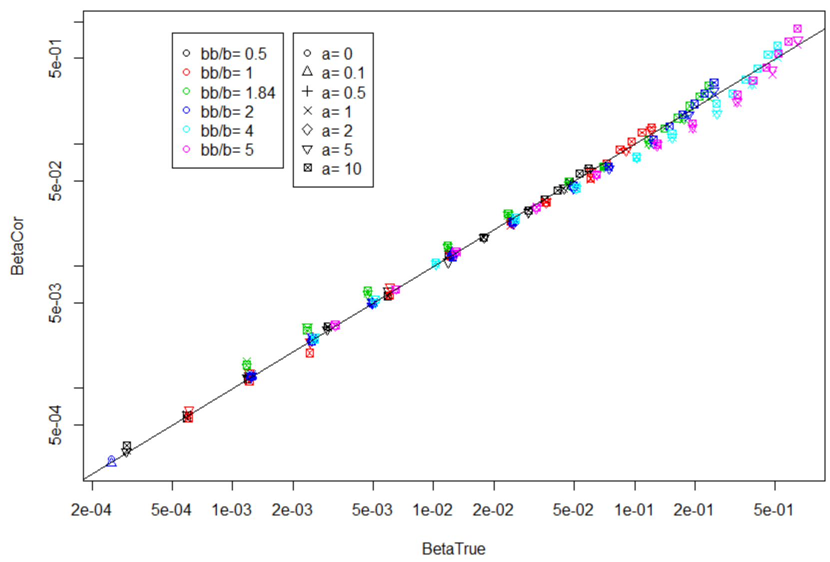
➔ Kscat is much lower than 0.4

➔ Kscat is a function of b_{bp}/b_p

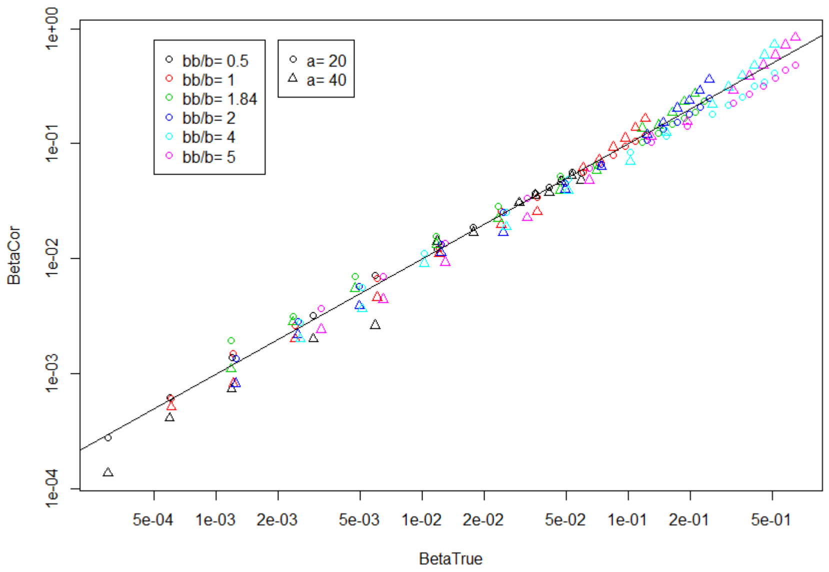


Results

$a < 10\ m^{-1}$ (400 – 900 nm)



$a \geq 20\ m^{-1}$ (1020 nm)



Field dataset

Rio de La Plata (Argentina)

SeaSWIR experiment, 15-23 November 2012

40 stations:

CTD from FastCat (SeaBird)

a, c, $b_p = c - a$ from AC-9 10 cm

β_u from Hydroscat-4 (550,700,850,1020 nm)

Rrs from Trios (UMM) and ASD (VITO)

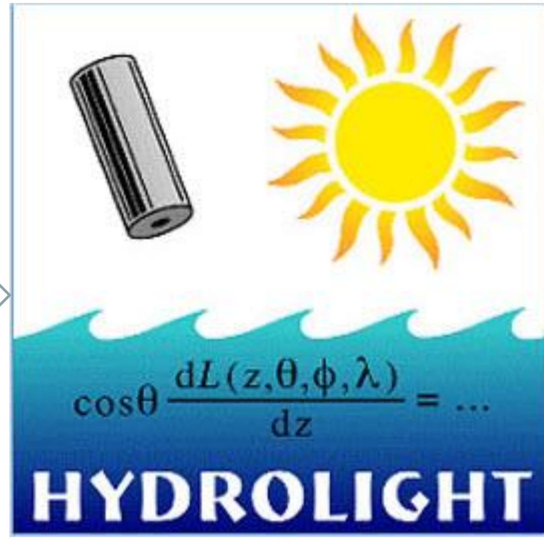
β_u, b_p → k_{scat} → β → b_{bp}

10 iterations

$$K_{scat} = 0.031 \times \ln(b_{bp}/b_p) + 0.0668$$

Methods

Date, location
a, b
b_{bp_s}
(sigma correction)
b_{bp_n}
(new method)

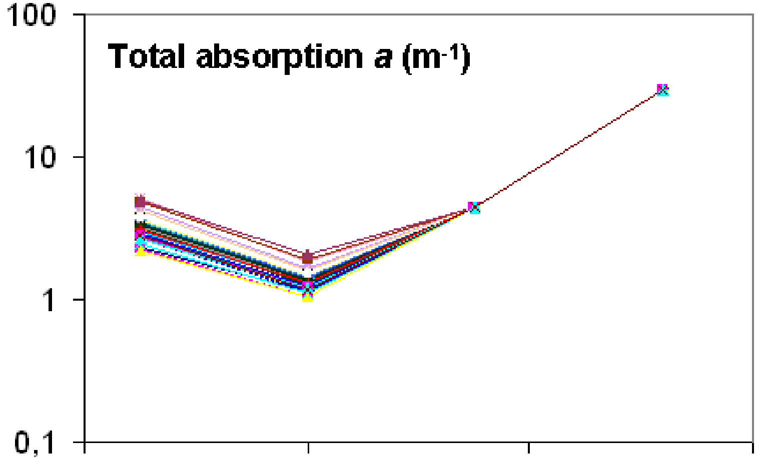


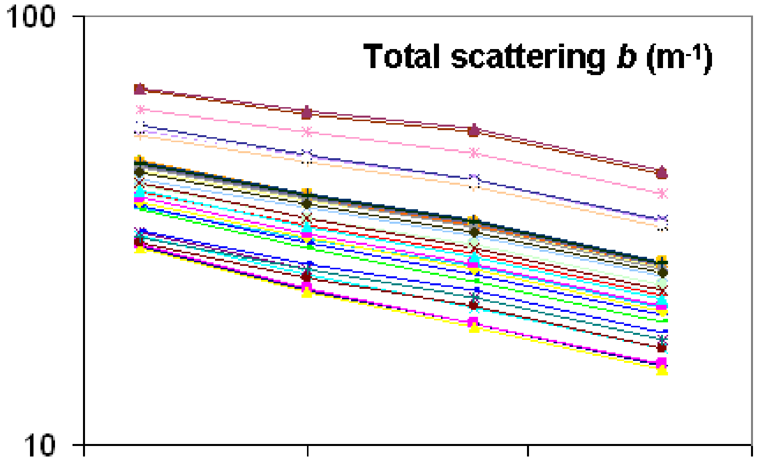
$Rrs_{\_s}$
(sigma correction)

$Rrs_{\_n}$
(new method)

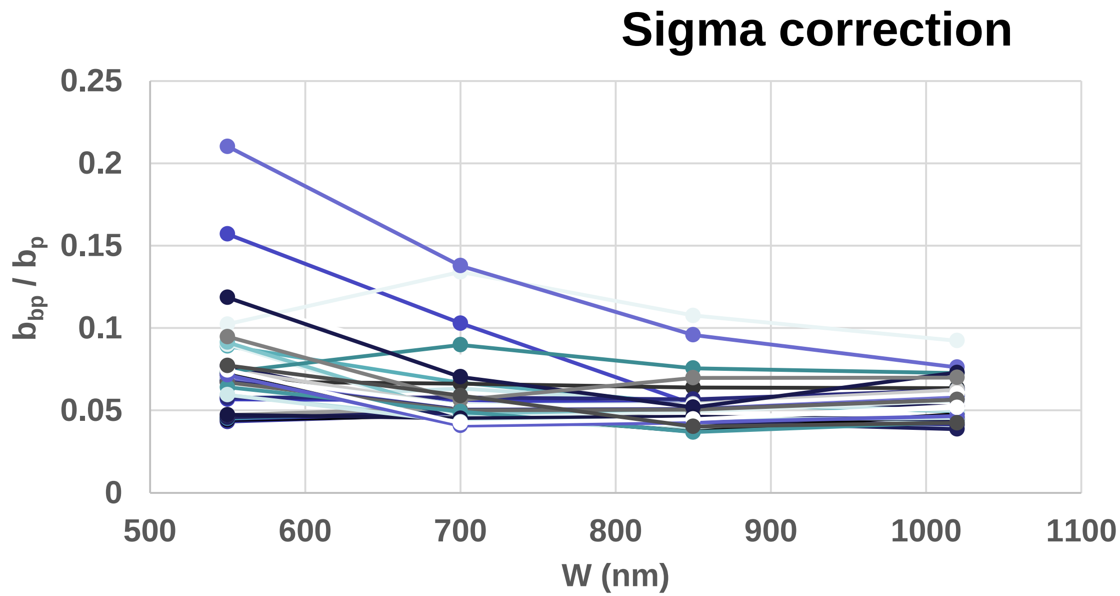
(Computations made by B. Nechad)

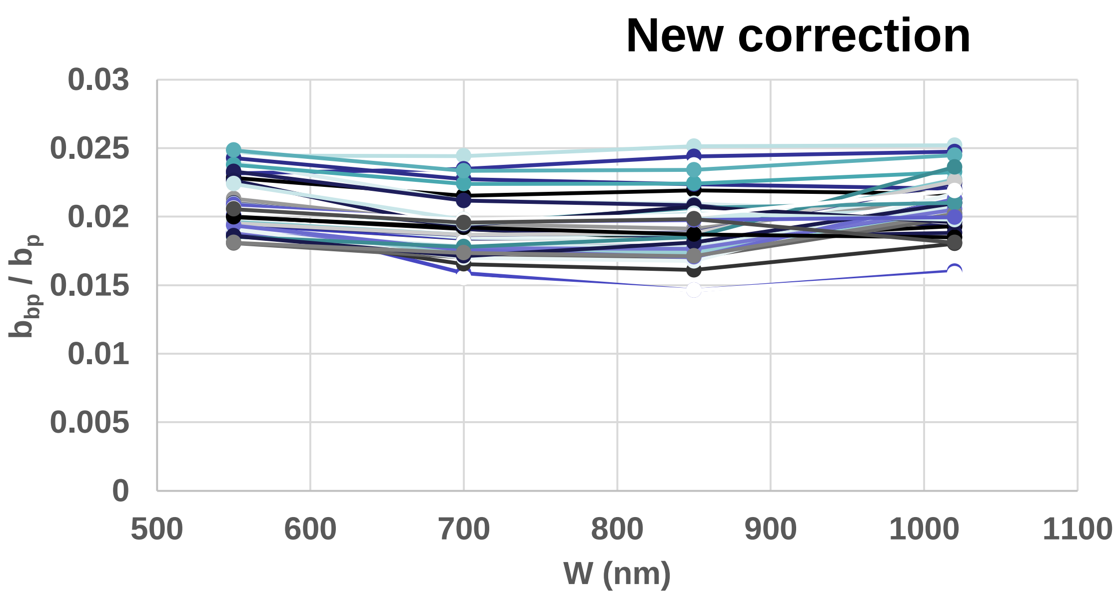
Results



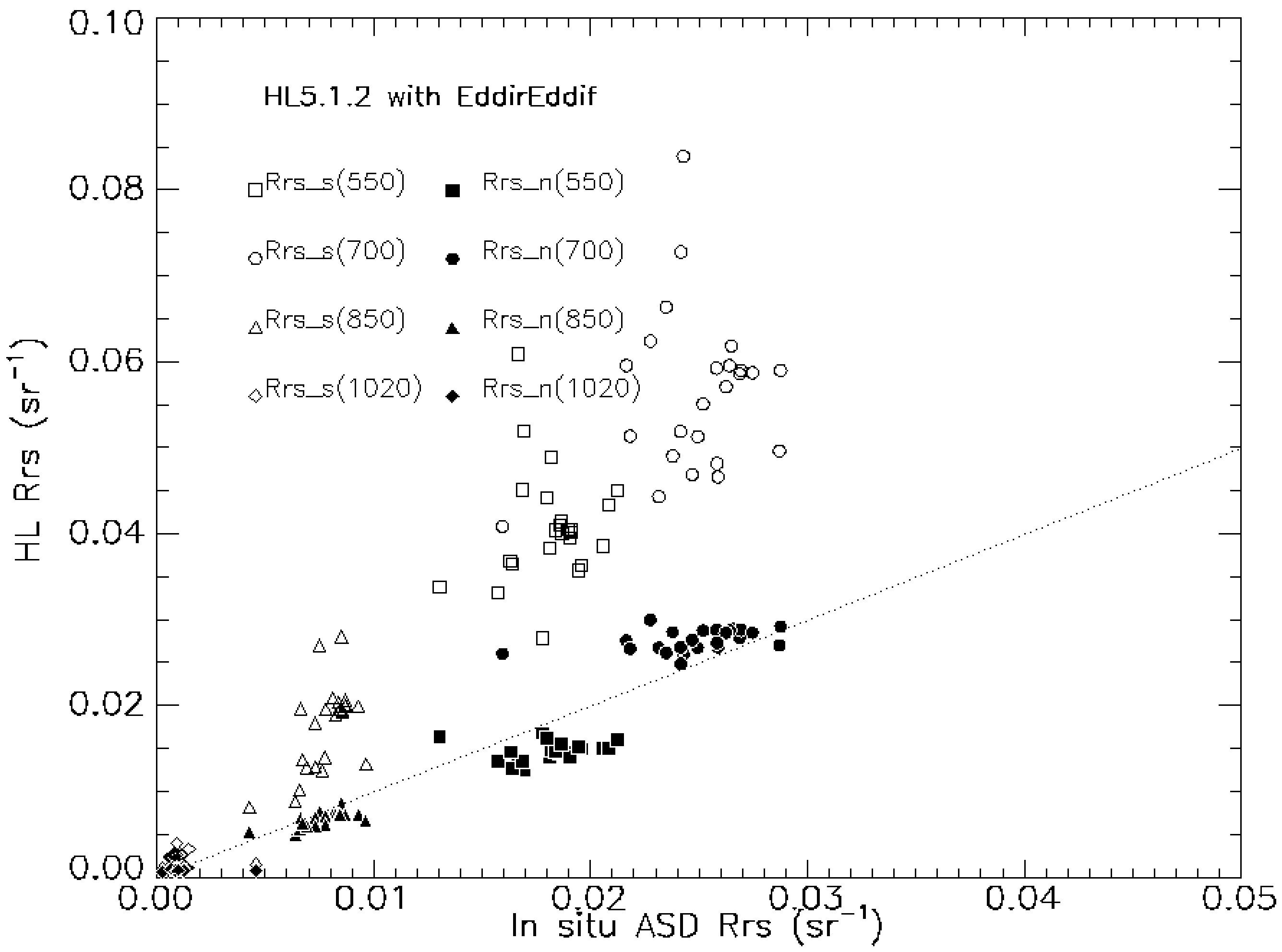


Results


Sigma correction
0.25
0.2
0.15
0.1
0.05
0
b_{bp} / b_p
500
600
700
800
900
1000
1100
W (nm)


New correction
0.03
0.025
0.02
0.015
0.01
0.005
0
b_{bp} / b_p
500
600
700
800
900
1000
1100
W (nm)

Results


HL5.1.2 with EddirEddif
Rrs_s(550)
Rrs_n(550)
Rrs_s(700)
Rrs_n(700)
Rrs_s(850)
Rrs_n(850)
Rrs_s(1020)
Rrs_n(1020)
HL Rrs (sr⁻¹)
In situ ASD Rrs (sr⁻¹)
0.00
0.02
0.04
0.06
0.08
0.10
0.00
0.01
0.02
0.03
0.04
0.05

Conclusions

- The sigma correction method (Hydroscat backscattering sensor) not valid in turbid sediment-dominated waters: overestimation (by factor 2 to 10) of light attenuation then of corrected b_{bp} coefficient
- Light attenuation from light source to detector is actually a function of b_{bp}/b_p (as demonstrated using SimulO)
- A new correction method is proposed and requires ancillary measurements: a and b_p
- The method has been tested on SeaSWIR dataset (Rio de La Plata) and has been validated based on optical closure (*Rrs*)

Perspectives

- Improvements in Hydroscat sensor modelling in SimulO
- Application to other field datasets:
  - Bay of Bourgneuf (France) 31 stations (in process)
  - Gironde or Scheldt (new SeaSWIR campaigns?)
  - archived: Mackenzie River plume
- Retrieval of SPM size distribution from b_{bp} & *Rrs* spectral slopes?