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Discussion on protocols for in situ measurements of Inherent Optical Properties for Ocean Colour Sensor Validation

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Starting point

NASA/TM-2003-211621/Rev4-Vol.IV

Ocean Optics Protocols For Satellite Ocean Color Sensor Validation, Revision 4, Volume IV:

Inherent Optical Properties: Instruments, Characterizations, Field Measurements and Data Analysis Protocols

James L. Mueller, Giulietta S. Fargion and Charles R. McClain, Editors

Scott Pegau, J.Ronald V. Zaneveld, B. Gregg Mitchell, James L. Mueller, Mati Kahru, John Wieland and Malgorzat Stramska, Authors

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Measured IOPs =

- **beam attenuation c(λ)**
- **absorption coefficient a(λ)**
- **VSF β(θ, λ)→ scattering coefficient $b_b(\lambda)$**

For every in situ instrumentation for measuring IOPs, more or less common deployment/processing protocol issues:

Consensus? **No strict recommendation?** **To be revised?**

Consensus ?

- Spectral resolution → depending on application;
- Pathlength → depending on environment properties;
- Calibration (pure water, beads, reflective plate);
- Deployment speed → depending on objectives: ≤ 0.3 m^{-1} for CAL/VAL is fine;
- T & S dependency → T & S measurements compulsory;
- In situ pure water offsets measurements, e. g. AC-9;

No strict recommendation ?

- In situ "dark" reference/ambient light measurements , e.g. HYD-6;
- Scattering corrections (acceptance angle) for transmissometers;
- Conversion factor $\beta(\theta, \lambda)$ → $b_b(\lambda)$ (e.g. HYD-6) ;

To be revised ?

- scattering correction for reflective tube absorption meters (e.g. AC-9);

- correction for Source and backward signal Attenuation for $\beta(\theta, \lambda)$ (e.g. HYD-6)
  → The "Sigma" correction;

- New instrumentation ?

Beam attenuation coefficient, c(λ)

Issue: Instrumental variability of Acceptance angle

Boss et al. (2009): comparison C-Star, AC-9, AC-s, LISST

→ **c(λ) decreases when Acceptance Angle increases**

Lemayrie et al. (2010): Monte-Carlo simulations AC-9

→ **c(λ) underestimated, by 10 to 40 % (if VSF unknown)**

Solution: Corrections using information on VSF?

Absorption coefficient, a(λ)

Issue: Scattering correction for reflective tube absorption meters (e.g. AC-9) and the hypothesis of null absorption at 715 nm (e.g. "Zaneveld #3")

McKee et al. (2008): Monte-Carlo simulations AC-9
→ Only **50-60 % of residual absorption at 715 nm = scattering error** (100% according to a(715)=0 hypothesis)

Rudiger et al. (in preparation): Measurements PSICAM & AC9
→ **about 75 % = scattering error**

Lemayrie et al. (2010): Monte-Carlo simulations AC-9
→ Relative error on a(λ) = 5-10% in high absorption, increase in low absorption, up to 100% in highly scattering waters, **potentially dramatic if non-null absorption in NIR**.

Absorption coefficient, a(λ)

Solution 1: McKee et al. (2008), McKee et al.(2013) = poster IOCS + JAOT(in press)

→ **<u>iterative scheme based on Monte-Carlo simulations</u>**

but

- needs simultaneous back-scattering measurements at same λ

- refinement: needs one instrument specific calibration versus PsiCam (JAOT, in press)

Solution 2: New instrumentation allowing No scattering error

→ **<u>"a-Sphere" HOBI Labs</u>** (Dana and Maffione, 2006) = in situ integrating sphere but not yet evaluated or validated

→ **<u>"OSCAR", TRIOS GmbH</u>** (PSICAM version)
but not yet evaluated or validated

VSF $\beta(\theta, \lambda)$ and back-scattering coefficient, $b_b(\lambda)$

Corrections for Source and backward signal Attenuation (e.g. HYD-6)

the present standard correction scheme uses simultaneous a and b coefficients

→ K = a +0.4 b

No real validation of this correction scheme

→ Doxaran et al. (2013, poster at IOCS):

$b_b(\lambda)$ can be over-erestimated be a factor 2 to 3 in highly turbid waters

→New iterative correction scheme (based on MonteCarlo simulations)

→ Need a and b measurements

VSF $\beta(\theta, \lambda)$ and back-scattering coefficient, $b_b(\lambda)$

New instrumentation ?

LISST-VSF

MASCOT

MVSM

→ Any particular recommendation ?

Haubrich et al. (2011) = direct measurement of b_b,

→ but not commercial and no evaluation yet

VSF $\beta(\theta, \lambda)$ and back-scattering coefficient, $b_b(\lambda)$

Determination of $b_b(\lambda)$ from ONE $\beta(\theta, \lambda)$ (e.g. HYD-6)

$$b_{bp}(\lambda) = 2\pi\ \chi_p(\theta)\ \beta_p(\lambda,\theta)$$

Oishi(1990)/HYD-6, standart:	$\chi_p(140) = 1.08$
Chami et al. (2006), MVSM:	$\chi_p(140) = 1.15$
Berthon et al. (2009), MVSM:	$\chi_p(140) = 1.18 \pm 0.05$
Sullivan and Twardowski (2009), MASCOT :	$\chi_p(140) = 1.17 \pm 0.05$
Whitmire et al. (2010), MVSM, cultures:	$\chi_p(140) = 1.21\text{-}1.30$ (443-620 nm)

$\chi_p(140)$

Optimum (θ)

Oishi (1990):	$\theta = 120°$
HYD-6, standart:	$\theta = 140°$
Maffione and Dana (1997):	$\theta = 112\text{-}119°$
Boss and Pegau (2001):	$\theta = 117°$
Chami et al. (2006):	$\theta = 110°$
Berthon et al. (2007)	$\theta = 118°$
Sullivan and Twardowski (2009):	$\theta = 110\text{-}120°$

New recommendation for χ_p ? for θ ?