Continuous integrating cavity absorption measurements – Extending the capability of the FerryBox to measure biological relevant parameters

Jochen Wollschläger, Maik Grunwald, Rüdiger Röttgers, Wilhelm Petersen

8-9 September 2014 / Marine Systems Institute at Tallinn University of Technology
Motivation

• Comprehensive environmental monitoring requires reliable measurements in high spatiotemporal resolution

• Sensors mounted on mobile platforms (e.g. FerryBox) can provide such data

• Many water constituents are optically active and can be detected by means of fluorescence, absorption, or scattering measurements

• Regarding *in situ* measurements, biological relevant information is mostly fluorescence-based

• Absorption measurements are probably less influenced by phytoplankton species composition, physiological state, and short term light acclimatization
Motivation

Aims:

1. Obtaining hyperspectral absorption coefficients measurements in the visible spectrum
   → in situ
   → continuously

2. Using these data for the determination of
   → important bulk parameters (chlorophyll-a, TSM)
   → differences in phytoplankton composition
Hyperspectral absorption measurements can be used to estimate important bulk parameters.
Absorption measurements

Shape of spectrum contains information for phytoplankton group identification
Obstacles in absorption measurements

1. Low concentration of absorbing material:
   - Requires the concentration of samples by filtering
   - Requires large cuvettes for *in situ* measurements

2. Additional light loss due to scattering on particles
   - Can lead to overestimation of true absorption
   - Requires correction
Integrating cavities

• Integrating cavities can overcome these problems

• **Point source integrating cavity absorption meter** (PSICAM)
  • Compact design
  • A long optical path length (high sensitivity)
  • Diffuse light field (eliminates scattering error)
  • Whole visible light spectrum

• Accurate device for analysis of discrete samples

• Continuous measurements would be desirable
Flow-through-PSICAM

- Water inlet
- Light source
- Water sample
- Integrating cavity
- Spectrometer
- Water outlet
- Optical fibre to detector
- Central light source
- Water outlet
Flow-through-PSICAM

Integrating cavity

Valves & pumps

Lamp

Spectrometer

RV „Heincke“

Water

FerryBox
Field tests

1. Comparison of PSICAM and flow-through-PSICAM

2. Evaluate absorption measurements for chl-a and TSM determination

Cruises:
April 2011
June 2011
Comparison of PSICAMs

Main error source for deviation: Contamination with particles
Less problematic in open ocean?
Determination of chl-a and TSM

Traditional approaches vs. absorption coefficient measurements

**Chlorophyll-a**

- **in situ fluorescence**
  - $R^2 = 0.71$
- **PSICAM**
  - $R^2 = 0.88$

**Total suspended matter**

- **in situ turbidity**
  - $R^2 = 0.93$
- **PSICAM**
  - $R^2 = 0.98$
Determination of chl-a and TSM

PSICAM vs. flow-through PSICAM

**Chlorophyll-a**

- PSICAM: $R^2 = 0.83$
- Flow-through-PSICAM: $R^2 = 0.81$

**Total suspended matter**

- PSICAM: $R^2 = 0.96$
- Flow-through-PSICAM: $R^2 = 0.94$
Summary

- Continuous hyperspectral *in situ* measurements of absorption coefficients were possible using the PSICAM approach.

- Absolute values have to be corrected using point measurements.

- Absorption measurements are less variable optical proxies for chlorophyll-a and TSM determination.
Future work

• Automation of the system to enable unattended use

• Mounting the device’s components in a more user-friendly setup

• Testing of a commercial sensor based on the PSICAM principle manufactured by the company TriOS, Germany
Future work

- Establishing of an algorithm for automatic detection of the dominant phytoplankton group in the sample
- Based on fourth derivatives of hyperspectral absorption data

Thank you for your attention