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CDOM-HEAT - Source and transformations of Chromophoric Dissolved Organic Matter and its role in surface ocean heating and carbon cycling in Nordic Seas and European Arctic.

Polish-Norwegian Research Programme

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Approved by (name and function):	Piotr Kowalczuk Principal Investigator	Approval date:	
Author(s):	Karolina Borzycka[1] Authors affiliations: [1] Institute of Oceanology Polish Academy of Sciences		

Powstańców Warszawy 55
81-712 Sopot, Poland
P.O. Box 148
tel. (+48 58) 551-72-81
fax (+48 58) 551-21-30
NIP PL 585 10 04 839
Regon 000632467
e-mail: office@iopan.gda.pl
home page: http://www.iopan.gda.pl
IO PAS SOPOT

Cruise Report

Changes of inherent optical properties along transect from Gdańsk, Poland to Tromso, Norway in the salinity gradient in Baltic Sea, North Sea and Norwegian Sea.

r/v Oceania, Cruise AREX 2013/1

12 June 2013– 18 June 2013
Gdańsk, Poland – Tromso, Norway

Karolina Borzycka

Institute of Oceanology, Polish Academy of Sciences
ul. Powstańców Warszawy 55, PL-81-712, Sopot, Poland

1. Work at sea

Underway and vertical profiles optical measurements of spectral attenuation and absorption coefficients, CDOM fluorescence and particles size distributions.

Measurements of inherent optical properties were measured *in situ*, along the ship track, using Integrated Optical-Hydrological Probe. The TRIOS MicroFlu-CDOM and TRIOS MicroFlu-Chla fluorometers and Sea-Bird Electronics SBE 49 FastCAT CTD were coupled with the WET Labs Inc. ac-9 plus spectrophotometer, which functioned as the data integrator. The instrument setup, referred to as the Integrated Optical-Hydrological Probe, was fitted into one rig and connected by telemetry cable with the power supply and data transmission and control deck unit. The ac-9 plus and CTD water intakes were installed on the same horizontal plane as the optical window of the fluorometer. The data from instruments were merged and synchronized along with their time stamps with WAP 4.25 software supplied by the WET Labs. All of the signals were processed further using software written in the Matlab® environment. This had calibration procedures for all the sensors, and it merged all the measured geophysical parameters and calibrated values in physical units into a depth binned matrix.

The Integrated Optical-Hydrological probe was deployed as the quasi-flow through instrument for continuous underway measurements of inherent optical properties of sea water. It was placed in the tank filled with flowing water pumped from the ships non-toxic water supply system. The retention time of water present in the tank was estimated for ca. 3 minutes. Assuming and average ship cruising speed for 10 knots and average retention time of water in the tank, this gives ca. 900 m spatial displacement between place where water volume was taken by the non-toxic water supply and actual ships position during measurement time in the tank. The underway measurements of inherent optical properties started on June 12, 2013 and were continued until June 18, 2012. All optical elements of the sensors were routinely cleaned every 24 h. Apart of that, maintenance and field calibration procedures recommended by manufactures were applied. During the whole deployment period readings from instruments were monitored continuously for bio-fouling effects; no anomalous readings were noticed.

The inherent optical properties of the sea water were measured using an ac-9 plus (WET Labs Inc., USA) spectral attenuation and absorption meter. In situ measurements of the light absorption a and attenuation c were performed at wavelengths of 412, 440, 488, 510, 532, 555, 650, 676 and 715 nm. The instrument was calibrated in pure water and routinely checked for stability with air-readings. Air and water offsets, temperature and salinity corrections were applied according to the manual. Since the ac-9 absorption signal needs correction for scattering, the so-called ‘Zaneveld method’ was applied, which assumes zero absorption for 715 nm (Zaneveld et al. 1995).

CDOM fluorescence was measured wi1th a MicroFlu-CDOM fluorometer (TRIOS GmbH, Germany), which is suitable for in situ measurements without the prior filtration of the water. The MicroFlu-CDOM fluorometer uses UV-LED in pulse mode as the excitation light source. The maximum of the excitation light spectrum is 370 nm. A small percentage of light is reflected by the dicroitic beam splitter and is used as the reference signal for calculating the excitation energy. The fluorometer excites samples of a small volume of water at the front of the optical window at a focal length of 15 mm. It uses a photo-diode with an interference filter as the light detector. The maximum emission of the light detector is set at 460 nm. Specially developed circuitry eliminates the influence of ambient light. The MicroFlu-CDOM

fluorometer was calibrated by the manufacturer annually during the deployment period (2008–2013). The measured signal was transmitted to the via telemetry cable to a deck power supply and telemetry control unit in the form of the analog DC voltages. The voltages were converted to QSE calibrated units, as described in details by Kowalczuk et al., (2010). The TRIOS MicroFlu-Chla fluorometer has the same functional features the one for CDOM measurements except different excitation, (470 nm), and emission (685 nm), wavelengths. The TRIOS MicroFlu-Chla fluorometer was factory calibrated in chlorophyll a concentration units – $\mu g\ l^{-1}$.

The laser in situ scattering and attenuation meter LISST 100X (Sequoia Instruments, Inc., USA) was deployed along with the Integrated Optical-Hydrological probe for continuous underway measurements of particle size distribution. This instrument was equipped with flow through measurements chamber fed with the marine water from the ship's non-toxic water supply system. This self-contained instrument consists of the a solid-state laser operating at 670 nm wavelength and fiber-optically connected to a laser beam collimating system, a beam manipulation and orienting system, a scattered-light receiving lens, the specially designed 32-ring detector, preamplifier electronics, a ring-selecting multiplexer circuitry, and a data logger. The principal measurement - angular scattering distribution - is obtained over 32 ring-detectors whose radii increase logarithmically from 102 to 20,000 microns. The detector is placed in the focal plane of the receiving lens. The rings cover an angular range from 0.0017 to 0.34 radians. This angular range corresponds, respectively, to size ranges from 1.2 to 250 microns. The laser diffraction method for sizing particles is used for determining size distribution for the simple reason that for laser diffraction, the composition or refractive index of the particles is not important. This method determines size distribution of an ensemble of particles, as opposed to counting type devices that size one particle at a time (Agrawal, et al., 2008). The cleaning, maintenance and field calibration schedule was the same as for the Integrated Optical-Hydrological probe.

The inherent optical properties spectra collected during the underway of the Integrated Optical-Hydrological probe would require the post cruise reprocessing, since the instruments have been operating nearly at limits of their characteristics due to extreme clear waters. This will include close inspection of potential spikes and unusual features in spectral distribution of the absorption coefficient and attenuation coefficient spectra.

Tab. 1. List of measurements carried out during the AREX 2013-1 Cruise

	start		stop	
Nr	date	time UTC	date	time UTC
1	12/06/2013	17:43	12/06/2013	23:59
2	13/06/2013	00:00	13/06/2013	16:15
3	13/06/2013	18:11	14/06/2013	05:23
4	14/06/2013	05:27	14/06/2013	08:07
5	15/06/2013	05:56	15/06/2013	18:44
6	15/06/2013	18:47	16/06/2013	05:23
7	16/06/2013	08:16	16/06/2013	18:54
8	16/06/2013	18:58	17/06/2013	05:56
9	17/06/2013	08:02	17/06/2013	20:22
10	17/06/2013	20:26	18/06/2013	10:00

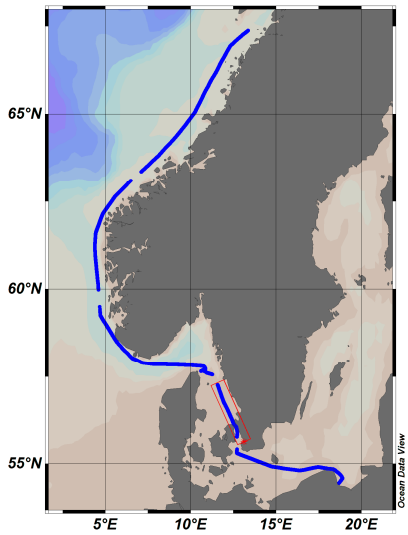
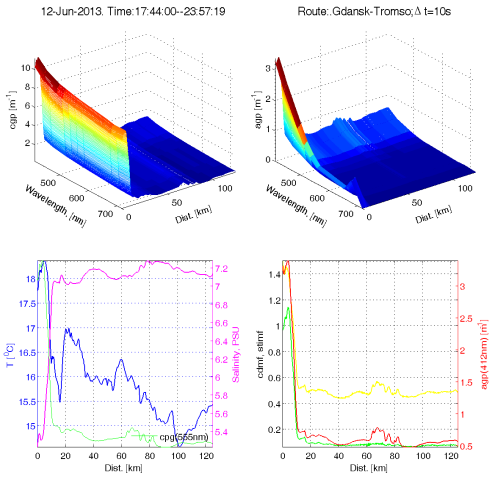


Fig. 1. Sampling grid during AREX2013-1 Cruise.

2. Results

2.1 Integrated Optical-Hydrological probe

1)



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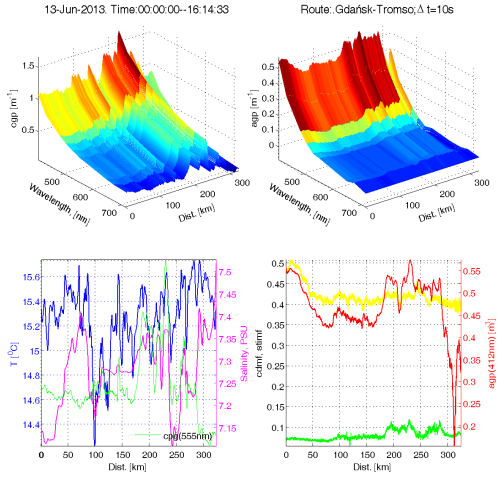
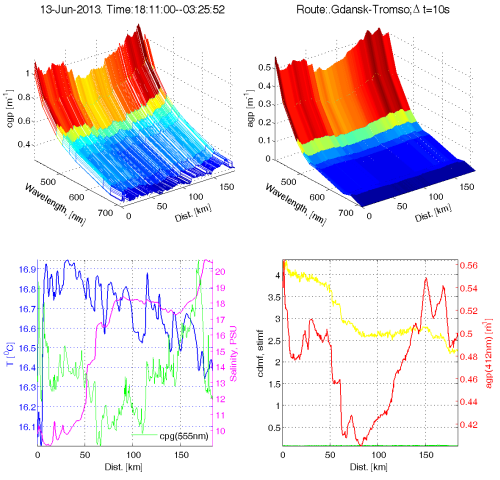
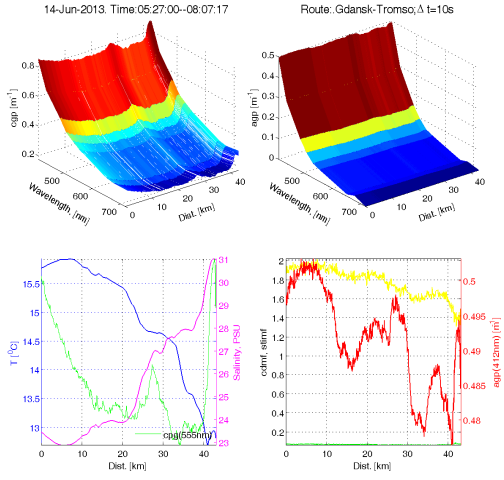


3)



4)



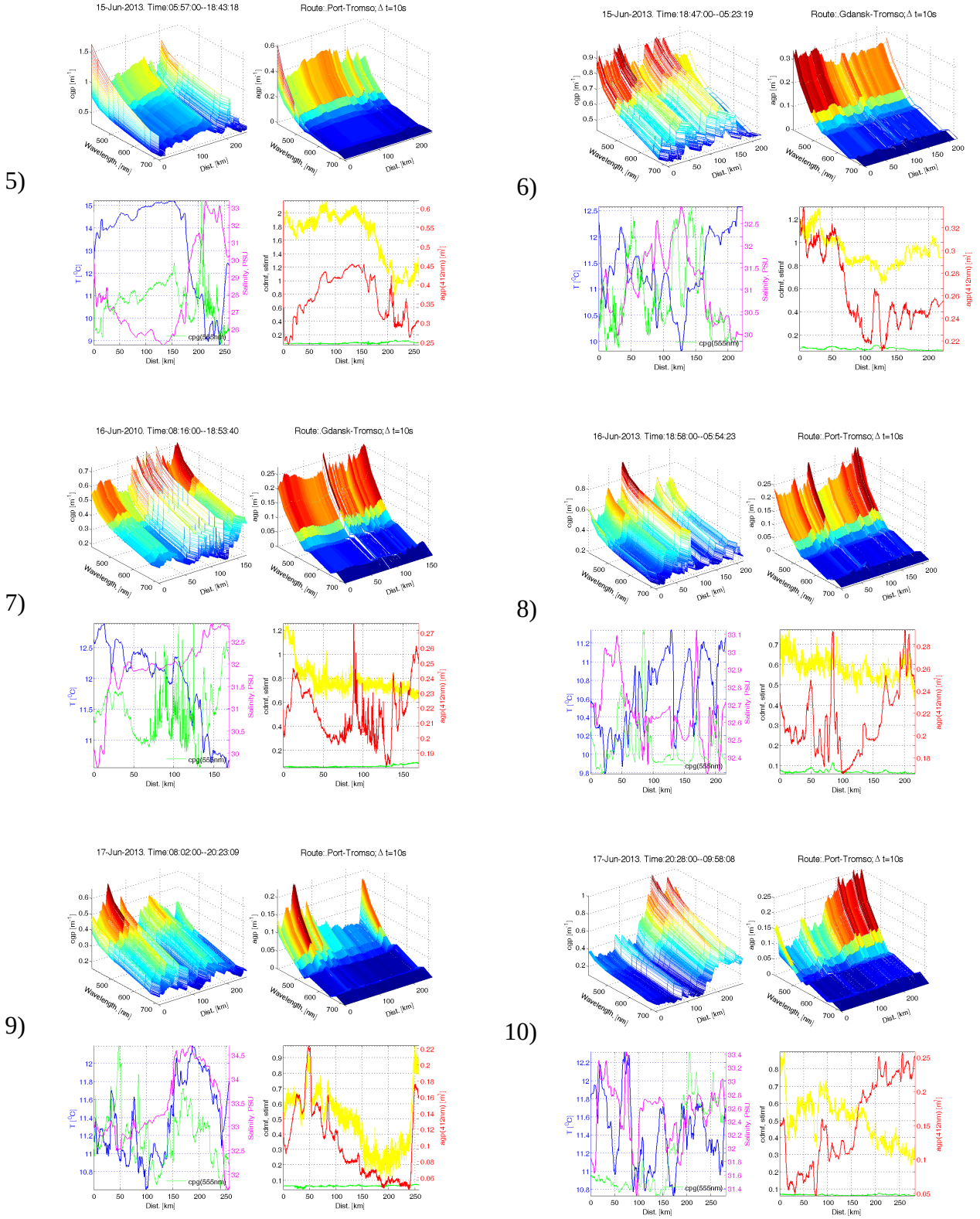


Fig. 2. Distribution of light attenuation by (cpg), absorption (agp) coefficients by particulate and dissolved materials, temperature, salinity and fluorescence by CDOM (in Volts, for range 0-5V) on transect of the AREX2013/1 cruise.

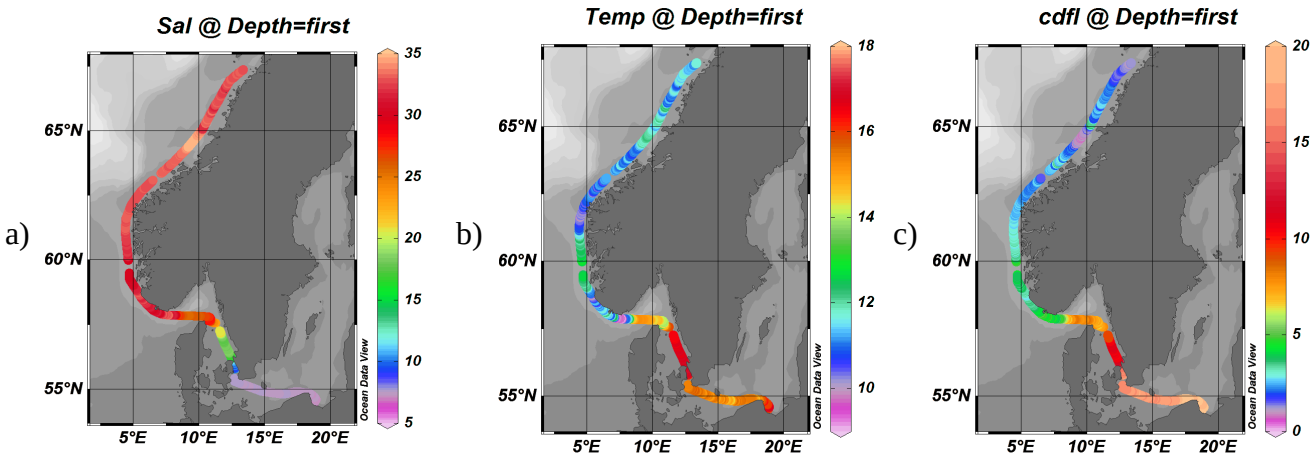
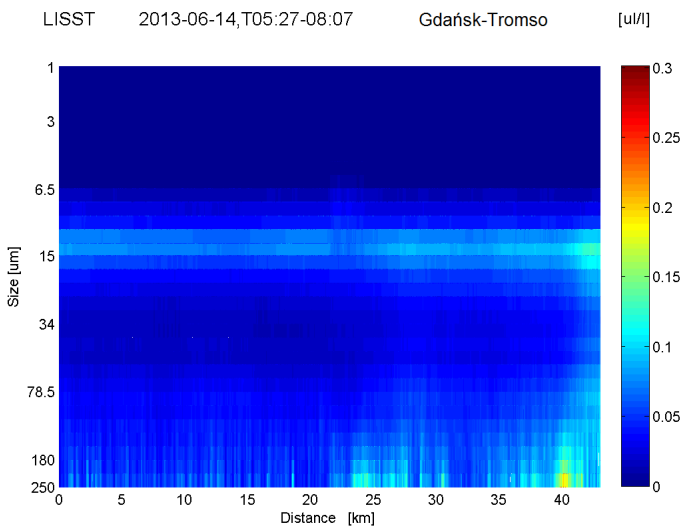


Fig. 3. Changes of the salinity (a), temperature (b) and fluorescence (c) (in QSE) by CDOM on transect of the AREX 2013/1 cruise.

2.2 LISST-100X



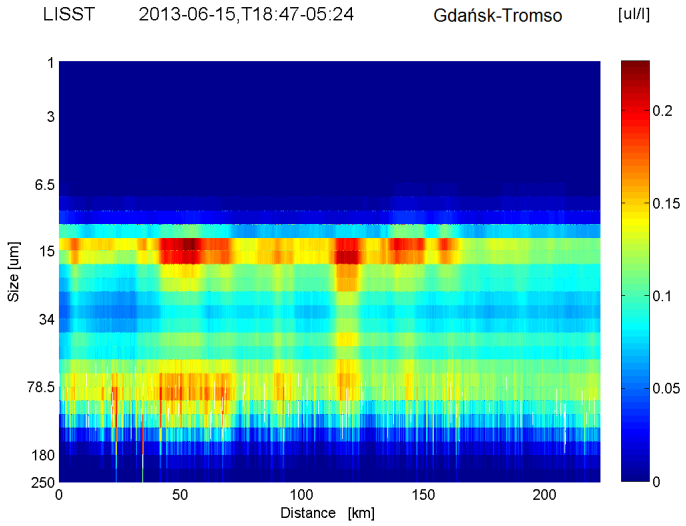


Fig. 4 Example spatial distribution of volume particle concentrations (measurement 4 and 6) of the Arex2013/1 cruise. Size distribution for 32 size classes in range of 1.2 to 250 µm, logarithmic scale.

3. References

Agrawal Y.C., A. Whitmire, O. A. Mikkelsen and H. C. Pottsmith, 2008. Light scattering by random shaped particles and consequences on measuring suspended sediments by laser diffraction. Journal of Geophysical Research, 113, C04023, doi:10.1029/2007JC004403

Kowalczuk P., M. Zabłocka, S. Sagan and K. Kuliński, 2010. Fluorescence measured in situ as a proxy of CDOM absorption and DOC concentration in the Baltic Sea. Oceanologia, 52 (3), 431–471

Zaneveld J. R. V., J. C. Kitchen and C. Moore, 1994. The scattering error correction of reflecting-tube absorption meters, Ocean Optics XII, Proc. SPIE, 2258, 44–55.