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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

Contract number: Pol-Nor/197511/40/2013

Milestone No: **M.1.1**			Workpackage: **WP 1**	
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Approved by (name and function):	Piotr Kowalczuk Principal Investigator	Approval date:		
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Cruise Report

Changes of inherent optical properties in the salinity gradient in the Barents Sea along transect from Nordkapp, Norway to Sorkapp, Spitsbergen.

r/v Oceania, Cruise AREX 2014/5

20 June 2014– 7 July 2014
Tromso, Norway -

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1. Work at sea

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* using Integrated Optical-Hydrological Probe. The TRIOS MicroFlu-CDOM and TRIOS MicroFlu-Chla fluorometers, Sea-Bird Electronics SBE 49 FastCAT CTD and WET Labs Inc. WETStar fluorometer 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 to record the vertical distribution of inherent optical properties at selected stations starting from June 23, 2014 and finished at July 4, 2014. All optical elements of the sensors were routinely cleaned every 3-6 profiles. 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 with a MicroFlu-CDOM fluorometer (TRIOS GmbH, Germany) and WETStar fluoromerer (WET Labs inc.). 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 (2008–2014). 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 – µg l^{-1}. The WETStar uses two UV LEDs centered at 370nm and modulated at 1 kHz to provide the excitation. The emitted blue fluorescence is synchronously detected at 1 kHz by a silicon photodiode. The very different excitation and emission wavelengths eliminate scattering interference and the small detection volume inside the flow tube strongly limits any attenuation effects due to increased path length resulting from scattering.

The laser in situ scattering and attenuation meter LISST 100X (Sequoia Instruments, Inc., USA) was deployed along with the Integrated Optical-Hydrological probe for measurements of particle size distribution. 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 2014/5Cruise

Sample no	Station name	Date	Time [UTC]	Lon	Lat
1	H1	23/06/2014	11:42	73 30.043 N	18 45.594 E
3	H14	24/06/2014	16:03	73 29.931 N	08 39.973 E
4	H19	25/06/2014	08:45	73 29.984 N	03 59.962 E
5	A17	25/06/2014	17:07	72 31.997 N	03 30.268 E
6	A9	26/06/2014	21:45	70 38.872 N	12 08.853 E
7	A1	27/06/2014	14:18	69 43.003 N	16 06.940 E
9	V8	28/06/2014	13:19	71 45.089 N	19 44.516 E
10	V10	28/06/2014	19:50	72 15,203 N	19 36.594 E
11	V14	29/06/2014	04:56	72 15.203 N	19 36.594 E
12	V16	29/06/2014	09:22	73 40.108 N	19 18.383 E
13	V18	29/06/2014	12:41	74 00.190 N	19 13.242 E
14	V20	29/06/2014	15:47	74 15.496 N	19 14.338 E
15	V29	30/06/2014	04:07	75 23.087 N	17 56.079 E
16	V31	30/06/2014	07:25	75 42.079 N	17 33.177 E
17	V33	30/06/2014	10:51	75 58.920 N	17 06.873 E
18	V35	30/06/2014	14:18	76 14.474 N	16 49.113 E

19	V37	30/06/2014	16:22	76 21.058 N	16 44.320 E
20	K4	01/07/2014	09:06	75 00.010 N	15 00.105 E
21	K8	01/07/2014	17:31	75 00.010 N	12 29.609 E
22	K15	02/07/2014	19:01	75 00.108 N	06 00.274 E
23	O-11	03/07/2014	09:36	75 47.047 N	06 00.274 E
24	O2	04/07/2014	07:34	76 04.089 N	15 59.926 E
25	O5	04/07/2014	09:48	76 09.529N	17 27.424 E

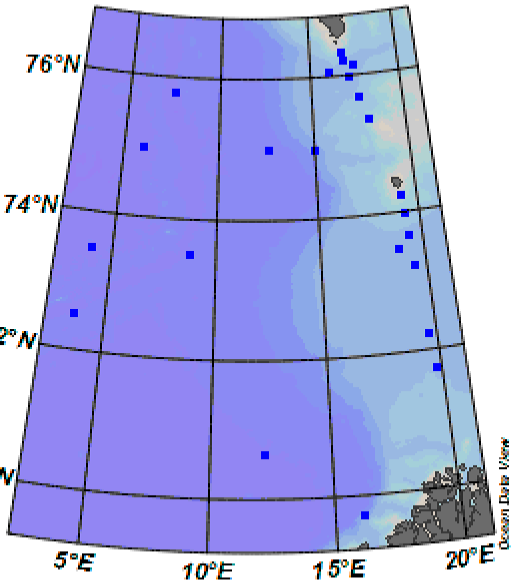
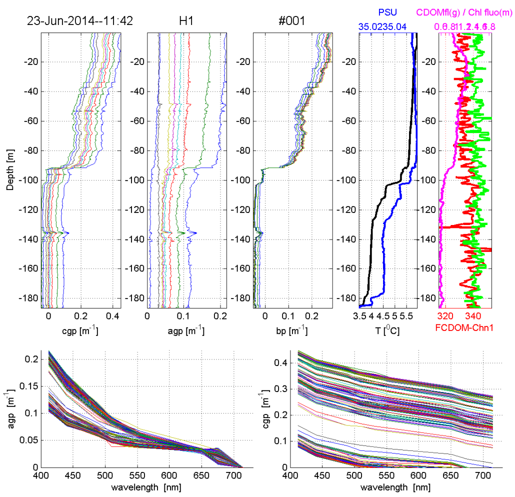


Fig. 1. Sampling grid during AREX2014/5 Cruise.

2. Results

2.1 Integrated Optical-Hydrological probe

1)



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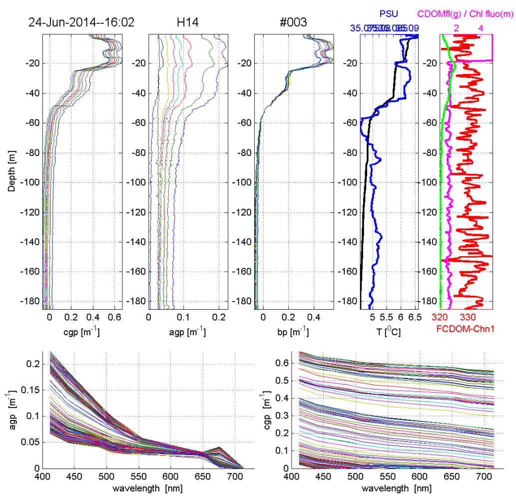

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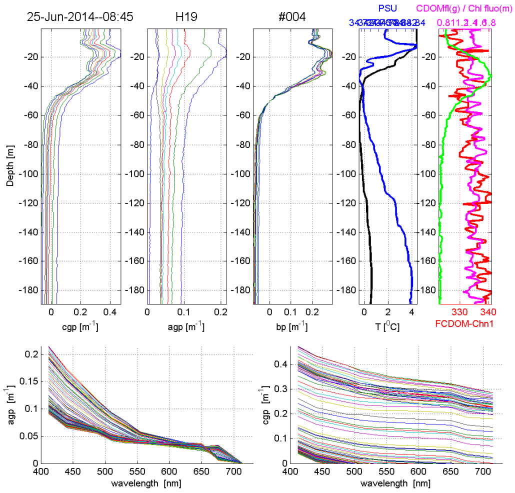
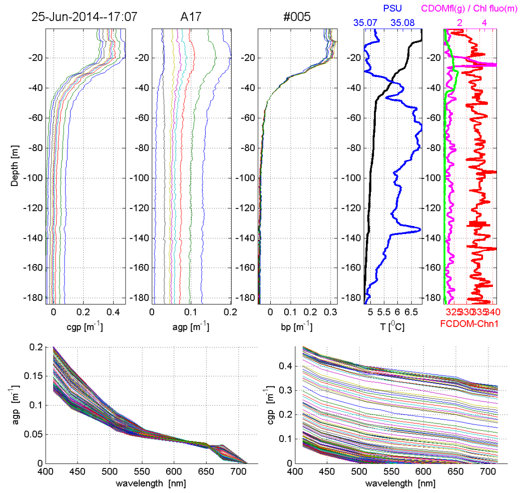


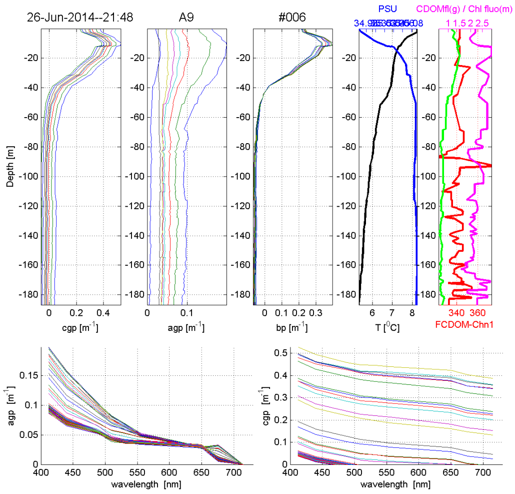
25-Jun-2014--08:45
H19
#004
PSU
CDOMfl(g) / Chl fluo(m)
Depth [m]
cgp [m^-1]
agp [m^-1]
bp [m^-1]
T [^0C]
FCDOM-Chn1
wavelength [nm]

5)



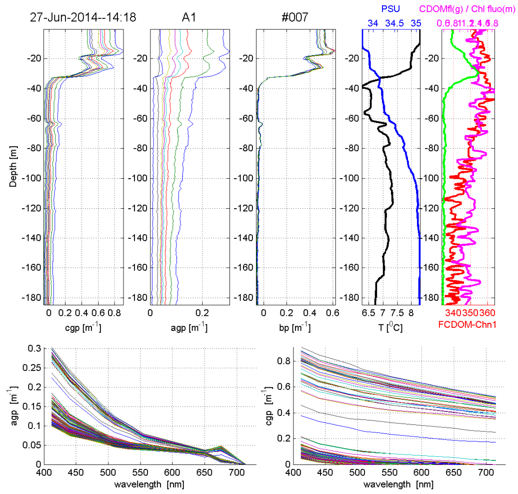
25-Jun-2014--17:07
A17
#005
PSU
CDOMfl(g) / Chl fluo(m)
Depth [m]
cgp [m^-1]
agp [m^-1]
bp [m^-1]
T [^0C]
FCDOM-Chn1
wavelength [nm]

6)



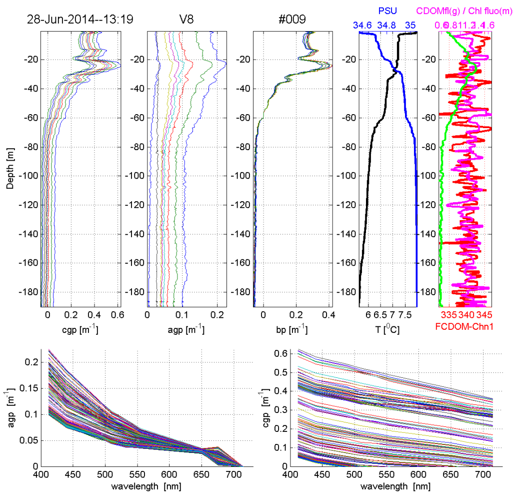
26-Jun-2014--21:48
A9
#006
PSU
CDOMfl(g) / Chl fluo(m)
Depth [m]
cgp [m^-1]
agp [m^-1]
bp [m^-1]
T [^0C]
FCDOM-Chn1
wavelength [nm]

7)



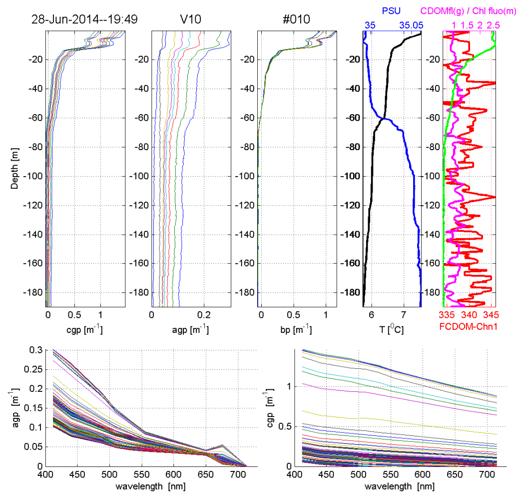
27-Jun-2014--14:18
A1
#007
PSU
CDOMfl(g) / Chl fluo(m)
Depth [m]
cgp [m^-1]
agp [m^-1]
bp [m^-1]
T [^0C]
FCDOM-Chn1
wavelength [nm]

9)



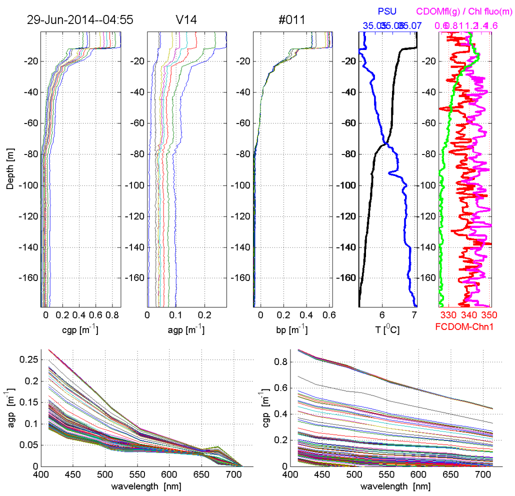
28-Jun-2014--13:19
V8
#009
PSU
CDOMfl(g) / Chl fluo(m)
Depth [m]
cgp [m^-1]
agp [m^-1]
bp [m^-1]
T [^0C]
FCDOM-Chn1
wavelength [nm]

10)



28-Jun-2014--19:49
V10
#010
PSU
CDOMfl(g) / Chl fluo(m)
Depth [m]
cgp [m^-1]
agp [m^-1]
bp [m^-1]
T [^0C]
FCDOM-Chn1
wavelength [nm]

11)



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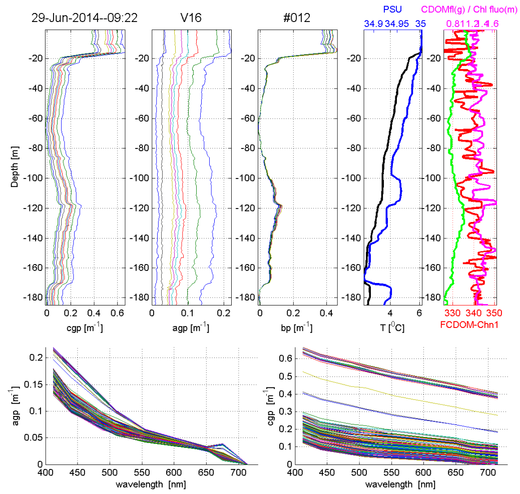

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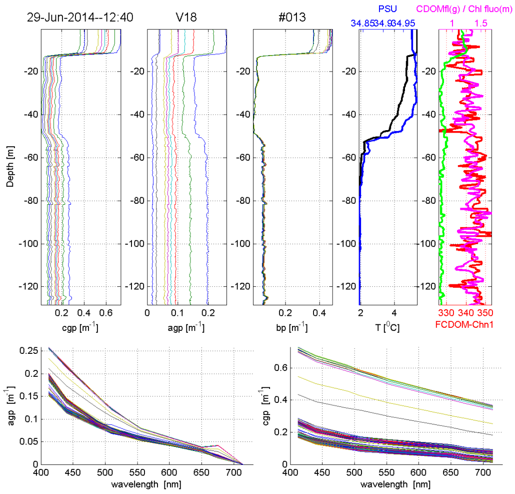

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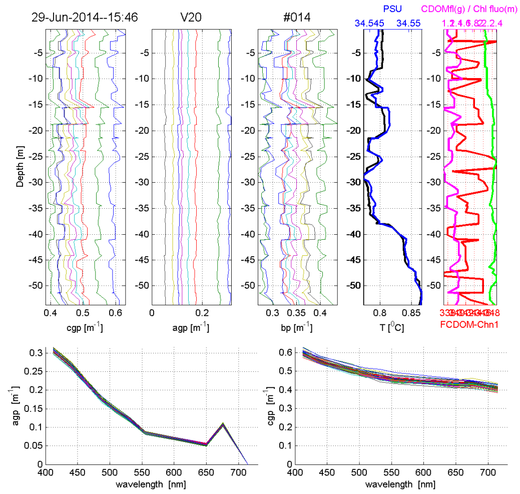

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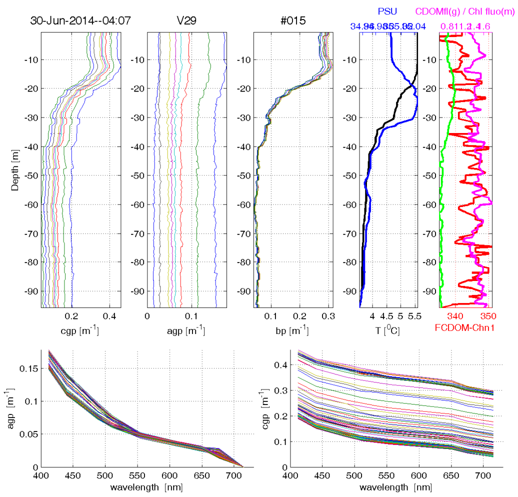

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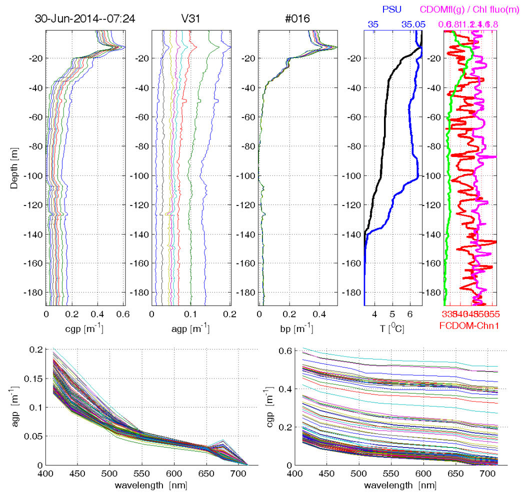

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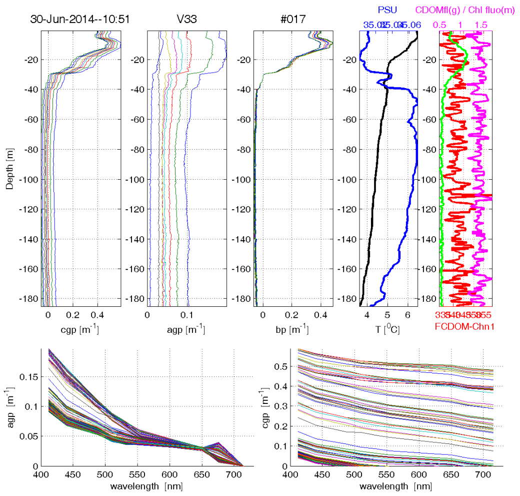

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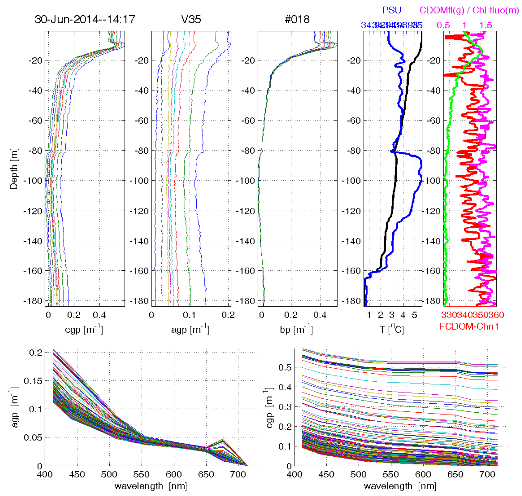

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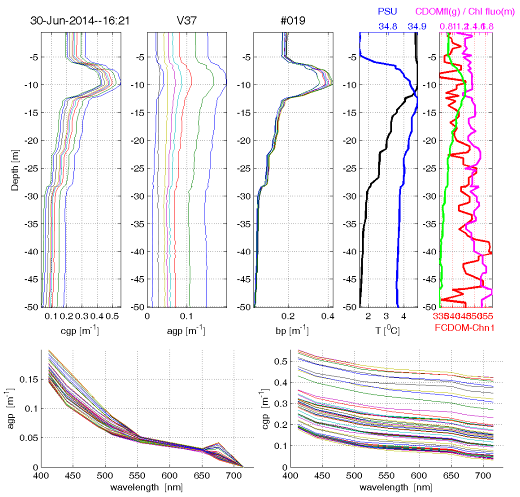

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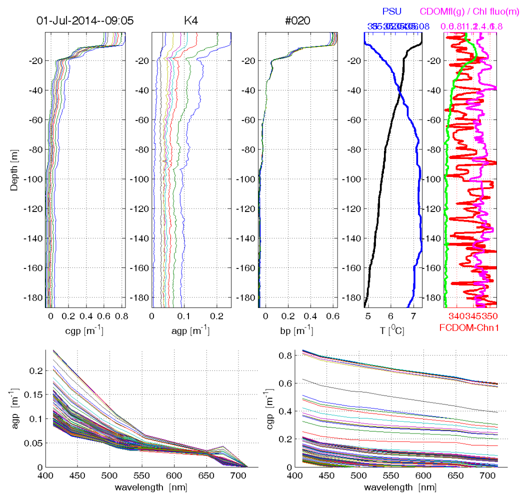

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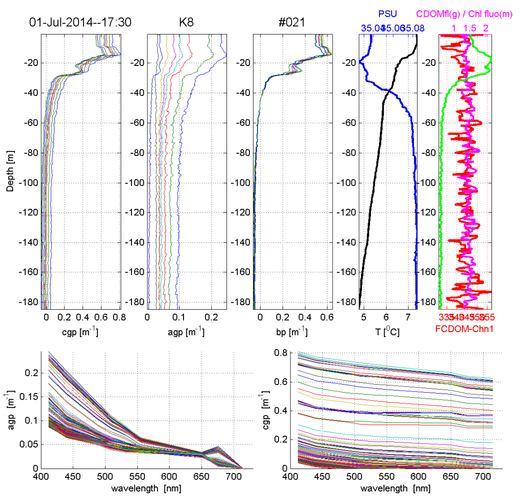

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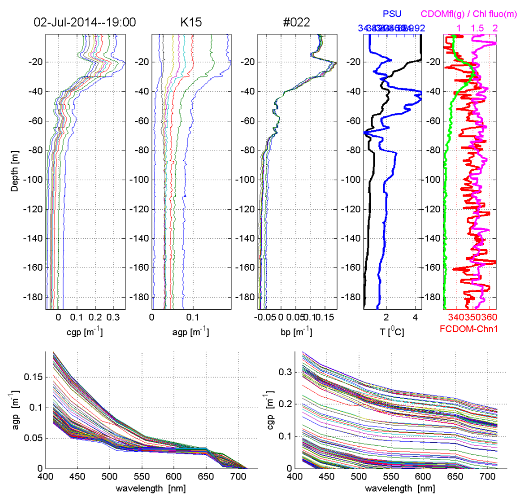

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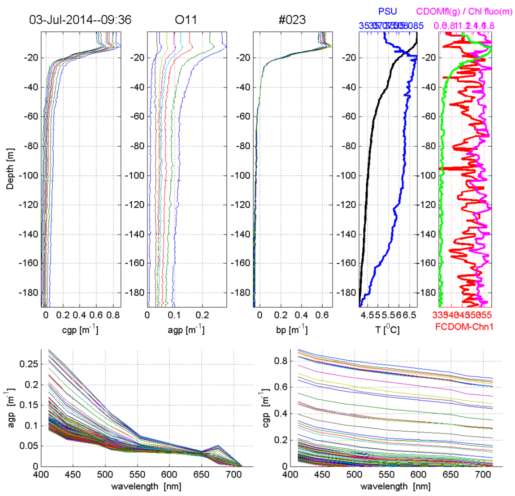

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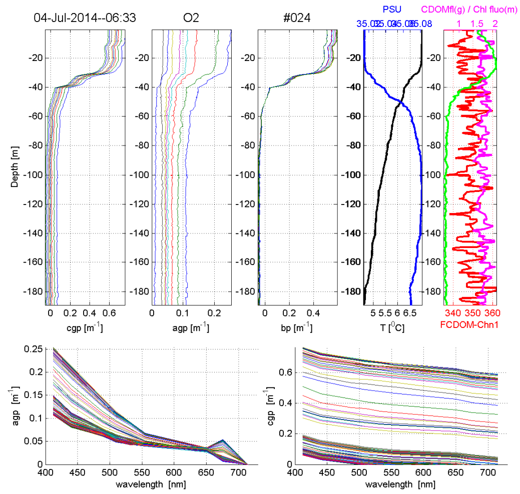

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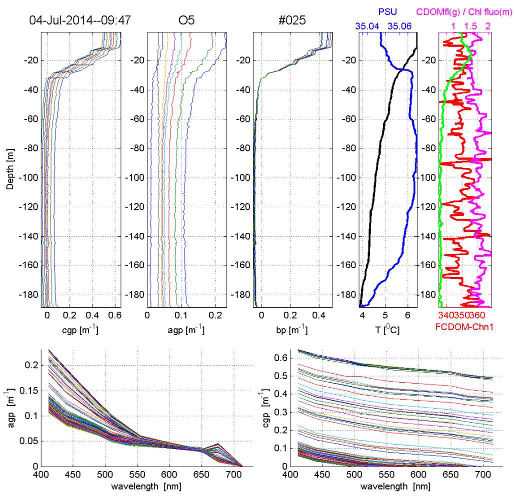
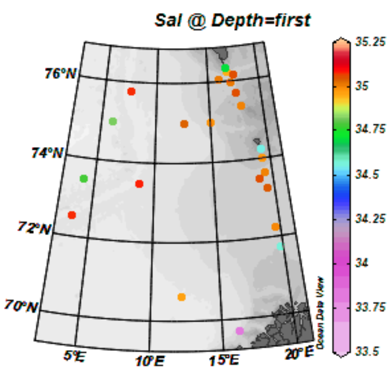
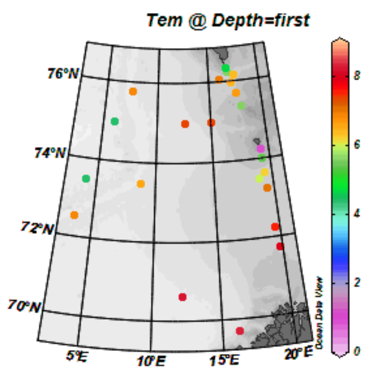


Fig. 2. Vertical distribution of light attenuation by (cpg), absorption (agp) coefficients by particulate and dissolved materials, temperature, salinity and fluorescence by CDOM (in Volts) on transect of the AREX 2014/5 cruise.

a)



b)



c)

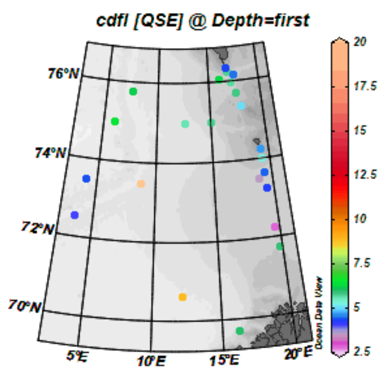
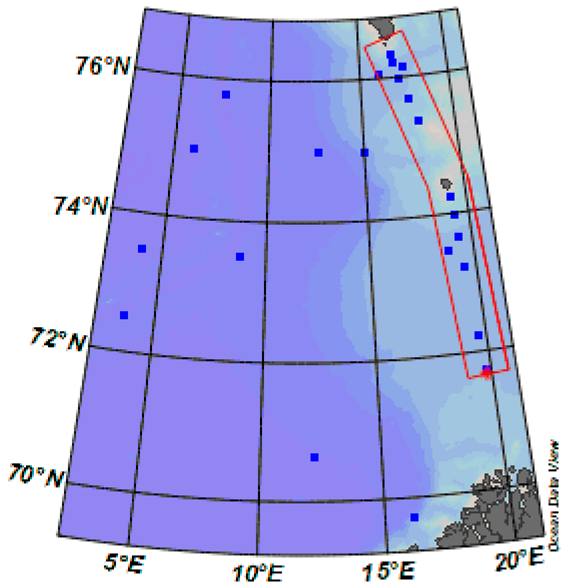
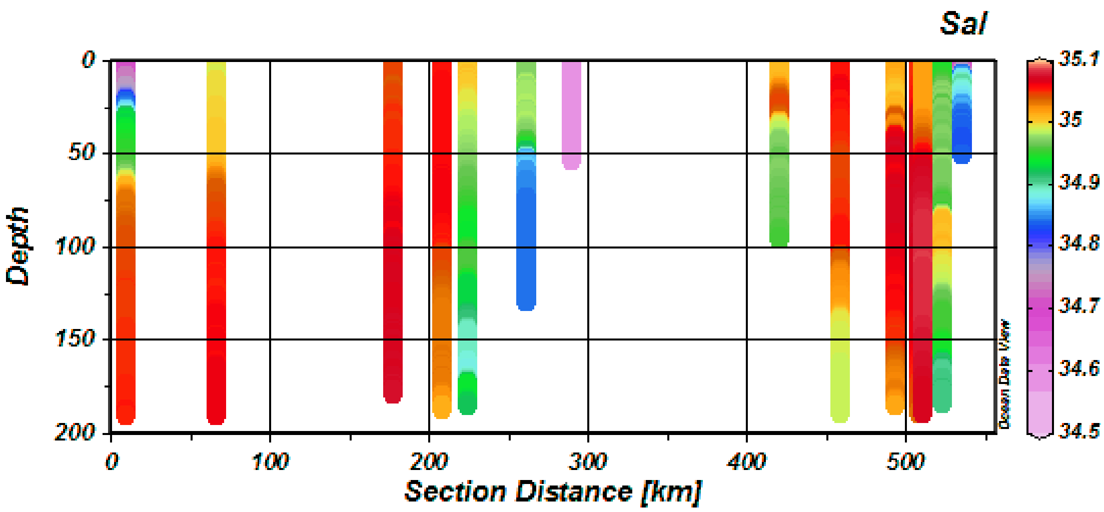


Fig. 3. Changes of the salinity (a), temperature (b) and fluorescence (c) (in QSE) by CDOM on transect of the AREX 2014/5 cruise (surface).

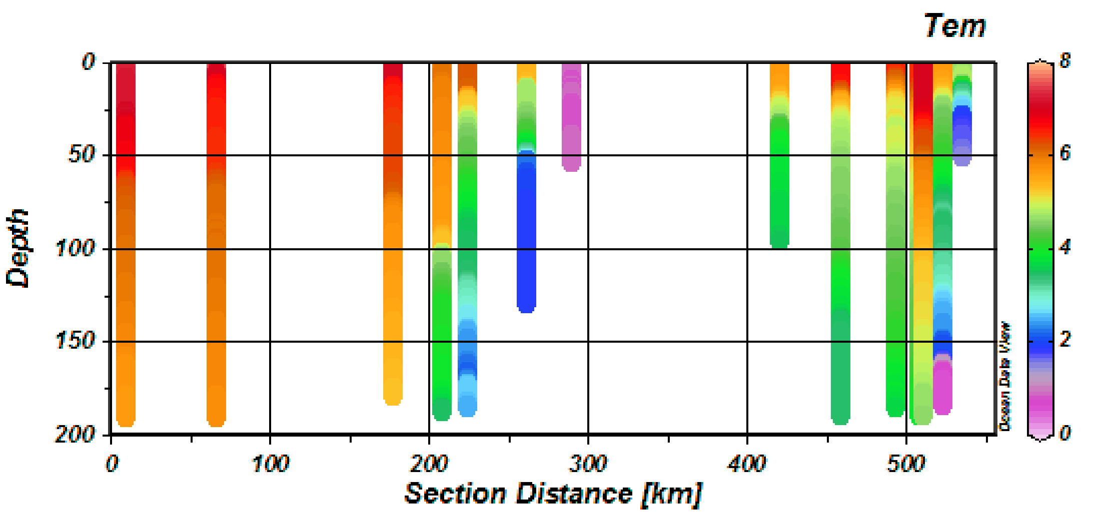
a)


76°N
74°N
72°N
70°N
5°E
10°E
15°E
20°E
Ocean Data View

b)


Sal
Depth
0
50
100
150
200
Section Distance [km]
0
100
200
300
400
500
35.1
35
34.9
34.8
34.7
34.6
34.5
Ocean Data View

c)


Tem
Depth
0
50
100
150
200
Section Distance [km]
0
100
200
300
400
500
8
6
4
2
0
Ocean Data View

d)

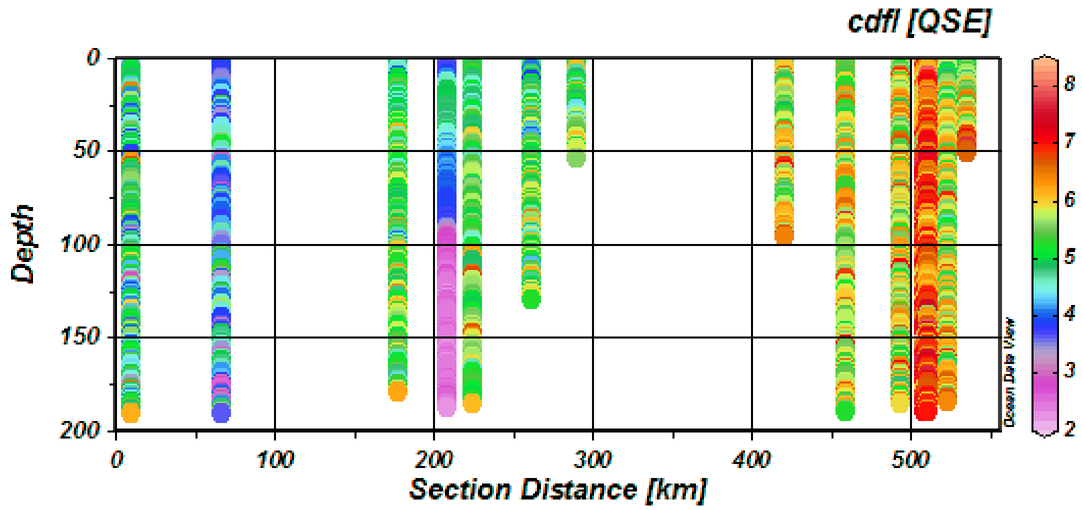
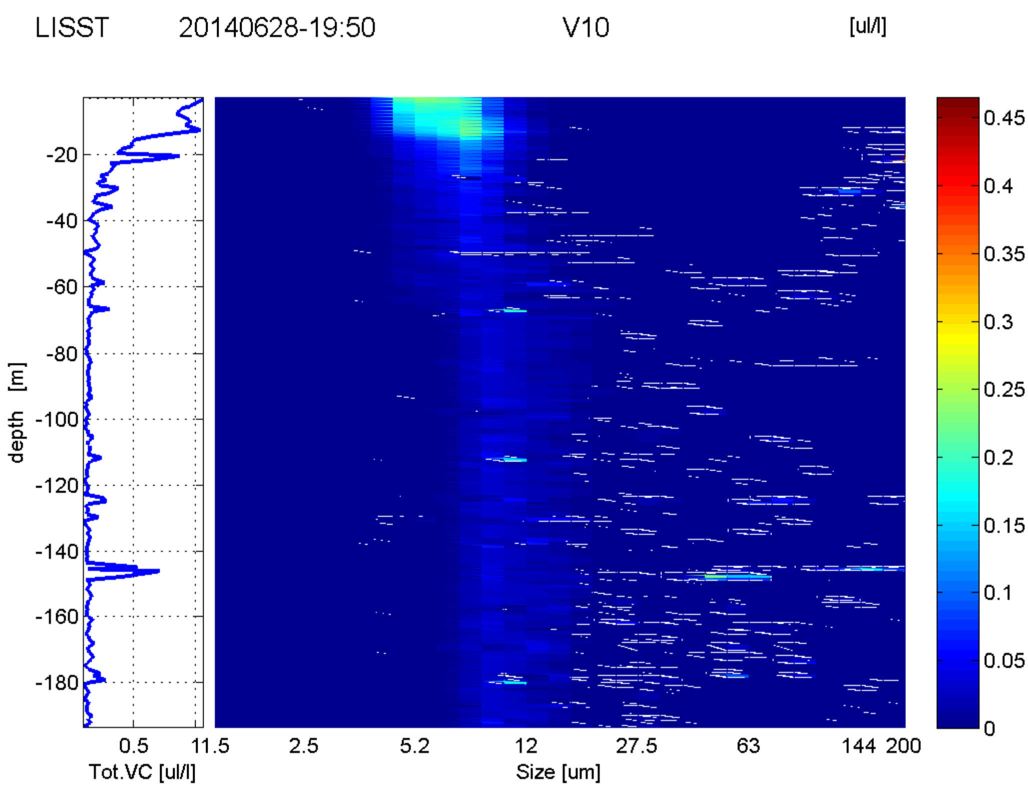


Fig. 4. Changes of the salinity (b), temperature (c) and fluorescence (d) (in QSE) by CDOM on transect V (red box in a) (vertical).

2.2 LISST-100X



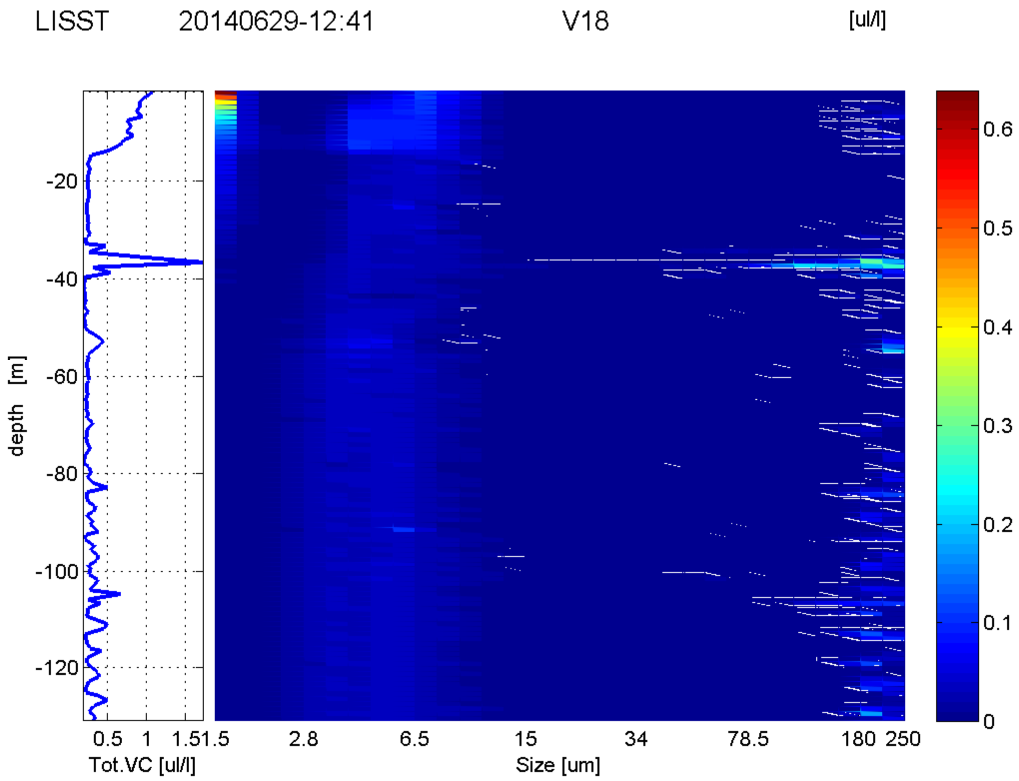


Fig. 5 Example spatial distribution of volume particle concentrations (measurement 10 and 13) of the Arex2014/5 cruise. Size distribution for 32 size classes in range of 1.2 to 250 µm, logarithmic scale.

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.